Environmental Impact Assessment Report

Extension of the Olkiluoto Nuclear Power Plant by a Fourth Unit

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Glossary and abbreviations

A

Activation
A process where atoms turn radioactive; for instance, as a result of neutron-induced changes in their nuclei.

Activation product
Radionuclides produced by activation.

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

Aerosol
Small floating particle.

Alpha radiation
Alpha radiation is of positively-charged particles emitted from the nucleus of an atom. Alpha particles are helium nuclei, with 2 protons and 2 neutrons.

Average dose
Average dose received by the population, part of population or a certain group during a certain period e.g. in one year.

B

Bar
A unit of pressure: 1 bar = 100,000 Pascal. Atmospheric pressure is approximately 1 bar.

Becquerel (Bq)
The unit expressing the activity of a quantity of radioactive material. The activity of the material equals one becquerel if it undergoes one nuclear disintegration per second.

Beta radiation
Particle radiation consisting of electrons or positrons.

Biodiversity
Biological diversity. A multi-faceted concept that includes, among other things, genetic variance within a certain species, the number of species, the spectrum of different biotic communities as well as the diversity of biotopes and ecosystems and the variance of different ecological processes.

Biotope
Type of natural environment. Biotopes are characterised by their physical and chemical properties (such as climatic conditions and soil properties), but also by the living organisms found in them (such as dominant plants). For example, forests, coniferous forests, herb-rich forests, meadows, bogs, lakes, seas and brooks are different biotopes.

Boiling water reactor
A light-water reactor in which water used as the coolant boils as it passes through the reactor core. The resulting steam is used to drive a turbine.

C

Carbon dioxide equivalent
A unit that allows the comparison of different greenhouse gas emissions on the basis of their impacts. Different substances have different effects on the greenhouse phenomenon. In order to facilitate the comparison of these emissions on the basis of their impact rather than their absolute quantities, the emissions of different substances are converted to correspond to carbon dioxide emissions using a particular factor called GWB (Global Warming Potential). Methane, for example, is a greenhouse gas 21 times stronger than carbon dioxide, which is why the emission of one ton of methane corresponds to an emission of 21 tons of carbon dioxide: we can therefore refer to an emission of 21 carbon dioxide equivalent tons.

Carbon-14
In addition to radon, the carbon-14 isotope is the most significant source of radiation exposure in a uranium fuel cycle. Carbon-14 is also formed in the atmosphere by cosmic radiation.

Collective dose
Population dose. The sum total of radiation doses received by a certain group of population, used for estimating the probability of delayed effects of radiation in that group. The unit of collective dose is mansievert (manSv).

Cooling water flow rate
The cooling water flow rate is expressed as cubic metres per second, or m^3/s. The total flow of cooling water of the current units in the Olkiluoto power plant is approximately 60 m^3/s and OL3 when completed will take 60 m^3/s. The new unit (OL4) would need approximately 40–60 m^3/s. For comparison, the average flow rate in the Kokemäenjoki river is about 230 m^3/s.

D

dB, decibel
A unit of noise level.

Dose rate
The dose rate expresses the radiation dose received by a person within a certain time. The unit of dose rate is sieverts per hour, or Sv/h. Normally, smaller units are used: millisieverts per hour (mSv/h) or microsieverts per hour (µSv/h). One sievert per hour therefore equals 1,000 millisieverts per hour or 1,000,000 microsieverts per hour. The dose rate describes how dangerous it is to be in a certain place exposed to radiation of a certain intensity.

E

Efficiency
The ratio of the amount of electrical energy produced by a power plant to the amount of energy contained in the consumed fuel.

EIA
Environmental Impact Assessment.

Electrical power
Capacity by which a plant generates electrical energy supplied into a power grid.

EMAS
Eco-Management and Audit Scheme is an environmental management scheme of the EU. The environmental management system of TVO complies with EMAS.

Encapsulation plant
Spent nuclear fuel is encapsulated for final disposal at the encapsulation plant.

F

Fission
The splitting of a heavy atomic nucleus into two parts, accompanied by the release of fast neutrons.

G

Gamma radiation
Gamma radiation is radiation travelling as electromagnetic waves whose wavelength is smaller and energy higher than those of X-rays.

Gray (Gy)
A unit of absorbed dose, expressing the amount of energy absorbed in the target media by ionizing radiation: 1 Gy = 1 Joule/kg. Multiple units mGy = 1/1,000 gray and µGy = 1/1,000,000 gray.

GWh
Gigawatt-hour (1 GWh = 1,000,000 kWh).

H

Half-life
The time it takes for the amount of radioactive matter to be reduced to half as a result of radioactive decay, i.e. as half the matter is converted into another type of matter. All radioactive matter has its own specific half-life.

I

IAEA
International Atomic Energy Agency.

ICRP
International Commission on Radiological Protection.

INES
International Nuclear Event Scale.

Iodine
An element with the symbol I. From the point of radiation protection, the most important iodine isotope produced in the uranium fuel is Iodine-131 with a half-life of 8 days.

Iodine tablet
A tablet containing potassium iodide, intended to be taken when specifically prompted to do so in a situation of radiation hazard. The iodine contained in the iodine tablet concentrates in the thyroid gland, saturating it so that it is protected against radioactive iodine.

Ion
An electrically charged atom or molecule.

Ion-exchange resin
Material used for removing ionic impurities from water.

Ionizing radiation
Radiation capable of producing ions in material, either directly or indirectly. Ionizing radiation can be electromagnetic or particle radiation.

ISO 14001
Environmental issues management standard.

Isotope
Isotopes are different forms of the same element, differing from each other in the number of neutrons in their nucleus and the properties of the nucleus. Hydrogen, for example, has three isotopes: hydrogen (protium), deuterium and tritium. Of these, tritium is radioactive.

K

KAJ Store
Interim storage facility for intermediate-level operating waste.

KPA Store
Interim storage facility for spent fuel.

L

Landscape province division
Prepared as a result of a report concerning Finland's nature and culture characteristics and their variation. The landscape province division was used as a tool for evaluating the value and representativeness of landscape areas.

M

MAJ Store
Interim storage facility for low-level operating waste.

Mansievert (manSv)
A unit of collective dose. If, for example, each person in a group of population having 1,000 members receives an average radiation dose of 20 millisieverts, the collective dose is 1,000 x 0.02 Sv = 20 manSv.

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

MW_f
Fuel power in megawatts (f=fuel).

N

Noble gas
The noble gases are helium (He), neon (Ne) argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn).

Nuclear fuel
Fuel elements containing fissionable material for use in nuclear power plants.

Nuclide
A type of atomic nucleus with a specific number of protons and neutrons. The nucleus can be either stable or radioactive.

O

ONKALO Underground rock characterisation facility for the final disposal of spent nuclear fuel.

Operating waste
Common name for waste with low- or intermediate-level radioactivity produced during the operation of a nuclear power plant.

P

Pressurized water reactor
A light-water reactor in which the water used as coolant and moderator is kept under such high pressure that prevents it from boiling regardless of the 300 °C temperature. The water that has passed through the reactor core releases its heat to the secondary circuit water in separate steam generators. It boils into steam that is used for driving a turbine.

R

Radiation
Electromagnetic waves or particle radiation consisting of the smallest particles of matter.

Radiation dose
Radiation dose describes the amount of radiation energy received by the target. The unit of radiation dose is sievert (abbreviation Sv), and it takes into account the different biological effects of different types of radiation. Sievert is a large unit, and one sievert is a large radiation dose. One thousandth of a sievert, or millisievert (0.001 Sv), is a more commonly used unit.

Radioactivity
Transformation of an atomic nucleus into other nuclei. A radioactive nucleus emits radiation characteristic to the transformation (alpha, beta or gamma radiation).

Radon
Radon is a noble gas, whose isotope Rn-222 is produced by the decay of uranium contained in the bedrock, and accounts for most of the exposure to natural radiation in Finland.

S

Sievert (Sv)
A radiation dose unit indicating the biological effects of radiation. Abbreviated as Sv. As it is a very large unit, millisieverts (1 mSv = 0.001 Sv) and microsieverts (1 µSv = 0.001 mSv) are more commonly used.

Spent fuel
Nuclear fuel after removal from the reactor core. Spent fuel emits radiation at high intensity.

STUK
Radiation and Nuclear Safety Authority.

T

TEM
Ministry of Employment and the Economy, to which the tasks of the Ministry of Trade and Industry (KTM) were transferred on 1st January 2008.

Thermal power
Capacity by which a plant generates thermal energy.

Tritium
A hydrogen isotope (H-3).

TWh, terawatt-hour
A unit of energy. One terawatt-hour equals one billion kilowatt-hours.

U

UNECE, United Nations Economic Commission for Europe
Founded in 1947, UNECE, the United Nations Economic Commission for Europe, is one of the five regional commissions of the United Nations. Its aim is to strengthen the economic cooperation between its member countries.

Uranium
An element with the chemical symbol U. Uranium comprises 0.0004% of the earth's crust (four grams in a ton). All uranium isotopes are radioactive. Natural uranium is mostly in the form of isotope U-238, which has a half-life of 4.5 billion years. Only 0.72% of natural uranium is in the form of isotope U-235, which can be used as a nuclear fuel.

V

VLJ Repository
A final repository for low- and intermediate-level operating waste.

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Summary

In the spring of 2007, Teollisuuden Voima Oyj (TVO) initiated an environmental impact assessment procedure (EIA procedure) for the fourth nuclear power plant unit project at Olkiluoto in accordance with the Act on Environmental Impact Assessment Procedure (EIA Act). The coordinating authority for the EIA procedure referred to in the EIA Act is the Ministry of Trade and Industry (as of 1 January 2008 the Ministry of Employment and the Economy).

The EIA programme was submitted to the coordinating authority in May 2007 and kept on public display between 12 June and 31 August 2007. The coordinating authority provided its statement on the programme on 28 September 2007.

The impacts of the project have been assessed from a broad perspective when surveying its environmental impact. The focus of the assessment was on those impacts that were considered and felt to be significant. Information about issues felt important by citizens and various interest groups has been obtained in connection with communications, interaction, a resident survey and international hearing, among other things.

The organisation responsible for the project is TVO, a private power production company owned by Finnish industrial and power companies. The company produces electricity for its shareholders at the Olkiluoto nuclear power plant. In addition, TVO procures electricity from the Meri-Pori coal-fired power plant.

The preparation of the EIA report has been the responsibility of Pöyry Energy Oy. Related investigations have also been performed at the Environmental Impact Assessment Centre of Finland Ltd (water system modelling), Ramboll Finland Oy (Natura requirements assessment), Ramboll Analytics Oy (noise assessment) and Posiva Oy.

Purpose, location and schedule for the project

The consumption of electricity in Finland continues to grow. Finland consumed approximately 90 TWh of electricity in 2006. The 80 TWh mark was exceeded in 2001, 70 TWh in 1996, 60 TWh in 1989 and 50 TWh in 1985. Electricity consumption has doubled in a quarter of a century. It is estimated to exceed 100 TWh in 6 to 8 years.

In order to improve its preparedness for constructing additional production capacity, TVO has initiated the environmental impact assessment procedure concerning a fourth nuclear power plant unit that would possibly be located at Olkiluoto. The purpose of the new nuclear power plant unit is to increase the production capacity for base-load power. The construction of a nuclear power plant unit will also improve Finland's independence on foreign electricity and increase supply in the electricity market.

The planned location for the nuclear power plant is on the west coast of Finland, on Olkiluoto Island in the municipality of Eurajoki. The TVO nuclear power plant units OL1 and OL2 located at Olkiluoto were constructed between 1973 and 1980. The net electrical output of each plant unit is 860 MW. Furthermore, the net electrical output of the OL3 plant unit under construction will be approximately 1,600 MW. Based on the information received from the plant supplier, OL3 is estimated to be completed in 2011.

Should TVO decide to continue the implementation of the project, an application for a decision-in-principle will be submitted. The realisation of the project is subject to a decision-in-principle issued by the Government and ratified by Parliament. If the decision-in-principle is ratified and, in addition to environmental issues, the technical and economic prerequisites for construction are fulfilled, construction of the plant could start in the early 2010s. Construction is estimated to take 6 to 8 years.

Options and limits for the project

The environmental impact assessment considers a new nuclear power plant unit having a net electrical output of 1,000 to 1,800 MW at Olkiluoto. TVO does not have any other realistic options for the location because it is essential for the project to utilise existing land use planning and infrastructure.

The options for the new nuclear power plant unit are as follows:

- two alternative sites at Olkiluoto
- two alternative locations for cooling water discharge
- two alternative locations for cooling water intake.

The zero option has assessed the situation in which a fourth power plant unit will not be built at Olkiluoto and there will be three nuclear power plant units (OL1, OL2 and OL3) in operation at Olkiluoto.

Links to other projects and plans

The new nuclear power plant unit requires reinforcements to the power transmission system. Fingrid Oyj has assessed the connection of the OL4 plant unit to the national grid and the required grid reinforcements. Fingrid Oyj will initiate environmental impact assessments for the power transmission lines supporting the grid connection of Finland's sixth nuclear power plant unit and the required reserve power capacity in 2008–2009. Fingrid Oyj will initiate the EIA procedures concerning the plant site power lines and the required reserve power capacity after the decision-in-principle for Finland's sixth nuclear power plant unit has been made. In this EIA report, the environmental impacts of the required power transmission connection have been assessed within the Olkiluoto partial master plan area. The OL4 power line area is located in the southern part of the Olkiluoto island.

In the partial master plan proposal for Olkiluoto (31 October 2007), a new road connection to the power plant site will be routed from the south side of the existing Olkiluodontie road directly to the present gate of the power plant site. The present road will remain in use, leading to the accommodation village from which it will continue as an internal road connection within the energy supply area. The partial master plan proposal also contains another road connection to the harbour in the northern part of Olkiluoto along the eastern and northern borders of the energy supply area.

With regard to the impacts of the final disposal of spent nuclear fuel originating from the new nuclear power plant unit planned for Olkiluoto, the EIA completed by Posiva Oy in 1999, and the research subsequently conducted, has been utilised. The task of Posiva Oy is to design and implement the final disposal of spent nuclear fuel originating at the nuclear power plants of its shareholders, TVO and Fortum Power and Heat Oy.

Impacts at the construction stage

The construction of the new unit will take approximately 6 to 8 years. Environmental impacts during the construction of the power plant include noise, vibration and dust caused by machinery and construction. These impacts will be limited to the site and its immediate vicinity and will occur mainly during the first two years of construction.

During the construction and dredging of cooling water passages, sea water will become muddy temporarily and locally. All construction at the power plant site will be planned and implemented so as not to compromise the operation or safety of the existing plants at Olkiluoto.

During construction, traffic on Olkiluodontie will increase threefold compared to the zero option in which the existing units, the OL3 unit and the disposal facility are in operation. Particularly at the initial stage of construction, the proportion of heavy traffic on the road will increase. The increased traffic volume may result in increased accident risk.

Excavation work, site traffic and separate functions (such as the concrete mixing plant, rock crushing and deposition of rock material) will locally generate dust during construction. Vehicles and machinery will cause atmospheric emissions. The quantity of the emissions is small, and it will not affect the quality of air outside the work site.

Noise during the construction of the new nuclear power plant unit will be at its highest when the power plant site is excavated. Because both alternative sites are in the inner parts of the island, noise impact during construction will not be too intense at holiday homes on nearby islands. During excavation, the daytime noise level north of Olkiluoto will increase by some 2–3 dB depending on the alternative site compared to a situation with three plant units in operation. The corresponding change to the south and southwest of Olkiluoto will be smaller, approximately 1 dB at maximum. During the construction stage after the completion of excavation, the noise levels will be lower. The daytime and night-time guideline values for the nearby islands and the nearest residence will not be exceeded during the construction stage.

Impacts during operation

In practice, the only environmental load factor that will substantially change in direct proportion to the electrical output of the new unit is the amount of heat conducted to the sea. In this EIA report, the estimates concerning the impacts of cooling water are presented on the basis of the cooling water consumption of a 1,800 MW unit – that is, maximum impacts. The impact of the size of the plant on radioactive releases is minor. The size of the plant will have some effect on the quantities of materials to be transported during construction and use, the quantities of waste generated, the number of employees and thus the volume of commuter traffic, as well as the economic impacts of the project. The size of the power plant may also affect the number of power transmission lines required.

Impact of the power plant project on land use, landscape and the built environment

The new power plant unit will be located at the Olkiluoto power plant site and utilise the existing infrastructure. The construction of the new unit will cause some rearrangements within the power plant site, such as changes to access routes. The construction of the new unit is in compliance with the valid local detailed plan.

Power plant units are already an element dominating the nearby landscape. The new unit will add a fourth element of a similar type to the existing complex but will not substantially change its characteristics. In the distant landscape, the top sections of the reactor plants and the vent stacks will be visible far out to sea.

Atmospheric emissions and their impacts

Radioactive releases during the operation of the new nuclear power plant unit will be minor and have no harmful effects on the natural environment.

Depending on weather conditions and the properties of each substance, radioactive substances will be carried to the surface of the earth or vegetation, water systems and organisms. In samples taken from these, sensitive analysis methods will, from time to time, detect radioactive substances originating from the power plant in addition to other radioactive substances.

Test runs of back-up power sources and reserve heat boilers will generate some carbon dioxide, nitrogen oxide, sulphur dioxide and particle emissions. Test runs of the boiler plant and back-up diesels at the OL1 and OL2 power plant units generate an approximate average of 400 tonnes of carbon dioxide, 1 tonne of nitrogen oxides, 0.1 tonnes of sulphur dioxide and 0.5 tonnes of particle emissions in total annually. The third power plant unit under construction is estimated to double the emissions from the back-up power sources at OL1 and OL2. Test runs of back-up power sources at OL4 will generate annual emissions on a par with those at OL3. The quantities of emissions from the OL4 back-up power sources and reserve heat boiler are minor and do not have any significant impacts on air quality or other impacts.

Impacts on the water system and fishing industry

The process increases the temperature of the cooling water by 11 to 13 °C. The average temperature of incoming cooling water has been approximately 16 °C while the maximum temperature has been 25 °C. Besides the increase in temperature, cooling water does not cause any nutrient or oxygen-consuming load in the sea around Olkiluoto.

The impact of the thermal load from the new unit on sea water temperatures and ice conditions in the sea area off Olkiluoto was investigated using a mathematical migration model. Cooling water from the new unit will increase the surface water area that warms by more than one degree approximately 1.5-fold compared to the zero option. The effect of weather on the extent of the warmed-up area is clearly greater than that of the difference between alternative discharge points.

At approximately 500 metres from the discharge point, the temperature of surface water (0.5 metres) will change only slightly, by 1 to 2 in comparison to the current situation. However, a water layer thicker than at present will warm up particularly if the cooling waters from the new unit are conducted to the same discharge point as cooling waters from the units OL1, OL2 and OL3. The change in maximum temperatures at the surface layer can also be considered minor but the water will warm up more clearly deeper down. Further outward, approximately one kilometre from the discharge point, the surface water will warm up by approximately 2.5 to 3.5 compared to the present situation both as the summer average and in the maximum situation but the change close to the bottom will be quite minor.

OL4 will increase the thermal load in the area and expand the area in which changes in aquatic vegetation will be observed. The extent to which changes in aquatic vegetation will be observed depends on the proportion of sea bed suitable for aquatic vegetation in the warmed-up area. In any case, vegetation will become less diverse, and production will increase in a larger area.

The new power plant unit will expand the area affected by cooling water but the impacts on fish populations will remain similar. Increased temperature has different impacts on fish populations. When taking into account the migration of fishes, cooling water as a whole is not estimated to impose any substantial or extensive harmful effects on the fish populations of the area. In the long-term, increased temperature and its consequences will favour fish species spawning in the spring (such as pike, perch, pike-perch, bream and roach). The unfrozen area attracts fish such as whitefish and trout in the winter. The increased growth of algae in the summer will cause an increased build-up of slime in stationary fishing tackle, calling for more frequent cleaning. Cooling water and its consequences are not estimated to have any effect on the usability of fish.

The new unit will increase the unfrozen area or area of weak ice approximately 1.5 fold compared to a situation with three power plant units in operation. Weakened ice conditions will limit operations on the ice. However, the sea area facing the open Botnian sea has naturally unstable ice conditions, and the cooling water from the existing units is already weakening the ice.

Possibilities to utilise the cooling water have also been investigated but there are no techno-economically or environmentally justifiable alternatives for substantially reducing the thermal load. The most efficient way of reducing the thermal load conducted to the water system is by aiming for the best available operating efficiency.

Waste water originating from the new nuclear power plant unit will be treated appropriately. As it is discharged to the open sea together with cooling water, it will be efficiently diluted and have no significant impact on the condition of the sea area. Radioactive discharges during the operation of the new unit are estimated to be minor and have no harmful effects on the aquatic environment.

Noise impacts

The noise generated by a nuclear power plant during operation is a continuous stable faint humming around the clock and will be masked by quite soft sounds such as the murmur of the sea or the sighing of the wind. In calm weather when sound is easily carried at sea, the noise from the existing power plant can be heard at the nearest holiday homes and islands. The noise levels will not exceed the guideline values set by the Government even at the nearest residence.

Waste and its impacts

Spent fuel is initially cooled down and stored for a few years in water pools at the power plant unit. After this, it is taken to interim storage in cooled water pools in the spent fuel interim storage facility at the Olkiluoto power plant. Intermediate storage in the spent fuel interim storage will continue for decades until the final disposal of the spent fuel.

The low- and intermediate-level operating waste produced by the power plant unit, as well as the dismantled components and other dismantling waste generated in connection with the decommissioning of the plant unit, will be placed in the operating waste repository. The implementation of the new power plant unit requires that the currently used interim storage facility for spent fuel and operating waste repository be expanded.

When handled appropriately, radioactive waste is not estimated to cause any harmful impacts on the environment or people.

Posiva Oy is responsible for the final disposal of spent fuel originating from its shareholders, TVO and Fortum Power and Heat Oy. The intention is to dispose of spent nuclear fuel in the bedrock of Olkiluoto at a depth of approximately 400 to 500 metres. Final disposal is scheduled to start in 2020.

Impacts on flora and fauna, objects of protection and biological diversity

The new unit will be located tightly integrated with the existing power plant site, which means that the project's direct impacts on flora, fauna and biodiversity will mostly be limited to the land areas required for buildings and structures, as well as the construction work, and will thus be quite small. Indirect impacts in the vicinity of the nuclear power plant may involve changes in the composition of species in the cooling water discharge area. The project will not have any substantial harmful impacts on objects of protection and Natura 2000 areas in the vicinity.

Impact of traffic and transportation

After completion, the new unit will increase the volume of traffic to Olkiluoto by approximately 25% compared with the zero option. The volume of traffic in Olkiluoto after the completion of the OL4 plant unit is estimated at 2,000 vehicles daily. The volume during annual outages will be approximately 4,500 vehicles.

Transportation to the power plant during operation mostly consists of light goods traffic, and the new unit will not significantly increase the volume of goods transport from the present. The increase in traffic during operation will not significantly increase the nuisance presently imposed on residences along the road by dust, noise or vibration.

Traffic noise will not exceed the daytime or night-time guideline values at residential buildings along Olkiluodontie.

Impacts on health

Releases of radioactive substances from the power plant to the atmosphere and sea are continuously measured, and radiation doses incurred in the vicinity are calculated annually on this basis. The greatest allowed release of radioactive substances into the environment is defined so that it must not cause an annual radiation dose exceeding 0.1 mSv to anyone living in the vicinity. The calculated radiation dose to nearby residents caused by releases from the Olkiluoto power plant into the atmosphere and water in 2006 was approximately 0.00027 mSv or 0.3% of the allowed limit.

The radiation dose caused by releases from the planned fourth unit for the Olkiluoto power plant to a member of the most exposed group of the population is estimated to be about 0.0003 mSv per year, which is on a par with the combined dose from the existing Olkiluoto units (OL1 and OL2) and the dose from OL3 under construction. After the completion of the new unit and the third unit currently under construction, the radiation dose caused by releases from the operation of the Olkiluoto nuclear power plant (OL1, OL2, OL3 and OL4) to a member of the most exposed group of the population will thus be about 0.001 mSv per year. The radiation dose caused by the fourth unit is so small that it is insignificant to human health.

Impacts of accident situations

According to the Nuclear Energy Act, the design, construction and operation of a nuclear power plant must be safe and shall not cause injury to people or damage to the environment or property. The safety objective can be considered achieved when the risk caused by releases from normal operations and potential accidents represents a very small increase in the total risk imposed on people by other functions of society and natural dangers.

A nuclear power plant must be designed in accordance with nuclear energy legislation and YVL Guides (NPP guides) published by the Radiation and Nuclear Safety Authority in order to ensure the safety of its operation. The guides apply to the safety of nuclear installations, nuclear materials and nuclear waste, as well as the physical protection and emergency preparedness required for the use of nuclear energy.

The latest safety requirements will be taken into account in the potential new power plant unit, and preparations have been made for severe accidents and the mitigation of their consequences.

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

- managing the chain reaction and the power it produces;
- cooling the fuel after the chain reaction has ended, also known as decay heat removal; and
- isolation of 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 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 the mitigation of their consequences.

An explosive event arising from an uncontrolled increase in power is impossible in a light water reactor due to structural reasons. An accident leading to severe reactor core damage will require the simultaneous failure of multiple safety systems and several incorrect actions from the operating personnel.

The EIA report examines the impacts of a radioactive release originating from a severe accident on people and the environment. The probability of the occurrence of the accident under review is less than once in 100,000 years.

The release would not cause an immediate health impact on even the nearest residents. In the absence of any protective measures, the radiation dose incurred during the first 24 hours by a person living ten kilometres from the power plant could be approximately five times the annual average dose of each Finn. The incurred doses can be substantially reduced by protective measures. Protective measures could include temporary evacuation up to an approximate distance of five kilometres, taking shelter indoors within 10 kilometres and the administration of iodine tablets to children within a few dozen kilometres, as well as restrictions on the consumption of foodstuffs.

Impacts on living conditions and comfort

The attitude of nearby residents towards the project was investigated through a resident survey and group interviews. Public events arranged during the EIA procedure have also provided information on attitudes towards the project and issues considered important by people.

55% of all respondents to the resident survey supported the construction of a new nuclear power plant unit in Eurajoki. Support for the project was greater among permanent residents than holiday residents.

The impacts on social conditions in Eurajoki and the relationships between different population groups depend on the domestic content of the potential fourth nuclear power plant unit and the extent to which any foreign construction site employees will adapt to the local conditions, values and norms. Systematic work to develop recreational opportunities for foreigners has already been found necessary during the construction of Olkiluoto 3. Internationalisation was experienced as a positive development. The construction of the fourth plant unit will have a positive effect on the public image of Eurajoki.

Normal operation of the fourth plant unit will not affect the safety of the region. Most residents of Eurajoki consider nuclear power plants to be safe and reliable. Some of the respondents to the resident survey were concerned about the impacts of radioactive releases and accident situations. Women in particular emphasised the safety and health impacts.

The impacts on the living comfort and recreational opportunities in the area are mostly dependent on the impacts of the increased thermal load imposed by cooling water on the Olkiluoto sea area. On the basis of the resident survey and the group interviews, the most negative impacts of the fourth plant unit were considered to be the impact to the water system. The warm-up of seawater was considered to affect water quality, fish and ice conditions in the area. Ramifications were identified as the deterioration of ice, diminishing fish populations, declining opportunities for fishing, eutrophication of shores and increased difficulty of access to the islands off Olkiluoto during the winter. More than half of the respondents to the resident survey estimated that the project will not affect recreational opportunities. One-third of the respondents estimated that the impacts on recreation will be negative. The impact was most often estimated to concern fishing or boating.

Impacts on employment and the regional economy

TVO is the largest employer in Eurajoki. The company has approximately 660 permanent employees in Olkiluoto. Various maintenance services at the power plant site employ an additional 200 to 250 people on the payrolls of other companies. An additional 1,000 people work at the power plant during annual outages.

The realisation of the fourth plant unit will have a great positive effect on employment in the region. In addition to direct employment effects, jobs will probably be created in the service sector. The effects on the economy and commercial life in the region's municipalities will be positive. Employment opportunities will improve, which will have a favourable effect on the residents' opportunities to receive income. The framework for developing public and private services will improve. The employment effects were seen as positive in the group interviews as well as in the resident survey.

The most substantial parts of the nuclear power plant unit investment constitute earth construction, the construction of power plant buildings and the acquisition of equipment. The employment effect during the construction stage of the new nuclear power plant unit in Finland is estimated at 22,000 to 28,000 man-years. The plant unit construction stage is very significant for the regional employment rate. The fourth nuclear power plant unit will require an operating staff of approximately 150, and the increased need for outsourced services will correspond to the work input of approximately 100 people.

Impacts of nuclear fuel production and transportation

In each country, the production, transportation and storage of nuclear fuel are carried out in accordance with the applicable environmental and other regulations. TVO procures uranium for fuel under long-term contracts from suppliers in countries such as Canada, Australia and the EU.

Impact of the dismantling of the power plant unit

The technical service life of the planned nuclear power plant unit is approximately 60 years. Dismantling will be carried out with a delay – that is, the plant unit will be dismantled approximately 30 years after the end of operation. Radioactive releases during dismantling are smaller than during the operation of the power plant. The objective is that the plant area will not require any separate supervision after dismantling but can be taken into other use.

Impact of the power transmission lines

The new nuclear power plant unit requires reinforcements to the power transmission system. According to the Electricity Market Act, Fingrid Oyj has an obligation of developing the national grid and carrying the system responsibility. According to preliminary reports, one or two new connecting lines from the power plant to the grid at Rauma will be required, depending on the size of the power plant unit. The regional transmission capacity from Rauma to other parts of the national grid must also be reinforced. The new power transmission lines will not be placed into the same line corridor with existing lines but a new area will be reserved for power lines going out of OL4. A terrain corridor for power transmission lines is reserved in the Olkiluoto partial master plan in the southern part of the island. The power line area is currently unbuilt and does not include any objects of significant natural value. There are no residences or holiday homes in the immediate vicinity of power lines in Olkiluoto.

Environmental impact monitoring

Environmental legislation requires parties responsible for projects and operations affecting the environment to carry out environmental impact monitoring. In the case of nuclear power plants, monitoring is also required on the basis of regulations and guidelines issued by virtue of the Nuclear Energy Act. The obligations of monitoring are specified in the licence conditions associated with different licensing decisions for the project. Once the licence conditions have been received, supervision programmes shall be prepared jointly with the authorities, specifying the details of load and environmental supervision and reporting.

The impacts of the new nuclear power plant unit planned for Olkiluoto shall be supervised in accordance with the same principles applicable to the existing units.

Environmental impact monitoring includes:

Supervision of load

- supervision of radioactive releases
- supervision of cooling water
- supervision of waste water
- supervision of groundwater conditions
- waste accounting
- noise supervision
- supervision of the back-up diesels and boiler plant

Supervision of impacts

- environmental radiation monitoring
- supervision of water systems
- supervision of fish
- follow-up of social impacts.

Zero option

The zero option is the non-implementation of the project. This means that the condition of the environment and the impact of environmental loads correspond to the situation in which OL3 has been commissioned. The social and economic impacts of the project will not be realised in the zero option.

Interaction

Interaction has been lively during the environmental impact assessment procedure for the Olkiluoto nuclear power plant extension project. Information and discussion events have been arranged for the public and small groups. In these meetings, the participants have had an opportunity to express their opinions and receive information about the project and its environmental impacts.

An audit group consisting of different interest groups was established to monitor the EIA procedure, the purpose of which is to promote the flow and exchange of information between the organisation responsible for the project, the authorities and other interest groups. The audit group convened three times during the EIA procedure.

A resident survey was carried out in connection with the EIA procedure, through which information about the residents' attitudes towards the project was obtained. Information about the EIA procedure has also been disclosed through press releases, TVO's Web pages, magazines and brochures, as well as in the form of various events.

1 Preface

Teollisuuden Voima Oyj (TVO) initiated the environmental impact assessment procedure (EIA procedure) in accordance with the Act on Environmental Impact Assessment Procedure (EIA Act).

The plan for assessing the environmental impact of the project and arranging the related communications, referred to as the EIA programme, was completed in May 2007. The EIA programme was on public display between 12 June and 31 August 2007. Acting as the coordinating authority of the EIA procedure referred to in the EIA Act, the Ministry of Trade and Industry, the tasks of which will be transferred to the Ministry of Employment and the Economy as of 1 January 2008, provided its statement on the programme on 28 September 2007 (Appendix 1).

The impacts of the project have been assessed from a broad perspective when surveying the environmental impact. The focus of the assessment was on those impacts that were considered and felt to be significant. Information about issues felt important by citizens and various interest groups has been obtained in connection with communications, interactions and international hearing, among other things.

The significance of environmental impacts has been assessed on the basis of, for example, the settlement and natural environment of the observed area as well as by comparing the tolerance of the environment with regard to each environmental burden. In addition to the investigations carried out, the existing specifications, such as release limits for radioactive materials, were employed in assessing the environmental tolerance.

The results of the environmental impact assessment have been collected in this Environmental Impact Assessment Report (EIA report). All relevant existing environmental data, as well as the results of the prepared environmental impact assessments, have been presented in the EIA report. The EIA report also presents a plan for the mitigation of detrimental environmental impacts.

At TVO, the EIA procedure has been the responsibility of the EIA project group. Mr. Olli-Pekka Luhta, Manager of Quality and Environment, has served as the project manager.

The preparation of the EIA programme and the EIA report on the assignment of TVO has been the responsibility of Pöyry Energy Oy. Ms. Päivi Koski, M.A, has served as the consultation project manager. The people who have contributed to the preparation of the EIA report include Ms. Pirkko Seitsalo, M.Sc. (Eng.) (environmental impact assessment), Ms. Maija Saijonmaa M.Sc. (Eng.) (non-implementation of the project), Ms. Elina Taanila (possibilities for thermal load utilisation), Mr. Pertti Kosunen, M.Sc. (Eng.) (energy efficiency), Ms. Mirja Kosonen, M.A. (assessment of health impacts), Mr. Arto Ruotsalainen, M.A. (assessment of social impacts), Ms. Tuija Hilli, M.Sc (Agric.) (assessment of water system impacts), Mr. Eero Taskila, M.A. (assessment of fish and fishing impacts) and Mr. Juha Tervonen, M.Sc. (Econ.) (assessment of regional economy impact).

Relating to the environmental impact assessment, investigations have also been performed at the Environmental Impact Assessment Centre of Finland Ltd (water system modelling), Ramboll Finland Oy (Natura requirements assessment) and Ramboll Analytics Oy (noise assessment).

23.1.2008

Pöyry Energy Oy *Teollisuuden Voima Oyj*

2 Project

Teollisuuden Voima Oyj (TVO) is examining the construction of a nuclear power plant unit with an approximate net electrical output of 1,000 to 1,800 MW and thermal power of 2,800 to 4,600 MW at Olkiluoto, which is the location of two existing nuclear power plant units (OL1 and OL2) and a third (OL3) under construction. In order to improve its preparedness for constructing additional production capacity, the company has initiated the environmental impact assessment procedure concerning a new nuclear power plant unit that would possibly be located at Olkiluoto.

According to Section 4 of the EIA Act (468/1994), projects subject to the environmental impact assessment procedure are specified in more detail by a Government Decree. According to point 7 b) in the list of projects within Chapter 2, Section 6 of the EIA Decree (713/2006), nuclear power plants are included in projects subject to the assessment procedure.

The project is subject to the international assessment procedure in which an opportunity is reserved for countries within the scope of the so-called Espoo Convention (67/1997) to participate in the environmental assessment procedure. Finland ratified this UNECE Convention in 1995. The Convention entered into force in 1997. The parties to the Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland if the project being assessed is likely to have significant detrimental effects in a trans-boundary context. Correspondingly, Finland is entitled to participate in an environmental impact assessment procedure concerning a project located in the area of another State if the impacts of the project are likely to affect Finland.

The construction of a new nuclear power plant unit is subject to a decision-in-principle issued by the Government and ratified by the Parliament. If the decision-in-principle is ratified and, in addition to environmental issues, the technical and economic prerequisites for construction are fulfilled, construction of the plant could start in the early 2010s. Construction is estimated to take 6 to 8 years.

TVO is prepared to submit a possible application for a decision-in-principle concerning a new plant unit after the EIA report has been submitted to the coordinating authority. TVO has not made any decisions concerning action to be taken subsequent to the EIA procedure.

2.1 Organisation responsible for the project

The organisation responsible for the project is TVO, a private power production company owned by Finnish industrial and power companies. TVO was established on 23 January 1969. The founders were 16 Finnish industrial and power companies. TVO's shareholders in 2008 comprise Etelä-Pohjanmaan Voima Oy, Fortum Power and Heat Oy, Karhu Voima Oy, Kemira Oyj, Oy Mankala Ab and Pohjolan Voima Oy. The company produces electricity for its shareholders at the Olkiluoto nuclear power plant. In addition to the Olkiluoto nuclear power plant, TVO produces electricity from the Meri-Pori coal-fired power plant.

TVO holds operating licences for the two existing nuclear power plant units in Olkiluoto, valid until 2018. In addition, the company has the Olkiluoto 3 nuclear power plant unit (OL3) under construction, for which the Government has issued a construction licence and which is estimated to be completed in 2011 according to the estimate received from the plant supplier.

TVO's Olkiluoto power plant has environmental management systems compliant with the ISO 14001:2004 standard and the EMAS Regulation (EC No 761/2001).

2.2 Purpose and justification for the project

The consumption of electricity in Finland continues to grow. Finland consumed approximately 90 TWh of electricity in 2006. The 80 TWh mark was exceeded in 2001, 70 TWh in 1996, 60 TWh in 1989 and 50 TWh in 1985. Electricity consumption has doubled in a quarter-century. It is estimated to exceed 100 TWh in 6 to 8 years. *(Finnish Energy Industries 2007a.)*

According to the WM (With Measures) scenario of the Ministry of Trade and Industry, updated in 2005, the total consumption of electricity in Finland will amount to approximately 105 TWh in 2020 and 108 TWh in 2025. Further, according to the WAM (With Additional Measures) scenario of the Ministry of Trade and Industry, also updated in 2005, the total consumption of electricity in Finland will amount to approximately 102 TWh in 2020 and 105 TWh in 2025.

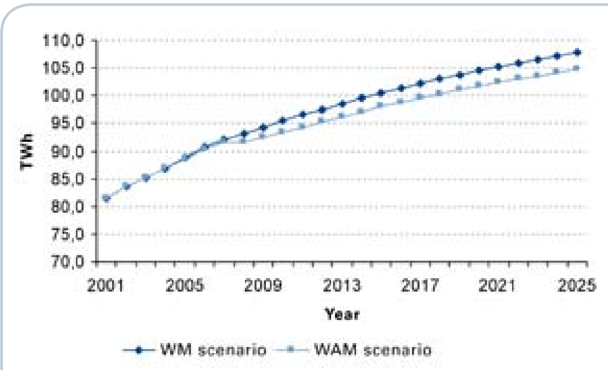
In both the WM and WAM scenarios it has been assumed that the development of the national economy will range between 2-2.5% on an annual level and that the global market prices of energy will remain stable. Both scenarios have also been prepared based on the assumption that the fifth nuclear power plant unit in Finland will be in operation. Furthermore, it has been assumed that the Vuotos reservoir will not be in use for the purpose of hydro power generation, the natural gas network will extend to the City of Turku, and there will be no changes in the imported electricity capacity compared with the present situation.

In the WAM scenario, considerations have also been made for the estimated impact of the EU emissions trading (with the emission allowance price of € 20 / tonne CO_2), application of the Kyoto mechanisms, energy conservation measures, and estimated changes to the taxation of energy.

According to both scenarios, the consumption of electricity will dramatically increase in Finland during the next 15 years, as can be seen from the figure 2-2.

Total energy consumption per capita is relatively high in Finland. Energy consumption is boosted by Finland's northern location, cold climate, sparse population

Figure 2-1 *WM and WAM scenarios for total electricity consumption dating from 2005 provided by the Ministry of Trade and Industry.*



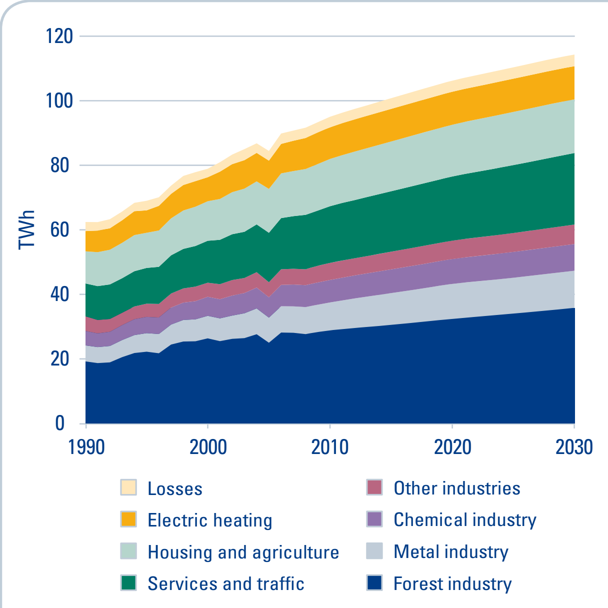


Figure 2-2 Total consumption of electricity in Finland and a forecast of the consumption trend up to 2030 (Confederation of Finnish Industries EK and Finnish Energy Industries ET 2007).

and long distances, and, in particular, the structure of Finland's basic industry.

The purpose of the new nuclear power plant unit is to increase the production capacity for base-load power. The construction of a nuclear power plant unit will also improve Finland's independence of foreign electricity and increase supply in the electricity market. In 2006, approximately 13 % (11.5 TWh) of the total electricity consumption in Finland was covered by imported electricity. In the above WM and WAM scenarios of the Ministry of Trade and Industry, the importation of electricity is estimated to decrease. In the WAM scenario, the share of imported electricity is 7 % of the total consumption in 2020, and 5 % in 2025. According to an estimate published in November by the Confederation of Finnish Industries (EK) and Finnish Energy Industries, the demand for electricity will increase to about 107 TWh by 2020 and to about 115 TWh by 2030. The average annual increase will be about 1.2 % until 2020, and 0.7 % between 2020 and 2030. During the last ten years, the consumption of electricity has increased by an average of 2.6 % per year. The total consumption of electricity in Finland by sector and a forecast of the consumption trend up until 2030 are shown in Figure 2-2. *(Confederation of Finnish Industries EK and Finnish Energy Industries 2007.)*

A nuclear power plant is characterised by the stable production costs, which means that the project will improve the predictability of the electricity market. Nuclear power generation does not cause greenhouse gas emissions, which is why the construction of a new nuclear power unit will reduce the average carbon dioxide emissions of Finnish power production, helping Finland to meet both international and national long-term objectives in the reduction of greenhouse gas emissions.

Preparation for the construction of a new nuclear power plant unit is also in line with the National Climate and Energy Strategy adopted by Parliament in 2006, in which nuclear power generation is seen as one of the crucial factors for guaranteeing the reliability of energy supply in Finland. Building a new nuclear power plant is also in keeping with the current Government Programme. According to the Programme, the Government will ensure that future energy generation in Finland will remain diverse and as self-sufficient as possible. No emission-free, low emission or emission-neutral, sustainable and cost-wise feasible form of power generation, including nuclear power, should be excluded; instead, all forms of energy must be assessed with the overall good of society in mind. *(Confederation of Finnish Industries EK and Finnish Energy Industries 2007.)*

Approximately one-quarter of Finland's total electricity consumption is produced by nuclear power. There are two nuclear power plants in operation in Finland, with a total of four plant units. These are the Olkiluoto nuclear power plant owned by TVO and the Loviisa nuclear power plant owned by Fortum Power and Heat Oy.

2.3 Location and land use

The planned location for the nuclear power plant is on the west coast of Finland, on Olkiluoto island in the municipality of Eurajoki. The distance from Olkiluoto to the nearest town, Rauma, is approximately 13 kilometres, 25 kilometres by road. The road distance from Pori to Olkiluoto is approximately 54 kilometres. The distance from highway 8 to the power plant is approximately 14 kilometres. The nearest neighbouring State is Sweden, located approximately 200 km west of the nuclear power plant.

The TVO nuclear power plant units OL1 and OL2 located at Olkiluoto were constructed between 1973 and 1980. The net electrical output of each plant unit is 860 MW. Furthermore, the net electrical output of the OL3

Figure 2-3 The location of Eurajoki and Olkiluoto. Eurajoki is located along highway 8. The distance from highway 8 to the Olkiluoto power plant is approximately 14 kilometres.

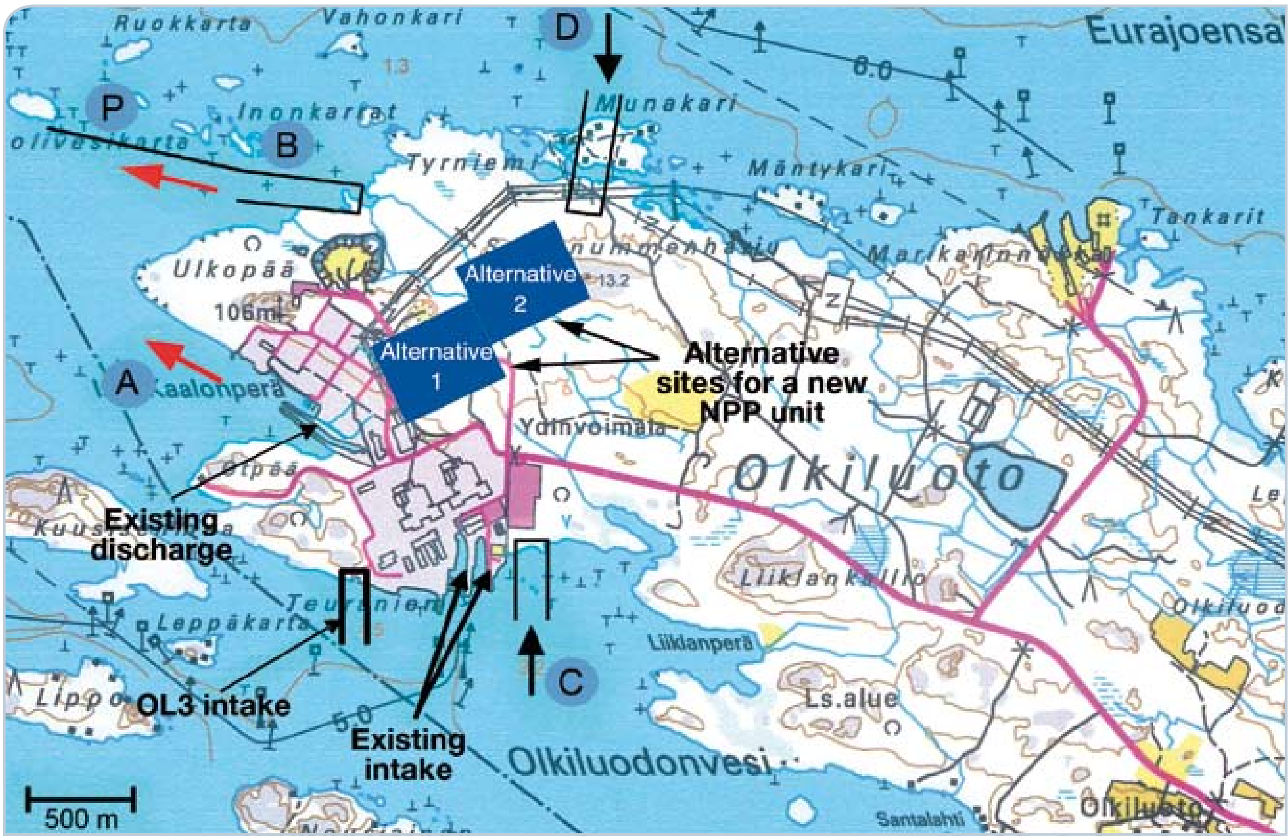
__Figure 2-4__ Guide map of Olkiluoto. Locations on the map include OL1 and OL2 (1), the OL3 construction site (2), KPA Store (3), VLJ Repository (4), Posiva's ONKALO construction site (5) and the Visitor Centre (6).

plant unit under construction will be approximately 1,600 MW. Based on the information received from the plant supplier, it has been estimated that the third plant unit will be completed in 2011.

In addition to the plant units, the site contains administrative buildings, a Training centre and a Visitor Centre, warehouses, repair shops, a backup heating plant, a raw water pool, a raw water treatment plant, a demineralization plant, a sanitary water treatment plant, a landfill, Intermediate storage facility for spent fuel (KPA Store), intermediate storage facilities for low-level and intermediate-level operating waste (MAJ and KAJ Store), a Final repository for operating waste (VLJ Repository), Posiva's ONKALO construction site, a contractors' area, accommodation villages, a wind power plant and a gas turbine plant. The OL3 unit under construction is located to the west of the existing units.

The area required for the buildings and auxiliary buildings of the new power plant unit (OL4) is approximately 4 to 6 hectares.

__Figure 2-5__ Alternative locations for the power plant unit and alternative locations for cooling water intake and discharge. A and B are locations for the cooling water discharge channel for plant unit OL4, while C and D are locations for the cooling water intake channel for plant unit OL4. P refers to a potential extension to the northern bank of discharge channel B.



2.4 Options for the project

2.4.1 Implementation options

The primary option for the project is a new nuclear power plant unit at Olkiluoto. TVO does not have any other realistic options for the location because it is essential for the project to utilise existing land use planning and infrastructure.

According to completed investigations, the sub-options for the new nuclear power plant unit are the following:

- two alternative sites at Olkiluoto, Alternative 1 and Alternative 2
- two alternative locations for cooling water discharge, A and B
- two alternative locations for cooling water intake, C and D.

The alternative locations for the power plant unit on the site and the alternative locations for cooling water intake and discharge are presented in Figure 2-5. In the figure, the alternative locations for cooling water intake and discharge are presented as arrows representing the direction of the water flow. The potential extension to the northern bank of the discharge channel in order to reduce the impact of water backflow has also been examined in connection with option B for the discharge site location. The implementation of the project also requires future extensions to the existing Intermediate storage facility for spent fuel (KPA Store) and Final repository for operating waste (VLJ Repository) at Olkiluoto, in addition to the extensions carried out due to the existing plant units.

2.4.2 Zero option

The zero option is that no nuclear power plant unit will be constructed at Olkiluoto. The zero option assesses the situation in which there will be three nuclear power plant units (OL1, OL2 and OL3) in operation at Olkiluoto.

The zero option also assesses the environmental impacts caused by generating the electricity corresponding to the plant unit's production using the average Nordic electricity production structure.

2.4.3 Option excluded from the investigation: energy conservation

The organisation responsible for the project does not have access to any energy conservation means that would allow replacement of the quantity of electricity produced by the new nuclear power plant unit while continuing the operations of the shareholders and other electricity consumers as planned. According to Section 26 of the Nuclear Energy Decree (161/1988), the Ministry of Employment and the Economy must submit a special review of the importance of the nuclear power plant unit for Finland's energy supply to the Government for the purpose of the decision-in-principle. The possibilities for conservation and more efficient use of energy on the national scale will also examined in this connection.

As regards national reviews of the energy economy, the Ministry of Employment and the Economy agrees in its statement on the EIA programme (Appendix 1) that their preparation does not fall under the remit of the organisation responsible for the project. The Ministry notes that should these reviews be necessary to support decision-making, they will be drawn up by the central Government. In its statement, the Ministry maintains that the organisation responsible for the project is a company that generates electricity only for its shareholders. Therefore, it cannot access any significant means of energy conservation or efficiency. The Ministry also notes that the report on the importance of a new nuclear power plant unit or units for the national energy supply, supporting the decision-making of the Government with regard to reaching the decision-in-principle, discusses energy conservation and energy efficiency measures on the national scale.

2.5 Project cost structure and cost comparison between alternatives for electricity production

The costs of the different alternatives for base load electricity production have been compared in a survey carried out by the Lappeenranta University of Technology in 2000. The results have later been updated to reflect the price level in the spring of 2003 *(Tarjanne, R. & Luostarinen, K. 2004)*. The comparison also included wind power, even though the variations in wind conditions make it unsuitable for the production of base load electricity.

The cost structures of the different forms of production are essentially different in terms of the proportions of capital costs and fuel costs. Among the examined alternatives for producing base load electricity, nuclear power was the most capital-intensive, while natural gas was the least capital-intensive. According to the survey mentioned above, the share of investment costs in the electricity production costs is approximately 60 % for nuclear power and slightly more than 15 % for natural gas. Thus the investment costs have a significant effect on the economy of nuclear power. On the other hand, the large share of investment costs makes nuclear power stable and predictable in terms of its costs.

In the case of nuclear power, according to the survey mentioned above, the share of fuel costs is less than 20 % of the total power production costs, while for natural gas it is almost 80 %. The fuel costs for nuclear power comprise the natural uranium, its conversion into material suitable for the isotopic enrichment process, enrichment, and manufacture of fuel elements. The share of the actual raw material for the fuel, the uranium, is approximately one quarter of the fuel costs, so the share of uranium in the production costs for nuclear electricity is to the order of 5 %. The rest of the fuel costs comprise the other phases of fuel manufacturing, which are normal industrial production and whose costs can be reliably predicted.

The dependence of nuclear power production costs on fluctuations in fuel price and exchange rates is low because the share of the fuel in overall production costs is minor. However, for the other forms of producing base load electricity the share of fuel costs is essentially larger. Fluctuations in the global market situation for coal and natural gas add to the uncertainty of predicted long-term production costs for these alternatives. Furthermore, the price of electricity produced by coal or natural gas is sensitive to foreign exchange rate fluctuations.

A significant factor of uncertainty in the cost estimates for electricity production based on coal and natural gas is associated with the reduction of greenhouse gas emissions. The fees levied on emissions exceeding the quotas may increase the production costs by tens of per cent.

2.6 Links to other projects

Olkiluoto is an area subject to changes. According to the current plans, the OL3 unit under construction is scheduled to start operation in 2011. In addition to OL3, Posiva's underground research facility, ONKALO, planned to form a part of the spent fuel final disposal facility, is also under construction in the area. Posiva's present target is to submit an application for a construction licence for the spent fuel final disposal facility by the end of 2012. The final disposal of spent fuel is scheduled to start in 2020. In addition, TVO is also planning to extend the Intermediate storage facility for spent fuel (KPA Store). The Final repository for operating waste (VLJ Repository) will be expanded when the current repository becomes full. The Final repository facility will be further expanded when the existing nuclear power plant units are decommissioned.

2.6.1 Olkiluoto 3

On 17 January 2002 the Government issued a decision-in-principle on the construction of the third nuclear power plant unit and on the expansion or construction of nuclear facilities needed for the operation of the unit at the same plant site. Parliament ratified the decision-in-principle on 24 May 2002. The decision on the construction licence for constructing a third nuclear power plant unit on the Olkiluoto plant site at Eurajoki was issued on 17 February 2005. Based on the information received from the plant supplier in the summer of 2007, the third plant unit will be completed in 2011.

The power plant unit (OL3) under construction is being built at a site located to the west of the existing units. The power plant unit comprises a reactor building and a turbine building, as well as support and auxiliary buildings.

OL3 is a pressurised-water reactor (PWR) with net electrical output of approximately 1,600 MW and total thermal power of approximately 4,300 MW. The existing storage facilities will be used for storing the spent nuclear fuel and radioactive operating waste generated in the unit. The spent nuclear fuel will be disposed of in the Final repository constructed in Olkiluoto, while operating waste will be disposed of in the Final repository for operating waste (VLJ Repository). The OL3 unit will be used for basic electricity production in a manner similar to the existing units. The annual production volume of OL3 will amount to approximately 13 TWh.

2.6.2 Connection to the national grid and production of reserve power

The new nuclear power plant unit will require reinforcements to the power transmission system. In the Electricity Market Act, Fingrid Oyj has been given systems responsibility, which means, among other things, that the company is responsible for the technical operability and reliability of Finland's electricity system and for the momentary balance of generation and demand for electricity. In readiness for a severe failure or disturbance in the operation of power plants or the grid, Fingrid Oyj needs a fast-activated disturbance reserve to ensure the operability of the system immediately after failure. Ensuring the availability of this fast disturbance reserve is part of the reserve obligation included in the systems responsibility of Fingrid.

Fingrid Oyj has preliminarily assessed the connection of the OL4 plant unit to the national grid and the required grid reinforcements. The new power transmission lines required for connecting the plant to the national grid to Rauma and, from there, elsewhere in the grid have been taken into account in the preparation stage of the

provincial plan work of the Satakunta Regional Council serving as the basis for land use planning. Fingrid Oyj will initiate an environmental impact assessment concerning the power lines supporting the grid connection of Finland's sixth nuclear power plant unit during 2008–2009. Fingrid Oyj will initiate the EIA procedures concerning the plant site power lines and the required reserve power capacity after the decision-in-principle for Finland's sixth nuclear power plant unit has been made. In this EIA report, TVO examines the environmental impacts of the required power transmission connection in the Olkiluoto partial master plan area. The OL4 power line area is located in the southern part of the Olkiluoto island.

2.6.3 New road connections

In the partial master plan proposal for Olkiluoto (31 October 2007), a new road connection will be routed from the south side of the energy supply area directly to the present gate of the power plant site. The present road will remain in use, leading to the accommodation village from which it will continue as internal road connection of the energy supply area. The partial master plan proposal also contains another road connection along the eastern and northern borders of the energy supply area.

The starting point of the solution was to maintain the integrity of the energy supply area. This has been achieved by directing the traffic to the harbour and holiday homes outside the energy supply area. The solution will reserve the Olkiluoto nuclear operations area for the use of internal traffic, thereby providing the best preconditions for implementing internal and external security and surveillance for the area. The solution also ensures maximal smoothness of traffic and enables the structuring of different types of traffic so that, for example, the connection to the central office can be arranged in a straightforward manner in the future as well.

A precondition for the implementation of the solution presented above is that the Government amends the Presidential Decree on the conservation of old forests (1115/1993) with regard to Liiklankari. The Municipal Board of Eurajoki has made a proposal for amending the Decree. *(Air-Ix Suunnittelu 2007.)*

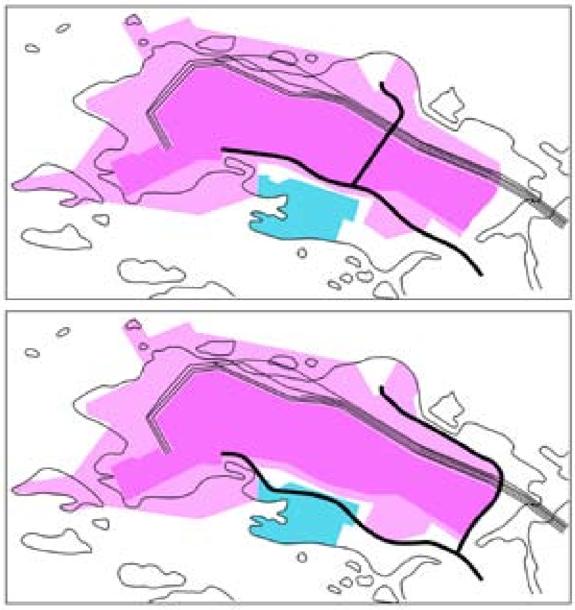


Figure 2-6 *The present road network of Olkiluoto and the solution presented in the partial master plan proposal. A new road connection will be routed from the south side of the energy supply area directly to the present gate of the power plant site, while another road continues to the harbour along the eastern and northern borders of the energy supply area.*

2.6.4 Spent nuclear fuel disposal facility

Established in 1995, Posiva Oy is an expert organisation responsible for the final disposal of the spent nuclear fuel originating from the nuclear power plant units of its owners located in Finland, as well as for research associated with disposal, and other expert tasks belonging to its scope of operations. Posiva is owned by TVO (60 % ownership) and Fortum Power and Heat Oy (40 % ownership), who are also responsible for the costs of nuclear waste management.

The Government issued a decision-in-principle on the matter in 2000. In addition, the Government issued a separate decision-in-principle in January 2002, according to which the final disposal facility could be extended so that it could also receive spent nuclear fuel final desposal from the new reactor (OL3) of Teollisuuden Voima Oyj currently under construction. Parliament has ratified both decisions-in-principle. The spent nuclear fuel from the sixth nuclear reactor in Finland is not included in the present decisions-in-principle concerning the final disposal facility but requires a separate decision-in-principle in accordance with the Nuclear Energy Act (990/1987).

Following the ratification of the decisions-in-principle, research activities have advanced at Olkiluoto. The construction of the underground bedrock research facility, ONKALO, was started in 2004. The research data obtained from ONKALO is used for ensuring the suitability of Olkiluoto for final disposal and for defining the location of final disposal tunnels in the bedrock.

The decision-in-principle is not a final decision on building the facility as this still requires a construction licence granted by the Government. According to the decision-in-principle, the construction licence for the final disposal facility must be applied for by 2016 at the latest. The construction licence application is intended to be submitted to the Government in 2012. Prior to the commissioning of the facility in 2020, an operating licence is required, also granted by the Government. The exact time of starting the construction is not yet known.

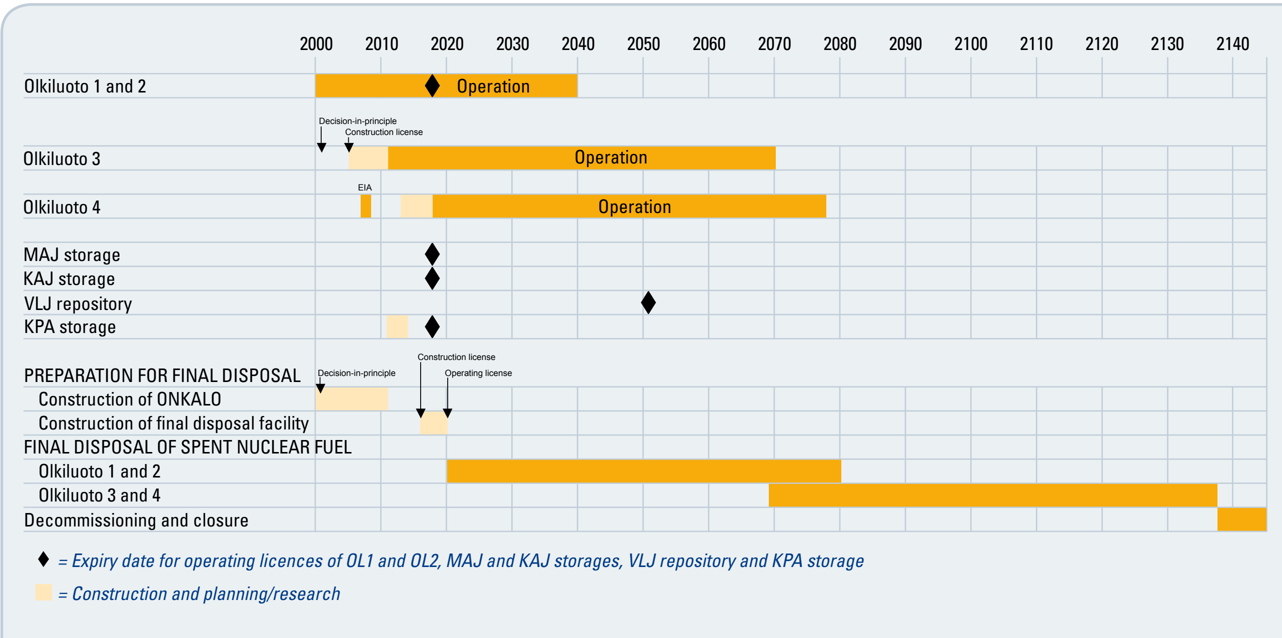
The ultimate goal of nuclear waste management is permanent disposal of waste in accordance with the Nuclear Energy Act and Decree, which refers to disposal in Finnish bedrock. The EIA procedure concerning the disposal of spent nuclear fuel , assessing the final disposal of a maximum of 9 000 tU, was completed in 1999. With regard to the impacts of the disposal of spent nuclear fuel originating from the planned new nuclear power plant unit, this EIA completed in 1999, and the research subsequently conducted, has been utilised so that the disposal of spent fuel is described to a sufficient extent

in this environmental impact assessment report as well. Posiva Oy is also preparing for the final disposal of the spent fuel generated in the operation of the possible other new plant units of its owners to be possibly built in Finland, and has started, in early 2008, the preparation for the EIA procedure regarding an extension of the final disposal facility so that a maximum quantity of 12,000 tU could be finally disposed of in Olkiluoto.

2.7 Schedules of the OL4 project and the related projects

If the OL4 project is implemented, the aim is to start construction of the new nuclear power plant unit early in the 2010s. Construction is estimated to take 6 to 8 years. Thus the plant can be commissioned in or around 2018. The schedule of the OL4 project and the related projects is presented in the figure below.

Figure 2-7 *The overall schedule of the OL4 project and the related projects. The construction of the new nuclear power plant unit is intended to be started in or around 2013. Thus the plant can be commissioned in or around 2018.*



3 EIA procedure, communication and participation

3.1 Needs and objectives for the EIA 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 virtue of the EIA Act (468/1994) and Decree (713/2006) on environmental impact assessment. According to Section 4 of the EIA Act, projects subject to the environmental impact assessment procedure shall be specified in more detail by Government Decree. According to point 7 b) in the list of projects within Chapter 2, Section 6 of the EIA Decree, nuclear power plants are included in projects subject to the assessment procedure. The coordinating authority for projects associated with nuclear facilities referred to in the Nuclear Energy Act is the Ministry of Trade and Industry, the tasks of which were transferred to the Ministry of Employment and the Economy as of 1 January 2008.

The objective of the environmental impact assessment (EIA) procedure is to promote the assessment and uniform observation of environmental impacts in planning and decision-making. Another objective of the procedure is to increase the opportunities for citizens to receive information, become involved in the planning of projects and express their opinion. Thus the EIA procedure does not make any decisions concerning the project or resolve any licensing issues; its objective is to produce information to serve as a basis for decision-making.

3.2 Main stages of the EIA procedure

The environmental impact assessment procedure is divided into two stages, during the first of which the environmental impact assessment programme (EIA programme) was prepared. The EIA programme, completed in May 2007, presented the implementation options for the project as well as how its impacts are intended to be assessed. Citizens were provided with an opportunity to present their opinions on the EIA programme and its comprehensiveness. The Ministry of Trade and Industry invited comments on the EIA programme from different authorities and other parties, combined the received opinions and comments together, and provided its own statement. In the second EIA report stage an environmental impact assessment report (EIA report) was prepared on the basis of the EIA programme and the opinions and comments made about it.

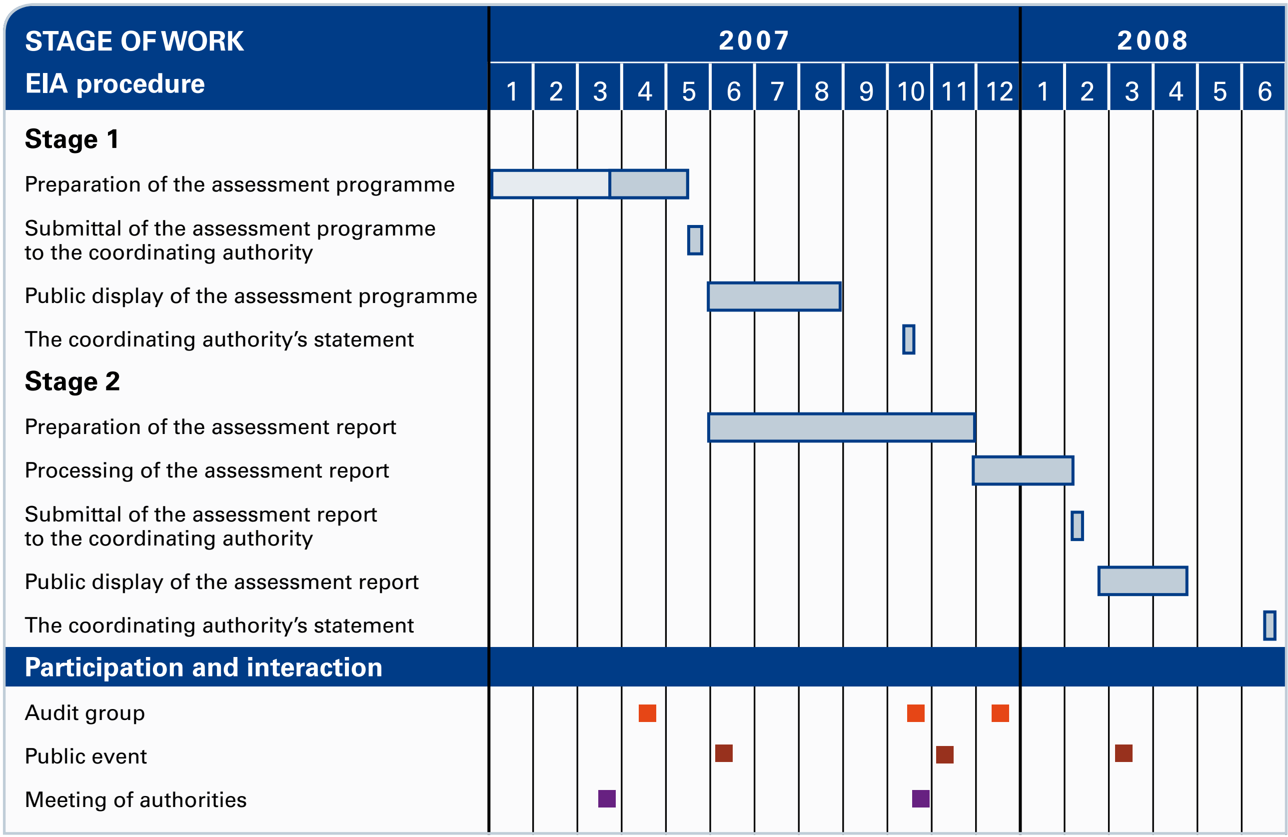
The EIA report presents information on the project and a coherent assessment of its environmental impacts resulting from the assessment procedure. The environmental impact assessment report presents:

- the options under assessment
- the current state of the environment
- the environmental impacts of the various options, as well as the significance of these impacts
- a comparison of the options
- measures for preventing and mitigating adverse impacts
- a proposal for an environmental impact assessment monitoring programme
- the actions taken to facilitate interaction and involvement during the EIA procedure
- how the statement of the coordinating authority on the EIA programme has been taken into account in the assessment.

Once the environmental impact assessment report is completed, citizens may present their opinions on it. The relevant authorities will provide statements on the EIA report.

The EIA procedure is completed when the Ministry of Trade and Industry submits its statement on the

*Figure **3-1** Main stages and schedule for the EIA procedure.*



EIA report to TVO. The licensing authorities and the organisation responsible for the project will use the assessment report and the Ministry's statement as base material for their decision-making.

The environmental impact assessment report and the statement on it provided by the Ministry of Employment and the Economy will be appended to the licence applications and plans required for the project. In its permit decision, the permit authority will present how the assessment report have been taken into account.

The main stages and schedule of the EIA procedure are presented in the figure 3-1.

3.3 Audit group work

An audit group consisting of different interest groups was established to monitor the EIA procedure, the purpose of which is to promote the flow and exchange of information between the organisation responsible for the project, the authorities and other interest groups. The following parties were invited to the audit group:

- Ministry of Trade and Industry
- Ministry of the Environment
- Provincial State Office of Western Finland
- Southwest Finland Regional Environment Centre
- Western Finland Environmental Permit Authority
- Town of Rauma
- Municipality of Eurajoki
- Municipality of Eura
- Municipality of Kiukainen
- Municipality of Lappi
- Municipality of Luvia
- Municipality of Nakkila
- Satakunta Regional Council
- Radiation and Nuclear Safety Authority (STUK)
- Safety Technology Authority (TUKES)
- Posiva Oy
- Satakunta Regional District of the Finnish Association for Nature Conservation
- Satakunta Employment and Economic Development Centre (TE Centre).

The composition of the audit group was supplemented by also inviting the following parties:

- Satakunta Fire and Rescue Department
- Rauman Seudun Kehitys Oy
- Southwest Finland Employment and Economic Development Centre (TE Centre), fishing industry unit.

The audit group convened three times during the EIA procedure.

The audit group convened for the first time at the EIA programme stage. The meeting was held on 24 April 2007 at TVO's Visitor Centre in Olkiluoto. In addition to the organisation responsible for the project and the EIA consultant, a total of 11 people attended the meeting. In the meeting, the project and the EIA procedure as well as a draft for the EIA programme were presented, which were commented on by the audit group both during the actual meeting and during the commenting session arranged after the meeting. The project and the assessment of its impacts were discussed at the meeting. Issues that raised discussion included, among others, the present state of the environment and nature of Olkiluoto, the water system impacts (such as impacts on water quality, currents, biology and ice conditions), water system modelling, impacts on groundwaters, impacts on the land use of surrounding areas, impacts of the required power lines, noise caused by the power plant, nuclear fuel transports, impacts of sea level rise and land uplift, mitigation of adverse impacts, impacts of emergency power projects, and the internal energy efficiency of the plant.

Comments and clarifications received during and after the meeting were taken into account in the preparation of the EIA programme to the widest possible extent as far as they concerned the EIA programme. The comments that related to the actual impacts have been taken into account in this EIA report.

The second meeting of the audit group was held on 11 October 2007 in Olkiluoto. In addition to the organisation responsible for the project and the EIA consultant, a total of 13 people attended the meeting. The topics of the meeting agenda included the statement on the EIA programme provided by the Ministry of Trade and Industry, which acts as the coordinating authority in the project, and the separate assessments of the environmental impacts of the project prepared for the EIA procedure, as well as the preliminary results of these assessments. The audit group was given the opportunity to present their opinions on the preparation of the assessments and the consideration of the results in the EIA report. The following topics were discussed at the meeting: accidents and their economic impact, vegetation survey, cooling water modelling, water system impacts, noise modelling, possibilities for heat utilisation, procurement of nuclear fuel, possibilities for precooling the cooling water, cooling tower, impacts arising from climate change, comparison between the locations for nuclear power production, and the impacts on the regional economy from not constructing the OL4 unit. On the basis of the comments, the consultant made amendments and further clarifications in the EIA report.

The third meeting of the audit group was held on 12 December 2007 in Olkiluoto. In addition to the organisation responsible for the project and the EIA consultant, a total of 11 people attended the meeting. The meeting discussed the draft for the EIA report. The draft report had been sent in advance by mail for study by the members of the audit group. The following topics were discussed at the meeting: Natura requirements assessment, the impact of the new power plant unit on the state of the sea area, the cooling water model and the results obtained for it, utilisation of the cooling water, noise model, resident survey and the extent of its distribution, the analysed accident situation and its definition, as well as the protective measures in an accident situation. On the basis of the comments, the consultant made amendments and further clarifications in the EIA report.

3.4 Small group meetings

TVO has arranged small group meetings for representatives of interest groups in which the various stages of the EIA procedure and the contents of the EIA programme were presented and the project was discussed. The meetings provided various interest groups with an opportunity to express their views on issues and impacts they consider important.

A public event for the nearby and holiday residents was arranged in TVO's Visitor Centre on 10 April 2007. Some 120 people attended the event. The project and the EIA procedure were presented in the event. The residents had an opportunity to present questions and comments relating to the project. The following issues relating to the new nuclear power plant unit and its EIA procedure were discussed at the event: the size of the new plant unit, the joint environmental impact of the four nuclear power plant units, the thermal load caused by the cooling water, seawater quality, ice conditions of the sea area, traffic quantities arising from the new plant, monitoring measurements in the nearby areas, life cycle of uranium, and mining operations in Finland.

A second event for the nearby residents, attended by some 100 people, was arranged on 11 October 2007 in TVO's Visitor Centre. In this event the statement on the EIA programme provided by the Ministry of Trade and Industry, which acts as the coordinating authority in the project, and the separate assessments of the environmental impacts of the project prepared for the EIA procedure as well as the preliminary results of these assessments were presented. Comments and questions concerning the following issues relating to the new nuclear power plant unit and its EIA procedure were presented at the event: procurement of uranium, background radiation, resident survey and its distribution area, assessment of ice conditions in the cooling water model, power transmission lines, sea research, alternative locations for cooling water intake and discharge, as well as traffic and traffic safety on the Olkiluodontie Road.

Small group meetings were arranged on 16 October 2007 for two separate groups. At the beginning of the small group meetings TVO and the EIA consultant presented the environmental impact assessment procedure and the separate assessments related to it. After the presentations the participants were given an opportunity to present their opinions and discuss things that concerned them. Parties involved with agriculture, forestry, fishing, hunting and the environment were invited to the first small group meeting, while parties associated with society and the business world were invited to attend the second meeting. The communities had the opportunity to freely select their representatives at the meeting.

A total of 14 people attended the first meeting, while the second meeting was attended by six people. In the first meeting the discussion focused on the project's water system impacts, fishing and ecological values. In the second meeting the discussion focused primarily on the impact of the new power plant unit on the public image and attractiveness of the region, as well as on the social and cultural impacts of the project. A method known as semi-structured thematic interview was employed in both small group meetings. With the consent of the participants, the free-form discussion was recorded for the purpose of facilitating the making of notes. The reporting has been so performed that the views of the interviewed people cannot be associated with an individual person. The results of the small group meetings are presented in section 9.11.5.

3.5 Information and discussion events

Two events open to the general public have been arranged during the EIA procedure. The events were held in the Eurajoki municipal hall. The first public event concerning the project and the assessment of its environmental impacts was arranged on 13 June 2007. The public had the opportunity to receive information and discuss the EIA procedure with the representatives of the Ministry of Trade and Industry and TVO, and the authors of the EIA programme. The public event was attended by approximately 30 people. The following topics emerged during the public event: the relationship of the project to the obligations under the Kyoto Protocol, the relationship of additional nuclear power to the renewable sources

of energy, energy conservation, the construction of the plant and its impacts, employment issues, exceptional and accident situations, production of uranium, the thermal load caused by the cooling water and its impacts on the water system, impacts on the Natura 2000 network areas, and the regulating power and power lines required for the plant unit. A memorandum has been prepared, and the issues raised have been considered when preparing the assessment report.

A public event concerning the project and the preliminary results of the assessment of its environmental impacts was arranged on 18 October 2007. The event was attended by approximately 20 people. In this event the statement on the EIA programme provided by the Ministry of Trade and Industry and the separate assessments of the environmental impacts of the project prepared for the EIA procedure, as well as the preliminary results of these assessments, were presented. Comments and questions concerning the following issues relating to the new nuclear power plant unit and its EIA procedure were presented at the event: cooling water flow masses, cooling water model, possibilities for waste heat utilisation, emissions arising from other energy production alternatives, recycling of nuclear fuel, final disposal of spent nuclear fuel, thorium fuel, protective zone, options for remote cooling water intake and discharge, power transmission links, stability of Olkiluoto soil, radiation impacts, and novel species. The comments presented in the event were considered in the preparation of the final EIA report.

A third public event will be arranged in the spring of 2008 with the Ministry of Employment and the Economy after the completion of the EIA report. This event will present the results of the EIA procedure and the final EIA report.

3.6 Resident survey

A resident survey was carried out in connection with the EIA procedure, through which information about the residents' attitudes towards the project was obtained. A summary of the environmental assessment programme was sent together with the survey, providing the residents with information about the project and its impacts on their living environment. The results of the resident survey are reported in section 9.11.5.

3.7 Other communication and interactions

TVO has provided information on the project through press releases. TVO also provides information through its publication "TVO Uutiset" issued four times annually and distributed to all households in Eurajoki, Rauma, Eura, Kiukainen, Lappi, Luvia and Nakkila. An additional issue of TVO Uutiset focusing on the EIA was published during the EIA programme stage in April 2007. The issues of TVO Uutiset published in July, October and December 2007 discussed the completion of the EIA procedure and

the related public event. Information about the EIA has also been provided in the corporate magazine Ytimekäs.

Two summaries have also been prepared for communication purposes. The first summary was prepared after the completion of the EIA programme, presenting the project, the EIA programme and the stages involved in the EIA procedure. The second summary was prepared after the completion of the EIA report, presenting the project and the most important outcomes of the environmental impact assessment.

Exhibition walls with posters discussing the EIA procedure are on display at the 'Electricity from Uranium' science exhibition at the Olkiluoto Visitor Centre and at the Eurajoki municipal hall throughout the entire procedure.

TVO's representatives presented the project and the related EIA procedure at the coffee event held in Eurajoki market place on 9 June 2007 and in Rauma market place on 16 June 2007.

In September 2007, TVO's EIA project was presented in the "Company of the Month" programme on Ganal TV, which can be viewed in the Satakunta region. Lasting approximately 15 minutes, the programme was broadcast twice a day throughout September.

Internal briefings are arranged for the personnel of TVO. The briefings arranged during the EIA procedure on 30 March 2007, 17 August 2007, 1 November 2007 and 3 January 2008 also presented information about the EIA.

Visits will be made to Eurajoki and the neighbouring municipalities during the EIA report stage to provide information on matters of topical interest relating to the EIA. Both the EIA programme and the EIA report are available on the TVO (www.tvo.fi) and Ministry of Employment and the Economy (www.tem.fi) Internet sites.

3.8 Public display of the assessment programme and international hearing

The EIA procedure was initiated by TVO submitting the EIA programme (a plan for environmental impact assessment) to the Ministry of Trade and Industry on 31 May 2007. The public announcement of the initiation of the assessment procedure was published on 8 and 9 June 2007 in the Helsingin Sanomat, Hufvudstadsbladet, Turun Sanomat, Satakunnan Kansa, Uusi Rauma and Länsi-Suomi newspapers. The announcement was also displayed on the Ministry of Trade and Industry Internet site.

The assessment programme was on public display between 12 June and 31 August 2007 at the municipal government offices of Eurajoki, Eura, Kiukainen, Lappi, Luvia and Nakkila, as well as at the environmental office of the City of Rauma. In addition, the assessment programme was also on display on the Ministry of Trade and Industry and TVO Internet sites. The Ministry of Trade and Industry arranged a public event with TVO at the beginning of the public display period on 13 June 2007.

The project is subject to the international assessment procedure in which an opportunity is reserved for countries within the scope of the so-called Espoo Convention (67/1997) to participate in the environmental assessment procedure. Finland ratified this UNECE Convention in 1995. The Convention entered into force in 1997. The parties to the Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland if the project being assessed is likely to have significant detrimental effects in a trans-boundary context. Correspondingly, Finland is entitled to participate in an environmental impact assessment procedure concerning a project located in the area of another State if the impacts of the project are likely to affect Finland.

The Ministry of the Environment is responsible for the practical arrangements relating to the international hearing. The Ministry of the Environment notified the following countries of the project: Sweden, Denmark, Norway, Germany, Poland, Lithuania, Latvia, Estonia and Russia. The notification was accompanied by a Swedish or English translation of the EIA programme and documents on the international hearing translated into the languages of the countries in question.

3.9 Statements and opinions received on the assessment programme

In addition to the announcement published in the newspapers, the Ministry of Trade and Industry invited the following organisations to comment on the EIA programme: Ministry of the Environment, Ministry of the Interior, Ministry of Social Affairs and Health, Ministry of Defence, Ministry of Finance, Ministry of Transport and Communications, Ministry of Labour, Ministry of Agriculture and Forestry, Ministry for Foreign Affairs, State Provincial Office of Western Finland, Satakunta Regional Council, Western Finland Environmental Permit Authority, Finnish Environment Institute, Radiation and Nuclear Safety Authority, Safety Technology Authority, Satakunta Employment and Economic Development Centre, Southwest Finland Employment and Economic Development Centre, Occupational Safety and Health Inspectorate of Turku and Pori, Regional Environment Centre of Southwest Finland, Satakunta Fire and Rescue Department, AKAVA – the Confederation of Unions for Professional and Managerial Staff in Finland, Confederation of Finnish Industries EK, Finnish Energy Industries, Greenpeace, Central Union of Agricultural Producers and Forest Owners (MTK), Central Organisation of Finnish Trade Unions (SAK), Finnish Association for Nature Conservation, Federation of Finnish Enterprises, Finnish Confederation of Salaried Employees STTK, WWF, Fingrid Oyj, Posiva Oy, Advisory Committee on Nuclear Energy, and the following cities and municipalities: Eurajoki, Eura, Kiukainen, Lappi, Luvia, Nakkila and Rauma.

A total of 36 statements were submitted to the Ministry of Trade and Industry. The following organisations did not provide a statement: the Ministry of Defence, the Ministry for Foreign Affairs, the Western Finland Environmental Permit Authority, the Finnish Environment Institute, and the Municipality of Kiukainen.

A total of 18 opinions or comments were submitted, eight of which were from organisations and ten from private individuals. The following organisations presented a comment or opinion: Women Against Nuclear Power, Finnish Youth for Nuclear Energy, Women for Peace in Finland and Amandamij (joint comment), Raumanmeri Fishing Area, the Swedish NGO Office for Nuclear Waste Review (MKG), the Reseau Sortir du nucleaire network, the Sorkkan partners and the Edelleen ei ydinvoimaa popular movement against nuclear energy.

The comments submitted consider the programme to be appropriate, in the main, and quite comprehensive.

The statements and opinions took a standing on, among other things, the following: the justification and social significance of the project, the selection of the options under consideration, the observed area of the impact assessments, energy conservation matters, safety aspects and rescue operations relating to the new nuclear power plant unit, trans-boundary environmental impacts, traffic arrangements, handling of spent fuel, combined effects of different projects, the thermal load arising from cooling water and its impacts, cooling water modelling, possibilities for utilising the thermal load arising from cooling water, the possible impacts of climate change (e.g. extreme phenomena relating to weather conditions), hazardous chemicals used at the power plant, the decommissioning of the plant units and its impacts, employment impacts and availability of workforce, as well as the environmental impacts of the entire chain of nuclear fuel supply. Several opinions do not present views relating to the EIA programme in addition to the aforementioned comments but either oppose or support the use of nuclear energy in general.

In the assessment procedure with respect to cross-border environmental impacts, the authorities of the following countries were notified: Swedish Environmental Protection Agency (Sweden), Ministry of Environment (Denmark), Ministry of Environment (Norway), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany), Ministry of Environment (Poland), Ministry of Environment (Lithuania), Ministry of Environment (Latvia), Ministry of Environment (Estonia), Ministry of Natural Resources (Russia).

Sweden, Norway and Estonia expressed their willingness to participate in the EIA procedure and submitted their comments on the EIA programme within the indicated time limit. Lithuania expressed its willingness to participate in the EIA procedure but did not provide a statement on the EIA programme. Russia expressed its willingness to participate in the EIA procedure but did not provide a statement on the EIA programme, notifying that it will submit its statement at a later date, at which point it will be delivered to the responsible organisation. Germany and Poland submitted their statements after the indicated time limit. Latvia has replied to the Ministry of the Environment stating that it will not participate in the EIA procedure. The Ministry of the Environment did not receive a reply from Denmark.

According to the Swedish Environmental Protection Agency (Naturvårdsverket), the EIA programme is, in the main, sufficient. The most substantial impacts are imposed on the sea, and information on the impacts is collected through the environmental monitoring programme of the existing units. The Swedish Nuclear Power Inspectorate (Statens Kärnkraftinspektion) also considers the EIA programme sufficient. In particular, the assessment of impacts arising from normal plant operation is comprehensive.

Comments invited by the Swedish Environmental Protection Agency emphasise the assessment of radioactive emissions from several perspectives. Particular attention should be paid to the potential long-range transportation of radioactive emissions and the related preparations, technologies to reduce emissions, and mitigating the potential harmfull effect. The impact of emissions on the environment and industries should be assessed, e.g. fish stocks and fishing. The comments also point out that it would be prudent to assess the combined impacts of the planned unit and the current units on the radioactivity of the Baltic Sea. The comments maintain that the assessment of impacts should be supplemented by taking the whole life cycle of the project into account and assessing the environmental effect due to the production of nuclear fuel and spent nuclear fuel. The comments also draw attention to the lack or deficient handling of the zero option, with particular mention of the lack of alternative means of power production.

In Norway, the Ministry of the Environment acts as the environmental authority. It emphasises the assessment of reactor safety, emergency situations, unexpected events and radioactive emissions. It would be prudent to describe the plans and monitoring systems for emergencies and exceptional situations. Comments invited by the Norwegian environmental authority also emphasise the assessment of radioactive emissions from several perspectives. Particular attention should be paid to the potential long-range dispersion of radioactive emissions and the related preparations, and mitigating potential harmfull effect. The impact of emissions on the environment and industries should be assessed, e.g. vegetation, animals, reindeer husbandry and recreational use.

Acting as the environmental authority, the Estonian Ministry of the Environment stresses the description of cross-border emergensies from several perspectives. The description should identify any impacts requiring protection from radiation, and the methods of informing neighbouring countries in emergencies.

The authority notes that it would be prudent to assess the combined impacts of the planned unit and the current units.

3.10 Statement of the coordinating authority on the assessment programme and the consideration of thereof

The Ministry of Trade and Industry provided its statement on the EIA programme on 28 September 2007. In its statement, the Ministry of Trade and Industry states that the EIA programme for the Olkiluoto 4 nuclear power plant unit meets the content requirements of EIA legislation and has been handled in the manner required by the legislation.

The issues pointed out by the Ministry of Trade and Industry in its statement have been considered in the preparation of the EIA report and included in it. Efforts have also been made to answer the considerations and questions presented in the other statements and opinions as comprehensively as possible. The statement of the Ministry of Trade and Industry is included herein as Appendix 1.

The statements provided and opinions given on the assessment programme, as well as the statement of the coordinating authority, are displayed on the Ministry of Employment and the Economy Internet site. The following table summarises the issues that, according to the statement, should be given attention when carrying out the assessment and preparing the report. The table also presents how the statement of the Ministry of Trade and Industry has been taken into account when reviewing the assessment programme and arranging the assessment procedure.

Table 3-1 Consideration of the statement provided by the coordinating authority on the assessment programme.

Statement of the coordinating authority on the assessment programme	How the statement has been considered in the assessment work (references to sections of this EIA report)
Project description and the alternatives	
A review of current nuclear power plants that are suitable for the project under review should be included in the assessment report.	It is not possible to provide detailed information on plant options at this stage. Section 4.1 of the EIA report presents a list of options currently available on the market. The list presented in the EIA report is not binding.
The report should present the safety design basis of the prospective plant as regards the limitation of radioactive emissions and environmental impacts, alongside an assessment of the feasibility of meeting the safety requirements in force.	The plant will meet the latest safety requirements in accordance with the Nuclear Energy Act and Decree, Government Decisions and YVL Guides published by the Radiation and Nuclear Safety Authority. The implementation of safety requirements at the new nuclear power plant unit is presented in section 10.2.
For the purposes of communicating the project it may prove advantageous to include a short description of the cost structure of the project and its alternatives in the assessment report.	The cost structure has been presented on the basis of the existing assessments. The cost structure of the other means of electricity production being assessed has been presented in section 11.1.
The Ministry recommends that the assessment report briefly introduce the energy efficiency and conservation efforts undertaken by the applicant.	The energy efficiency and conservation measures undertaken by TVO are described in section 4.5. The possibilities for conservation and more efficient use of energy on the national scale will be examined in the decision-in-principle.
Impacts and their assessment	
The Ministry is of the view that the impacts of cooling waters form the most significant environmental impact during normal plant operation. Therefore, when analysing the environmental impacts of seawater warming, any background material available must be utilised extensively and the analyses must be linked on a wider scale to the state of the Bothnian Sea and the Baltic Sea.	The available background material and water system monitoring results have been extensively utilised in the analysis of the environmental impacts of seawater warming. The cooling water model comprises a part of the Baltic Sea spanning from the level of Hiiumaa Island up to the Merenkurkku Archipelago. A broad modelling area has been utilised to ensure that the impact of phenomena taking place on the scale of the Baltic Sea, such as the impact of flows in the actual area affected by cooling waters off Olkiluoto, could be presented. The description of the model employed, the author of the model, a description of the observed area and the results have been presented in section 9.7.
Uncertainties in calculation results must be illustrated clearly.	The uncertainties in calculation results are presented in section 9.7.
The alternatives for cooling water intake and discharge options must be presented clearly, and any possibilities for remote intake and discharge must be examined.	The alternative locations for cooling water intake and discharge are presented in Figures 2-5 and 9-37. The remote options have been discussed in the test proper.
The calculations for cooling water should be presented in a conservative way and so that the thermal load caused by all four units is taken into account.	Scenarios including 3 (zero-option) or 4 plant units were used as calculation options for the model. The calculation options used in cooling water modelling are presented in section 9.7.8.
The need for a Natura review pursuant to Section 65 of the Nature Conservation Act should be considered (concerning the Natura area FI0200073).	The question of whether the project, either individually or in combination with other projects and plans, is likely to have a significant adverse effect on the ecological values that serve as the conservation basis of the nearest Natura areas has been reviewed in the assessment work. The results of the assessment are presented in section 9.10.3.

Impacts and their assessment	
The interrelationships between Olkiluoto 3, ONKALO/final disposal facility, Olkiluoto 4 and other planned projects (such as schedules, environmental impacts during the construction and operational phases, the need for licensing in accordance with the Nuclear Energy Act, traffic volumes and safety) should be explained in an illustrative way so that a clear overall picture can be formed of the state of, and changes to, Olkiluoto.	The presentation of combined impacts and licensing situation has been supported by graphical presentations. The combined impacts of the planned projects have been considered in the traffic assessment and noise model.
The new recommendations for radiation protection, will be published in October 2007 by the International Commission on Radiological Protection (ICRP), must be taken into account when assessing the impacts on vegetation and animals.	Experts from the Radiation and Nuclear Safety Authority and Posiva have been consulted when assessing the impacts on vegetation and animals. The radiation recommendations define the radiation dose limits for nature. The recommendation will also be taken into account in the Natura review. The recommendations have not been published.
TVO is obligated to provide information on the environmental impact of the required power transmission in the Olkiluoto area.	The environmental impacts of the required power transmission in the Olkiluoto area has been assessed on a general level in this EIA report. As regards power lines, Fingrid Oyj will initiate the assessment of environmental impacts after the decision-in-principle for Finland's sixth nuclear power plant unit has been made.
Assessing the impacts of exceptional and emergency situations must not be limited to the exclusion area or the emergency planning zone for rescue operations.	The discussion of accidents involving radioactive releases has been prepared in cooperation with Fortum. The sufficiency of protective zones and emergency planning zones has been discussed in the EIA.
The EIA report must present various emergency scenarios involving radioactive emissions and, with the help of illustrative examples, should describe the extent of the affected zones and the impacts of emissions on people and the environment.	Section 10 of the EIA report presents various types of accidents causing different kinds of radioactive releases and describes the extent of the respective affected zones and the impact of releases on people and nature.
The assessment may use the classification system (INES) of the International Atomic Energy Agency (IAEA), and the EIA report must present a clear summary of the basis used in the review.	The classification of accidents and the basis used in the review are presented in section 10. The subject is also discussed in Appendix 2.
The assessment must also include a review of the possible environmental impact of radioactive substances on the States around the Baltic Sea and on Norway.	A radius of 1,000 km has been used as the limit for the assessment.
As exceptional situations, any eventual phenomena caused by climate change and the related preparations to cope with such phenomena must be examined (changes in sea level and other exceptional weather phenomena).	Changes in sea level, snowstorms and other potential conditions have been taken into account in the assessment. The EIA provides a general assessment of what kinds of impacts may arise from climate change and the impact they may have on the Olkiluoto nuclear power plant. The impacts have been examined on the basis of the existing assessments.
In the assessment of the environmental impacts of transport, particular attention should be paid to defining the observed area in order to include the traffic arrangements for the junction of road 2176 and highway 8.	The changes to traffic volumes and the resulting impacts on the Olkiluoto area have been examined in the EIA. The impacts of traffic during construction are assessed in section 8.6 and the impacts of traffic during operation in section 9.3. The traffic arrangements for the junction of road 2176 and highway 8 have been taken into account in the assessment. The EIA provides a description of the present plans (e.g. the overall development assessment of highway 8).
The combined effects of other projects under construction or at the planning stage should be included in the assessment of the environmental impacts of traffic.	The other projects under construction or at the planning stage have been considered when assessing the environmental impacts of traffic.

Impacts and their assessment	
With regard to the socio-economic review of the EIA procedure, a detailed assessment should be provided of the project's impact on employment during the construction and operational stages of the power plant.	The project's impact on employment during the construction and operational stages has been assessed, and the results are presented in sections 8.7.1 and 9.11.4.
The Ministry finds it reasonable that the organisation responsible for the project should examine the environmental impacts of the entire fuel supply chain in general and, additionally, the company's opportunities to influence this chain.	The environmental impacts of the production and transportation of nuclear fuel, based on the existing specifications, are described in section 9.1. The mining operations of the uranium supplier typically used by TVO have been described in the EIA report.
When assessing the environmental impacts of the disposal of spent nuclear fuel, the latest available data must be quoted in the assessment.	The environmental impacts of the disposal of spent nuclear fuel are discussed in section 9.2. The environmental impacts of the disposal of spent nuclear fuel are described utilising the results of the environmental impact assessment procedure carried out by Posiva Oy in 1999, as well as the studies carried out thereafter.
The report should review nuclear waste management as a whole, including extensions to the necessary storage and final disposal facilities and their environmental impacts.	The extensions to the storage and final disposal facilities required for nuclear waste management have been taken into account in the assessment of impacts.
Plans for the assessment procedure and participation	
The Ministry of Trade and Industry considers that the arrangements for participation during the EIA procedure can be made according to the plan presented in the assessment programme. However, sufficient attention should be paid to communications to, and interaction with, the entire affected area of the project, across municipal borders and all population groups.	The representatives of the municipalities have been invited to the audit group. Participation and interaction have been arranged in the manner presented in the EIA programme.
The Ministry requests that the parties consider ways of presenting the impact of participation in the assessment report.	Efforts have been made to answer the considerations and questions presented in the statements and opinions as comprehensively as possible.
The Ministry of Trade and Industry does not consider it appropriate that an EIA report and an application for a decision-in-principle be presented for comments at the same time, since they relate to the same project. The Ministry hopes that the coordinating authority is able to submit the EIA report for comments and provide the coordinating authority's statement before the application for a decision-in-principle is presented to the Government.	TVO has not made any decisions concerning action to be taken subsequent to the EIA procedure. According to the Nuclear Energy Decree, the application for a decision-in-principle must be supplemented with an EIA report. TVO has not made any decisions concerning the actions to be taken subsequent to the EIA procedure.

3.11 Public display of the assessment report and international hearing

The Ministry of Employment and the Economy will announce the public display of the assessment report once TVO has submitted the report. The public display will be arranged similarly to that of the assessment programme. According to the EIA Act, the deadline for submitting opinions and statements to the coordinating authority shall be no less than 30 and no more than 60 days after the publication of the announcement.

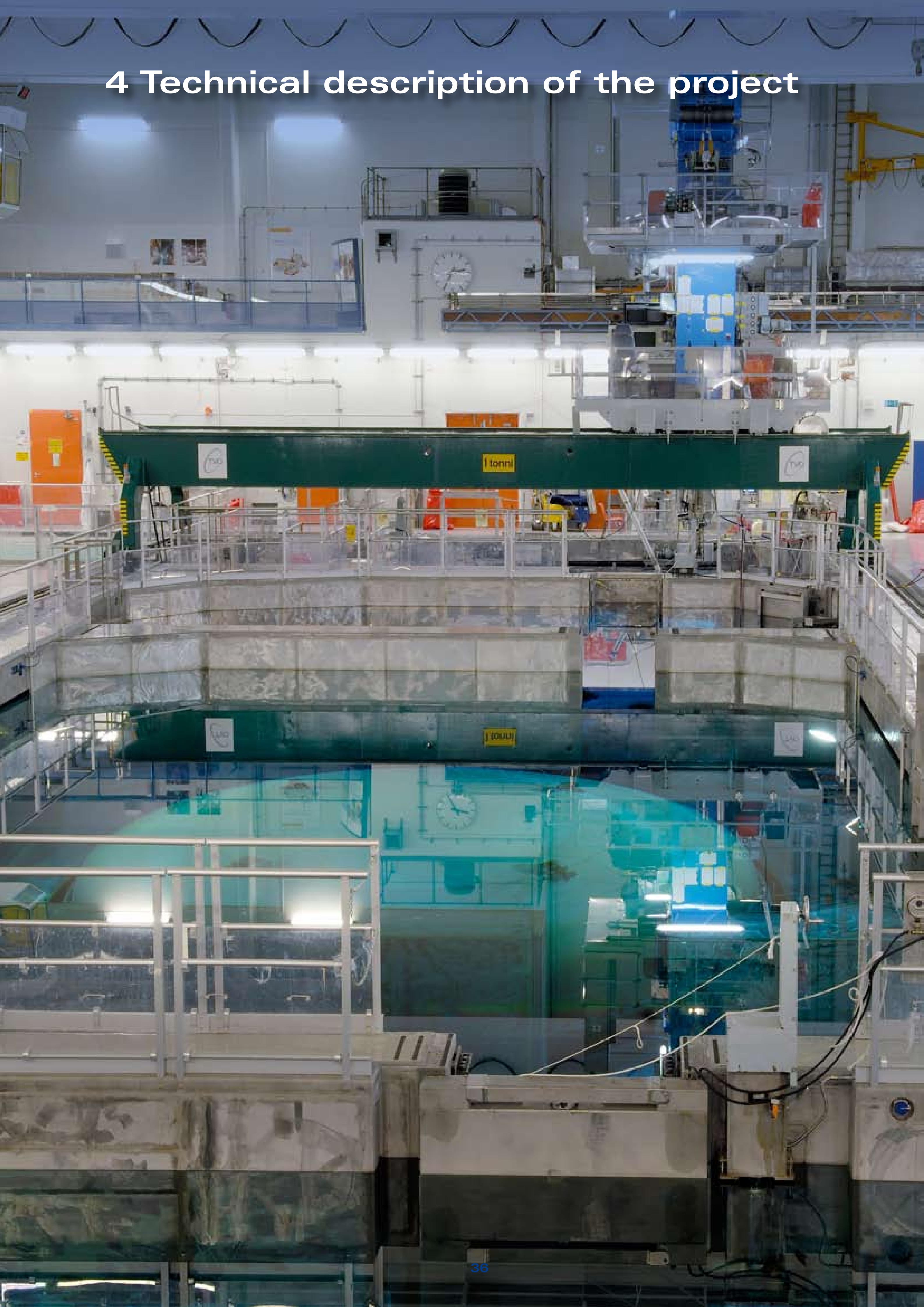
The countries participating in the international hearing of the assessment report stage are Sweden, Norway, Estonia, Lithuania, Russia and Germany.

3.12 Completion of the EIA procedure

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

The EIA report will be appended to the possible licence applications concerning the project, and the licensing authorities will use it as base material for their decision-making. The EIA report, together with the interactions that have taken place and the material that has accumulated during the EIA procedure, will constitute one of the starting points of planning if the project advances to the detailed planning stage.

4 Technical description of the project



4.1 Power plant types

Several different types of reactors were constructed during the early years of nuclear energy use. The majority of contemporary reactors are so-called light water reactors in which ordinary water is used as the coolant and the moderator.

Light water reactors are simple in terms of their basic functions, and they have proven to be secure and reliable. Hence the development of new reactors is presently almost exclusively focused on light water reactors. A new feature in the development of light water reactors is the increased use of the so-called passive safety systems. The operation of these systems is characterised by partial or complete independence from external power sources. A simple example of such systems is a water tank located above other structures, which makes it possible to direct water to the desired location without using pumps.

There are two types of light water reactors: boiling water reactor and pressurised water reactor. The units currently in operation at Olkiluoto (OL1 and OL2) are boiling water reactors, while the unit under construction (OL3) as well as both of the units at Loviisa (Loviisa 1 and 2) are pressurised water reactors. The prospective new unit at Olkiluoto (OL4) will be a light water reactor facility of either of the two types.

The specifications of the above plant units are publicly available. The table 4-1 is not binding, and another supplier may also come into question.

The plant option chosen will be modified to meet the Finnish safety requirements and the requirements imposed by the local conditions at Olkiluoto. Feasibility studies will be performed for some of the plant types indicated in table 4-1 for the procurement of the OL4 plant unit.

The requirements concerning nuclear safety are practically the same for all plant types, which means that the chosen plant type is of no significance in that regard. Also, the plant types that come into question do not significantly differ from each other with regard to radioactive releases. However, the size of the chosen plant type is of significance with regard to environmental impacts because the size affects the thermal load conducted to the sea.

4.2 Operating principles of the planned nuclear power plant unit

The energy production of a nuclear power plant is based on the controlled chain reaction of fissions occurring in the reactor. A central component of a nuclear reactor is the core that consists of the fuel and neutron moderator. The fission reactions occur in the fissile material contained in the fuel. The fuel used in the light water reactors at Olkiluoto is uranium dioxide that heats water, and the resulting heat is used to produce steam at a high pressure. The steam is conducted to a turbine that drives an electric generator.

In the reactor, the fuel is in the form of small uranium dioxide pellets encased in gas-tight fuel rods of approximately four metres in length. The fuel rods are assembled into fuel assemblies, and there are hundreds of these in the reactor. The typical amount of uranium fuel in the reactor is approximately 100 to 150 tonnes. Approximately one-quarter of the fuel is replaced with fresh fuel at each annual outage.

Natural uranium consists mainly of two isotopes: 99.3 % of the isotope U-238 and 0.7 % of the isotope U-235. For use as nuclear fuel, uranium is isotope enriched so that the fuel to be placed in a reactor contains approximately 2 to 5 % of uranium U-235 and approximately 95 to 98 % of uranium U-238. During operation, the U-235 in the fuel produces energy and is transformed into fission products. A fraction of the isotope U-238 is transformed into plutonium, which also produces energy. Spent fuel contains almost 96 % U-238 and approximately 3 % fission products, as well as a total of more than 1 % fissionable uranium and plutonium. In figures 4-1 and 4-2 are presented the main principles of the two reactor types.

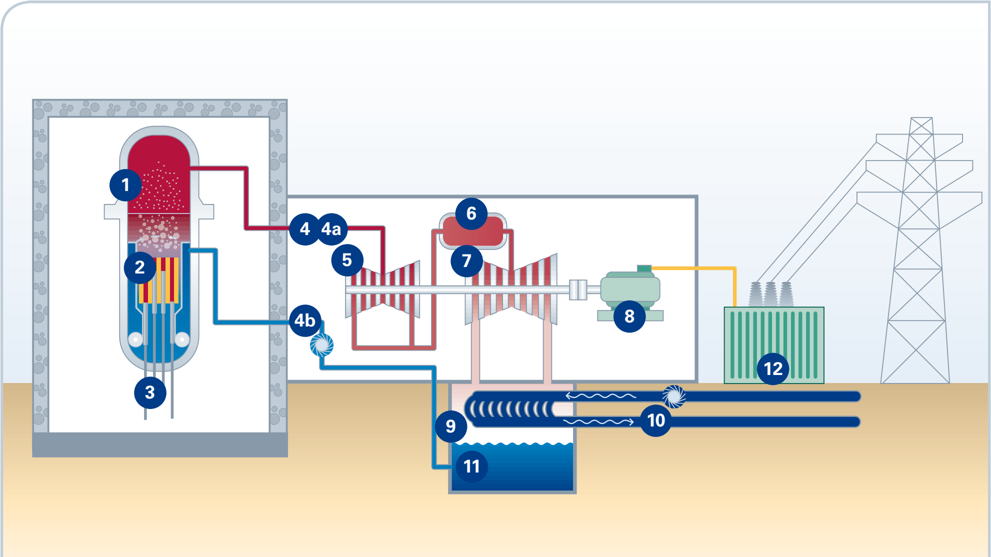
4.2.1 BWR (Boiling Water Reactor)

The fuel in the reactor of a BWR plant is cooled by pure water. Within the pressure vessel, reactor coolant pumps circulate water through the fuel bundles. This heats the water to a temperature of approximately 300 °C, which makes it boil and generate steam at a pressure of approximately 70 bar. The saturated steam is conducted through steam separators and a steam dryer located

***Table 4-1** Plant types on the market, presenting boiling water reactors and pressurised water reactors.*

Manufacturer	Country of Domicile	Type	Abbreviation	Power (MW_e)
Boiling water reactors				
General Electric (GE)	United States	Advanced Boiling Water Reactor	ABWR	Approx. 1,500
Toshiba/Westinghouse	Japan / Sweden	Advanced Boiling Water Reactor	ABWR	Approx. 1,600
General Electric (GE)	United States	Economic Simplified Boiling Water Reactor	ESBWR	1,600–1,700
Areva	Germany	Siede Wasser Reaktor (Boiling Water Reactor, BWR)	SWR-1000	Approx. 1,250
Pressurised water reactors				
Areva	France / Germany	Evolutionary Pressurized Water Reactor	EPR	Approx. 1,700
Mitsubishi	Japan	Advanced Pressurized Water Reactor	APWR	1,600–1,700
KHNP	South Korea	Advanced Power Reactor (PWR)	APR-1400	Approx. 1,400
Westinghouse	United States	(PWR)	AP-1000	Approx. 1,100
Gidropres	Russia	Vodo-Vodyanoy Energeticheskiy Reactor (Water-Cooled, Water-Moderated Energy Production Reactor, PWR)	VVER-1000	Approx. 1,000

Figure 4-1 *The operating principle of a boiling water reactor plant.*



1. Reactor
2. Core
3. Control rods
4. Primary circuit
4a. Steam for the turbine
4b. Water to the reactor
5. High pressure turbine
6. Reheater
7. Low pressure turbine
8. Generator
9. Condenser
10. Sea water circuit
11. Condensate water
12. Transformer

within the pressure vessel to high-pressure turbines, an intermediate reheater and a low-pressure turbine. The turbines are linked by a shaft to a generator that produces electricity. The amount of water present in the reactor is regulated by feedwater pumps. The safety valves attached to the steam tubes protect the reactor pressure vessel from overpressure, releasing steam into the large water pool inside the containment if necessary.

In addition to control rods, a boiling water reactor also employs reactor coolant pumps for regulation purposes. These pumps affect the reactivity through reactor coolant flow by changing the steam concentration in the reactor core. Rapid shutdown of the reactor is performed by inserting the control rods into the reactor core using a hydraulic reactor trip system.

The steam coming from the low-pressure turbine is conducted to a condenser, in which it is condensed into water using seawater. There is underpressure in the condenser, meaning that in the case of a leak, seawater will leak into the process, not vice versa. From the condenser, the water is pumped into pre-heaters. In the pre-heaters, steam extracted from the turbine heats the water before it is conducted back to the reactor. The existing nuclear power plant units at Olkiluoto (OL1 and OL2) are of the BWR type.

4.2.2 PWR (Pressurised Water Reactor)

The fuel heats water in a PWR plant, but the reactor pressure vessel is maintained at such a high pressure that the water will not boil at any stage. The pressure is typically approx. 150 bar and the temperature in the reactor is approx. 300°C. The safety valves attached to the pressurizer protect the primary circuit against too high a pressure. The pressurised water generates steam in separate steam generators, from where it is pumped into the reactor (primary circuit). The steam circulates in the secondary circuit, driving the turbine and generator.

In a pressurised water reactor, power regulation is mainly performed through control rods and boron added to the coolant. Control rods are also used for rapid shutdown of the reactor in operating transients by dropping them into the reactor from above with the help of gravity.

The OL3 unit under construction and the existing nuclear power plant units at Loviisa are of the PWR type.

4.3 Technical data

The planned nuclear power plant unit will be a base-load power plant that will operate continuously with the exception of an annual maintenance outage. The technical service life of the plant unit is approximately 60 years. Table 4-2 presents some technical data on the prospective power plant unit. The figures are preliminary.

4.4 Power plant buildings

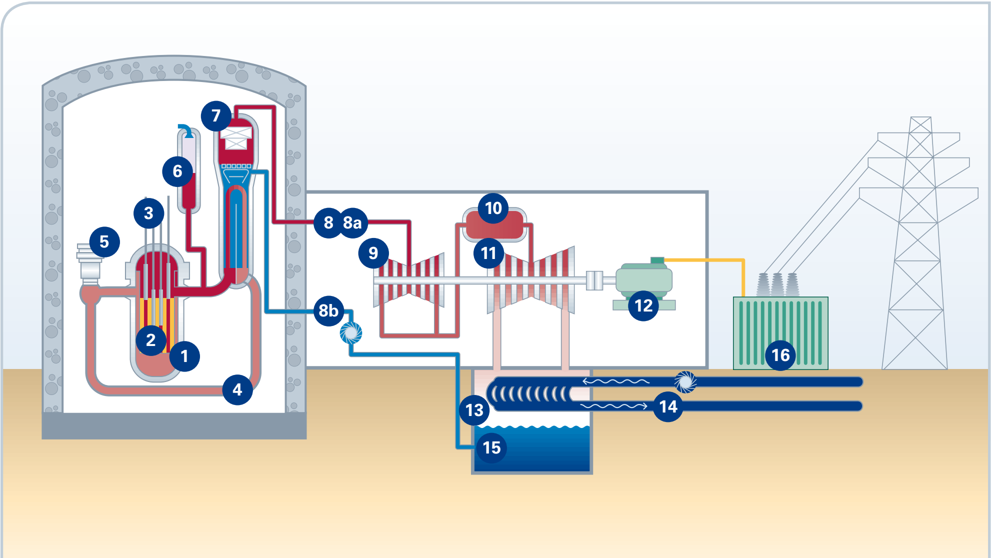
The new unit makes use of the existing infrastructure of the Olkiluoto power plant area and the auxiliary and administrative buildings used by the two existing units and the new unit presently under construction. The volume of the power plant building is 500,000 to 1,000,000 m3 and its height approximately 60 metres. The vent stack reaches an altitude of approximately 100 metres. In addition, a number of lower auxiliary buildings will be constructed in the vicinity of the new unit.

Supply of standby power and the boiler plant

The supply of electric power at the nuclear power plant in extraordinary situations will be secured with diesel generators or a gas turbine that serve as the source of standby power. Both of the present power plant units (OL1 and 2) have four standby diesel generators using light fuel oil as their fuel. The third unit under construction (OL3) will likewise be equipped with four standby power diesel units.

A boiler plant serves as the backup heat plant for the nuclear power plant. The boiler plant is used in cases where the thermal energy required for heating the building on the power plant area cannot be obtained from the nuclear power plant for some exceptional reason (e.g. start-up and outage conditions). The present boiler plant has two hot-water boilers, the rated power of which is 12 MW and 8 MW. The boiler plant uses light fuel oil as its fuel. The boiler plant has been rarely used. Between 1997 and 2006 the boiler plant has been used three times for short periods (6.5 hours in 1997, 33 hours in 2004, and 4 hours in 2005) for the purpose of generating

Figure 4-2 *The operating principle of a pressurised water reactor plant.*



1. Reactor
2. Core
3. Control rods
4. Primary circuit (water circuit)
5. Main reactor coolant pump
6. Pressurizer
7. Steam generator
8. Secondary circuit (steam)

8a. Steam to the turbine

8b. Water to the steam generators

9. High pressure turbine
10. Reheater
11. Low pressure turbine
12. Generator
13. Condenser
14. Seawater circuit
15. Condensate water
16. Transformer

thermal energy; otherwise the operation has consisted of test start-ups. The power plant unit under construction (OL3) will be equipped with a boiler plant intended for generating steam for house load operation. The boiler plant will include two boilers, the combined heat power of which is 28 MW.

The new power plant unit (OL4) will also be equipped with emergency power systems.

4.5 Best available techniques (BAT) and the energy efficiency of the plant

The new power plant unit will be an advanced nuclear power plant in comparison with the plants that are currently in operation. In particular, its safety features will be developed based on previous experience. Minimisation of fuel damages will be considered in the design, and the best available techniques will be taken into account in the design of its systems.

In accordance with the Nuclear Energy Act, the basic principle for the design, construction and operation of a nuclear power plant is that the plant must be safe and it shall not cause injury to people or damage to the environment or property. This is complied with through precautionary measures in the design, construction and operation of the plant, functions protecting the plant in cases of disturbance and damage, and as functions limiting the consequences of accidents.

Energy efficiency

Part of the gross electric power generated by the plant will be consumed internally by the units of the plant, mainly for the purpose of pumping the cooling water, circulating water and feedwater, and for ventilation needs. Part of the heat generated in the production process will be used for heating the plant buildings.

TVO has participated in the energy conservation agreement for the power plant industry that terminated at the end of 2007. In the agreement, TVO undertook to prepare an energy conservation plan and to implement the measures defined therein, as well as to report them to the Finnish Energy Industries. The measures required by the energy conservation agreement have been reported since 1998. At the beginning of 2008, TVO joined the energy conservation programme of Finnish Energy Industries. The goal of the programme is to improve energy efficiency and to include energy conservation actions as part of its members' operating system.

Flow-through-based seawater cooling is the best available cooling method in the conditions prevailing at Olkiluoto. The method employed makes it possible to achieve a better power generation efficiency than through other cooling methods. Its investment and operating costs are also smaller. Depending on environmental conditions, the relative advantage of flow-through cooling may, at maximum, amount to several percentage points compared with a cooling tower solution. Several efficiency-improving investments have been made for the OL1 and OL2 plant units operated by TVO, last in 2005 and 2006. The investments improved the efficiency of both plant units to 34.1 %. Improving the efficiency reduces the amount of heat discharged into the sea. During the operation of the plant units, their nominal electricity output has increased from 660 MW to 860 MW as a result of investments and plant modifications.

The utilisation of nuclear fuel has been improved during the operation of the plant. TVO is currently using 40 % less uranium fuel to produce one kilowatt-hour than in the 1980s. This will also reduce the quantity of spent nuclear fuel.

Table 4-2 *Preliminary technical data on the nuclear power plant unit planned for Olkiluoto.*

Description	Value and unit
Thermal power of reactor	approx. 2,800 to 4,600 MW_{th}
Electrical power	approx. 1,000 to 1,800 MW_e
Overall efficiency	approx. 35 to 40%
Fuel	Uranium dioxide UO_2
Consumption of uranium fuel	approx. 20 to 40 tonnes/year
Average degree of fuel isotope enrichment	approx. 2 to 5% U-235
Amount of uranium in the reactor	approx. 100 to 150 tonnes
Annual electricity production	approx. 8 to 14 TWh_e
Need for cooling water	approx. 40 to 60 m^3/s

MW = megawatt = one thousand kilowatts
TWh = terawatt-hour = one billion kilowatt-hours

5 Licences, permits, plans, notifications and decisions required for the project

5.1 Land use planning

The construction of the planned power plant unit does not require any changes to land use planning. The Olkiluoto partial master plan, as well as an amendment to the partial master plan for the northern shores of Rauma, in which considerations are made for the future land use at Olkiluoto, are under preparation in the Olkiluoto area. The local detailed plan of Olkiluoto will be updated after the completion of the partial master plan.

5.2 Licences pursuant to the Nuclear Energy Act

5.2.1 Decision-in-principle

The new nuclear power plant unit is a nuclear facility of considerable general significance referred to in the Nuclear Energy Act (990/1987), the construction of which requires a Government decision-in-principle in that the construction project is in line with the overall good of society.

A decision-in-principle is applied for by submitting an application to the Government. The processing of the application for a decision-in-principle is not solely based on the material submitted by the applicant; instead, the authorities will also obtain other reports, both those defined in the Nuclear Energy Decree (161/1988) and those otherwise considered necessary, in which the project is assessed from more general points of view. For the purpose of processing the decision-in-principle application, the Ministry of Employment and the Economy will invite statements from the municipal council of the municipality intended as the site of the facility and from its neighbouring municipalities, as well as from the Ministry of the Environment and other authorities indicated in the Nuclear Energy Act. In addition to the above, the Ministry must also obtain a preliminary safety assessment of the project from the Radiation and Nuclear Safety Authority.

Before the decision-in-principle is made, the applicant shall, according to instructions by the Ministry of Employment and the Economy, compile an overall description of the facility, the environmental effects it is expected to have and its safety, and make it generally available to the public after being checked by the Ministry. The EIA report shall be enclosed with the decision-in-principle application.

The Ministry of Employment and the Economy shall provide residents and municipalities in the immediate vicinity of the nuclear facility, as well as the local authorities, with an opportunity to present their opinions on the project before the decision-in-principle is made. Furthermore, the Ministry shall arrange a public gathering in the municipality in which the planned site of the facility is located and during this gathering the public shall have the opportunity to give their opinions. Those opinions shall be made known to the Government.

The granting of the decision-in-principle will be considered in accordance with section 14 § of the Nuclear Energy Act. A supporting statement from the municipality intended to be the site of the planned nuclear facility is an essential prerequisite for approving a decision-in-principle.

The Government pays special attention to:

- the need for the nuclear facility project with regard to the country's energy supply
- the suitability of the intended site of the nuclear facility and its effects on the environment, and
- arrangements for the nuclear fuel and waste management.

The Government decision-in-principle shall be forwarded to Parliament for ratification. Parliament may reverse the decision-in-principle as such or may decide that it remains in force as such.

Prior to the entry into force of the decision-in-principle, the applicant shall not enter into any financially significant procurement agreements relating to the construction of the facility.

5.2.2 Construction licence

The decision-in-principle issued by the Government is followed by the actual licensing procedure. The Government grants the licences to construct and operate a nuclear facility. A licence to construct a nuclear facility may be granted if the decision-in-principle ratified by Parliament has deemed the construction of a nuclear facility to be in line with the overall good of society and the construction of a nuclear facility also meets the prerequisites for granting a construction licence for a nuclear facility as provided in section 19 of the Nuclear Energy Act. These preconditions include:

- the plans concerning the nuclear facility, its central operational systems and components entail sufficient safety and protection for workers, and the population's safety has otherwise been taken into account appropriately when planning operations
- the location of the nuclear facility is appropriate with regard to the safety of the planned operations and environmental protection has been taken into account appropriately when planning operations
- physical protection has been taken into account appropriately when planning operations
- a site has been reserved for constructing a nuclear facility in a town plan or building plan in accordance with the Building Act (370/58), and the applicant has possession of the site required for the operation of the facility
- the methods available to the applicant for arranging nuclear waste management, including the final disposal of nuclear waste and the decommissioning of the nuclear facility, are sufficient and appropriate
- the applicant's plans for arranging nuclear fuel management are sufficient and appropriate
- the applicant's arrangements for the implementation of control by the Radiation and Nuclear Safety Authority as referred to in paragraph 3 of section 63(1) of the Nuclear Energy Act, in Finland and abroad, and for the implementation of control, as referred to in paragraph 4 of section 63(1), are sufficient
- the applicant has the necessary expertise available
- the applicant has sufficient financial prerequisites to implement the project and carry on operations
- the applicant is otherwise considered to have the prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations

- the planned nuclear facility otherwise fulfils the principles laid down in sections 5–7 of the Nuclear Energy Act.

5.2.3 Operating licence

The operation of a nuclear power plant requires an operating licence issued by the Government. The licence to operate a nuclear facility may be issued as soon as a licence has been granted to construct it, providing the prerequisites listed in section 19 of the Nuclear Energy Act are met. These preconditions include:

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

Operation of the nuclear power plant shall not be started on the basis of a licence granted until the Finnish Radiation and Nuclear Safety Authority (STUK) has ascertained that the nuclear facility meets the prerequisites prescribed by law and the Ministry of Employment and the Economy has ascertained that provision for the cost of nuclear waste management has been arranged in a manner required by law.

In Finland, the operation licence of a nuclear power plant is only granted for a fixed term. In considering the duration of the licence, special attention is paid to safety precautions and the estimated duration of operations. The Radiation and Nuclear Safety Authority can interrupt the operation of a nuclear power plant if it is necessary for ensuring safety.

The licensing procedure required by the Nuclear Energy Act is presented in the figure 5-1.

5.3 Notifications pursuant to the Euratom Treaty

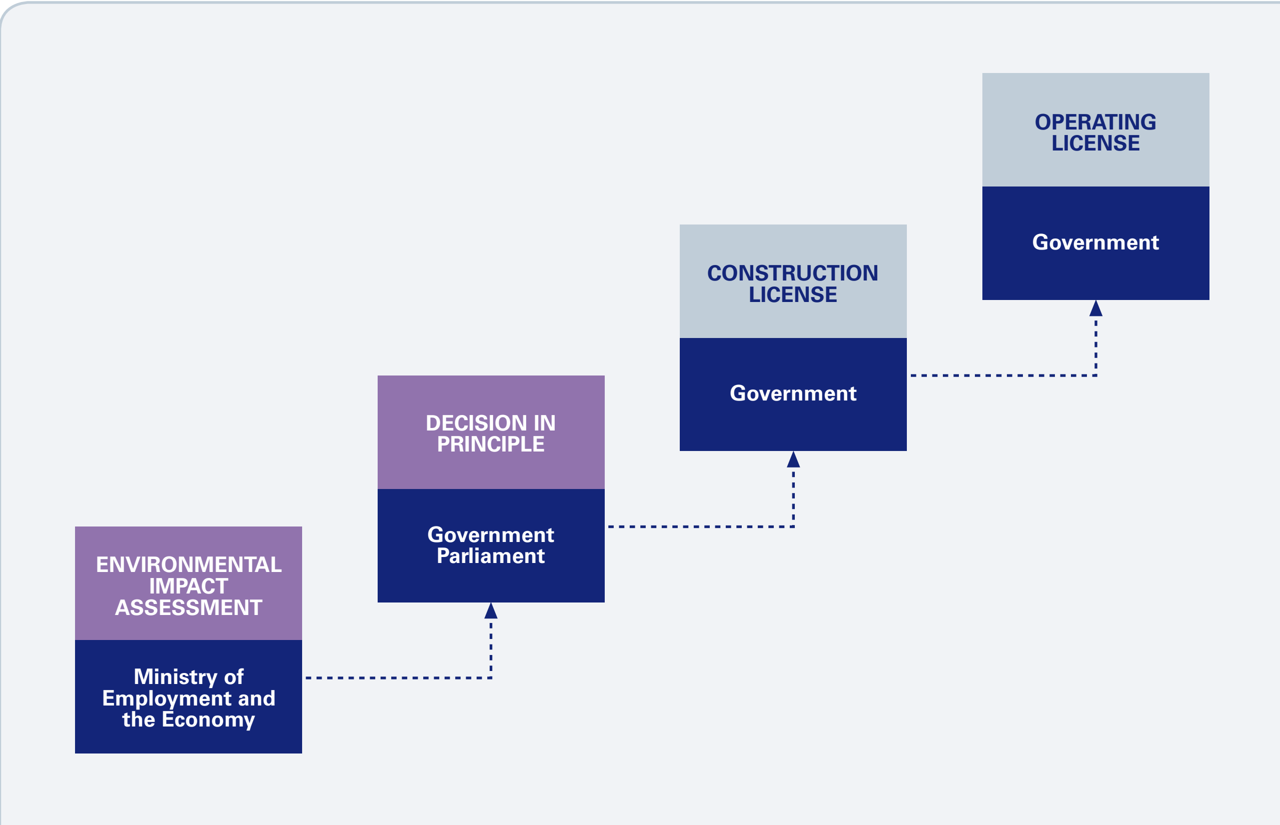
The European Atomic Energy Community (Euratom) Treaty requires that each Member State provides the Commission with plans relating to the disposal of radioactive waste (Article 37) and that the licensee declares to the Commission the technical characteristics of the installation for its control (Article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

5.4 Construction-time environmental permit and permit pursuant to the Water Act

A separate environmental permit is required if a rock-crushing plant with operating time exceeding 50 days per year is located in the area during construction work. The permit authority is the environmental authority of the Eurajoki municipality.

An environmental permit pursuant to the Water Act will be applied for the water construction measures concerning the cooling water intake and discharge structures from the Western Finland Environmental Permit Authority.

***Figure 5-1** The licensing procedure required by the Nuclear Energy Act.*



5.5 Building permit

A building permit in accordance with the Land Use and Building Act (132/1999) must be applied for in connection with all new buildings. The building permit is obtained from the building permit authorities of the Eurajoki municipality (Environmental Committee), which, when granting the permit, will ensure that the construction plan is in accordance with the local detailed plan and the building codes. The building permit is required before the construction can be started. The issuance of a building permit also requires that the environmental impact assessment procedure has been completed.

Section 159 of the Aviation Act (1242/2005), which entered into force in early 2006, requires that a flight obstacle permit is needed for the erection of equipment, a construction or a sign if the obstacle extends more than 30 metres above ground level. The permit is an appendix to the building permit. The statement of Finavia (the provider of air traffic services) about the obstacle must be included in the permit request *(Finnish Civil Aviation Authority 2007)*.

5.6 Operation-time environmental permit and water permit pursuant to the Water Act

An environmental permit pursuant to the Environmental Protection Act is needed for activities that involve the risk of pollution of the environment. An environmental permit must also be obtained for a nuclear power plant. A permit is required for the operations based on the Environmental Protection Act (86/2000) and the Environmental Protection Decree (169/2000) enacted on the basis of the Environmental Protection Act. An environmental permit covers all matters relating to environmental impacts, such as atmospheric and aquatic releases, waste and noise matters, as well as other related environmental matters. One of the prerequisites for granting the permit is that the operations must not cause harmful health effects or significant pollution of the environment or the risk of it.

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

A water permit pursuant to the Water Act (264/1961) is required for conducting waters from the water system relating to the operation of the power plant. The Water Act is an Act pertaining to the use of waters. The use of waters refers to all activities targeted at water areas and groundwaters. Water system pollution issues are processed pursuant to the Environmental Protection Act. The permit authority for the project is the Western Finland Environmental Permit Authority.

5.7 Other permits

Other permits of relevance to environmental matters mainly include technical permits, the primary purpose of which is to ensure occupational safety and prevent material damages. These include, among others, permits concerning flammable liquids, pressure equipment permits, and permits pursuant to the Chemicals Act.

6 Relationship of the project to regulations, plans and programmes concerning environmental protection

The following table presents a summary of the relationship of the project to the regulations, plans and programmes concerning environmental protection currently in force.

Table 6-1 *Relationship of the project to the regulations, plans and programmes concerning environmental protection currently in force.*

Name	Content	Relationship to the project
Relationship of the project to the environmental protection regulations currently in force		
Environmental Protection Act (86/2000) and Decree (169/2000)	General regulations for preventing the pollution of the environment.	Obligation to apply for an environmental permit after the EIA procedure
Guideline values for noise (Government Decision on Noise Level Guideline Values 993/92)	The guideline values for noise level in residential areas and recreational areas in urban areas or in their vicinity are 55 dB (A) during the daytime (7am to 10pm) and 50 dB (A) during the night. For new areas, the nighttime guideline value is 45 dB (A). The guideline value for holiday home areas is 45 dB (A) in the daytime and 40 dB (A) during the night. The guideline values pertaining to the so-called narrow-band noise are stricter than those pertaining to ordinary noise. If the noise is found to be narrow-band, 5 dB will be added to the measured noise before comparison to the guideline value.	The chosen implementation option will be so designed that the noise guideline values will not be exceeded in the vicinity of the plant as a result of its operation. The generation of narrow-band noise will be prevented in the noise abatement design of the plant.
Waste Act (1072/93) and Decree (1390/93)	The objective is to support sustainable development by promoting the rational use of natural resources, and preventing and combating the hazard and harm to health and the environment arising from wastes. The efforts to meet this objective should primarily focus on decreasing the generation of waste and increasing waste recovery. If the recovery of waste is not possible technically or with reasonable additional costs, the waste must be disposed of in a manner that minimises the harm to the environment and health.	The waste fractions generated at the power plant will be sorted and recovered so that the requirements of the Waste Act are met. The waste that is unsuitable for recovery will be disposed of in the manner required in the environmental permit.
Relationship of the project to plans and programmes		
Name	Content	Relationship to the project
International commitments concerning sulphur emissions (ECE/UN Convention on Long-Range Transboundary Air Pollution)	The protocol concerning the second stage of the reduction of sulphur emissions was signed in Oslo in June 1994. According to this protocol, the maximum limit for Finland's sulphur emissions for 2000 was 116,000 tonnes calculated as sulphur dioxide, which amounts to approximately 80% of the level of 1980. The emissions target was reached sooner than planned as Finland's sulphur dioxide emissions in 1996 amounted to 105,000 tonnes.	Binding to Finland as a State, not to individual undertakings. The commitments will be fulfilled through directive means targeted at undertakings deemed necessary by the State. With the exception of the use of emergency power, nuclear power generation does not generate sulphur dioxide emissions. The emissions generated are very minor, mainly consisting of the test runs of the emergency diesel generators and boiler plants. Therefore, the construction of a new nuclear power plant unit in Finland will not significantly increase Finland's sulphur emissions. The substitution of combustion processes causing sulphur emissions by nuclear power generation will reduce Finland's sulphur emissions, thereby contributing to Finland's effort in achieving both international and national long-term objectives in the reduction of sulphur emissions.

Relationship of the project to plans and programmes		
Name	**Content**	**Relationship to the project**
International commitments concerning nitrogen oxide emissions (ECE/UN Convention on Long-Range Trans-boundary Air Pollution)	The protocol concerning the reduction of nitrogen oxide emissions entered into force in 1991. According to this protocol, the emissions of nitrogen oxides will not exceed the level of 1987 in 1994. In addition to the actual protocol, Finland has also signed a declaration according to which the objective is to further reduce the emissions of nitrogen oxides by approximately 30 % by 1998 at the latest. Finland has chosen the year 1980 as the baseline year for the reduction of emissions. The objectives for the reduction of nitrogen oxide emissions have proven to be difficult to achieve due to, among other things, multiple emission sources and difficult controllability, and no significant reduction of emissions has yet taken place. The objective to freeze the emissions at the level of 1994 has been attained, but the 30 % reduction objective for 1998 was not met.	Binding to Finland as a State, not to individual undertakings. The commitments will be fulfilled through directive means targeted at undertakings deemed necessary by the State. With the exception of the use of emergency power, nuclear power generation does not generate emissions of nitrogen oxides. The emissions generated are very minor, mainly consisting of the test runs of the emergency diesel generators and boiler plants. Therefore, the construction of a new nuclear power plant unit in Finland will not significantly increase Finland's nitrogen oxide emissions. The substitution of combustion processes causing nitrogen oxide emissions by nuclear power generation will reduce Finland's nitrogen oxide emissions, thereby contributing to Finland's effort in achieving both international and national long-term objectives in the reduction of nitrogen oxide emissions.
Implementation of the emission ceilings directive (programme approved by the Government on 26 September 2002, emission ceilings directive 2001/81/EC)	The Directive 2001/81/EC of the European Parliament and of the Council of October 2001 on national emission ceilings for certain atmospheric pollutants, also known as the emission ceilings directive, defines for each of the Member States the maximum release limits for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia in 2010. Finland will implement the emission ceilings directive by virtue of a programme approved by the Government. The programme contains a plan for reducing emissions. As regards energy production, the reduction measures that remain viable are mainly the renewal of energy production and the new emission regulations entering into force as considerable investments in the reduction of sulphur and nitrogen emissions have already been made in Finland at the late 1980s and early 1990s.	Finland's emission ceiling for sulphur dioxide is 110,000 tonnes per year. Finland has already met this objective. The limits will next be revised in 2008. For 2010, the aforementioned emission ceilings directive sets a limit of 170, 000 tonnes per year as the emission ceiling for nitrogen oxides for Finland. The implementation of the program is not estimated to incur additional costs for Finland since, in Finland, the reduction objectives are likely to be met through limiting measures that would be realised otherwise as well. The construction of the new nuclear power plant unit will help Finland to meet the objectives of the emission ceilings directive.

Relationship of the project to plans and programmes		
Name	**Content**	**Relationship to the project**
Finland's energy and climate strategy (a report on the actions to be taken in the energy and climate policy in the near future, approved by the Government on 24 November 2005 and submitted to Parliament). The Parliamentary Finance Committee approved the report on 2 June 2006 (Statement of the Finance Committee TaVM 8/2006). Parliament approved the Finance Committee's statement on the Government report on climate and energy strategy on 6 June 2006 (Minutes of the Plenary Session PTK 66/2006).	The reduction of greenhouse gas emissions in accordance with the obligations under the UN Climate Convention will be primarily implemented through emissions trading under the Kyoto Protocol and by utilising the Kyoto mechanisms. The strategy takes into account Finland's starting points for international negotiations to limit global greenhouse gas emissions after the Kyoto period.	Preparation for the construction of a new nuclear power plant unit is also in harmony with the National Climate and Energy Strategy, in which nuclear power generation is seen as one of the crucial factors for guaranteeing the reliability of energy supply in Finland. With the exception of the use of emergency power, nuclear power generation does not generate greenhouse gas emissions. The emissions generated are very minor, mainly consisting of the test runs of the emergency diesel generators and boiler plants. The construction of a new nuclear power unit will reduce the average carbon dioxide emissions of Finnish power production, helping Finland to meet both international and national long-term objectives in the reduction of greenhouse gas emissions.
An Energy Policy for Europe, 10 January 2007	An Energy Policy for Europe was published on 10 January 2007. According to its basic principles, the competitive and clean supply of energy in the EU must be secured while responding to the control of climate change, the increasing global demand for energy, and uncertainties in energy production. A ten-point action plan for the implementation of the policy has been issued. One of the points in the action plan is the future of nuclear power. The Commission views nuclear power as a viable source of energy if the Member States are to achieve strict emissions targets in the future. According to the Commission, the advantages of nuclear power include its relatively stable and low production costs and low carbon dioxide emissions. According to the International Energy Agency, the use of nuclear power is increasing globally, and for this reason the Commission wants the EU to retain and develop its technological lead in this sector. The Commission advises the authorities of the Member States to improve the efficiency of their nuclear licensing procedures and eliminate unnecessary restrictions to enable the industry to act quickly if required in the context of decisions concerning additional nuclear power construction.	In terms of its cost structure and intended purpose, a nuclear power plant is a typical base-load plant with a long service life. The purpose of the new nuclear power plant unit is to increase the production capacity for base-load power. The construction of the nuclear power plant will also increase supply on the electricity market. With the exception of the use of emergency power, nuclear power generation does not generate greenhouse gas emissions. The emissions generated are very minor, mainly consisting of the test runs of the emergency diesel generators and boiler plants. The construction of a new nuclear power unit will reduce the average carbon dioxide emissions of Finnish power production, helping Finland to meet both international and national long-term objectives in the reduction of greenhouse gas emissions.

Relationship of the project to plans and programmes		
Name	Content	Relationship to the project
UN Climate Convention (1997 the Kyoto Climate Summit, 1998 the EU countries agree upon their mutual allocation of the emissions reduction objectives)	The Conference of Parties to the UNFCCC held in Kyoto in December 1997 approved the EU objective of reducing total greenhouse gas emissions by eight per cent below the 1990 baseline. The obligation must be achieved between 2008 and 2012, which is known as the first commitment period. The objective for reductions in Finland's greenhouse gas emissions was set at 0 % below the 1990 baseline, which means that emissions in 2008-2012 must be at the level of 1990 (71.09 million tonnes).	With the exception of the use of emergency power, nuclear power generation does not generate greenhouse gas emissions. The emissions generated are very minor, mainly consisting of the test runs of the emergency diesel generators and boiler plants. The construction of a new nuclear power unit will reduce the average carbon dioxide emissions of Finnish power production, helping Finland to meet both international and national long-term objectives in the reduction of greenhouse gas emissions.
Target Programme for Water Protection (Government decision-in-principle on the targets of water protection until 2015)	The decision presents measures for achieving good water quality and preventing the present state from deteriorating. The programme concerns inland waters, coast waters and groundwaters. The outlines support the preparation of regional water management plans. They also support the preparation and implementation of the EU marine strategy directive and the common action programme of the countries in the Baltic Sea region concerning the protection of the Baltic Sea. The aim is to • reduce loads that cause eutrophication • reduce the risks caused by hazardous substances • reduce the detrimental effects caused by water construction and regulation of water systems • protect groundwaters • protect aquatic biodiversity • restore ecologically damaged water bodies.	The nuclear power plant and its wastewater treatment plant represent the best available technology. The most significant aquatic release from the nuclear power plant is the thermal load contained in the cooling water. The cooling water does not contain nutrients that cause eutrophication or hazardous substances.

Relationship of the project to conservation programmes: Nature conservation programmes can be used for reserving areas for nature conservation purposes to secure ecological values of national significance. However, nature conservation programme areas are not actual nature conservation areas, which areas are areas that are protected by virtue of the Nature Conservation Act.

Name	Content	Relationship to the project
Natura 2000 network (Natura Decision by the Government on 20 August 1998, based on the Habitats Directive 92/43/EEC and the Birds Directive 79/409/EEC, amended 91/244/EEC)	The purpose of the Natura 2000 network is to conserve biodiversity within the European Union. The objects of protection include both valuable natural habitats and endangered species of flora and fauna.	The nearest area belonging to the Natura 2000 network is the Rauma archipelago (FI0200073). The nearest islands belonging to this area are located approximately 2 km from the power plant. The Liiklankari old-growth forest located on the southern shore of Olkiluoto also belongs to the Natura area of the Rauma archipelago.
Old-growth forest conservation programme	The objective is to conserve the ecological values of old-growth forests in sufficiently large entities. The bases for selecting the areas were, among other things, biological diversity and the structure of tree stands.	The Liiklankari nature conservation area located on the southern shore of Olkiluoto island, in the immediate vicinity of the spent fuel disposal facility, approximately one kilometre southeast of the existing power plant units, is included in the old-growth forest conservation programme.
Herb-rich forest conservation programme	The objective is to conserve the diversity and quality of the Finnish herb-rich forest vegetation and flora.	The Reksaari coastal grove area belonging to the herb-rich forest conservation programme and the Natura 2000 network is located approximately 5 kilometres south of Olkiluoto. The groves of Prami and Mäentausta are located at the Sorkka village in Rauma.
Shore conservation programme	The basic objective is to retain the areas included in the programme as unbuilt and in a natural state to conserve sea and lake habitats.	The outer archipelago north of Rauma, including the Susikari, Kalla and Bokreivi islands, belongs to the shore conservation programme. The western shore of Nurmes is also included in the shore conservation programme.
Valuable bedrock areas	Bedrock areas that are valuable in terms of nature and landscape conservation. The material provides support for decision-making when resolving matters in accordance with the Land Extraction Act and the Building Act. The material also has key significance for land use planning, but it does not have a legal status.	The Rannanvuori and Huikunvuori bedrock areas are located at the Sorkka village in Rauma, approximately 8 km from the nuclear power plant.
Strategy for protection and sustainable use of biological diversity 2006–2016 (continuation of the national action plan concerning Finland's biological diversity 1997–2005)	The objective is to stop the impoverishment of biodiversity by the end of 2010, establish the favourable development of Finnish nature during 2010–2016, prepare for the global environmental changes, climate changes in particular, that threaten Finnish nature by 2016, and strengthen Finland's impact on the conservation of biological diversity on a global scale through means of international cooperation.	The Omenapuumaa nature conservation area and the Särkänhuivi cape have regional conservation value. The luxuriant grove island of Omenapuumaa is located in the Rauma archipelago, approximately 5 km south of Olkiluoto. The low, narrow, long and curved cape of Särkänhuivi is the outermost tip of the Irjanteenharju ridge that protrudes to the sea. The Kalattila grove has local conservation value.

7 Limits of environmental impact assessment

The EIA procedure has primarily assessed the environmental impacts of operations taking place on the power plant site. Operations extending outside the site include, for example, traffic during the construction and operation of the plant. The impacts of these operations have also been assessed to the required extent. The environmental impacts of the construction of a power transmission link will be assessed in a separate EIA procedure for which Fingrid Oyj is responsible.

The impacts of discharging the cooling water to the sea have been analysed using a three-dimensional flow model created for the sea areas outside Olkiluoto. The neighbouring areas of Olkiluoto have been modelled using a resolution of 40 metres. For the purpose of calculating the boundary values, the roughest grid of the flow model included the entire Botnian sea area.

In connection with the EIA procedure, it has been assessed whether the project will have impacts extending beyond the territory of Finland. The impacts of exceptional and accident situations have been assessed throughout the territories of all countries in the Baltic rim.

The impact of transportation and the intermediate storage of nuclear fuel and waste produced at the plant have been assessed. The different stages in the production chain of the fuel to be brought to the nuclear power plant take place in several different countries. Fuel is produced in compliance with the environmental and other regulations of these countries. The main aspects of the fuel chain and its environmental impacts are described in this EIA report.

The impacts of the handling and final disposal of waste have been assessed to the required extent. The EIA report on the disposal of nuclear waste was completed in May 1999 *(Posiva 1999)*. This EIA report shows the major findings of the assessment regarding the disposal of spent nuclear fuel with a view of the spent nuclear fuel produced in the new Olkiluoto unit, in particular.

The joint impacts of the present and planned activities in Olkiluoto have been discussed as part of the assessment of impacts.

In this context, observed area refers to the area defined for each type of impact within which the environmental impact in question is examined and assessed. The extent of the observed area depends on the environmental impact being examined. The affected area refers to the area within which the environmental impact is estimated to occur in accordance with the assessment.

8 Impacts during construction

The environmental impacts occurring during the construction of the power plant unit have been examined separately because they differ from the impacts occurring during the operation of the power plant unit in terms of temporal duration and partly also with regard to other characteristics.

This chapter describes the construction work and traffic arrangements carried out during construction, and presents the means of transport used. The routes of construction-time traffic have also been described. The impact of construction-time traffic have been examined in the vicinity of roads leading to the power plant site. The volumes of transportation and traffic during the construction phase are estimates based on the experience gained from the construction of existing power plant units, traffic during their operation and the OL3 project, as well as on the traffic forecast prepared in conjunction with the Olkiluoto partial master plan.

The impacts on soil and bedrock, groundwater, water systems, vegetation and animals, employment, noise and people's comfort arising from construction have been assessed on the basis of experience gained from the OL3 project and the feedback received in connection with the interactions.

The area under review during the construction phase is limited to include the power plant unit site and roads leading to it, as well as the surrounding areas at a radius of approximately one kilometre.

8.1 Description and duration of construction works

The construction work of the new plant unit is estimated to take 6 to 8 years. The first phase of the construction work will take about 1 to 2 years and consists of rock blasting, quarrying and levelling of the building site. The building engineering work to be carried out after that is estimated to take 3 to 4 years. Equipment installations will be carried out inside the plant unit partly in parallel to these works, and they are also estimated to take 3 to 4 years. The commissioning phase of the power plant unit will take about 1 to 2 years. Figures 8-1 and 8-2 illustrate the different construction phases of the nuclear power plant unit using photographs taken during the construction of OL3.

The basic infrastructure of the power plant site must be extended and reorganised for the duration of the construction work. Such reorganisation includes, for example, the extension of the water supply and drainage network as well as the construction of cooling water intake and discharge channels and cooling water tunnels. The internal traffic arrangements within the power plant site will also change depending on the location chosen for the new unit. However, these arrangements will not have any impact outside the power plant site.

Other significant building projects will also be implemented at the power plant site during the construction and operation of the OL4 plant unit. The extension of the spent fuel interim storage involves building two or three new water pools, and that will take place in the 2010s. The final repository of spent nuclear fuel will also be built in parallel with the construction work of the OL4 plant unit. The final repository will be extended as required when spent fuel is disposed of.

The final repository for operating waste (VLJ Repository) will be extended when the new plant is in operation. In the 2030s, the repository will be extended for the disposal of the waste produced during operation, and later also for the disposal of waste produced when dismantling the plant. To the west-southwest of the power plant site, there is the Kuusisenmaa island separated from Olkiluoto by a shallow inlet of approximately 0.2 to 0.3 km in width. The inlet is to be closed in order to reduce the impact of cooling water backflow and to enhance the surveillance of the Olkiluoto site.

8.2 Impacts of civil engineering work

It is estimated that the construction work of OL4 will produce at most some 310,000 m^3 of quarry material and some 400,000 m^3 of surplus soil. These soil masses will be temporarily deposited on the power plant site and utilised in civil engineering work, for example, in road and embankment structures. The rest of the masses will be deposited on a soil and rock material dumping site in Olkiluoto.

Extension of the operating waste disposal facility (VLJ Repository) requires underground quarrying, the environmental effects of which are related to the transportation and disposal of quarry masses, the waste waters produced when keeping the quarried cave dry and the flow of groundwater inside bedrock.

The quarry material produced by excavating the spent fuel repository will be dumped in compliance with the permit regulations issued for it. The rock material will be used as quarry or crushed aggregate for, among other things, the foundations of buildings and roads on the plant site, for the floor structures of the repository tunnels, and for filling in the repositories. The repository tunnels will be quarried as the final disposal progresses.

Near the cooling water intake and discharge channels, the construction work will change the water depth readings and the properties of the sea bottom. The water structures of the cooling water system will not affect the water level of the area. The water construction work is carried out in a confined area in the immediate vicinity of the power plant. There is no such traffic on these waterways that would be significantly disturbed by the construction work.

The water construction work will primarily affect the water quality by introducing material that makes the water cloudy. Cloudiness will primarily occur in conjunction with dredging operations and dumping of dredging masses, but also to some degree in connection with filling-in water areas. The amount of material causing cloudiness depends on the composition of the dredged mass. The more fine particles the mass contains, the more cloudiness occurs. In cooling water discharge option A where the discharge takes place in the current location, cloudiness will be limited to the bay of Iso Kaalonperä, and in alternative B where the discharge takes place north of the current location, to the waters in front of Tyrniemi. In cooling water intake option C where the discharge takes place adjacent to the water intakes of the current plants, cloudiness will be limited to the Olkiluodonvesi, and in alternative D where the intake is located on the northern shore of Olkiluoto, to the Eurajoki inlet. The cloudiness will be localised and temporary, and it is not estimated to cause any significant detriment. The locations for cooling water intake and discharge are presented in Figure 2-5.

The water construction work for OL3 has not revealed any significant amounts of heavy metals or other hazardous substances in the ground soils of dredging, dumping or landfill sites. Therefore the dredging, dumping or landfill operations will not cause any detrimental changes in chemical water quality.

The impacts of constructing the structures required by OL3 to the aquatic environment were monitored in 2004. The monitoring did not reveal any impacts on the seawater quality during the construction work. The cloudiness and highest solid content were observed on the outermost observation station near Puskakari where the mixing of seawater layers and wind conditions had probably resulted in the nutrients and bottom algae being mixed in the water *(Kirkkala 2004)*.

From the point of fishes and fishing, the impacts will primarily depend on how the spawning and fishing waters are located in relation to the working sites and how much

silted solids travel to these areas. Taking into account the location of spawning sites and the small amount of material causing cloudiness, dredging and the associated dumping are not estimated to have a significant impact on the proliferation of fish. The water construction work is not estimated to impact fishing either because the significant fishing sites are rather far away from the work sites.

The dredging and dumping operations will temporarily limit the living area of seabed organisms that several species of fish feed on. Judging by the properties of the seabed outside Olkiluoto, at least Baltic tellin *(Macoma balthica)* is found in the area; this mollusc is one of the main sources of food for flounder, for example. However, experience from similar situations has shown that the bottom fauna is revived rather quickly after the work has ended. The impacts are further alleviated by the fact that the dredging and dumping sites are in this case rather small.

The closest fringes of Rauma archipelago (FI0200073) that belong to the Natura 2000 network are some two kilometres away from the westernmost point of Olkiluoto. The conclusion of the assessment made in 2001 regarding the impacts of OL3 on the Natura 2000 area of the Rauma archipelago was that the impacts will be minor both during the construction phase and operation, and they cannot be considered significant from the point of protection of the natural values of the Natura scheme.

According to the Natura requirements assessment completed in 2007 *(Ramboll Finland Oy 2007d)*, the detrimental effect of the temporary cloudiness of water caused by construction work on the sea area is at its largest near the work areas and quickly decreases with distance. The affected area is at its largest as a result of strong and long-lasting easterly wind. In front of Iso Kaalonperä, the current jet of cooling water effectively mixes the water masses. This prevents the cloudiness effects from occurring in the nearest Natura area.

The area of cloudy water caused by the parts of the cooling water channels built in the sea will depend on the discharge area alternative under consideration. In alternative B where the northern bank of the discharge channel is continued to the front of Tyrniemi, some cloudiness of water may also occur at times in the sea area surrounding individual islands and islets in the Natura area of the Rauma archipelago. However, the minor and temporary change in water quality will not cause significant detrimental effects on algae growth on the rocks and rocky shores. The islands and islets closest to Olkiluoto are not part of the conservation area. *(Ramboll Finland Oy 2007d.)*

8.3 Dust and noise impact caused by building operations

Land building work, site traffic and separate operations (such as concrete mixing stations, rock crushing and quarry aggregate dumping) result in the localised generation of dust during the building work. The vehicles and machines cause atmospheric emissions. These emissions are small and will not impact the quality of air outside the building site.

Noise and vibration will be caused by the land building work, rock blasting, handling and crushing of quarry rock, as well as by the operation of vehicles and machines. In land building operations, the main sources of noise are quarrying, crushing and rock drilling. Vibration is limited to the power plant site. The noise caused by quarrying and building can be heard the further out to sea, the more calm the weather is.

The operations causing the most noise during the survey, building and operational phases of the disposal facility are quarrying, crushing and transportation. Quarrying and crushing is not carried out during the night. There will be little surface quarrying in the project, and underground quarrying will not generate noise that would be heard above ground. The most significant noise effect is caused by crushing the rock quarried from the disposal facility for land building aggregates. The noise area of the operation can be affected by choosing the location of the rock crushing plant and by using the quarry hill as a noise barrier. *(Posiva 1999.)*

The noise generated during the construction work of the nuclear power plant unit OL4 will be at its highest during the quarrying work at the location of the power plant itself. Due to the location of the new nuclear

Figure 8-1 Daytime noise during the construction phase of OL4 for location alternative 1.

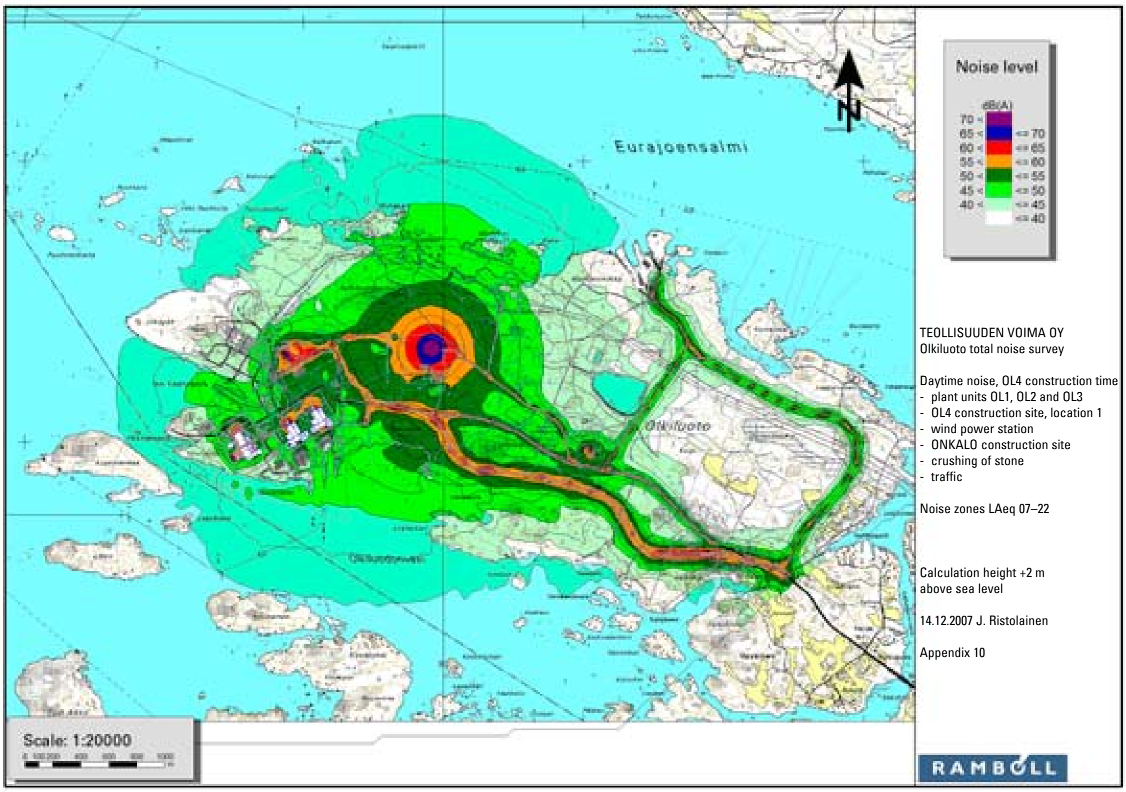
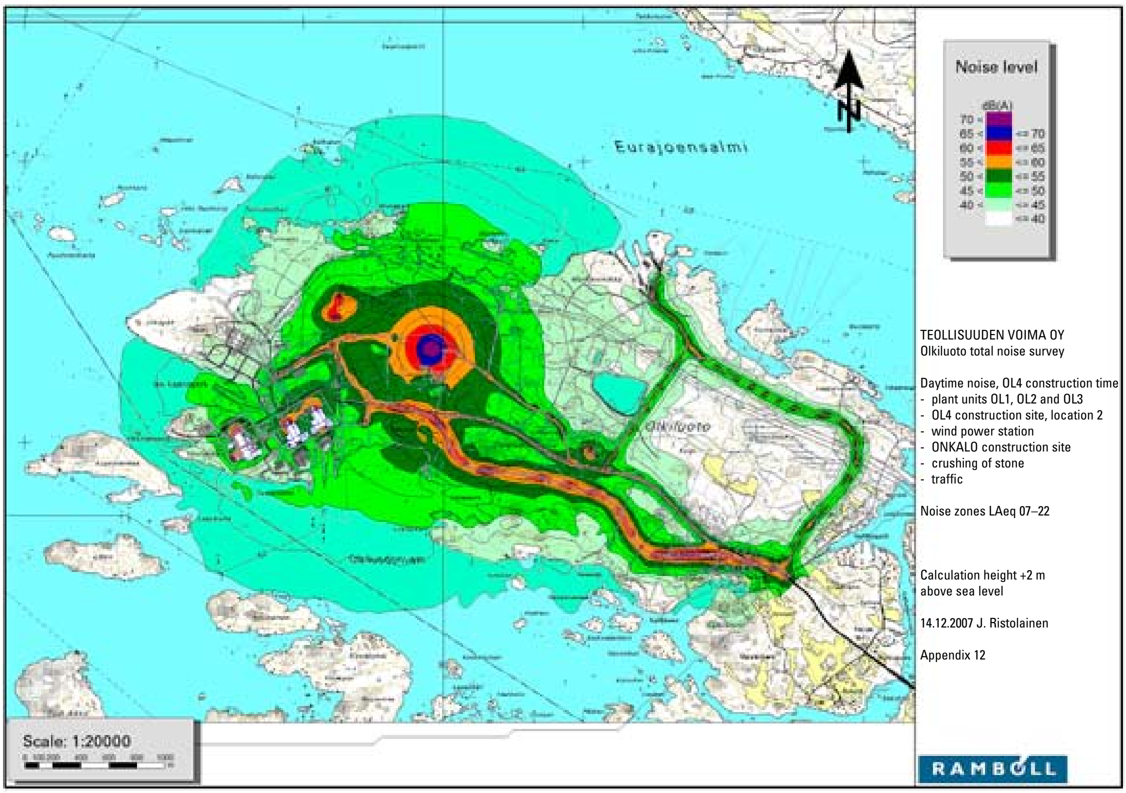


Figure 8-2 Daytime noise during the construction phase of OL4 for location alternative 2.



power plant unit in the inner part of the island, the change compared to the situation with the three plant units in operation will, however, be at most some 2 dB in the areas south and southwest of Olkiluoto during the day. When quarrying has been completed, the noise levels during the construction phase will be lower than those quoted above, and construction work will also be carried out during the night. The night-time noise level observed south and south-west of Olkiluoto during the construction phase will be at most some 1 dB higher, depending on the location of the new unit, compared to the situation where three plant units are in operation. The noise levels generated during the construction phase will not exceed the guide values during day or night times to the surrounding islands. In the zero option, when OL3 has been completed, the noise level at the nearest holiday house on the island of Leppäkarta will be 41 dB. The corresponding noise level at night will be 38 dB. *(Ramboll Analytics Oy 2007.)*

The volume of traffic to and from Olkiluoto will be considerably greater during the construction phase of OL4 than during its normal operation. However, the change in noise levels caused by traffic will be limited to the immediate vicinity of Olkiluodontie where it will be about 2 dB. The traffic noise in the area under consideration will not exceed the day or night time guide values at the houses located by the Olkiluodontie road during the construction phase or normal operation of OL4.

Figures 8-1 and 8-2 show the situation regarding daytime noise during the construction phase of OL4 for location alternatives 1 and 2.

The locations of residential buildings will be taken into account in planning, and the intention is to keep the noise levels below guide values.

The construction work phases that are most taxing to the environment, such as land building and foundation work, are of short duration. The period during which disturbances may be caused is estimated to last for about one year.

8.4 Impact of waste waters generated during the construction phase

During the construction phase, waste water loading will be higher than during the normal operation of the power plant unit because the number of personnel working in the area will also be higher. The various rinsing and rain waters drained from the construction site will also contain more solids than the waters drained from surrounding areas with normal tarmac paving.

The waste waters from sanitary facilities will be drained to the biological-chemical waste water treatment plant at the Olkiluoto plant area; its current capacity (100 m^3/h) will also be sufficient for the new plant unit. The volume of waste waters from social facilities will increase by about 90 m^3/day for the duration of the construction phase of the nuclear power plant unit. The total volume of waste water from the social facilities of all plant units will be about 230 m^3/day during the construction phase of the new unit (OL4). A pumping station will be constructed at the new unit to pump the waste waters to the existing sewer network. The volumes of waste waters generated in the social facilities of different units during the different phases of operation are shown in Table 8-1.

Table 8-1 The volumes of waste waters generated in social facilities during the construction and operation phases of the units.

The treated waste waters are drained to the cooling water discharge channel via a volume metering unit. The slurry generated during waste water treatment is pumped from the sedimentation pools via the compaction pools to slurry pools and finally transported to the waste water treatment plant of the City of Rauma for further treatment.

Waste water loading will be higher during the construction phase of the power plant than during its operating phase. The additional loading is limited in time and very small in comparison to the diffuse loading of the Olkiluoto area. In the sea areas, as a result of efficient mixing and dilution, the principal area of impact of the waste waters is limited to the immediate vicinity of the discharge point. On the above basis, it is not to be expected that the increased waste water loading would cause detrimental changes in the quality of seawater and, in that way to, the conserved natural values even at the closest parts of the Natura area in the Rauma archipelago. *(Ramboll Finland 2007d.)*

The groundwater collected during the quarrying work for the foundations of the power plant and the KPA Store, the extension of the VLJ Repository and the cooling water tunnels will be pumped to the sea after it has been appropriately treated. The water may contain nitrogen compounds originating from the explosives, as well as solids. The quality and quantity of water drained to the sea will be monitored. On the basis of experience gained from similar operations, the resulting loading is expected to be relatively small.

8.5 Waste management during the construction phase

The waste management of construction sites in Finland is governed by the Waste Act (1072/1993) and Decree (1390/1993), as well as the Government Decision on building waste (295/1997). The collection of waste is further governed by the general waste management regulations issued by the Municipality of Eurajoki. The Government Decision states that at least the following fractions of waste material must be sorted on construction sites: surplus soil, rock-based material, wood material and metals.

It is estimated that some 11,000 tonnes of waste will be generated during the construction of OL3. Of this, about 500–1,000 tonnes of waste unsuitable for further utilisation will be deposited on the Olkiluoto waste

Table 8-1 *The volumes of waste waters generated in social facilities during the construction and operation phases of the units.*

Operational state of the nuclear power plant units	Volume of waste waters from social facilities, m^3/day
OL1/OL2	100
OL1/OL2/OL3 construction phase	190
OL1/OL2/OL3 operation	140
OL1/OL2/OL3/OL4 construction phase	230
OL1/OL2/OL3/OL4 operation	180

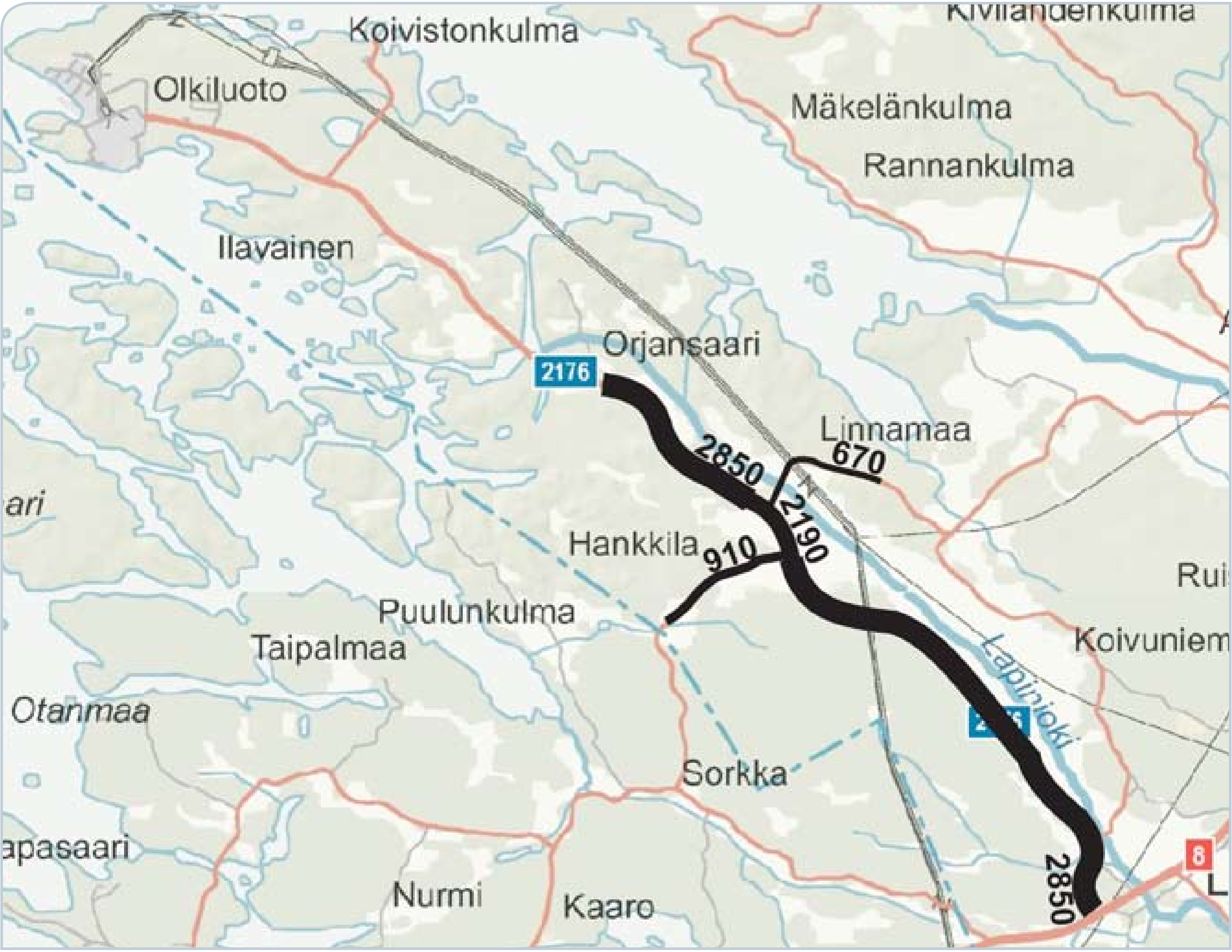


Figure 8-3 Roads to Olkiluoto, and the traffic volumes (vehicles per day) metered in August-September 2007 (Ramboll Finland Oy 2007a).

dumping site. The amount of waste generated during the construction of the new unit is estimated to be of the same order of magnitude as that for OL3.

The treatment, storage and transportation of hazardous waste will be carried out in compliance with legislation.

8.6 Impact of transportation and traffic during the construction phase

8.6.1 Present state of traffic

Eurajoki central village is located along highway 8 between Rauma and Pori. The Olkiluodontie road (connecting road number 2176, Lapijoki–Olkiluoto) leading to Olkiluoto separates from highway 8 at Lapijoki. The crossing is some seven kilometres from Rauma and some 40 km from Pori. Olkiluoto can also be accessed from Rauma via the Sorkantie road via the Hankkila village to Olkiluodontie. A road goes from Hankkila to Eurajoki via Linnamaa. The roads to Olkiluoto and the average traffic volumes (vehicles per day) metered in 2007 are shown in Figure 8-3.

The traffic volumes in Olkiluoto vary a great deal as a result of major construction projects and maintenance carried out during annual plant outages. Traffic has been livelier than normal in 2007 due to traffic attributable to the OL3 and ONKALO construction sites. The busiest section of the Olkiluodontie road (highway 2176) is the one kilometre long stretch immediately after the junction of highway 8 towards Olkiluoto. The average daily number of vehicles metered on Olkiluodontie during a two-week period in late August to early September 2007 was 2,850 vehicles per day. The volume of traffic arriving at the power plant site was 2,670 vehicles per day on average *(Ramboll Finland Oy 2007a)*. The volume of heavy vehicle traffic was 203 vehicles per day on average, i.e., some 8 % of the total traffic volume. During weekdays, the traffic volumes were about 25–30 % greater than average.

Most of the traffic is the result of people commuting to work. The total number of people working on the plant site in September 2007 was estimated at 2,600, of which 1,600 were working on the OL3 construction project. However, the total number of people working on the site is likely to exceed 4,000 in late 2008 – early 2009. In addition, the annual maintenance outages of plant units OL1 and OL2 in May-June will increase the total number of people working in Olkiluoto by an average of 1,200 *(Ramboll Finland Oy 2007a)*.

The amount of traffic metered on the road (12766) leading from Sorkka to Hankkila in August-September 2007 was 910 vehicles per day on average, while that of the road (12771) from Linnamaa to Hankkila and Olkiluodontie was 670 vehicles per day on average *(Ramboll Finland Oy 2007a)*. In 2006, an average of 10,015 vehicles per day used highway 8 between Rauma and Eurajoki *(Road Administration 2007)*.

Waterway and air traffic

The power plant's quays are located on the southern coast of Olkiluoto, beside the cooling water intake channels. A navigable passage having a depth of five metres leads to the quays. A maximum of 1 or 2 ships per year call at the OL1 quay. The OL3 quay is expected to see the same number of ships per year.

A six metre passage leads from the west to the Tankokari industrial harbour on the northern side of the Olkiluoto island, north of the Kalla island. The harbour serves both exports and imports and is only operational when the sea is open. Approximately 90 to 100 ships call at the harbour each year.

Other traffic in the waters close to the power plant site mainly constitutes boating associated with recreational use and fishing. Ships with a maximum draught of nine metres can utilise the harbour at the Port of Rauma. There are also good connections to the harbours in Pori and Turku.

The nearest airport is in Pori, 31.5 km north-east from the power plant. In 2006, a total of 64,387 passengers travelled through the airport. The nearest flight route travels some 10 km away from the power plant.

8.6.2 Transportation during the construction phase

Large plant components are transported to the Olkiluoto harbour by ship. Some 40 transports by sea to the OL3 quay will take place during the construction of OL3.

The road transportation to the power plant includes that of building materials, equipment and components. The amount of different goods deliveries and maintenance-related transport will also increase during the construction phase.

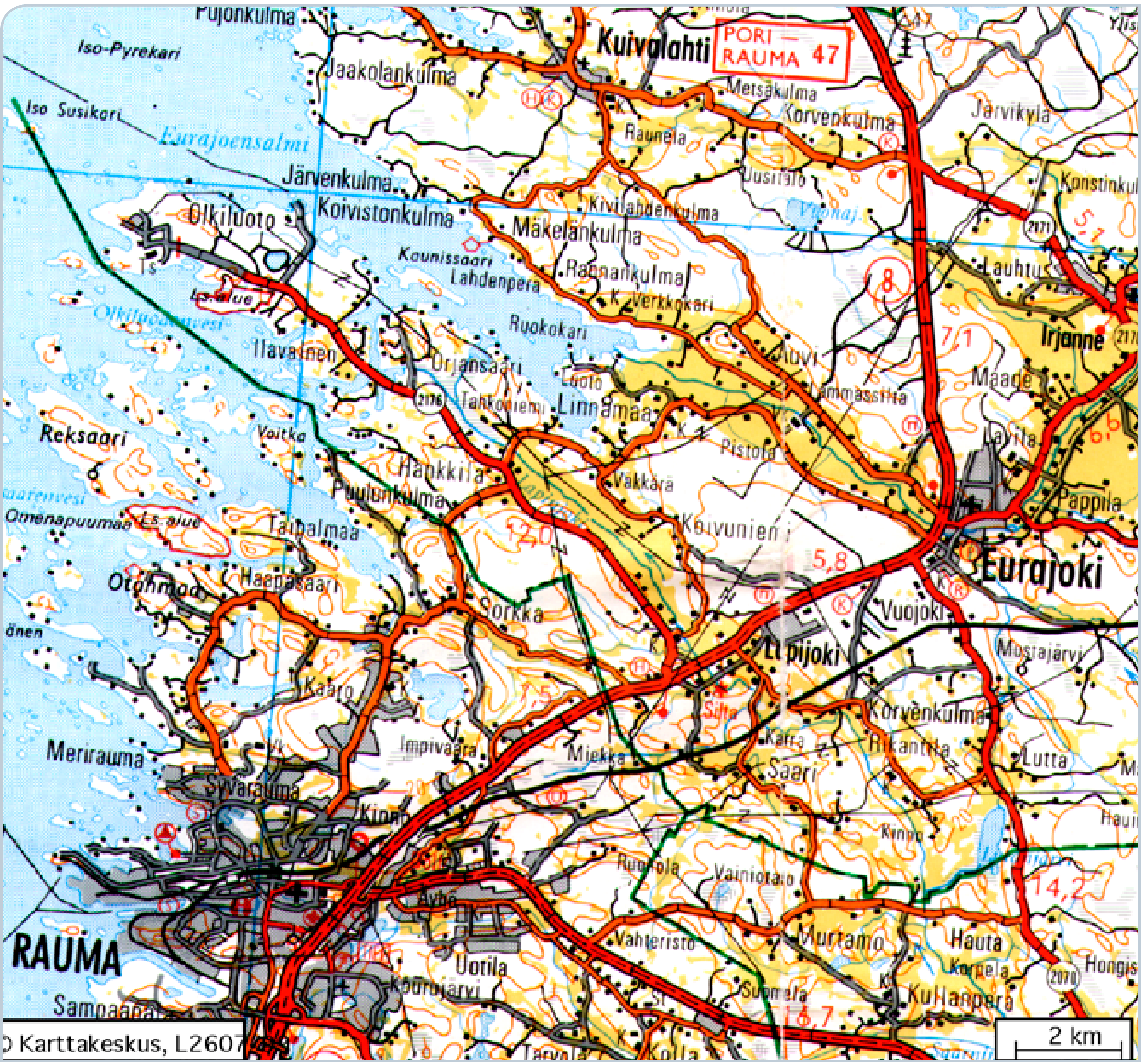
The soil and rock material generated during the land building work will be utilised, as far as possible, as building material for embankments and roads. The rest will be deposited to a dumping site in Olkiluoto. This will reduce the amount of transportation during the construction phase.

During the construction phase, transportation increases the traffic volumes by an average of 100 vehicles per day. This means some 50 round trips per day. In particular, the amount of heavy vehicles will increase.

8.6.3 Commuter traffic during the construction phase

The construction site of OL4 is estimated to employ 1,000–3,500 persons. Some of them will stay in the

Figure 8-4 Roads leading to Olkiluoto and their surroundings.



Olkiluoto accommodation village. The employees travelling from Eurajoki, Rauma and other nearby municipalities commute to Olkiluoto either by car or by bus.

Olkiluoto has good public transport connections. Approximately half of the people working in Olkiluoto commute by bus. There are currently 11 scheduled buses from Rauma and 6 buses from Eurajoki to Olkiluoto on weekdays. In addition to these, a few school buses travel via Olkiluoto. Extra buses are also added during the annual maintenance outages.

There are two accommodation villages in the immediate vicinity of the nuclear power area where a total of some 1,000 workers are currently staying. In particular, the workers staying in the old accommodation village (some 400 persons) are primarily using light vehicles for short-distance commuting.

If construction work is carried out in two shifts, the traffic peaks will take place at the time of shift turnovers. The traffic caused by the employees of existing units and service and maintenance personnel takes place between 6–8 a.m. and between 3–5 p.m.

8.6.4 The impact of transportation and other traffic

In a zero option situation where both OL3 and the final repository have been completed, the traffic volume on the Olkiluodontie is estimated at 1,600 vehicles per day, increasing to about 3,900 vehicles per day during the annual maintenance outages.

In 2015, OL3 will have commenced its operations and the construction work for OL4 is expected to be in progress. The ONKALO survey phase will have ended and the final repository will be under construction. The traffic volume at that time is expected to be 4,300 vehicles per day, increasing to about 6,600 vehicles per day during the annual maintenance outages.

The traffic volumes of the current situation, the zero option and construction phase of OL4 are shown in Table 8-2.

There are a few houses and the Lapijoki School by the first section of Olkiluodontie near the junction of highway 8. There is also plenty of heavy vehicle traffic on the first section of the road as a result of the transport from the rock crushing plant by it. There are also a few houses in Hankkila and Ilavainen. Otherwise, the road mainly runs through fields and forests. The speed limit on most of Olkiluodontie is 80 km/h. Significant actions have been taken in order to manage the impact of transportation and traffic with regard to road safety and dust generation. The basic upgrade of Olkiluodontie has included the elimination of curves, re-paving, building of a light traffic lane from Lapijoki to Hankkila, as well as the construction of a pedestrian subway by the Lapijoki School.

The road from Rauma to Olkiluoto is winding and narrow and has quite a few hills. There are houses and the Sorkka School by the road. The light traffic lane on the Sorkka highway road from Rauma ends at the Haapasaarentie crossing.

The road from Hankkila to Eurajoki via Linnamaa is narrow. There are mainly fields and forests by the roadside, but also some houses.

The construction work of the new unit will take about 6 to 8 years. During the construction phase, the traffic on the Olkiluodontie will increase three-fold compared to the zero option situation where the units OL1, OL2 and OL3, as well as the disposal facility, are in operation. Particularly during the early stages of the construction work, the relative share of heavy vehicle traffic will also increase on the road.

The volume of traffic on Olkiluodontie during the construction phase of OL4 is estimated at about 4,300 vehicles per day, of which the share of heavy vehicle traffic

Table 8-2 *Traffic volumes on the Olkiluodontie (highway 2176) at the power plant's approach in the current situation, zero option and construction phase of OL4.*

	Current situation, in 2007 [1]	Zero option [2]	Construction of OL4, in 2015 [3]
Total traffic to the plant area	2,600	1,600	4,300
Total traffic to the plant area during annual outages	4,800	3,900	6,600

[1] Current situation with OL1 and OL2 in operation, OL3 and ONKALO under construction
[2] OL1, OL2 and OL3 in operation, final repository completed
[3] OL1, OL2 and OL3 in operation, OL4 under construction, final repository under construction

Table 8-3 *Emissions of Olkiluoto traffic (tonnes/annum) as well as the total emissions of traffic in the Rauma and Eurajoki region (tonnes/annum) in 2006.*

Type of emission	tonnes/a [1]		
	Zero option [2]	Construction of OL4, maximum situation [3]	Total emissions of traffic in Rauma and Eurajoki in 2006
Sulphur dioxide, SO_2	0.1	0.3	0.5
Nitrogen oxides, NO_x	17	79	340
Particles, PM	0.6	2	18
Carbon monoxide, CO	76	244	1,432
Carbon dioxide, CO_2	2,236	9,359	80,700

[1] The roads: Highway No. 8 (Rauma–Eurajoki), Highway No. 2176 to Olkiluoto, the roads: Hankkila - Sorkka - Rauma and Hankkila - Linnamaa – Eurajoki
[2] OL1, OL2 and OL3 in operation, disposal facility completed
[3] OL1, OL2 and OL3 in operation, OL4 under construction, disposal facility under construction, annual maintenance outage in progress

is expected to be about 5 %, or 200 heavy vehicles per day. The traffic will also increase during the construction phase on highway no. 8 and the roads leading to Olkiluoto from Rauma and Eurajoki compared with the initial situation, but the difference compared with the 2007 situation is small.

During the annual maintenance outages coinciding with the construction work of OL4, the traffic volumes on the Olkiluodontie will be about 6,600 vehicles per day.

The increasing traffic volumes will increase the risk of accidents. Travelling by foot or by bicycle will become more difficult, as will crossing the road. The detrimental effects of noise, dust and vibration experienced by the roadside houses will also increase. In particular at the time of shift changes in the afternoon, there is plenty of traffic in both directions on the roads leading to Olkiluoto.

Traffic emissions

The road traffic emissions during the construction phase of OL4 were calculated for the following road sections: Olkiluodontie, Rauma–Olkiluoto, Eurajoki–Olkiluoto and highway no. 8 (between Rauma and Eurajoki), taking into account the division of traffic between each section. The emissions were calculated using the average unit emission factors for cars and heavy vehicles (VTT). The emission figures, as well as the total emissions of traffic in Rauma and Eurajoki in 2006, are shown in Table 8-3.

The emissions caused by the traffic to and from the Olkiluoto power plant site during the construction phase of OL4 have some impact on the traffic emission figures of the Rauma and Eurajoki region. The traffic to and from the Olkiluoto power plant site during the construction phase of OL4 accounts for about 23 % of the total emissions of nitrogen oxides from the traffic in the Rauma and Eurajoki region. The most intense phase of the construction work lasts for about one year. During other years of construction, there will be about 20–30 % less traffic and emissions, therefore accounting for about 10–30 % of the total emissions in the Rauma and Eurajoki region.

Although there will be more sea transport during the construction phase, the impact on traffic emissions will be minor.

8.7 Impacts on people and living conditions during the construction phase

8.7.1 Economic impacts during the construction phase

Building the new power plant unit is an important project from the local, regional and national economy standpoint, and it will have various effects on the business life and employment in Eurajoki and its neighbouring areas. Some of these effects have a more extensive area of impact, the province of Satakunta, whole of Finland and even abroad. It is typical of major projects that a significant part of the economic effects are realised indirectly or transferred outside the area, which means that there is a considerable degree of uncertainty associated with their assessment.

The effects on the regional economy are discussed in more detail in section 0.

8.7.2 Impacts on living conditions and comfort during the construction phase

The OL3 construction site has induced changes in the neighbouring areas of Olkiluoto both economically and culturally. More homes have been built in Rauma during the construction phase of OL3 than in the whole decade before the project started. New shops have sprung up in the area, and existing ones have been expanded. Many local service providers in Rauma and Pori have also benefited from the increased clientele.

Local residents have suffered from the way foreign workers have interpreted the rights of public access. Fishing, for example, has taken place on the moorings of holiday residents, or close to the shore of their holiday plots.

The effects on living conditions and comfort are discussed in more detail in section 0.

9 Impacts during normal use; assessment methods, present state of the environment and estimated impacts

9.1 Impact of nuclear fuel production, transportation and storage

The most important potential procurement sources of uranium and its isotope enrichment and nuclear fuel manufacture have been examined. The environmental impacts of the production and transportation of nuclear fuel are described based on the existing specifications. The mining operations of the uranium supplier typically used by TVO have been described in the EIA report.

9.1.1 Availability of uranium

Currently, the nuclear reactors in the world require a total of some 70,000 tonnes of uranium per year. At the moment, the production of new natural uranium covers about 60–70 % of the demand. The rest is covered by emptying stockpiles, by producing fresh fuel through the reprocessing of spent fuel and by diluting the large stockpiles of weapon-grade uranium. The availability of uranium is not an obstacle for continuing or expanding the use of nuclear power, but new uranium production will require a higher price level than that prevailing in the 1990s.

The known uranium resources that can be exploited at a reasonable cost (some 5 million tonnes) will last for well over 60 years at the current consumption rate. In reality, the amount of known resources is considerably larger when the poorer deposits with higher exploitation costs are taken into account. The largest known uranium deposits are in Australia, North America, Kazakhstan, Russia, South Africa, Niger and Namibia. The latest discovered deposits of uranium, particularly in Canada, have been considerably rich, which means that they allow uranium to be produced at a reasonable cost. However, the world market price of uranium has increased – since the rock-bottom prices of the 1990s caused by the entry in the market of weapons-derived uranium – so that extensive prospecting activities have started for finding new deposits.

There are plenty of potential uranium deposits. These additional resources are estimated to be many times bigger than the currently known resources. In most parts of the globe, uranium prospecting has so far been rather limited which means that more extensive prospecting is likely to lead to the discovery of new deposits that are totally unknown as yet. The history of other metals tells us that increased demand speeds up prospecting activities and leads to new deposits being discovered. The uranium resources have been estimated on a statistical basis, taking into account the extent and geological properties of the areas so far left outside the scope of systematic uranium prospecting.

Uranium and plutonium (that is used for so-called Mixed Oxide fuel, or MOX) are recovered in considerable quantities both from reprocessed spent nuclear fuel and as a result of reducing the nuclear weapon stockpiles. The uranium deluted from nuclear weapons is estimated to provide enough fuel for about one hundred medium-sized nuclear reactors for 20–30 years. In addition, considerable amounts of uranium are also obtained as by-products from other processes, such as the production processes for copper and gold *(Finnish Energy Industries 2006)*.

The utilisation rate of uranium in reactors can also be improved by technical means, which means that more energy can be produced using less uranium. OL3 produces 20 % more electricity from each kilogram of raw uranium than OL1 and OL2. It is to be expected that OL4 will have at least an equally good fuel efficiency.

9.1.2 Uranium mining in Finland

The bedrock in Finland also contains uranium, in places so much that it is of interest to prospectors. A total of some 30 tonnes of uranium was mined in Eno and Askola in the late 1950s – early 1960s. However, this operation was quickly discontinued as unprofitable. Now that the price of uranium has increased, international mining companies are interested in surveying the deposit again, and a few mining companies have, during 2004–2007, filed claim reservations and claim applications that entitle them to start prospecting for uranium. There is a long way to go from a claim application to starting actual mining operations in Finland. In order to be able to start prospecting for uranium, the claim application must first be accepted by the Ministry of Employment and the Economy. It typically takes 10–15 years from the start of prospecting for uranium until the mining operations start. Uranium mining requires a permit granted by the Government pursuant to the Nuclear Energy Act. An environmental impact assessment in accordance with the EIA Act has to be conducted before applying for this permit. In addition, the permit pursuant to the Mining Act, the Mining Certificate and Environmental Permits must be obtained before commencing mining operations *(Finnish Energy Industries 2006, Äikäs 2007, Ministry of Trade and Industry 2007)*.

9.1.3 Impacts of nuclear fuel production

TVO has been monitoring and supervising the environmental matters of its uranium suppliers throughout its history in business. During recent years, Canada and Australia have accounted for about half of the world's uranium production. So far, TVO has procured about half of its uranium from Canadian suppliers and 20% from Australia. In these countries, environmental protection is of a very high standard. Both the Canadian and Australian mines operate in compliance with the permit conditions set by the national authorities. Obtaining a mining licence in these countries requires carrying out an assessment of environmental impacts as well as issuing an EIA report and having it approved.

The existing plant units (OL1 and OL2) consume approximately 23 tonnes and the plant unit under construction (OL3) will consume approximately 32 tonnes of isotope enriched uranium per year. The fuel is brought to the power plant in fuel bundles. The new plant unit (OL4) will consume approximately 20 to 40 tonnes of isotope enriched uranium fuel per year. This equals approximately 200 tonnes of raw uranium material.

The stages of nuclear fuel production are the quarrying of raw uranium or direct extraction from the soil and the separation of enriched uranium from the ore or extract (ore enrichment), conversion, isotopic enrichment, and manufacture into fuel bundles.

A so-called "Uranium Steward-ship" document (sharing of responsibility) is being prepared within the

World Nuclear Association (of which TVO is a member); when committing to this document, each member in the procurement chain for nuclear fuel becomes, for its part, responsible for taking social and environmental issues into account and for managing them in a responsible manner in its operations.

9.1.3.1 Ore mining and enrichment

The nuclear fuel chain starts at the uranium mine which can be an open pit quarry, underground mine or a so-called solution mine (ISL method) depending on the depth of the ore deposit and the particular characteristics of the soil. In addition, uranium is produced as a by-product from the mining waste of other metals *(Rissanen et al, 2001)*.

As in any mining operation, the quarrying and rock blasting in uranium mines, the traffic and transportation to and from the mines as well as various machines all generate noise, vibration, dust and particle emissions. Other environmental impacts of mining include changes in groundwater flow rates and levels as well as radon emissions. Strict environmental, industrial safety and radiation protection regulations are observed in uranium mining. The requirements of these regulations are normally included in the permit conditions of the production plants involved in uranium mining.

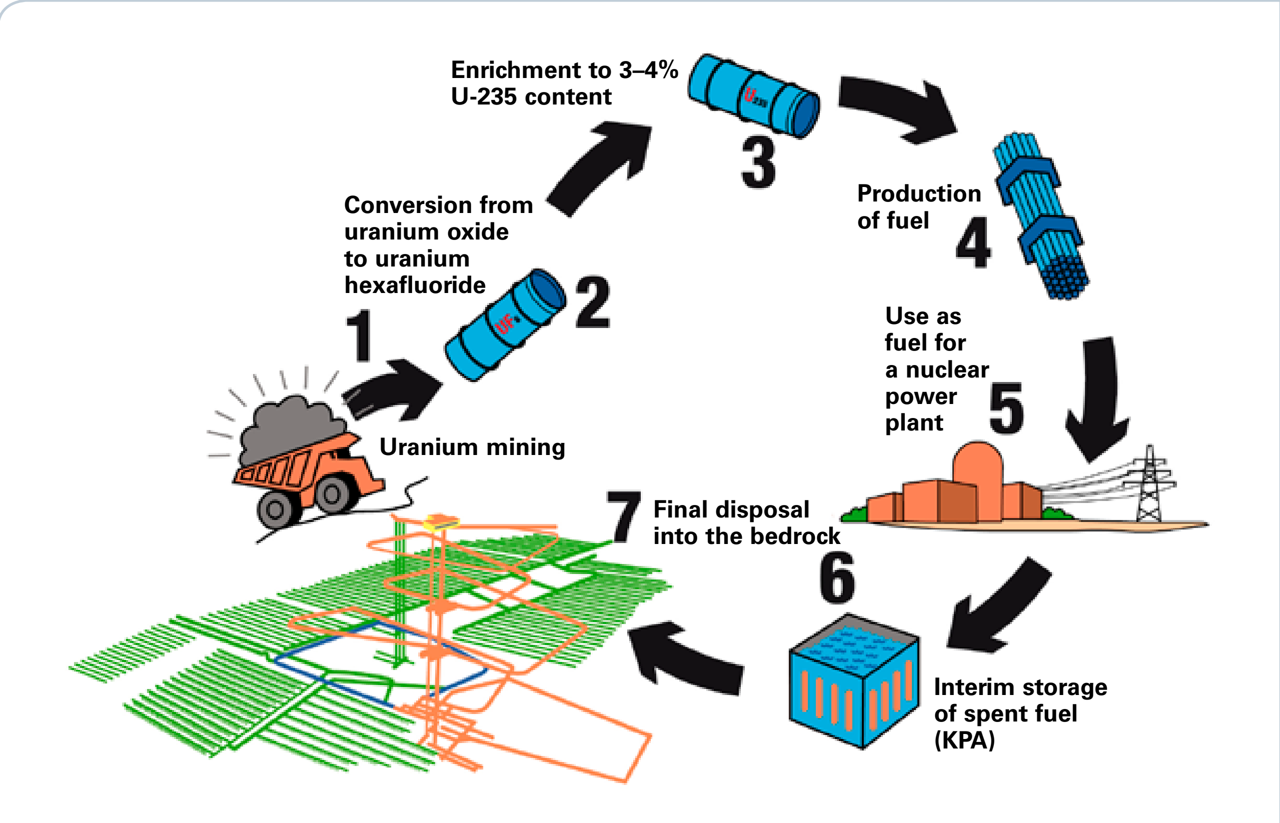
The quarrying techniques are similar to those used in mining other ores. Pure uranium does not emit radiation, but its daughter substance radon that has accumulated in the uranium ore over a long period of time does. In some cases, the level of radioactivity caused by the high uranium and radon content of the ore requires special measures: for example, the Canadian McArthur River mine deploys remote controlled equipment as will the future mine in Cigar Lake where the uranium content of the deposit is as high as 50 % in places, and some 20 % on average.

When uranium ore is quarried, the product of decaying uranium, gaseous radon (Rn-222), is released in the air. Radon is present everywhere where there is uranium, but the concentration of gaseous radon is considerably higher in underground mines than in open pits. The exposure to radon can be significantly reduced even in underground mines by ample ventilation. Radon is also present in other mines and tunnel construction sites if the soil contains uranium.

Mining operations may cause local detriments such as noise, increased traffic and dust. The extent of the detrimental effect, at least in the case of dust, depends on the type of mine, i.e., whether it is an open pit or an underground mine. The industrial safety risks of mine workers have traditionally been greater than those of other parts of the population and other industrial workers on average. All mine workers are exposed to radiation more than the rest of the population and industrial workers on average. The radiation doses received by uranium mine workers are monitored in the same manner as those of all other people working in conditions where radiation is present. The dosage limits are the same irrespective of the type of work or the country where the work is carried out.

The radon content of air may be higher than average near bedrock that contains uranium. The radon content is affected by many other factors besides the uranium content of bedrock. The rich uranium deposit deep down in the bedrock in Cigar Lake, Canada, for example, has not been observed to increase the radon content of the air above the ground near the deposit. When a deposit

Figure 9-1 *Life cycle of nuclear fuel.*



is mined out, for example in the case of open pits, the gaseous radon escapes more readily and the radon content of air in the immediate vicinity of the mines increases slightly. However, the radon content quickly decreases with distance because radon quickly decays into other substances due to its short half-life. Ten kilometres away from the mine the radon content is considerably lower and does not stand out from the natural environmental variation. Measurements carried out in Canada have revealed that the average radon content is higher in the southern agricultural regions of Saskatchewan than in the north where the uranium mines are. Tilling of the soil has been thought to be the reason for this.

Apart from radon, all of the other decay products of uranium are solids, and they can only escape into the environment via waterways. In practice, only radium is significant due to its mobility and toxicity, and that is why it is nowadays precipitated from the waters. For example, all waters coming from the Key Lake mine area in Canada are monitored, and the limit value set for radium content is lower than the recommendation of ICRP, the International Commission on Radiological Protection, for drinking water *(Finnish Energy Industries 2006)*.

The ore enrichment plants located at the mines enrich and purify the uranium ore. The uranium content of enriched uranium, also called raw uranium, is about 60–85 %. Most of this uranium is in the form of uranium oxide U_3O_8. The liquid enrichment waste contains radioactive substances and heavy metals. The solid waste consists of side rock and sand-like enrichment waste which both contain radium.

In the enrichment process, the primary materials producing radon (Ra-226 and Th-230) remain in the slurry-like mining waste and form a potential radon source for a long time after the actual mining operations have been discontinued. However, careful treatment of the mining waste can reduce the radon emissions even below the level that prevailed before the mining operations began. Therefore, the correct disposal of enrichment waste is one of the key measures in reducing the harmful environmental effects of uranium mining. For example, in the mines in Saskatchewan, Canada, the waste is piled in pools insulated with bentonite clay or to exhausted open pits. Then it is finally covered with layers of gravel and moraine. Measurements have shown that the average radon emissions are equal or less than those observed before the mining operations began *(Finnish Energy Industries 2006)*.

Other possible reasons for environmental impacts caused by enrichment plants include releases into air and waters, use and storage of chemicals required for the enrichment process, noise and dust generated in grinding the ore, and, particularly in arid regions, the acquisition of process water *(CEEA 1998, Environment Australia 1997)*.

The studies carried out by the supervising authorities of Canada and Australia have not indicated that uranium production would increase the health risks of employees or the rest of the population. Nor have mining and enrichment operations been shown to increase the risk of the population or mining workers to develop illnesses caused by radiation *(Purra 2001)*.

Mining has an impact on the living environment of the original population living nearby which must be taken into account when assessing the environmental impacts of mining. The increasing interaction of indigenous people with the rest of the country's population provides the representatives of indigenous people with better opportunities of having their opinions taken into account and to assume an influencing role in the social development of their country *(Purra 2001)*.

The productivity and profitability of the mines have meant a revolution in looking after the welfare of the local population. The mines are important sources of employment to local people, and the population are of the opinion that this is the most important element that mining has brought to their lives. In Canada, for example, mining provides employment opportunities to many local services such as lorry drivers, laundries and maintenance companies. This has also improved the availability of various services, such as healthcare and education.

In Australia, mining companies pay the aboriginals rent for use of their land and provide employment opportunities for them. The aboriginals also get to share the profits of the mining operations. In Australia, the operating licences of mines are also conditional on taking the rights of aboriginal people into account.

With the increasing awareness of environmental issues, their importance has also increased in uranium mining. There are still mines with plenty of scope for improvement in environmental care. The harmful impacts on the environment have decreased in these mines also as a result of environmental protection measures.

9.1.3.2 Conversion, isotope enrichment and production of fuel

For isotope-enrichment, the enriched ore is converted in conversion plants into uranium hexafluoride salt UF_6, which is gaseous under reduced pressure or temperatures exceeding 56 °C. The isotope-enrichment takes place in gas diffusion or centrifuge plants. In the isotope-enrichment process, the concentration of the lighter uranium isotope U-235 is increased to the 2–5 per cent required by light water reactors.

About 5.5 tonnes of natural uranium is required to produce one tonne of uranium isotope-enriched to 3 %.

The uranium procured by TVO is mainly isotope-enriched within the EU (Holland, Germany, England and France) while a part of it comes from Russia.

The uranium, isotope-enriched at the fuel production plant, is chemically converted into uranium dioxide (UO2). It is compressed into pellets with about 9 mm diameter and 10 mm thickness that are then packed into long metal tubes. Both ends of the tubes are hermetically sealed to form sealed fuel rods. Several dozens of fuel rods are fixed to each other to form bundles, or fuel elements. The fuel arrives at the nuclear power plant as such elements. The nuclear fuel bundles currently delivered to Olkiluoto are manufactured in Germany, Spain and Sweden.

The conversion and isotope-enrichment plants are part of process and chemical industries, and their operations and environmental impacts are regulated and supervised in accordance with the legislation of the respective countries. The processes of the fuel manufacturing plant also include different metal industry processes. For most of the process, uranium is isolated in process vessels in

Figure 9-2 *The fuel bundle used in Olkiluoto 1 and 2 power plant units.*

these plants and does not cause any radiation exposure to workers. After the conversion, uranium is kept in a solid state as uranium hexafluoride in tanks under pressure. It is also transported to the enrichment plant in such containers that comply with official regulations. The plants do not release any radiation under normal operating conditions.

The uranium hexafluoride isotope enriched to a few per cent produced at the enrichment plant is only mildly radioactive, but chemically it is toxic. The plants have detectors for the eventuality of leaks; they help protect the plant workers and prevent any releases outside the plant. However, small leaks have occurred. No radiation hazards have been created because only hydrogen fluoride has escaped the plant while the uranium has remained near the location of the leak. In such cases, the concentration of hydrogen fluoride in air had fallen below the detection limit even in the close vicinity of the plant.

For transportation to the fuel manufacturing plant, the isotope-enriched uranium is packed in containers that are similar to those used for bringing it to the isotope-enrichment plant. During transportation, the uranium hexafluoride is in a solid state. International transport regulations require that the transport container and packing maintain their tightness even in an accident situation. Uranium is slightly soluble in water. Even in the case of an accident during sea transportation, it is quickly diluted into small concentrations. Furthermore, sea water naturally contains both uranium and fluorine. When transporting isotope enriched uranium, care must be taken to maintain sub-critical conditions. This means preventing the start of a continuous chain reaction in the transport container. The requirements of a sub-critical condition have been taken into account in the regulations governing transportation and packing *(Finnish Energy Industries 2006)*.

9.1.3.3 Reprocessing of spent nuclear fuel

Spent fuel can also be reprocessed so that part of it is returned to the fuel cycle. Spent fuel is not reprocessed in Finland; instead, it is disposed of be placing it in a repository in Finland in the manner required by the Nuclear Energy Act.

9.1.4 Nuclear fuel material input per the amount of electricity produced

A study was carried out at the University of Lappeenranta in 2001 *(Rissanen et al 2001)* regarding the nuclear fuel material input in relation to the amount of electrical energy produced.

The material input factor is the ratio of the total mass of materials required for producing the fuel and the mass of ready fuel. The material input factor of nuclear fuel greatly depends on both the mining technique deployed and the uranium content of the ore.

In case of nuclear fuel, the utilisable energy content per unit of weight is more than 120,000 times higher than that for coal and more than 60,000 times higher than that for natural gas. While 344 kg of coal or 133 kg of natural gas is required to produce one megawatt-hour of electricity, less than only four grams of isotope-enriched uranium oxide is required for the same amount of energy. This is why the material input of nuclear fuel in relation to the amount of electricity produced is smaller than that for coal or natural gas. According to calculations, the material input of fuel compared to the amount of electricity produced (MIPS, or Material Input Per Service Unit), was 1,160 kg/MWh for a new Finnish coal condensate power plant, 170 kg/MWh for a natural gas combination power plant, and 42 kg/MWh for a nuclear power plant. Of the electricity generation alternatives studied, nuclear power is by far the most environmentally friendly when measured using the MIPS indicator *(Rissanen et al 2001)*.

9.1.5 Impact of nuclear fuel production, transportation and storage

The nuclear material transportation between different stages of manufacture and the transportation of ready fuel elements take place as supervised sea, railway and road transport using special containers and normal transport vehicle stock. The starting point for the national transport regulations in different countries regarding packaging and arrangements are the recommendations of the International Atomic Energy Agency (IAEA).

Most of the transportation at the different stages of the fuel chain take place early in the fuel chain, i.e., from the uranium mine to the ore enrichment plant. As the degree of processing the fuel increases, its mass and the required amount of transportation both decrease. The estimated amounts of transportation at the various stages of the fuel chain required for producing the fuel consumed by a 1,000 MW nuclear power plant in one year are approximately as follows:

- 15,500–18,700 tonnes (some 375 articulated lorries) of ore containing 1% uranium from the mine to the enrichment plant
- 185–220 tonnes (15–17 transport containers) of raw uranium from the enrichment plant to the conversion plant
- 155–185 tonnes (19–23 transport containers, 10–12 articulated lorries) of uranium hexafluoride from the conversion plant to the isotopic enrichment plant
- 23 tonnes (16 containers, 6 articulated lorries) of isotope-enriched uranium to the fuel manufacturing plant
- 135 fuel bundles (5–6 articulated lorries) from the fuel manufacturing plant to the nuclear power plant.

Uranium or nuclear fuel emits very little radiation at the different stages of manufacture, which means that transportation does not cause any adverse health effects to the transport personnel or population living by the transport routes. Well-established procedures are adhered to in this transport. There are international recommendations regarding the transportation equipment and the regulations to be observed during the transportation, and most countries have adopted these in their national legislation.

Due to the low activity of fresh nuclear fuel, radiation protection properties are not required of the transportation packages used for materials of this category. However, a few other aspects have to be taken into account when designing the packaging. The packages containing nuclear materials must ensure that no energy-producing nuclear reaction is created during transportation. This is called criticality safety. Criticality safety must be ensured if the transported material has been enriched with respect to the fissile isotope, uranium-235. Criticality safety is ensured in transportation packaging by only packing a limited amount of nuclear material in one package and by keeping the lots of nuclear material separated from each other. As an example, the packing of fresh nuclear fuel usually only contains one or two fuel bundles *(Finnish Energy Industries 2006)*.

In addition to criticality safety, it is important to protect fresh fuel during transportation against physical impacts and other strains that might compromise the durability of the fuel in reactor conditions. The transportation packages have been custom-designed for the purpose, and they are required to be stronger than ordinary industrial packages. If an accident took place during the transportation of fresh fuel, the fuel would not cause any hazard to people or the environment *(Finnish Energy Industries 2006)*.

Most of the uranium for the Olkiluoto power plant is purchased from Canada or Australia. The enriched uranium produced in Canada is usually also purified and converted in Canada. It is transported to Europe for isotopic enrichment. After isotopic enrichment, it is manufactured into fuel bundles in Germany, Spain or Sweden. The finished fuel bundles are transported by sea, for example, to the Port of Rauma, and further transported by road on lorries to Olkiluoto. There will be 1 or 2 fuel transportations per year for the new plant unit.

Fuel is stored in Olkiluoto in the dry storage of the plant unit where rack storage space is available for one year's fuel. The dry storage facilities are included in the scope of normal security, safety and radiation supervision.

9.1.6 Mining operations of the uranium suppliers typically used by TVO

TVO procures uranium for fuel under long-term contracts from suppliers in countries such as Canada, Australia and the EU. The following section provides an overview of the mining operations of the suppliers typically used by TVO, the different stages of the fuel chain and their most typical environmental impacts. Fuel is produced, transported and stored in these countries in compliance with the environmental and other regulations of the respective country. The operations of the described mines and industrial plants within the fuel chain are not tied to the new unit planned for Olkiluoto; instead, they operate irrespective of whether this project is implemented or not.

9.1.6.1 Canada

TVO procures uranium under a long-term contract from Cameco Inc., among others. Cameco holds shares in uranium mines in Canada, the United States and Kazakhstan. Of the currently producing mines, the ones in Saskatchewan, Canada, are McArthur River, Key Lake and Rabbit Lake. The new mines in Canada are underground mines which only require about one square km of space above ground.

Initially, the uranium for Olkiluoto came from the Beaverlodge mine where the ore had a uranium content of 0.1 %. Beaverlodge was shut down when richer deposits were discovered. Next, the uranium came from Rabbit Lake (about 1 %) and Key Lake (2 %). The uranium content of the ore in the latest mine, McArthur River, is 20%, as is that of the new mine under construction in Cigar Lake. Several rich deposits have been discovered recently in Canada in addition to the above.

An ore enrichment plant operates in conjunction with Key Lake and Rabbit Lake. The rich ores from McArthur River and Cigar Lake are mixed with the residual ores from Key Lake and Rabbit Lake and enriched in the existing enrichment plants. Each of the above sites operates an

Table 9-1 The radiation doses (Full Time Equivalent doses) of Canadian uranium mine workers in 2006 and the corresponding dose readings of conversion plant workers in 2005 (Jander, P. 2007).

	McArthur River	Key Lake	Rabbit Lake	Cigar Lake	Blind River (conversion plant)	Port Hope (conversion plant)
mSv per year	1.87	1.40	3.39	0.47	3.5	1.5

environmental management system. The environmental management systems of McArthur River and Key Lake have ISO 14001 certification. Cameco's top management is responsible for issues related to the environmental management system. Each mine has nominated a person responsible for safety/security, radiation protection and environmental issues. This person reports directly to the managing director of that production plant. The radiation protection programme requires that environmental issues are reported to the top management.

In Canada, the company has to assess the environmental impacts of projects before commencing or expanding its operations. The EIA procedure has been applied in Canada since the mid-1970s, and the companies there have plenty of experience in carrying out the EIA procedures. The reformed EIA legislation entered into force in Canada in 1995, and the procedure includes, among other things, extensive participation and hearing procedures. In addition to the EIA procedure, the uranium mine projects also require an environmental permit. All mines and conversion plants in Canada have implemented the EIA procedure. Rabbit Lake, for example, has implemented the EIA procedure in 1980, 1992 and 1996, and the impacts of expanding production were assessed in 2005. In Canada, the operating and building permit includes an Environmental Effects Monitoring Programme that must be approved by public authorities.

In 1999, TVO co-operated with the expert groups of Swedish power companies who audited the uranium production plants in Key Lake and Rabbit Lake and the conversion plants in Blind River and Port Hope with regard to their management of environmental issues. TVO assessed the biggest environmental impact in Blind River to come from the treatment and storage of waste materials and from decontamination. The audit team of Swedish nuclear power companies found that the audited mining operations and conversion plants fulfilled the approval criteria used in fuel procurement. *(Teollisuuden Voima Oy 2005a.)*

Radiation protection in mines

Radiation protection is based on the Radiation Protection Program that the radiation protection regulations require as a prerequisite for obtaining an operating licence. The nuclear safety authority CNSC approves the Radiation Protection Program drawn up by Cameco as the operator. The purpose of the Radiation Protection Program is to prevent the employees from being exposed to radiation. The programme includes tests carried out in co-operation with Health Canada.

The public authority supervises the adherence to the Radiation Protection Program. In 2001–2004, for example, 15 inspection visits were made to McArthur River during which any deviations from the Radiation Protection Program were recorded. Corrective actions, such as increasing training, were taken after the inspection visits. The radiation intensities of packages were also inspected. The transportation of hazardous goods has also been included in the training programme, and the maintenance of transport containers has been developed. In Rabbit Lake, for example, the Radiation Protection Program is developed through adherence to timetables and increasing the frequency of reporting.

Mine workers wear radiation dosemeters. Those working in radioactive areas have taken the test for the required permit (Radiation Work Permit). The radiation doses are reported to public authorities and employees.

The mines, enrichment plants and conversion plants operated by Cameco observe radiation dose limits set according to the recommendations of the ICRP. The highest permissible radiation dose of employees is 20 mSv per annum. The employees' radiation dose measurements include metering the gamma radiation and radon doses as well as monitoring the accumulation of long-lived alpha particle emitters. In uranium mines, exposure to radiation may occur through contact with the groundwater or ore, as well as through dust carried in the air. Radiation protection was already taken into account at the process development stage for the McArthur River mine and the future mine in Cigar Lake because of the high uranium content of their ore deposits.

The internationally recognised ALARA principle is also deployed in Canada for radiation protection. According to authorities, the employees' dose limits have not been exceeded in the mines or enrichment and conversion plants operated by Cameco. The computational exposures of Canadian mine workers to radon and radioactive dust are low. In Cameco's mines, the employees' exposure is reduced by ventilation, remote-controlled work phases and processing techniques.

The state of the surrounding environment is monitored using several measurement points and sampling. As an example, there are about one hundred measurement points in the surroundings of Cigar Lake, and measurement readings are available from 1993. The radiation doses of the community do not exceed the set limits. The limit is 1 mSv per year. *(Teollisuuden Voima Oy 2005a.)*

Decommissioning and reconditioning

Cameco's mines have the decommissioning and landscaping plans as well as the financial guarantees as a provision for the decommissioning costs that are required by the operating licence conditions. The plans have been approved by the Canadian Nuclear Safety Commission (CNSC).

The decommissioning plans of the mines are preliminary. Their basic principle is to cover built-up areas with vegetation. Vegetation planting work included in the landscaping plans is already taking place in areas where operations have been discontinued, such as the Key Lake area. *(Teollisuuden Voima Oy 2005a.)*

9.1.6.2 Australia

In Australia, TVO procures uranium from the Olympic Dam mine. Copper ore is mined from the mine, and uranium, gold and silver are produced as by-products. The mine has a production capacity of 4,500 tonnes of uranium oxide (U_3O_8), and in 2004 it produced 4,404 tonnes of U_3O_8. The long-term target is 15,000 tonnes of U_3O_8 per annum. The proprietor of the mines has announced that it is investigating the possibilities for a further expansion of the mine, and the trade magazines have mentioned a capacity of up to one million tonnes of copper per annum, which would mean a uranium production of 30,000 tonnes per annum. The ore resources have been found to be much greater than originally thought. The Olympic Dam mine has an environmental management system that received ISO 14001 certification in February 2005.

Australian legislation (the Environment Protection Act 1978) requires an EIA procedure to be completed for mining projects, including a public assessment and approval of the EIA procedure. Two EIA procedures associated with the production of the mine have been carried out at Olympic Dam: one in 1982 before commencing operations and another in 1997 before increasing the production of copper.

Environmental protection and management as well as monitoring in compliance with legislation takes place in the Olympic Dam area. The practical measures are based on a programme drawn up every three years. In 2003, the public authority (the Environmental Protection Agency, EPA) made an on-site inspection of the operations at Olympic Dam and required that a separate Environment Improvement Program be drawn up because minor deficiencies were found in certain procedures such as the handling of fuels. No major flaws with environmental implications were detected.

In 1999, TVO visited the Olympic Dam mining area to inspect the uranium production (including the mine and enrichment plant) and the state of the management of environmental issues. On the basis of the visits and the contract negotiations, TVO assessed that environmental issues are amply managed at Olympic Dam and that the technical condition and production technology are of a high standard.

The current plan is to triple the production of the Olympic Dam mine. Expansion of the mine will, in particular, impact the landscape when the present closed mine is turned into a rather deep and long open pit quarry. The expansion will be carried out in compliance with national legislation and applying an EIA procedure. The mine is located in a sandy desert in the middle of a salt lake, far away from inhabited areas. If uranium was not separated from the copper ore at the mine, the amount of waste materials produced would be roughly equal to that caused by copper production alone, and the uranium would remain in the waste materials coming from copper ore enrichment *(Mikkola 2007)*.

Some mines or mine reservations in Australia are also located in areas inhabited by indigenous people. The EIA and environmental permit procedures in Australia are not only aimed at managing the environmental impacts but also at promoting the participation of indigenous, or aboriginal, people and taking their interests into account *(CEAA 1998, Environment Australia 1997)*.

Roxby Downs is a small Australian mining community with about 4,000 inhabitants, predominantly mine workers, located about 16 km from the mine. This small town was established after the mining operations began. There are no old communities near the mining area, and the nearest aboriginal community is about 200 km away *(Purra 2001)*.

The radiation doses received by the mine and enrichment plant workers are small, corresponding to those of nuclear power plant workers, and considerably below the dose limits. The amount of radiation received by the workers is monitored by personal dosemeters in addition to which the companies operate occupational health care inspection schemes and monitoring programmes. For example, the radiation dose caused by mining operations in Roxby Downs, Australia, is about 0.005 mSv per year, while the natural background radiation in the area normally amounts to 1.5 mSv per year. The average amount of natural sources of radiation in Finland is about 2,8 mSv per year which means that the radiation dose received by the inhabitants of Roxby Downs is well below that received from Finnish nature on average *(Purra 2001). (Teollisuuden Voima Oy 2005a.)*

9.1.6.3 Kazakhstan

In the future, Kazakhstan will be the third major producer of uranium alongside Canada and Australia. The uranium production of Kazakhstan in 2015 is estimated at about 18,700 tonnes and in 2025 at 27,000 tonnes. In 2004, the production amounted to some 3,600 tonnes of uranium and in 2007, to almost 7,000 tonnes (Nuclear Fuel September 10, 2007). This means that Kazakhstan may account for as much as 25% of the whole world's uranium production in 2015.

In Kazakhstan, uranium is produced using solution leaching where uranium is leached directly from the soil (In Situ Recovery, ISR). This method can be used when the deposit is suitably located in relation to a water-conducting layer. Uranium is leached into a dilute mother solution that is then injected downstream to the groundwater and later collected using pumping wells. The dissolved uranium is separated in ion exchangers, and water is circulated to the ground from other bore wells around the production wells. This production method is efficient and only produces minimal environmental impacts because nearly all other materials besides uranium remain in the ground. Nowadays, almost 25 % of uranium is produced using underground leaching. After uranium production has been discontinued, the soil is rinsed with water in order to remove leaching residues and to bring the soil condition in compliance with the permit conditions. Besides Kazakhstan, the method is used at least in Uzbekistan, the USA, Australia and China. *(Teollisuuden Voima Oy 2005c.)*

9.2 Impacts of processing waste materials generated at nuclear plant

9.2.1 Nuclear waste management and its principles

This chapter describes the quantity, quality and treatment of ordinary, hazardous and radioactive waste generated at the power plant, and assesses the related environmental impacts. The environmental impacts of the disposal of spent nuclear fuel are described utilising the results of the environmental impact assessment procedure carried out by Posiva Oy in 1999, as well as the studies carried out thereafter.

This chapter discusses the handling of spent nuclear fuel in its entirety, including the required extensions of storage facilities and their environmental impacts.

Nuclear waste refers to those radioactive materials generated in connection with or as a result of the use of nuclear energy that are not intended for further use. Radioactive nuclear waste is generated at almost all stages of the nuclear fuel cycle.

The processing of nuclear waste is governed by the Nuclear Energy Act and the Nuclear Energy Decree which entered into force in 1988 and were last amended in 2004. Before that, the operation of nuclear power plants was governed by the Atomic Energy Act. For the purposes of the Nuclear Energy Act, nuclear waste includes spent nuclear fuel, low and intermediate-level operating waste produced by the power plant unit, as well as the radioactive waste generated in connection with the decommissioning of plants. In 1994, the Nuclear Energy Act, was amended so that the export from and import to Finland of nuclear waste was prohibited.

Public authorities draw up the safety regulations pertaining to nuclear power plants and nuclear waste management and enforce them. The highest administration and supervision of nuclear waste management are the responsibility of the Ministry of Trade and Industry, the tasks of which transferred to the Ministry of Employment and the Economy as of 1 January 2008 that prepares the legislation governing nuclear waste and the associated international agreements for the part of Finland. The Ministry also supervises adherence to the legislation and agreements. The safety aspects related to the treatment and storage of nuclear waste are supervised by the Radiation and Nuclear Safety Authority (STUK).

According to the Nuclear Energy Act, the overall responsibility for waste management lies with the party producing the nuclear waste. The responsibility covers the research, engineering and implementation phases including their costs. The waste management operations are subject to licensing, and even the research phase is supervised by the authorities.

In line with the principles set out in the Nuclear Energy Act, the funds required for implementing nuclear waste management are collected in advance as part of the price of electricity. The money is deposited in the Nuclear Waste Management Fund. These funds are also used to cover the cost of decommissioning the nuclear power plants. The practical final disposal measures of spent fuel and the preparations for final disposal as well as research activities are taken care of for TVO and Fortum Power and Heat Oy by Posiva Oy, a company jointly owned by them. Both licence holders are separately responsible for the final disposal of operating waste.

As required by the Radiation Act, the Olkiluoto power plant is divided into controlled and uncontrolled areas. Waste materials produced in the uncontrolled area (conventional waste) are processed in the same manner as in any industrial operation. The waste materials produced in the controlled area are classified on the basis of their radioactive material content. Some waste materials produced in the controlled area can be released from control and moved to the uncontrolled area for processing as ordinary waste.

9.2.2 Spent nuclear fuel

Immediately after use, spent uranium fuel is strongly radioactive, but its activity is reduced to one hundredth of the original in one year. At the time of final disposal, that is some 40 years after removal from the reactor, roughly 1/1,000 of the original radioactivity of the nuclear fuel is left. The radioactivity of materials emitting the most intense radiation gradually disappears, leaving mainly substances that are only toxic when ingested or inhaled *(Posiva 2007a)*.

There are two principal methods for spent fuel management: it is either stored until final disposal or transported for reprocessing. In Finland, spent fuel is stored for a few decades in water pools after which it is encapsulated and disposed of in the bedrock.

During the service life of a plant unit, about 1,400–2,500 tonnes of spent fuel are produced, depending on the power of the unit, capasity factor, service life and type of fuel used. The spent nuclear fuel from the planned new power plant unit will be managed in accordance with the same procedures as those observed for OL1, OL2 and the OL3 unit under construction.

9.2.2.1 Interim storage of spent nuclear fuel

The spent fuel bundles are transferred from the reactor for cooling in the water pools of the power plant unit. Water both cools the bundles and provides an effective radiation shield. Plenty of heat continues to be generated by the decay of the radioactive materials in the fuel bundle. This is why the spent fuel bundles must be cooled. The heat generation of spent nuclear fuel after its removal from the reactor is directly proportional to its radioactivity; hence the heat generation also quickly decreases during the first few years. When the heating power of one tonne of uranium is about 1,400 kW at the time of its removal from the reactor, after one year it is only about 10 kW *(Finnish Energy Industries 2006, 2007b)*.

After a few years of cooling, the fuel bundles are taken to the interim storage for spent fuel (KPA Store) located at the power plant site for intermediate storage. The transfer to the KPA Store takes place in transfer container where the bundles are kept immersed in water at all times. The water cools the nuclear fuel and provides protection against the radiation emitted by it. The heat transferred from the fuel to the water in the KPA Store is further transferred to an intermediate cooling circuit by means of a heat exchanger and from there to the sea water cooling circuit by means of another heat exchanger. All cooling circuits are separate, and the water contained

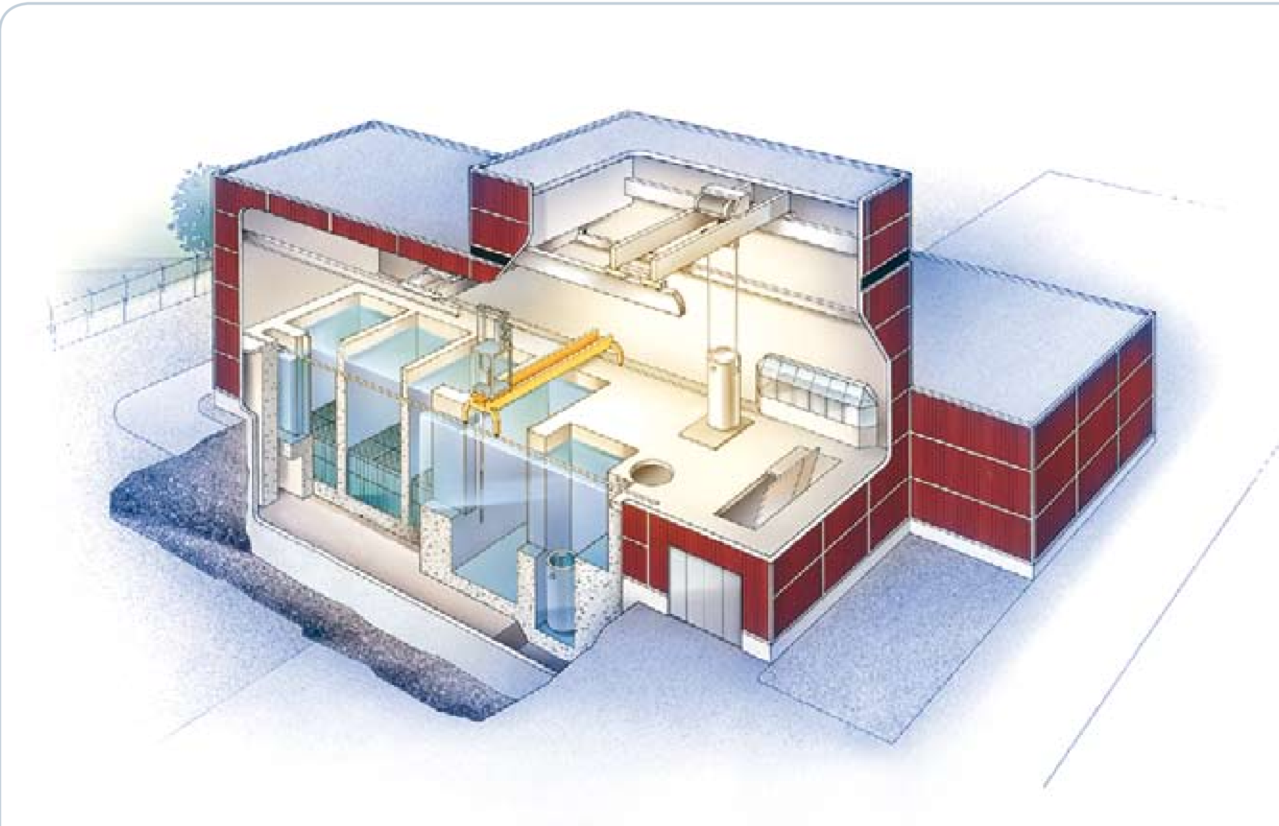
in them does not come into contact with water in any other circuit.

The radioactive waste water from the KPA Store and the filter rinsing water containing cleaning masses are drained to the liquid waste processing plant at OL1. The exhaust air from the KPA Store is led to a central vent stack that has sampling and monitoring systems for radioactive materials. The interim storage for spent nuclear fuel does not give rise to significant releases. Intermediate storage will continue for decades until the disposal of the spent fuel. The activity of final the nuclear fuel and the heat generated in it decrease during storage. The KPA Store currently has three storage pools and one reserve pool. The total volume of the pools is 4,300 m³ and their storage capacity is about 1,200 tonnes of uranium. At the end of 2006, a total of 6,508 bundles of spent fuel was being stored in the Olkiluoto nuclear power plant, an equivalent of some 1,100 tonnes of uranium. The KPA Store had 5,412 bundles, the water pools of Olkiluoto 1 had 522 bundles and those of Olkiluoto 2 had 574 bundles.

The KPA Store will also serve the nuclear power plant unit currently under construction (OL3) and the new power plant unit (OL4). An extension to the KPA Store is scheduled for 2011–2014. The possibility of extension has been taken into account in the original design of the KPA Store. Extension means building one or several new storage pools in conjunction with the existing storage. The current operating licence of the KPA Store is valid until the end of 2018.

The impacts of radioactive releases from the KPA Store are, in this EIA report, discussed together with the impacts of radioactive releases from the power plant.

Figure 9-3 *Spent nuclear fuel is kept in water pools for intermediate storage. Intermediate storage in the KPA Store will continue for decades until the eventual disposal of the spent fuel.*

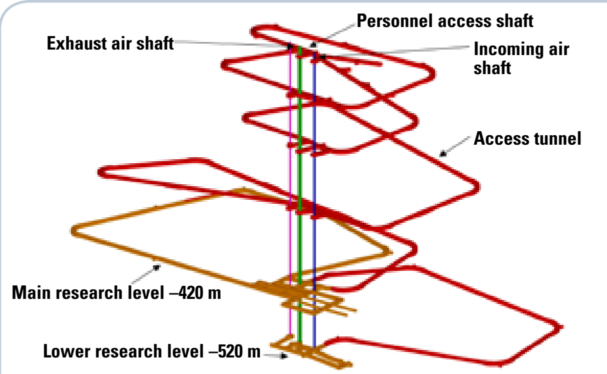


9.2.2.2 Impacts of the final disposal of spent nuclear fuel

Final disposal refers to the final isolation of spent nuclear fuel away from living nature and human activities.

The intention is to place the spent nuclear fuel from TVO and Fortum Power and Heat Oy for final disposal in the bedrock at Olkiluoto in the repository located 400–500 metres underground. An environmental impact assessment concerning the final repository for spent fuel was completed in 1999. After a positive decision-in-principle (in 2001 and 2002), Posiva Oy focused its further research concerning disposal on Olkiluoto and started preparations for building an underground research facility called ONKALO. The construction of ONKALO started in the summer of 2004, and by December 2007 it had progressed to a depth of approximately 250 metres. The objective of the project is to obtain detailed information concerning the bedrock for the purpose of designing a disposal facility and assessing its safety, and to test disposal technology in actual deep underground conditions.

Figure 9-4 Structure of ONKALO. ONKALO is an underground rock characterisation facility (Posiva).



Posiva intends to submit an application for a construction licence for the spent fuel disposal facility by the end of 2012. The disposal of spent fuel is scheduled to start in 2020. The spent fuel from a potential new plant unit will be disposed of in the bedrock at Olkiluoto in the same manner as spent fuel from the other nuclear power plant units of TVO and Fortum Power and Heat Oy.

The final disposal facility comprises a plant above ground and a final repository deep inside the bedrock. The encapsulating plant and facilities for auxiliary operations are located above ground. When in operation, the final disposal facility requires a site of about 15 hectares above ground *(Posiva 2006)*. The parts of the final disposal facility located above ground are shown in Figure 9-5.

In addition to the access tunnel, several vertical shafts lead down to the repository. They include the ventilation, personnel and capsule transfer shafts. The final repository consists of 100–300 metre long disposal tunnels located at about 25 metres from each other and connected by a central tunnel

At the encapsulation plant, the spent fuel is packed into airtight metal canisters, that are transferred to the final repository 400–500 metres underground. The final disposal canister consists of an inner part made of nodular graphite cast iron surrounded by a solid copper jacket that is about 5 centimetres thick. The conditions in the final repository are almost totally void of oxygen-free. Research indicates that copper will withstand corrosion in the repository conditions for at least 100,000 years. The inner part manufactured of nodular graphite cast

Figure 9-5 Visualisation of the parts of the final disposal facility located above ground (Posiva).

iron makes the capsule so strong that it will endure any mechanical strain exerted by the bedrock.

The releases of radioactive materials from the final disposal facility during the encapsulation process are insignificant under normal conditions. The radiation doses received by the workers at the encapsulation plant are estimated to be smaller than those received by the personnel at the nuclear power plants. The quantities of radioactive material processed at a time in the encapsulating plant are also small when compared to the material quantities at the nuclear power plants. The encapsulation plant will not release any detrimental amount of radiating materials even in case of a disturbance at the fuel handling stage.

The safety of the final disposal of spent fuel is based on technical and natural barriers that prevent and slow down the release of radioactive materials from the final repository to the bedrock and living nature. Such barriers include the solid state of spent fuel, very corrosion-resistant and mechanically strong disposal canister and bentonite clay buffer surrounding it and, finally, the bedrock.

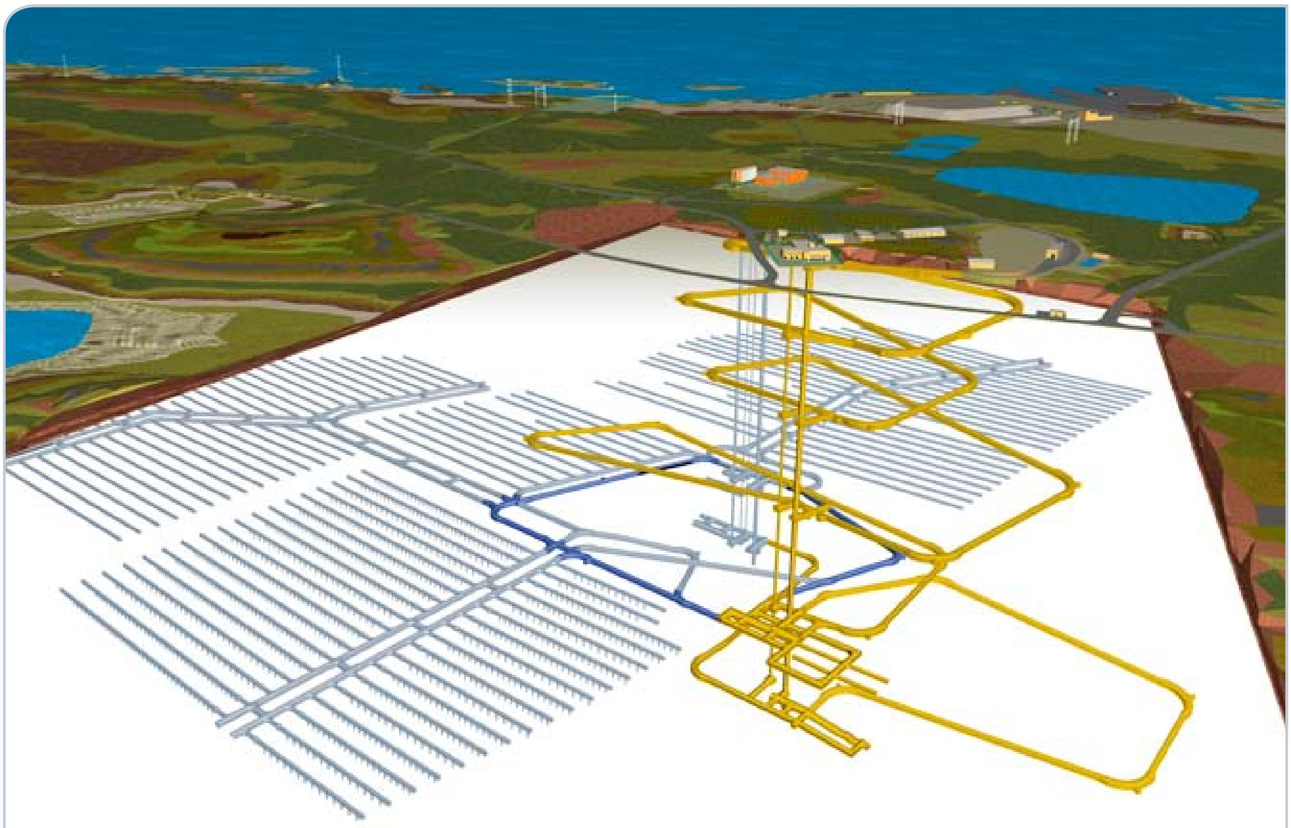
The canisters are placed in holes drilled into the floor of the final disposal tunnels. Then the canisters are surrounded with bentonite clay that swells considerably when impregnated with water. The clay restricts the flow of water over the canister's surface and dampens any minor movements of the rock, preventing damage to the canister.

The rock isolates the disposed fuel from the living environment. It protects the canisters against external impacts, creates mechanically and chemically stable conditions to the repository and limits the amount of groundwater coming into contact with the final disposal canisters. Research results indicate that hundreds of metres down in the bedrock, the groundwater is virtually void of oxygen-free and flows very slowly; hence its corroding effect on the canisters and the spent nuclear fuel is very small. If spent fuel would, due to unforeseen circumstances, come into contact with groundwater, the substances dissolved from it would mainly remain in the bentonite buffer and bedrock surrounding the canisters. The bedrock also effectively stops the radiation emanating from the canisters because two metres of rock alone is sufficient to attenuate the radiation to the level of natural background radiation *(Posiva 2007a)*.

The long-term safety of the final repository is proven using models based on empirical studies; these models can also be used to assess very improbable developments

Figure 9-7 *The final disposal canister consists of a copper jacket and an inner core made of nodular graphite cast iron. The final disposal canister can accommodate 12 spent fuel bundles used in OL1 and OL2 as illustrated, or four fuel bundles of an EPR of the OL3 type.*

Figure 9-6 *Computer image of the final disposal facility in Olkiluoto (Posiva 2006).*



and events. The analysed events even include disturbances of very small low expected probability, such as ice ages with fault movements, land uplift, earthquakes and the creation of new weakness zones. Human activities near the repository will not compromise the safety of disposal either *(Posiva 2007a, Finnish Energy Industries Federation Finergy 2002)*.

When all spent fuel has been finally disposed of, the encapsulation plant is dismantled, the tunnels are filled in using filling material compressed into blocks, and all connections leading to the surface are sealed. When the party responsible for waste management has sealed off the final repository in an acceptable manner and paid the State the fee due for the future surveillance and monitoring of nuclear waste, the ownership of and responsibility for the waste materials is transferred to the Government. According to the Nuclear Energy Act, the final disposal must in its entirety be implemented in such a manner that no surveillance is required afterwards in order to ensure its safety. The final repository has been dimensioned for an annual capacity of 100 canisters, or 200–250 tonnes of uranium. This capacity is sufficient to also cover the final disposal of the fuel coming from the possible new plant unit. Depending on the cooling requirements of the fuel, the final disposal activities will continue for at least 20 years after the last plant unit has been shut down.

Posiva carried out an Environmental Impacts Assessment (EIA) procedure for the final repository in 1999. The EIA procedure carried out by Posiva took into account the change in environmental impacts brought about by an increase in the quantity of nuclear fuel to be finally disposed of. Those environmental impacts that would change in case of building new nuclear power capacity were identified with regard to the spent fuel coming from new plant units. The increased quantity of fuel will prolong the operation and sealing-off phase of the final repository. The nature of operations will not change. In addition to the duration of the operation and sealing-off phase of the final repository, changes will have to be made to the lengths and numbers of tunnels to be built. The area potentially affected by groundwater will expand, and the volume of quarried material will increase.

In its letter dated 29 May 2007, Posiva Oy has requested the Ministry of Trade and Industry to express its opinion regarding whether Posiva Oy must carry out a fresh EIA pursuant to the EIA Act for its project regarding the final disposal of spent nuclear fuel because of the possible sixth nuclear power plant unit. The Ministry of Trade and Industry provided its statement regarding the necessity of an EIA procedure on 25 October 2007. In its statement, the Ministry of Trade and Industry stated that the EIA procedure carried out by Posiva Oy during 1998–1999 does cover the EIA of the final disposal of spent nuclear fuel coming from the sixth nuclear power plant unit. However, this is conditional: the total amount of fuel to be finally disposed of must be less than 9,000 tonnes of uranium.

The quantity of finally disposed nuclear fuel is of little relevance to the people living near the final repository. According to the safety assessments, the most probable scenario is that the canisters will not release any radioactive substances for millions of years. Even if the quantity of disposed fuel would increase, the radioactivity of even larger quantities would be at such a low level that they would not cause any harmful effects *(Posiva 1999)*.

Impacts of the final repository on nature, utilisation of natural resources, use of land, cultural heritage, landscape, buildings and urban scenery

The construction site has no natural objects of national or regional importance, or any Natura 2000 areas. The closest object belonging to the Natura 2000 network is the Liiklankari old-growth forest located on the southern shore of Olkiluoto; it belongs to the Natura area of the Rauma archipelago. There are no endangered (nationally speaking) plants or animals in the area either. No territory-ecological connections will be severed. The final repository will have a minimal impact on the landscape. The scenery in Olkiluoto is dominated by the existing power plants. Due to the location of the plant, the impact on the landscape cannot be considered significant.

The activities causing vibration, dust and noise will be implemented so that they will not have any environmental impacts. The traffic caused by the plant will expand, to a certain extent, the area affected by noise.

Impact of the final repository on people's health

Under normal circumstances, the radioactive materials are at all times tightly isolated from nature and people. Therefore, the main attention has been focussed on the consequences of different disturbance and accident situations and the assessments of long-term safety.

The suitability of the final disposal site as well as the fulfillment of safety requirements are shown by safety analyses. These analyses study both probable developments and improbable developments that would have a deteriorating effect on long-term safety, and assess the consequences to people and nature as a whole in each case.

The conditions in the bedrock of Olkiluoto, selected as the site for the final repository, can be predicted on the basis of the studies carried out. The geological history of the area is reasonably well known for a period dating back hundreds of thousands of years. Ice ages and their possible impacts have been taken into account in the safety analysis. The time span of the analysis extends over one ice age cycle which is about 100,000 years long. After such a long time, the disposed uranium fuel will correspond to naturally occurring uranium deposits and their radiation loads. Any possible future movement of the bedrock has been taken account in the safety analysis scenarios. In these scenarios, a major rock fault is assumed to occur after the ice age, with the result of several repository canisters breaking and the groundwater washing away the bentonite clay protecting the canisters. The assumption is also made in these scenarios that a quickly flowing route to the groundwater would open from above ground, carrying oxygen-rich water to the repository tunnels. Even in this case, living nature would not be exposed to radiation doses exceeding the natural background radiation level, thanks to the fact that bedrock is capable of attenuating the harmful effects.

Figure 9-8 *Geologists surveying the bedrock of Olkiluoto in ONKALO (Posiva).*

Even though it is impossible to analyse and assess every possible sequence of events, the conservatively prepared safety analysis can be used to show that the final disposal of spent nuclear fuel will not cause detrimental effects to people or the environment *(Finnish Energy Industries 2007b)*.

So far, six safety analyses have been carried out regarding the final disposal of spent nuclear fuel, the most recent one in 1999. The most recent repository safety analysis (TILA-99) *(Vieno & Nordman 1999)* uses the Government's safety requirements and the more detailed instructions drawn up by STUK as the comparison point. The international team of experts assembled by STUK issued its statement of expert opinion regarding the safety analysis. The team of experts recommended that the decision-in-principle regarding the final disposal is approved and that research activities are concentrated in Olkiluoto.

Disturbance and accident situations

The safety requirements laid out in Finland for the operation of the final repository are very strict compared to international practices. The radiation exposure caused by the plant will be in all situations insignificant.

The 50-year dose caused by normal operation received by the most exposed person is insignificantly small. The most important disturbance situations assessed are:

- all radioactive substances are not duly collected when emptying the transport containers
- fuel bundles are subjected to impacts in the encapsulation facility and fuel rods are damaged
- the temperature of fuel rises unusually high during drying, and the rod starts to leak.

The dose caused by a single incident received by the most exposed person would, if continued over 50 years, correspond to the dose of cosmic radiation received by a person during one domestic return flight. The disturbance situation would, in 50 years, cause a dose that is less than one hundredth of the limit value of 0.1 mSv per year. The doses caused by a disturbance situation would be so small that they would not call for any protection measures to the surroundings.

The start of a chain reaction is prevented by structural solutions. Precautions for malicious damage are taken by security arrangements. There are no explosive materials in the encapsulation plant, and the fire load is kept sufficiently small. The following situations are deemed the most serious potential accidents:

- a transport vessel falls down and all rods are broken
- a canister falls down and all rods are broken
- the cover of a transport container falls down and 1/10 of rods are broken
- a fuel bundle falls down on top of other bundles, and all rods in two bundles are broken
- the canister hoist falls down and all rods in the canister are broken.

Besides gaseous substances, these accident situations could also release particles. The resulting dose received by the most exposed person would be less than 0.8 mSv over 50 years, an equivalent of three chest X-rays. The resulting doses would not exceed the limit value for accidents, 1 mSv per year. The doses caused by the potential accidents would be so small that they would not call for any immediate protection measures in the surroundings.

Requirements for bedrock in the repository

In order to be suitable for repository purposes, the bedrock must be geologically stable and without major fragmented structures. The type of rock must also be common so that future generations will not see any need to quarry rock at the repository site.

Geological investigations have been carried out to establish the fractures and water conductivity properties of rock, as well as groundwater flows. Since groundwater only flows along the fractures in the rock, the investigations were focussed fractures and water conductivity of rock.

The results of numerous investigations have been compiled into models, the most important of which are the geological model hydro-geological model, hydro-geo-chemical model and rock mechanical model.

The research and development work has also included the engineering of fuel transportation and the encapsulation plant, layout of the required underground facilities and development work for the design of the final disposal canister. Laboratories in Finland and abroad have also studied the effects of groundwater and the heat generated by spent fuel on the canister materials and the bentonite clay used for isolating the canisters *(Posiva 2007a)*.

9.2.2.3 Monitoring programme for the repository bedrock and its surrounding environment

The possible long-term changes in the environment caused by the construction of ONKALO are monitored through a monitoring programme separately established for this purpose. The programme includes monitoring properties of rock mechanics as well as hydrological and hydro-geo-chemical properties, environmental properties and foreign substances. Monitoring has mainly been carried out from above the ground. As the construction of ONKALO progresses, monitoring will also increasingly take place underground.

Figure 9-9 *The properties of bedrock are investigated, among other things, by drilling cores. Thousands of metres of drilling samples obtained from the bedrock in Olkiluoto will be examined (Posiva).*

The monitoring programme of 2006 for rock mechanics included the measurements taken by GPS stations and micro-seismic stations. Four new stations were introduced during the year. In addition to these, the measuring station network was supplemented by two sensors (electromagnetic seismometers) in late 2006. The sensors were installed in a 250 m deep hole drilled in the vicinity of ONKALO. The sensors were installed at the approximate depths of 150 and 250 metres.

Hydrological monitoring measurements were carried out in both shallow and deep observation holes. The observation holes were used to monitor the level and pressure head of groundwater both by manual and automatic measurements. In addition to these, the following parameters were monitored: the flow conditions in open holes, groundwater salinity, seepage waters in ONKALO and the water balance of the tunnel system, seawater level, the thickness of ground frost and snow, as well as the volume of runoff surface waters.

Seepage water volumes were systematically monitored in ONKALO during 2006, and water samples were taken from seeping cracks for hydro-geo-chemical analyses. The tracer compound contents of the water used in the construction work of ONKALO was also monitored.

Environmental monitoring included monitoring the amount of dust as well as the quality and level of water in household water wells. The quality and circulation of surface waters in woodlands as well as meteorological properties were monitored in intensive test areas. In addition to these, the extensive inventory study of woodland test areas started already in 2005 was completed. Aerial photography of the Olkiluoto island was carried out in the summer; this was also included in the environmental monitoring measures of 2006.

Records have been kept of the foreign substances used in the construction of ONKALO. The monitoring of changes caused by the construction of ONKALO has primarily been carried out in compliance with the report "Programme of Monitoring at Olkiluoto During Construction and Operation of the ONKALO", and no major long-term changes caused by the construction work have been observed. *(Posiva 2007b.)*

9.2.3 Transportation of spent nuclear fuel and the impact of transportation

There is plenty of experience on transporting spent nuclear fuel. Several European countries and Japan export spent fuel to be reprocessed in France and UK. Sweden has transported spent fuel by sea from all of its nuclear power plants to an interim storage facility in Oskarshamn *(Posiva 2007a)*. Finland also has plenty of experience in the safety of transporting spent nuclear fuel. Spent fuel has been transported from power plants to interim storage, and in 1981–1996, spent nuclear fuel was exported to Russia (The Soviet Union) from the Loviisa nuclear power plant.

For transportation, the fuel assemblies to be moved into interim storage are packed into a crash-resistant transport container. The container protects the fuel assemblies from damage during transportation. It also operates as radiation shielding. Similar containers are also used when transporting spent fuel from on-site interim storages to the final repository.

The transportation of spent nuclear fuel is strictly regulated by national and international regulations and agreements. The International Atomic Energy Agency IAEA published the first transportation guideline already in 1961. In Finland, permission from the Radiation and Nuclear Safety Authority (STUK) is required when transporting spent nuclear fuel. STUK will inspect the transportation plan, the structure of the container, the qualification of transportation personnel and the provisions made for accidents and malicious damage.

At the moment, spent nuclear fuel is not transported outside plant areas in Finland. Spent fuel is stored in on-site interim storage facilities and will later be moved into the tunnels of the final repository currently under construction in the bedrock at Olkiluoto. Final disposal operations are planned to begin in 2020.

9.2.4 Operating waste

Low and intermediate level operating waste originates from the cleaning of the power plant's radioactive process water, as well as from maintenance and repair work. Low level operating waste includes protective plastic, protective clothing and equipment, towels, tools, wood waste, scrap metal, sludge and concentrates. Intermediate level waste includes ion-exchange resin and filter materials used in the cleaning of process water. For OL1 and OL2, wet waste is mainly solidified with bitumen. For OL3, it will be packed in drums to dry. At the end of 2006, the cumulative amount of operating waste at the Olkiluoto power plant was 6,011 m^3. 4,557 m^3 of the Olkiluoto waste was disposed of into the final repository for operating waste (the VLJ repository).

The new OL4 power plant unit is expected to generate an average of 100–200 m^3 of waste (with packaging included) per year. The annual amount will vary depending on the maintenance, repairs and modifications carried out. The total amount of operating waste to accumulate over the plant unit's 60-year service life is estimated at 6,000 to 12,000 m^3.

The low and intermediate level waste generated at OL4 will be disposed of in the same way as the waste generated at OL1, OL2 and OL3. Waste will be sorted, processed and packed into disposal packages at the plant unit and in storage rooms designed for the purpose. The low and intermediate waste interim storages at Olkiluoto (the MAJ and KAJ storages) are used for processing and packing the operating waste. The current operating licences of the MAJ and KAJ storages are valid until the end of 2018. All operating waste should be moved directly into the final repository for operating waste (VLJ repository) with no interim storage period. The Olkiluoto VLJ repository received an operating licence in 1992. The licence will be valid until the end of 2051.

Plant storage

Low level maintenance waste will be packed in the storage rooms of plant unit waste disposal plants by compressing the waste into 200 litre drums, which will be further compressed at the KAJ storage to half their original size to save space. Sludge and solvents are also solidified into 200 litre drums at the plant storage rooms. No radiation protection is required to handle drums containing low level waste. The waste will be placed into the MAJ silo of the VLJ repository.

Intermediate level waste includes used ion-exchange resin, filters and possibly dried sludge. Ion-exchange resin is solidified by mixing it with bitumen and casting the mixture into steel drums. Radiation protection must be used when handling and moving intermediate level waste. Intermediate level waste will be placed into the KAJ silo of the VLJ repository.

Possible waste water from the plant storage rooms are processed together with the waste water from the plant unit. Exhaust air will be processed by the exhaust filters of the plant unit before flowing into the vent stack.

Low level waste storage

The low level waste storage (MAJ storage) is meant for processing and storing operating waste and the low level waste produced by the KPA storage. The MAJ storage is a one-floor construction with an approximate volume of 8,600 m^3. The storage includes both controlled and non-controlled areas.

The MAJ storage is mainly used for the processing of very low level maintenance waste originating from the plant units. The maintenance waste sorted by dose rate is compressed into bales and transported through radiation control to the plant refuse dumping site.

The drainage from the washing room and storage areas of the building is led to a drain tank located in a concrete basin. From the tank, the water is led to the plant units for processing. Under-pressure, in relation to the outdoor atmosphere, is maintained in the storage rooms, and exhaust air is filtered.

Intermediate level waste storage

The intermediate level waste storage (KAJ storage) is meant for processing and storing operating waste and the intermediate level waste produced by the KPA storage. The KAJ storage is a one-floor construction with an approximate volume of 14,200 m^3. The building is divided into two parts, the actual storage and the control room. The control room is a non-controlled area separated from the storage by a radiation protective wall.

Currently, the KAJ storage is used primarily for the processing of scrap to prepare it for final disposal or release from radiation control. Scrap and filter materials packed in concrete containers is usually placed into the MAJ silo of the VLJ repository.

The drainage from the washing room and storage areas of the building is led to a drain tank located in a concrete basin. From the tank, the water is led to the plant units for processing. Under-pressure, in relation to the outdoor atmosphere, is also maintained in the storage rooms of the KAJ storage, and exhaust air is filtered.

The final repository for low and intermediate level operating waste

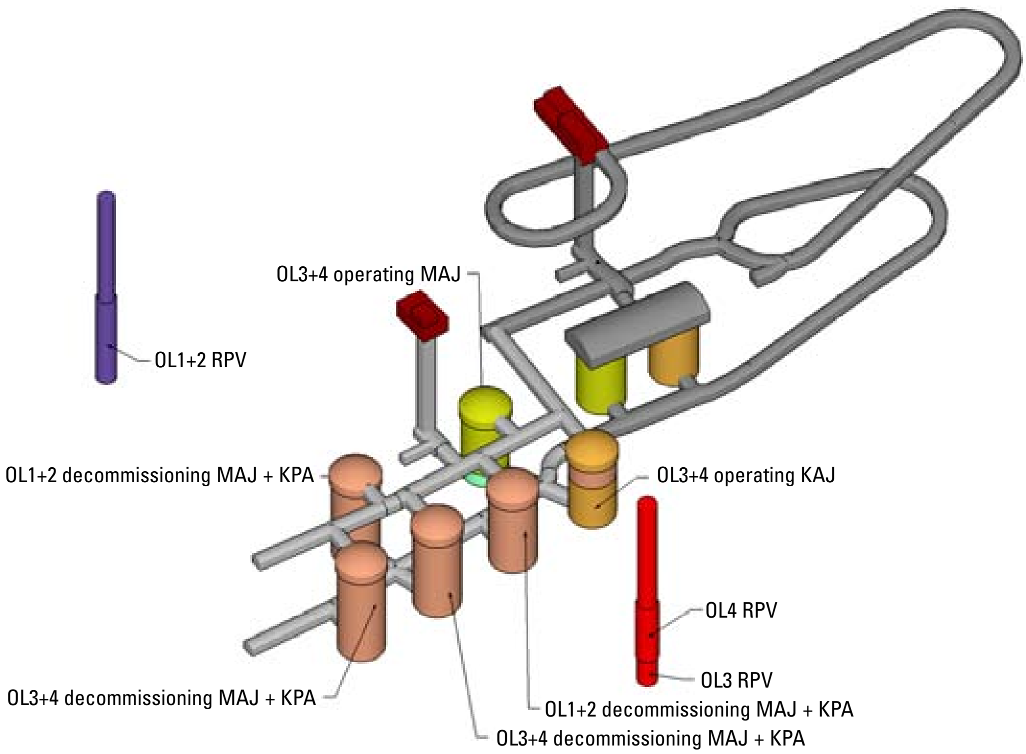
A disposal facility for low and intermediate level power plant waste, known as the VLJ repository, was built at Olkiluoto in 1992. The repository consists of two rock silos, a hall connecting them and auxiliary facilities; all constructed approximately 60 to 100 metres deep into the bedrock of the Ulkopää peninsula at Olkiluoto. The final disposal of the operating waste produced at the planned new plant unit will be done similarly to that of the operating waste from the OL1, OL2 and OL3 plant units.

The waste is moved into the final repository through a tunnel with a special vehicle. When the repository is no longer used, the connections to it will be closed. After this, the facilities will no longer require monitoring. The radioactive substances of the waste will, in time, become harmless. Finally, the waste will no longer pose a threat to the living nature. Low level waste is placed into a rock silo. A reinforced concrete silo is constructed in another rock silo for intermediate level waste. The capacity of the low level waste silo is approximately 5,000 m^3. The capacity of the intermediate level waste silo is approximately 3,500 m^3.

The drainage (groundwater) from the VLJ repository and the wash water from the controlled area are normally led through radiation control into an open channel leading to the northwest shore of the Olkiluoto island. If the radioactivity exceeds the limit of 10 Bq per litre, the water will be directed to the power plant for processing.

The microbiological decomposition of low level maintenance waste is being studied in a large-scale

Figure 9-10 *Structure of the VLJ repository. The control building, the shaft leading down from it, the access tunnel and the two silos on the right are all parts of the existing VLJ repository. The two silos in the centre of the picture will be added during the operational life of OL3 and OL4. When plant units are decommissioned, the final disposal facility for operating waste will be further expanded by building four new silos for decommissioning waste (on the left), a process building, a shaft down from the process building, an access tunnel and two separate vertical shafts for the final disposal of reactor pressure vessels.*



Type of waste	OL1 and OL2 (2002–2006) tonne/year	OL4 tonne/year
Landfill waste	180	90
Paper and cardboard	50	25
Waste suitable for energy production	90	45
Biowaste	50	25
Metal	130	65
Wood	200	100
Glass	1	0,5
Hazardous waste	40	20

Table 9-2 The average volumes of waste components generated at the Olkiluoto power plant in 2002–2006 (tonnes/year) and a prediction of the waste generated at the new OL4 plant unit (tonnes/year).

experiment in a pilot plant built into the drift tunnel of the VLJ repository. The study aims at further defining the estimate for gas developing in maintenance waste and adding to the knowledge of the entire decomposition process in circumstances that correspond to the status of the VLJ repository after sealing. In addition, the transfer of radioactivity from the waste drums into the surrounding water is being monitored. The most significant variable resulting from the experiment is the gas generation rate in maintenance waste needed for the safety analysis of the VLJ repository. Based on the results, the gas rate is lower than the rate proposed in the safety analysis. The water quality at the groundwater stations of the Olkiluoto VLJ repository has been monitored since the second half of the 1980s, and no clear trends or significant changes have been observed in the results *(Posiva 2007b)*.

The impacts of radioactive releases from the low and intermediate waste processing process are, in this EIA report, discussed together with the impacts of radioactive releases from the power plant.

Extension to the VLJ repository

The original design of the VLJ repository allows for expansion. The repository will be extended as necessary when the existing parts become full. The VLJ repository will be further expanded when the existing nuclear power plant units are decommissioned. The excavated rock will be used for earthwork at the plant area or dumped in a designated area.

Figure 9-10 presents the structure of the VLJ repository. The control building, the shaft leading down from it, the access tunnel and the two silos on the right shown in the picture are all parts of the existing VLJ repository.

The VLJ repository will be expanded by two silos to accommodate for the low and intermediate level waste generated during the service life of OL3 and OL4 (Figure 9-10).

When plant units are decommissioned, the final disposal facility is further extended by building the four silos on the left, the connected vertical shaft and a process building above ground, as well as two separate vertical shafts for the final disposal of the reactor pressure vessels (Figure 9-10).

9.2.5 Conventional waste

Municipal waste

Conventional waste is also generated at a power plant. Conventional waste must be disposed of as prescribed by the environmental permit decisions. The Olkiluoto power plant has its own landfill site that receives the waste that is unsuitable for recovery. As recycling has become increasingly efficient, the amount of waste received at the landfill has constantly decreased. The primary components of recyclable waste generated at TVO plants are paper and cardboard, metal, wood, biowaste, glass and waste suitable for energy production. Screens and travelling band screens are used to separate solids, that is, algae, fish, garbage, etc., from the cooling water. Screens and travelling band screens are cleaned at regular intervals. The resulting waste is separated and processed as required by the power plant's environmental permit and the permit pursuant to the Water Act.

Table 9-2 presents the average volumes of waste components generated by the operation of the Olkiluoto power plant in 2002–2006 (tonnes per year) and a prediction of waste volumes from OL4. The conventional waste volume of the OL3 nuclear power plant unit currently under construction is estimated at about 50 % of the combined waste volume of the OL1 and OL2 units. Correspondingly, the waste volume generated at the OL4 plant unit is estimated at 50 % of the volume generated at the existing units.

The old Olkiluoto landfill was closed on 31 October 2007 as specified in the environmental permit. The application for a new landfill was submitted in October 2003, and the environmental permit (LSY-2003-Y-324) was granted in December 2006. The new landfill has been built northeast from the old landfill. Its area is one hectare and has a capacity of 60,000 m^3. The first phase (approximately 6,000 m^2) was commissioned on 1 November 2007. The second phase of the landfill will be built later. The lifetime of the new landfill is estimated at 40 years. The flow of water into the landfill area is prevented by cut-off drains. Seep water and drainage flow into a bordering ditch and from there to processing. Processed water is led through a measuring point into the channel and further into the sea.

Based on the results of the gas measurements carried out at the baseline survey of the landfill, no significant anaerobic decomposition of waste takes place at the old Olkiluoto landfill. The waste placed into the new landfill area contains even less biodegradable materials. Thus, smaller quantities of gas will be produced. According to calculations and measurements, the volume of landfill gas is very small in both the old and particularly the new landfill area.

The impact of the landfill on surface waters can be seen in the quality of the water in the nearby gutters. The impact decreases after the landfill is closed. The impact on surface water decreases continually due to the separate collecting of biowaste and improved technology at the new landfill area.

The landfill is located in an area where the generation of groundwater is poor due to the structure of the soil. Based on the research carried out in connection with the baseline survey, the landfill has not caused any deterioration to the quality of the groundwater.

The impact of the landfill seep water on the quality of groundwater and the water streaming from the area has been monitored according to a plan approved by the Southwest Finland Regional Environment Centre since 1999. The oxygen content of the groundwater has normally been low. As a result of this, iron and manganese have been found in the groundwater. No clear signs of any impact of the seep water have been observed in the groundwater samples. The soluble nitrogen compound contents have been relatively small, and the fairly high chloride contents are probably due to the close proximity of the sea. The landfill water has low contents of polychlorinated biphenyls (PCB), absorbable organic halogens (AOX) and total organic carbon (TOC). Heavy metal contents are below the norms set for drinking water. The opening of the new landfill reduces releases and makes operation easier.

Due to correct processing, the conventional waste produced at the power plant has no environmental impacts of any consequence.

Hazardous waste

The operation and maintenance of the new plant unit will increase the amount of hazardous waste. In recent years, the most significant hazardous waste components produced at the Olkiluoto nuclear power plant have been scrapped electrical and electronic components, batteries, coolants, solid oily waste, solvents and fluorescent tubes and light bulbs. The hazardous waste created at the power plant is disposed of appropriately according to the provisions of the environmental permit decisions.

In 2002–2006, approximately 40 tonnes of hazardous waste per year was produced by the operations of the Olkiluoto power plant. The amount of hazardous waste is expected to increase by approximately 50 % after the completion of the OL3 plant unit currently under construction. Correspondingly, the new OL4 plant unit would increase the amount of hazardous waste by approximately 50 % of the amount produced by the currently operational plant units. The hazardous waste produced at the plant will be delivered to a toxic waste disposal plant. Due to the small amount and correct processing of hazardous waste, it has no environmental impacts of any consequence.

Figure 9-11 *The new landfill at Olkiluoto, in use since 1 November 2007.*

9.3 Impacts of transportation and traffic during operation

To evaluate the impact of traffic, the changes that the transportation causes to the current traffic volumes on roads leading to Olkiluoto, as well as the means of transport and the routes used, have been determined. The traffic report of the Olkiluoto partial master plan and the traffic volume calculations carried out from 27 August to 10 September 2007 to prepare the report have been used as a starting point for the evaluation *(Ramboll 2007)*.

The noise impact and the impacts on comfort and traffic safety caused by traffic have been assessed on the basis of the traffic changes affecting residential areas and the experience gained from the OL3 project. A model was prepared on the noise impact of the traffic. The necessary changes to traffic arrangements on the areas have been considered.

Road 2176 from Lapijoki to Olkiluoto, and the roads from Hankkila via Sorkka to Rauma and from Linnanmaa to Eurajoki were defined as the observed area for road traffic impacts. The impact on traffic volumes on highway 8 between Rauma and Eurajoki has also been examined.

The volumes of transportation and traffic during the construction phase as well as during operation are estimates based on the experience gained from the construction of existing power plant units, traffic during their operation and the OL3 project, as well as on the traffic forecast prepared in conjunction with the Olkiluoto partial master plan.

9.3.1 Present state of traffic

The traffic routes leading to Olkiluoto and the current traffic volumes have been described in section 8.6, Impacts of transportation and traffic during the construction phase, under 8.6.1, Present state of traffic.

9.3.2 Predicted traffic flows in the Olkiluoto partial master plan

The traffic report of the Olkiluoto partial master plan considers the current status with OL1 and OL2 operational and OL3 and the underground Posiva research facility ONKALO currently under construction. The prediction also reviews the status during annual maintenance outages, including the increase in the number of maintenance employees. The annual maintenance outages of OL1 and OL2 normally take a few weeks.

For future developments, traffic in 2015 was considered. At that time, OL3 will be operational and OL4 would be under construction. The ONKALO research phase will have ended and the disposal facility will be under construction.

In addition, the year 2020 was selected as another prediction time point. By then, OL1, OL2, OL3, OL4 and the final disposal facility will all be operational. Outside the annual maintenance outages, the estimated work force at the plant will be 1,700 persons. During the annual maintenance outages, the estimated work force will be 3,200 persons.

The main traffic route will be along the entrance road into the Olkiluoto plant area. In comparison, the traffic volumes to the targets along the road (the harbour, visitor centre, accommodation village, etc.) are very small. The incoming traffic volume depends on the number of jobs and operations, being approximately 2,000 under normal circumstances and approximately 4,500 during the annual maintenance outage.

***Figure 9-12** Prediction of Olkiluoto traffic volumes for the current traffic network. The figure includes the traffic volumes for the 2007 situation and the predicted volumes for 2015 and 2020 during normal operation and annual maintenance outages (Ramboll Finland Oy 2007a).*

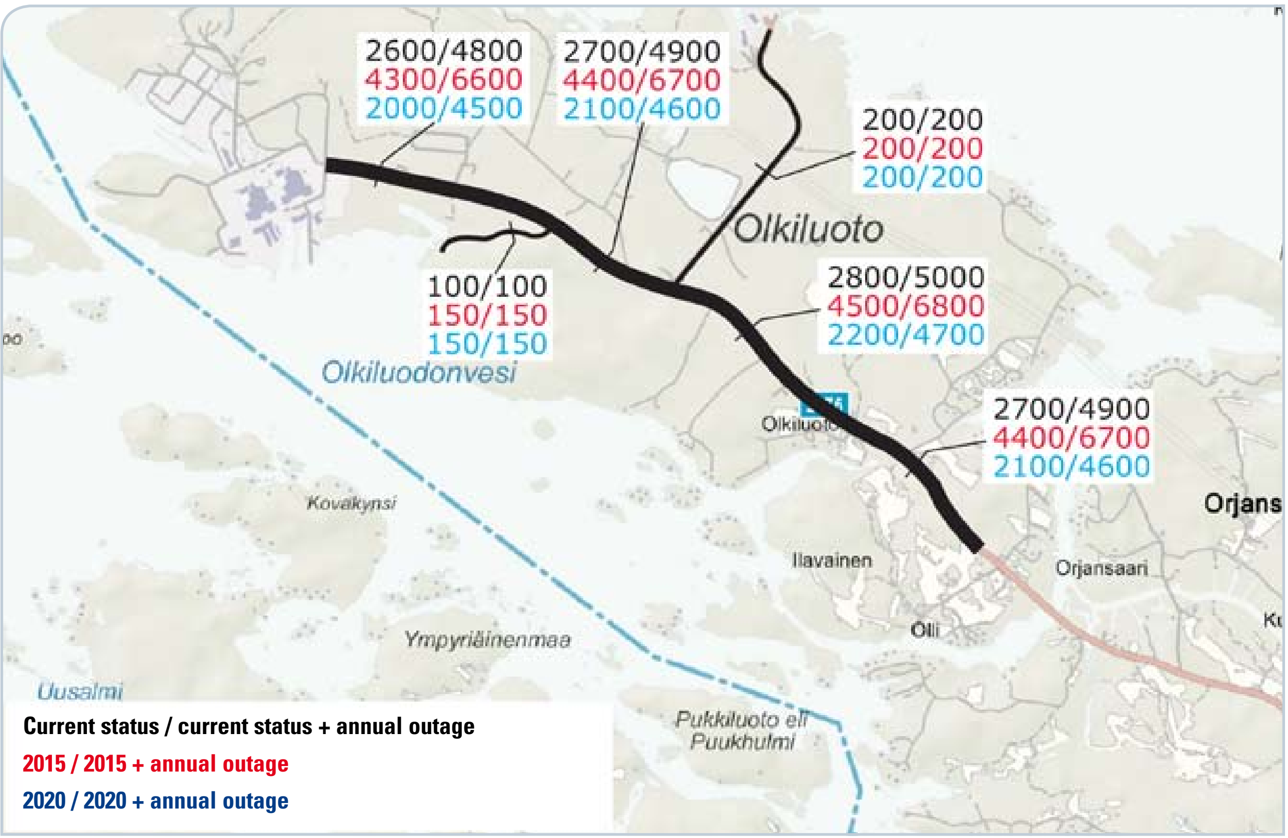


Table 9-3 Olkiluodontie traffic volumes (highway 2176) entering the plant area while the plant is operational.

	Current situation 2007	Zero option [1)]	OL4 completed [2)] 2020
Total traffic to the plant area	2,600	1,600	2,000
Total traffic to the plant area during annual outages	4,800	3,900	4,500

1) OL1, OL2 and OL3 in operation, disposal facility completed
2) OL1, OL2, OL3 and OL4 in operation, disposal facility completed

Figures 9-12 and 9-13 present the traffic volumes of the current traffic network and the traffic volumes of the new Olkiluoto entrance road and Satamatie under present circumstances in 2007, as well as in prediction years 2015 and 2020 during normal operation and during maintenance outage, as described in the traffic prediction.

In a zero option situation, where both OL3 and the final disposal facility have been completed, the traffic volume into the plant area is estimated at 1,600 vehicles per day, increasing to about 3,900 vehicles per day during annual maintenance outages.

9.3.3 Transportation

During normal plant operation, transportation into the plant area mainly consists of light goods traffic. The ratio of heavy traffic is fairly small. The current average volume of maintenance and goods traffic into the plant area is 20–30 vehicles per day. Most of the transportation takes place during the day between 9am and 4pm. The OL3 and OL4 plant units will not significantly increase the amount of goods traffic during operation. Within the plant area, operating waste is transported into the VLJ repository. Used nuclear fuel is transported into the KPA storage. The impact of nuclear fuel transportation is estimated in chapter 9.1.5.

9.3.4 Commuter traffic

Journeys to and from work constitute a major part of the traffic to the plant area. With the completion of OL3 and the final disposal facility, the number of employees will increase to an approximate total of 1,400–1,500. Approximately half of the people working in Olkiluoto commute by bus and half by car.

The new plant unit (OL4) will employ approximately 200–300 people, increasing the number of employees in the plant area to approximately 1,700. Depending on where the new employees live, there may be additions to the bus schedules. Commuter traffic mainly focuses on the hours between 7 and 9 am and between 4 and 5 pm.

9.3.5 The impact of transportation and other traffic

Table 9-3 presents the Olkiluodontie traffic volumes under current circumstances, the situation corresponding to the zero option and after the completion of OL4.

The residential area along the roads leading to Olkiluoto, as well as other circumstances, have been described in the chapter discussing the impact of transportation during construction.

The traffic for the new OL4 plant unit will increase the Olkiluoto traffic volume by 25 % after completion compared to the zero option with units OL1, OL2 and

Figure 9-13 Traffic prediction for the new Olkiluoto entrance road and Satamatie. The figure includes the traffic volumes for the 2007 situation and the predicted volumes for 2015 and 2020 during normal operation and annual maintenance outages (Ramboll Finland Oy 2007a).

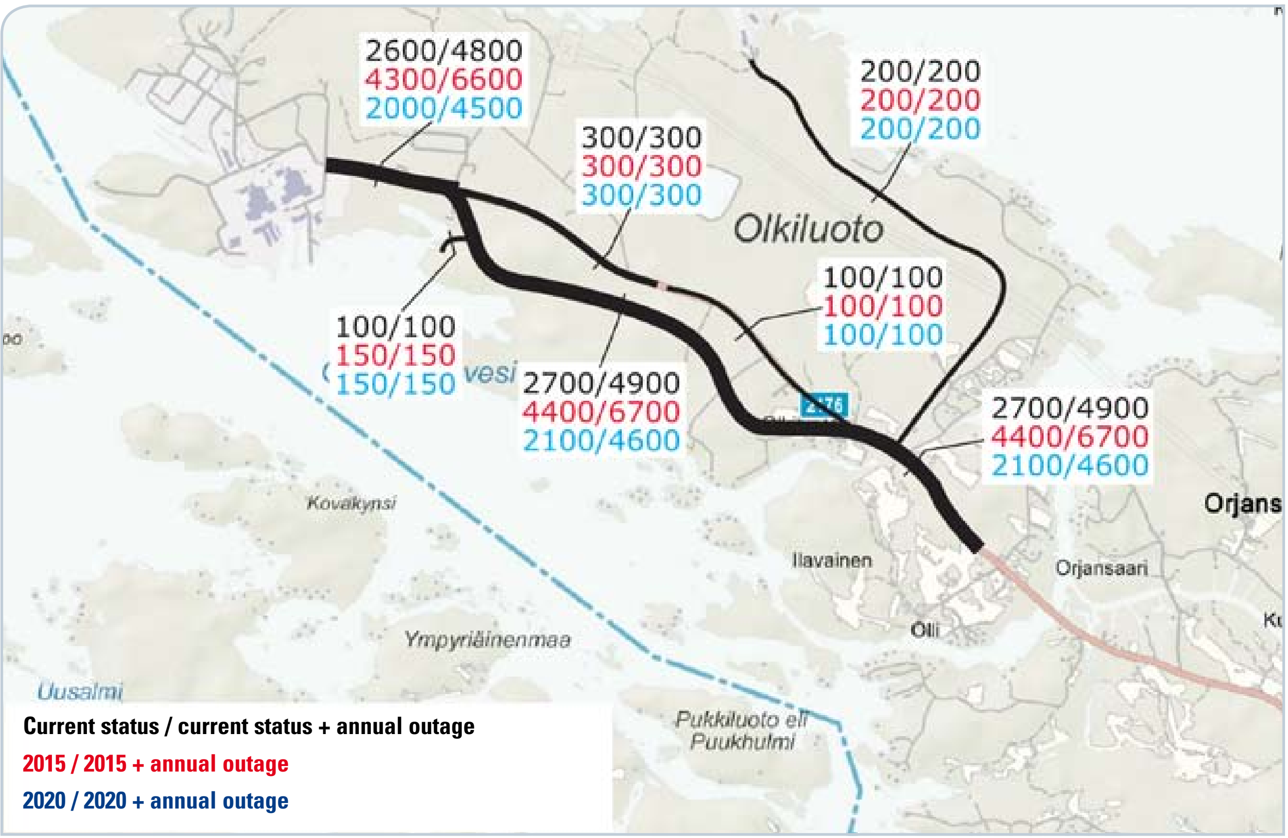


Table 9-4 Emissions of Olkiluoto traffic as well as the total emissions of traffic in the Rauma and Eurajoki region in 2006.

Type of emission	tonnes/a [1]		
	Zero option [2]	OL4 completed [3] 2020	Total emissions of traffic in Rauma and Eurajoki in 2006
Sulphur dioxide, SO_2	0.1	0.1	0.5
Nitrogen oxides, NO_x	17	22	340
Particles, PM	0.6	0.8	18
Carbon monoxide, CO	76	100	1,432
Carbon dioxide, CO_2	2,240	2,900	80,700

1) *The roads: Highway No. 8 (Rauma–Eurajoki), Highway No. 2176 to Olkiluoto, the roads: Hankkila–Sorkka–Rauma and Hankkila–Linnamaa–Eurajoki*
2) *OL1, OL2 and OL3 in operation, disposal facility completed*
3) *OL1, OL2, OL3 and OL4 in operation, disposal facility completed*

OL3 and the final disposal facility in operation. After the completion of the OL4 plant unit, the Olkiluoto traffic volume would be 2,000 vehicles per day. During annual maintenance outages, the traffic volume would be about 4,500 vehicles.

The increase in traffic during normal operation will not significantly increase the inconvenience caused to the roadside population by dust, noise or vibration from the traffic of the currently operational units. Compared to construction phase traffic, the traffic during operation will have a substantially lower impact. During operation, the share of heavy traffic is lower, and the traffic will mainly consist of private cars.

Part of the commuter traffic will take place in the morning at the same time that schools open, when the increased traffic may impact road safety.

Possible changes to improve traffic flow and safety in the traffic network have been described in chapter 13.1.1.

Traffic emissions

The road traffic emissions during the operation of OL4 were calculated for the following road sections: Olkiluodontie, Rauma–Olkiluoto, Eurajoki–Olkiluoto and highway no. 8 (between Rauma and Eurajoki), taking into account the division of traffic between each section. The emissions were calculated using the average unit emission factors for cars and heavy vehicles *(VTT 2006)*. Table 9-4 presents the emission levels.

With the commission of OL4, both traffic and emissions increase by a maximum of 30 % compared to the situation where OL4 will not be built. The traffic emissions during the operation of the plant have no significant impact on the traffic emissions in the Rauma and Eurajoki region.

Impact on waterborne traffic

The new plant unit has no impact on waterborne traffic on waterways shown on marine charts. The connection of Kuusisenmaa to the Olkiluoto island will prevent water traffic through the inlet between them. The rocky and shallow inlet is currently only suitable for small boats, and traffic has been slight.

9.4 Noise impact of the nuclear power plant

9.4.1 The current noise status of the Olkiluoto area

Noise impacts have been assessed based on the results of noise measurements carried out in the vicinity of the power plant area, the design data, the experience gained from other similar operations, noise modelling and the data and standards concerning the level of environmental noise.

Ramboll Analytics Oy has carried out a calculation on the noise from the current and planned operations in the Olkiluoto area in autumn 2007 *(Ramboll Analytics Oy 2007)*. The noise survey is largely based on the surveys carried out earlier (2005 and 2006). Noise calculations were made with the SoundPlan (version 6.3) programme, which uses a 3D landscape model and is based on a common Nordic road and industrial noise calculation model.

Noise zones were calculated for daytime ($L_{Aeq\ 7\text{-}22}$) and nigthtime ($L_{Aeq\ 22\text{-}7}$). The model considers the topography, the barrier and reflection effect of buildings and the damping effect of the soil. It was assumed that the soil dampens and the buildings and water areas reflect sound. The effect of trees and other vegetation was not considered in the survey. The modelling included the current buildings, the OL3 plant unit under construction and the new OL4 plant unit. Models were created for both of the options for the site of OL4. For traffic volumes, the information shown in the figure 9-13 was used. Traffic noise was calculated using the status of 2007. The increase in traffic caused by the annual maintenance outage was not considered. The information is taken from the traffic prediction based on the 2007 traffic volume calculations by Ramboll Finland Oy. The ratio of the night-time traffic was estimated at 10 %.

The area affected by noise releases from the new power plant units is typically 100 to 200 metres from the wall of the plant unit. The plant units will be designed so that within this distance, the noise level does not exceed 45 dB(A) during normal operation. In the environmental impact assessment, the observed area for noise release has been extended to approximately 2 km from the power plant. Previous noise measurement data exists for this area and has been used for comparison.

The main sources of noise at the plant include the turbines, generators and fans. The noise caused by them is a continuous faint humming around the clock. The plant unit is designed so that the noise levels in the environment will not exceed the target values set by authorities.

If the new plant unit is a pressurised water reactor, the steam circuit will have safety valves. Safety valves will be tested during annual maintenance. As the valve releases high pressure steam, a loud but short noise will emerge above the general noise of the plant area.

In addition to the current TVO plant units OL1 and OL2 and the construction site of the OL3 unit, the noise level of the Olkiluoto power plant area is affected by a wind power station, the ONKALO construction site of Posiva Oy, the harbour and the gas turbine power plant of Fingrid Oyj.

Measurements and calculations have been carried out in 2005, 2006 and 2007 to survey the Olkiluoto noise levels. The noise measurements on the nearby islands varied between L_{Aeq} 42–46 dB. The measurements were conducted during the daytime while the OL3 construction site was operating. Calculated noise levels at the nearest holiday homes in various circumstances varied between 36–38 dB at night in 2005 and 45–47 dB by day during construction. According to the results, the OL3 construction site may cause the daytime directive value for noise in holiday home areas (L_{Aeq} 45 dB) to be exceeded at the nearest holiday homes. However, the night-time directive was not exceeded in the situation prevailing in 2005.

According to noise calculations updated in 2006, the noise levels in the nearest affected location at a holiday home on Leppäkarta island will not exceed the daytime or night-time directive value after the OL3 unit is completed. In circumstances corresponding to normal operation, the noise level at the nearest holiday home on Leppäkarta island is 38–39 dB, which is lower than the night-time directive value for holiday home areas (L_{Aeq} 40 dB) *(Insinööritoimisto Paavo Ristola Oy 2006a)*.

9.4.2 Effects of the noise

The level and timing of noise vary in the construction and operation phases. Construction time noise effects have been discussed together with other effects of the construction phase in chapter 8.

During operation, a continuous, faint humming can be heard from the nuclear power plant 24 hours per day. This noise is easily covered by other sounds, such as the murmur of the sea, the sound of the wind or a boat engine. In calm weather, when water carries sounds far, the sound coming from the current plant units can be heard at the nearest holiday homes and islands. The closest permanent residences are located approximately 2–3 kilometres from the plant. The sounds of the power plant do not carry that far.

The noise effect of the new plant unit on nearby residences and holiday homes during operation will be diminished by its location further away from the shoreline and the southwestern tip of the peninsula than the current units OL1 and OL2 and the OL3 unit under construction are located.

The final disposal facility for spent nuclear fuel, also called the repository, will be extended as required when spent fuel is disposed of. During the extension work, the crushing of blasted stone will cause noise during the day. The disposal and the crushing of stone will end when the spent fuel to be placed in the Olkiluoto bedrock has been disposed of.

Noise levels are presented using the decibel unit (dB). The decibel reading is often followed by the letter A. This indicates a method of weighing the frequency distribution of a sound to correspond to the way the human ear responds to the sound. The following is a list of examples of the noise levels of different sounds:

• Auditory threshold	0 dB
• Tick of a wrist watch (1 m)	20 dB
• A quiet forest	20–30 dB
• Whisper (1 m)	30 dB
• An office	55 dB
• A conversation (1 m)	50–60 dB
• Office noise	65–70 dB
• A busy street (2 m)	70–80 dB
• A rock drill (7 m)	100 dB
• A concert (forte)	110 dB
• A rock concert	110–130 dB
• Pain threshold	130 dB
• A jet plane (2 m)	140 dB.

The results of the noise survey

The following figures show the daytime and night-time noise zones ($L_{Aeq\ 7\text{-}22}$ and $L_{Aeq\ 22\text{-}7}$) caused by the Olkiluoto operations for the zero option and for both location options of OL4. In all calculated situations, the noise levels remain below the target values at the nearest permanent residences and holiday homes during the day and at night alike.

In the zero option, when OL3 has been completed, the calculated daytime noise level during normal operations at the nearest holiday house on the island of Leppäkarta will be 41 dB. The corresponding noise level at night will be 38 dB ($L_{Aeq\ 22\text{-}7}$). The difference between the noise levels at night and by day at the nearest holiday homes on nearby islands would be approximately 3 dB. In addition to the slowing down of traffic flow, the difference is mainly due to the absence of stone crushing by night. The power plant units operate 24 hours per day. *(Ramboll Analytics Oy 2007.)*

The two-hour test drive of the gas turbine plant has no practical influence on the noise levels calculated for the whole day outside the plant area. The operation of the harbour has the most effect on noise levels north from Olkiluoto. The noise level caused by the harbour is approximately $L_{Aeq\ 7\text{-}22}$ 36–39 dB at a distance of 1–1.5 km from the Olkiluoto harbour in the direction of the holiday houses.

The completion of the OL4 plant unit at location option 1 will cause an increase of approximately 1 dB in the night-time noise level at the nearest holiday home on the Lepp äkarta island. Location option 2 has no practical difference to option 1 with regard to the noise effect on the Leppäkarta island. *(Ramboll Analytics Oy 2007.)*

Figure 9-14 *Zero option, day time noise levels.*

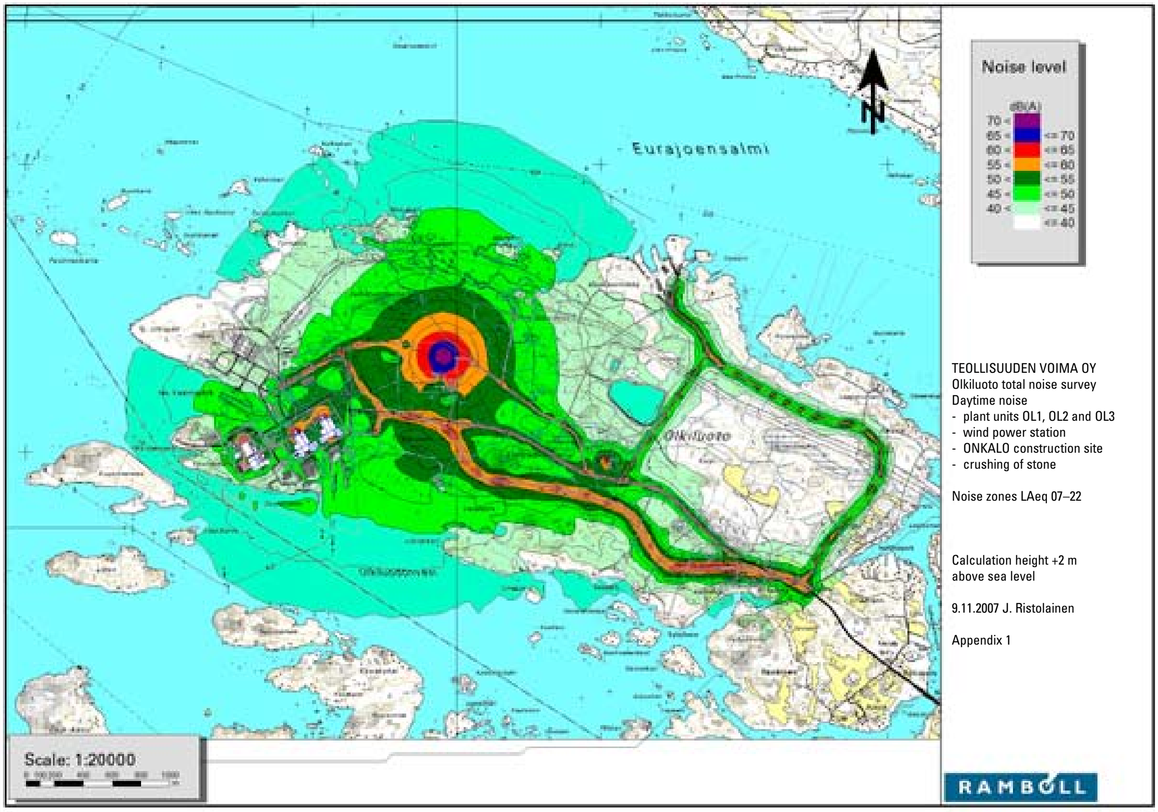


Figure 9-15 *Zero option, night-time noise levels.*

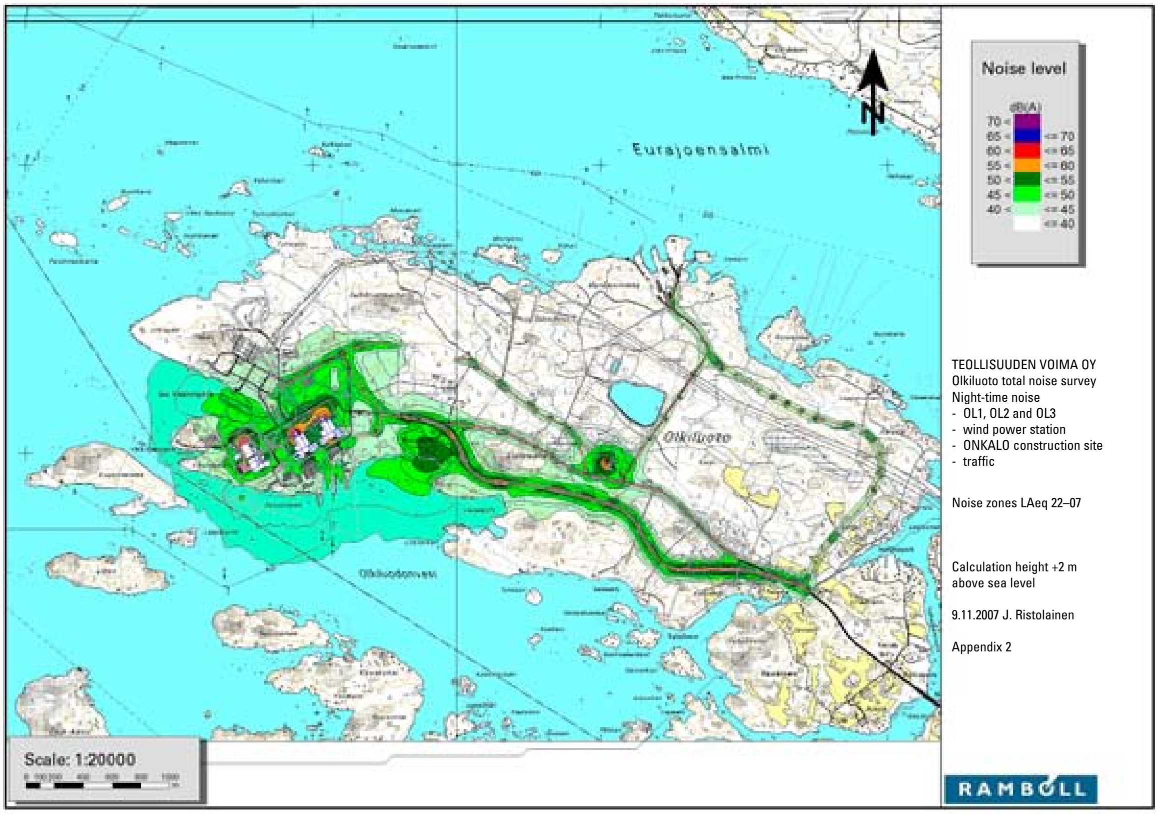


***Figure 9-16** OL4 location option 1, daytime noise.*

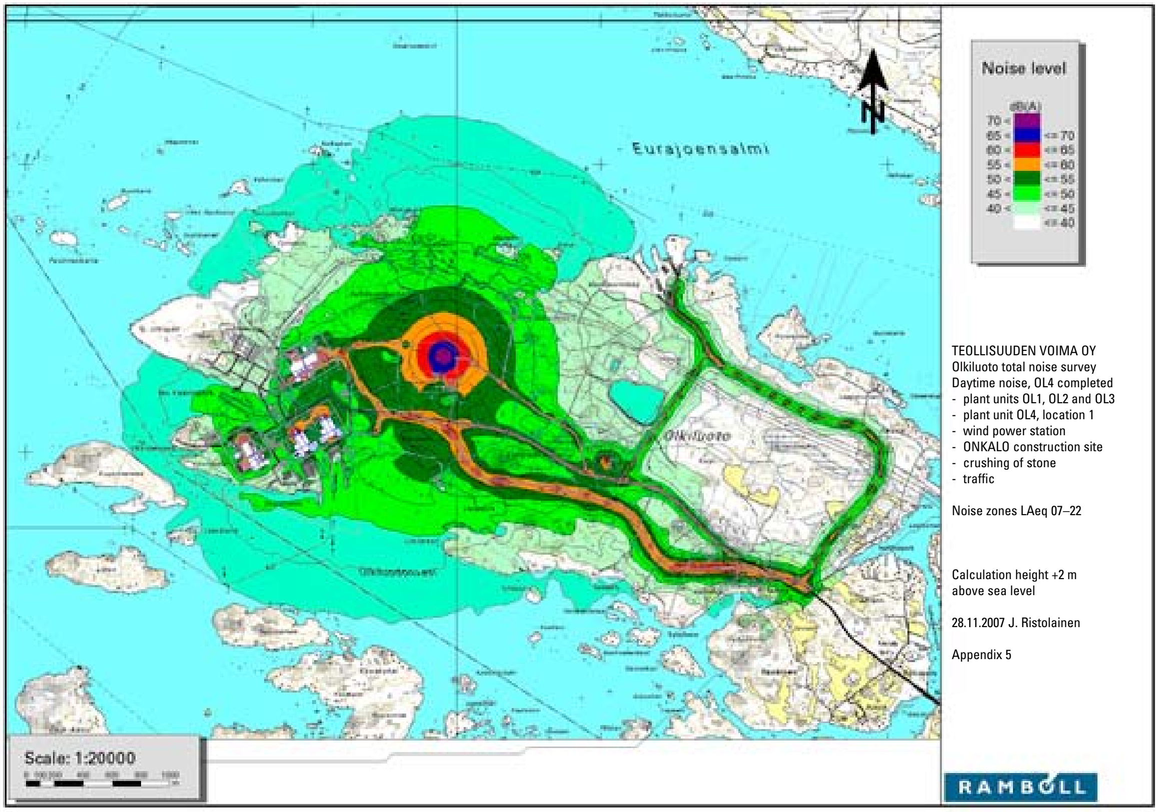


***Figure 9-17** OL4 location option 1, night-time noise.*

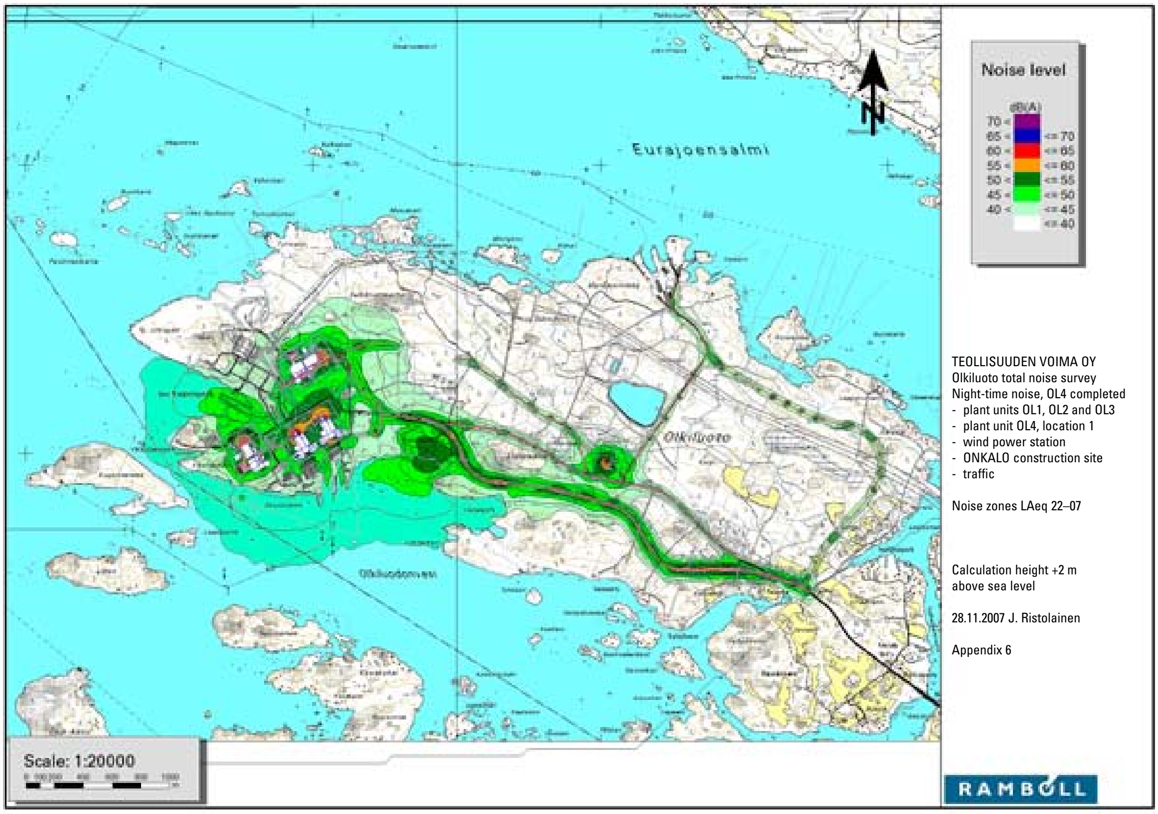


Figure 9-18 *OL4 location option 2, daytime noise.*

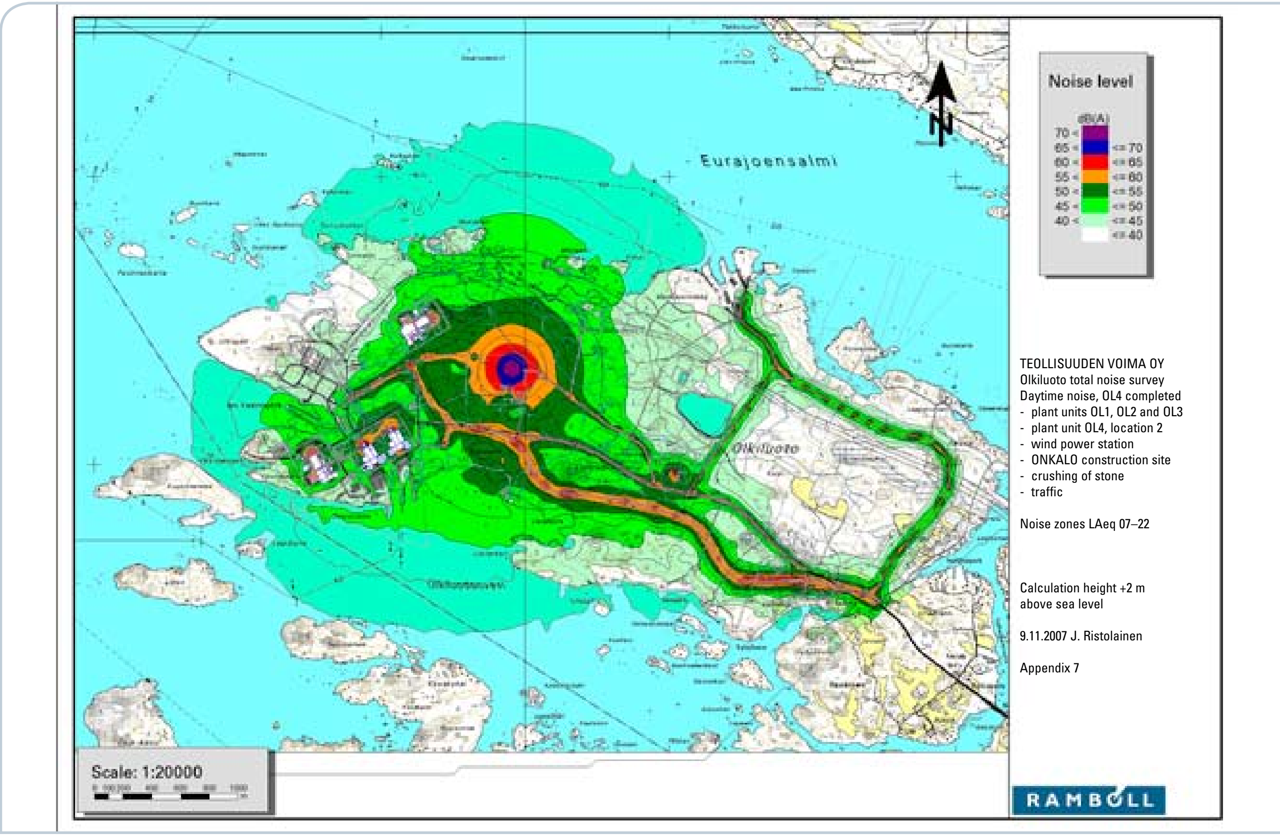
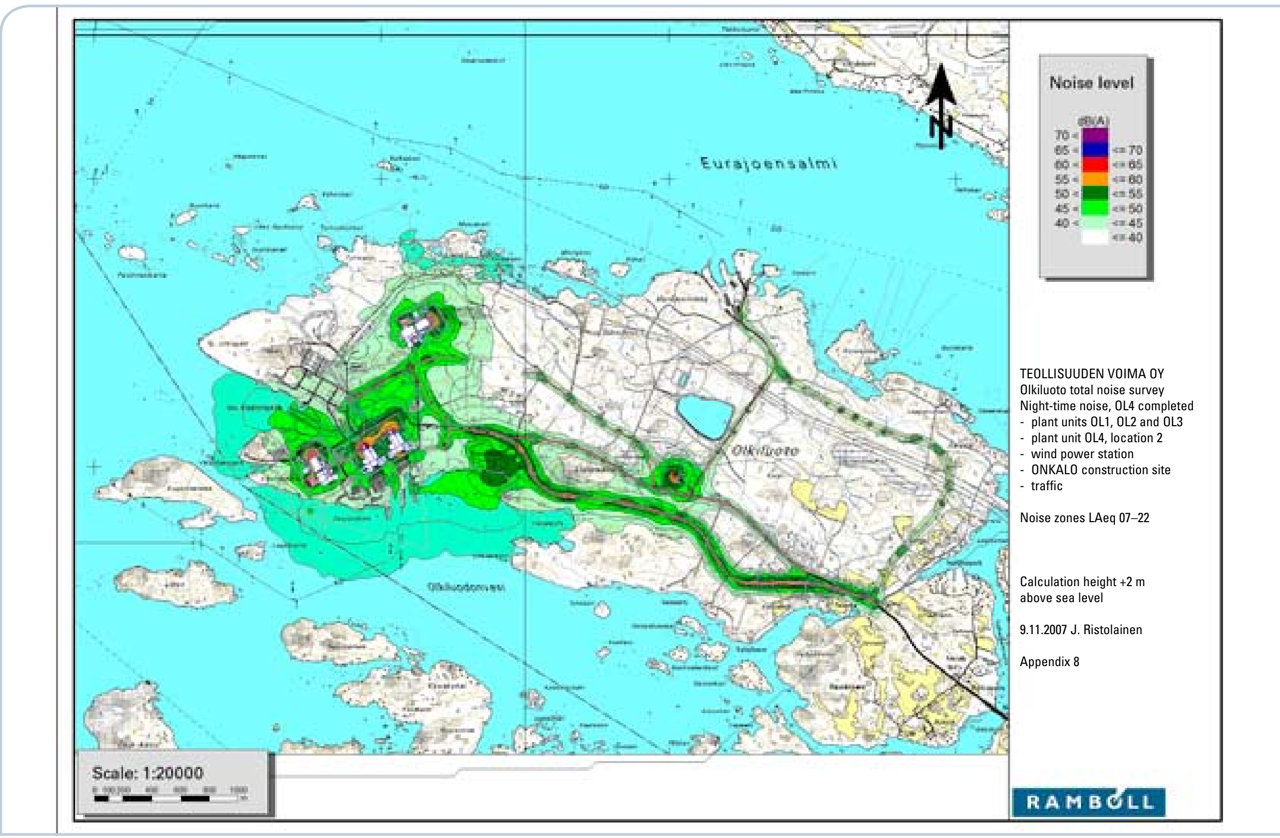


Figure 9-19 *OL4 location option 2, night-time noise.*



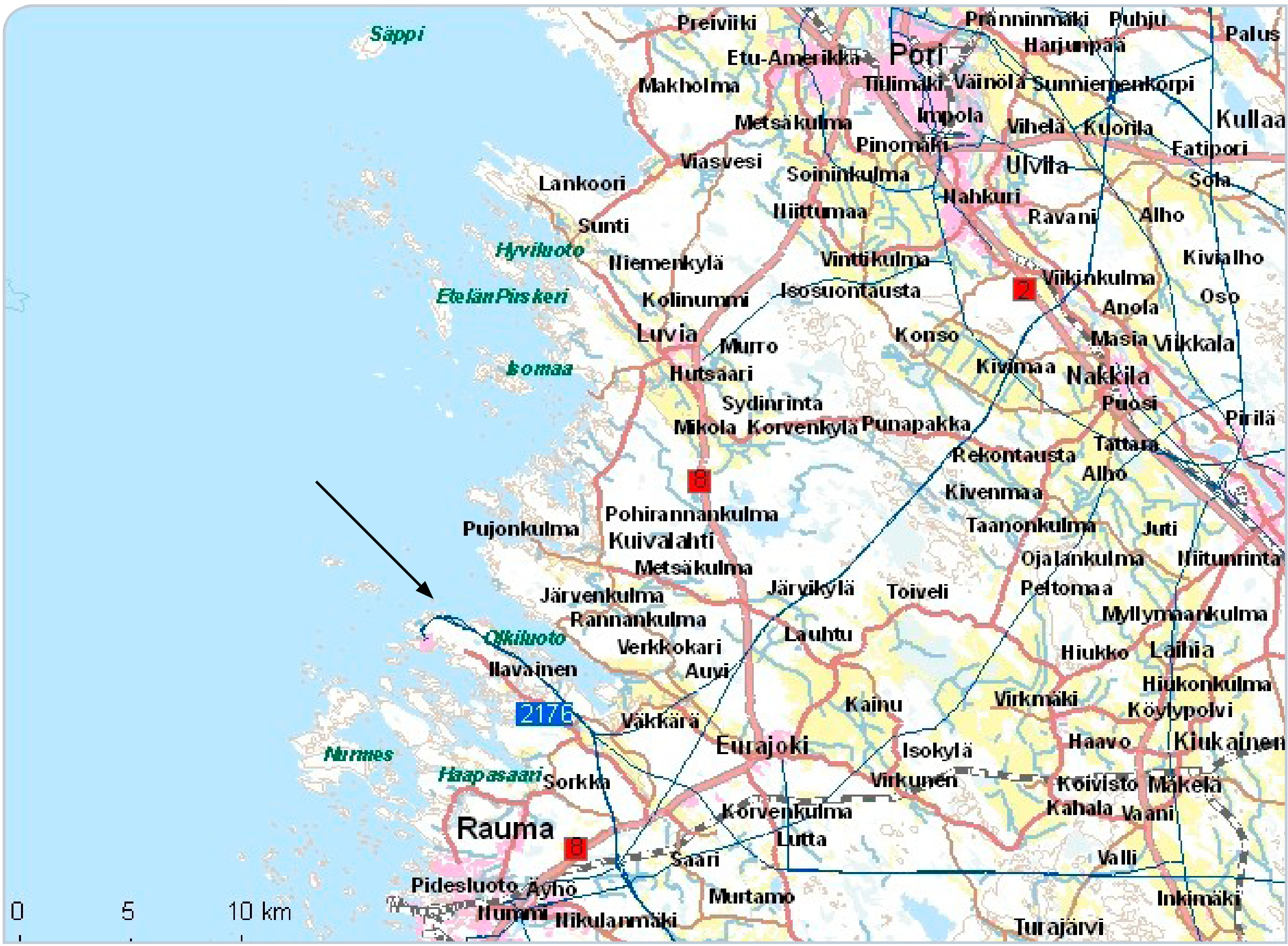


Figure 9-20 Villages and towns near Olkiluoto.

9.5 Impact on land use, landscape and the built environment

The project's impacts on landscape, present and planned land use, and the built environment have been assessed in terms of the land use plans and development of the area.

The impacts on the landscape have been assessed based on the plans prepared for the project, existing reviews and terrain visits, as well as map and air photo investigations. Landscape changes will be due to the plant unit itself and the related activities. The characteristics of the environment in the vicinity of the location site alternatives, as well as the sites of value in the landscape and cultural environment, have been described by means of text, maps and photographs. In the impact assessment, the question of whether the power plant unit will change the landscape characteristics of the sites, from which direction the view towards the location will change significantly, and whether significant impacts on the sites of value in the landscape and environment will arise have been examined. Changes to the landscape have been illustrated by photomontages. The impacts on residential and recreational areas in the vicinity of the location sites have been examined in particular detail.

The areas where the power plant buildings will be notably more visible than other landscape elements have been defined as the power plant project's observed area in terms of landscape. A vent stack approximately 100 metres high will be visible further than the actual power plant buildings.

9.5.1 Functions located in and around the area

The present Olkiluoto power plant site is located on the western half of the Olkiluoto island and has an area of approximately 350 hectares. The construction of the power plant at the site started in 1973. The site contains TVO's present power plant units OL1 and OL2. Furthermore, OL3 is under construction and is scheduled to start operation in 2011. In addition to the plant units, the site contains administrative buildings, a Training centre and a Visitors' centre, warehouses, repair shops, a back-up heating plant, a raw water tank, a raw water treatment plant, a desalination plant, a sanitary water treatment plant, a landfill, intermediate storage for spent fuel (KPA storage), intermediate storage for low-level and intermediate-level power plant waste (MAJ and KAJ storage), a disposal facility for power plant waste (VLJ repository), and accommodation villages.

Olkiluoto is also the location of Fingrid's power substation, TVO's wind power station, Fingrid's gas turbine power plant for back-up power purposes and, currently under construction, Posiva's underground research facility ONKALO.

The power plant is connected to the national grid by three 400 kV and two 110 kV power lines. The Olkiluoto 400 kV substation is located on the northern shore of the island approximately two kilometres from the power plant. The 110 kV substation is located in the immediate vicinity of the power plant on its northern side.

To the east of the power plant site, Olkiluoto island is mainly forest. In the middle of the northern shore of the island, Olkiluoto's industrial harbour is located. The eastern end of Olkiluoto island contains agricultural areas and holiday homes. The area contains a new accommodation village and caravan park providing temporary housing for nuclear power plant construction and maintenance personnel.

TVO owns most of Olkiluoto. In the eastern parts of the island, there are holiday homes and empty holiday home sites as described by the master shore plan of the area, and a few privately-owned larger areas. The state owns the Liiklankari conservation area and the western part of the Kornamaa island. The Liiklankari area is governed by Metsäallitus.

TVO owns some of the waters around Olkiluoto directly and some through joint ownership. TVO owns approximately 69 % of the water rights of Olkiluoto and Orjasaari, as well as approximately 33 % of the Munakari joint area.

Eurajoki village centre is located approximately 16 kilometres east of Olkiluoto. Rauma town centre is located approximately 13 kilometres south of Olkiluoto, Luvia central village approximately 16 kilometres northeast and Pori approximately 32 kilometres northeast. The map 9-20 illustrates the locations of Eurajoki and Olkiluoto.

Hankkila, the village closest to Olkiluoto, is located approximately 8 kilometres from the power plant site. Linnamaa, which is located approximately 10 kilometres from the power plant site, belongs to the Vuojoki cultural landscape that includes the Vuojoki mansion area and the Liinmaa castle ruins from the 1360s. The Kuivalahti village centre is located to the north of the Eurajoensalmi inlet approximately 9 kilometres from the power plant site, and Lapijoki village centre is located along highway 8 approximately 14 kilometres from the power plant site. The nearest village centre in Rauma is called Sorkka and is located approximately 9 kilometres to the southeast of the power plant site.

9.5.2 Status of land use planning

National land use objectives

The national land use objectives are part of the land use planning system in accordance with the Land Use and Building Act. The Government decided on national land use objectives in accordance with Section 22 of the Land Use and Building Act on 30 November 2000 and the decision gained legal validity on 26 November 2001. The Government decision divides the national land use objectives into six categories:

1. a functioning regional structure;
2. an integrating community structure and quality of the living environment;
3. cultural and natural heritage, recreational use and natural resources;
4. functioning networks of connections and energy;
5. special issues in Greater Helsinki; and
6. special regions with regard to natural and cultural environments.

The objectives are intended to serve as a tool for the proactive guidance of land use planning related to nationally significant issues. The objectives must be taken into account in master planning and also in local planning when the plans are associated with nationally significant issues. However, decisions of a principal nature, which are crucial for meeting the objectives at the municipal level, are often made in master plans. *(Ministry of the Environment 2003.)*

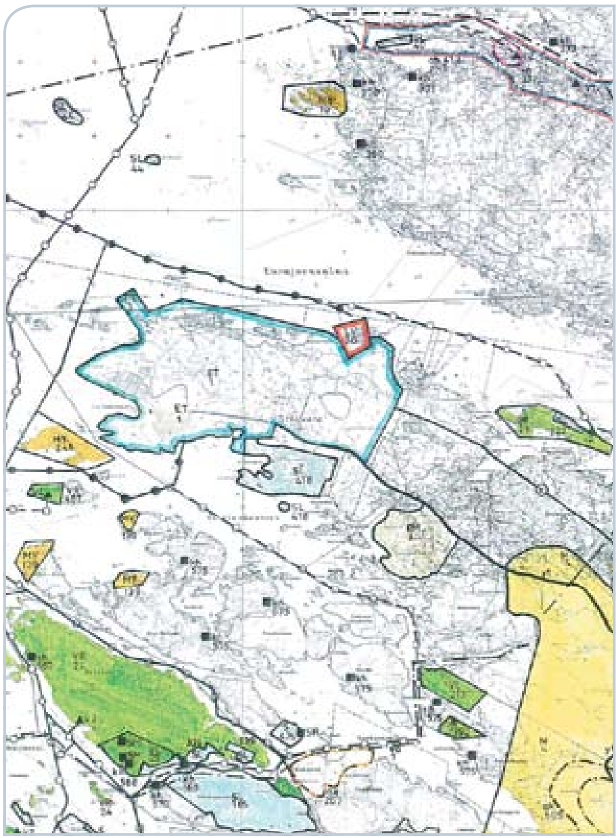
Objectives aimed at securing the national energy supply are of particular importance in the preparation of a partial master plan for Olkiluoto. Land use must ensure the protective zones required for nuclear power plants and prepare for the disposal of nuclear waste. Land use and its planning related to networks of connections and energy must pay attention to surrounding land use and the nearby environment, particularly settlements, valuable natural and cultural sites and areas, as well as the special characteristics of the landscape.

In addition, land use planning must pay attention to the power line routes that have significance to national energy supply so that the lines can be constructed when necessary.

The current regional plan

In the Satakunta regional plan 5 ratified by the Ministry of the Environment on 11 January 1999, the TVO site is designated as a community management zone (ET-1). According to the special provisions concerning the zone, detailed planning and design must pay special attention to environmental protection, and the handling and storage of radioactive waste must be arranged in a completely safe manner. Furthermore, the regional plan also allows other

Figure 9-21 *An extract from Satakunta regional plan 5.*



energy production besides the nuclear power plants, as well as other industry based on the energy production in the region.

There is a harbour and a dockyard (LV) in the north-eastern part of Olkiluoto. The protected Liiklankari old-growth forest (SL) is located to the east of the power plant site. Kuusisenmaa (MY, area dominated by agriculture and forestry, environmental value) is located to the southwest of Olkiluoto.

The Olkiluoto nuclear power plant site is surrounded by a hazard zone (va1, remote protection zone) extending to a distance of approximately 5 to 7 kilometres. In detailed planning and design, this zone must not be used for any large residential areas or facilities with a large number of employees or patients, or any facilities whose operations would be severely hampered by the potential effects of an accident. Furthermore, the zone must not be used for any facilities or equipment that could be a danger to the nuclear power plant, such as explosives factories, warehouses or airports. *(Satakunta regional plan 5, 2001.)*

Provincial plan in preparation

The Satakunta Regional Council is preparing a provincial plan that will replace the current regional plan. The preparation of the Satakunta provincial plan was initiated in February 2003. The provincial plan is currently at the drafting stage. The current regional plan from 2001 will be revised and updated to comply with the requirements of the Land Use and Building Act. The provincial plan will include a general provision for an energy supply zone (EN) and designate power lines, a regional road, navigable passages for ships and boats, and conservation areas. The draft should be available for public viewing during 2008.

Master plans

The Eurajoki master shore plan ratified by the Southwest Finland Regional Environment Centre on 25 October 2000 is valid in the Olkiluoto area. The power plant site and the surrounding areas are designated as a zone for industrial and warehouse buildings (T). Most of the area east of the power plant site is designated as a zone dominated by agriculture and forestry (M). The master shore plan also includes zones for holiday homes (RA), farmsteads (AM) and detached residential houses (AP). The Liiklankari area located along the southern shore of the Olkiluoto peninsula is designated as a nature conservation area (SL).

Eurajoki Municipal Council approved an amendment to the master shore plan on 12 December 2005, assigning an accommodation village and other functions serving energy production to the southeastern part of Olkiluoto.

Figure 9-23 *Amendment to the master shore plan assigning an accommodation village and other functions serving energy production in the south-eastern part of Olkiluoto.*

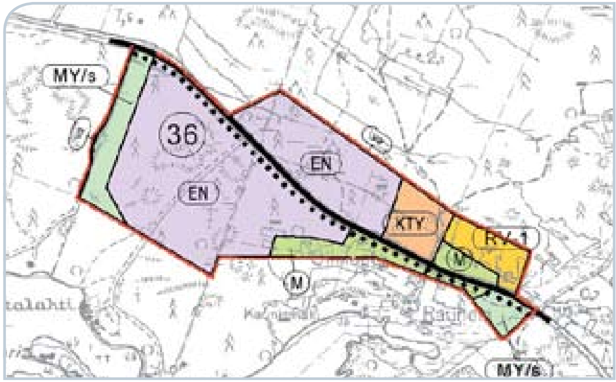
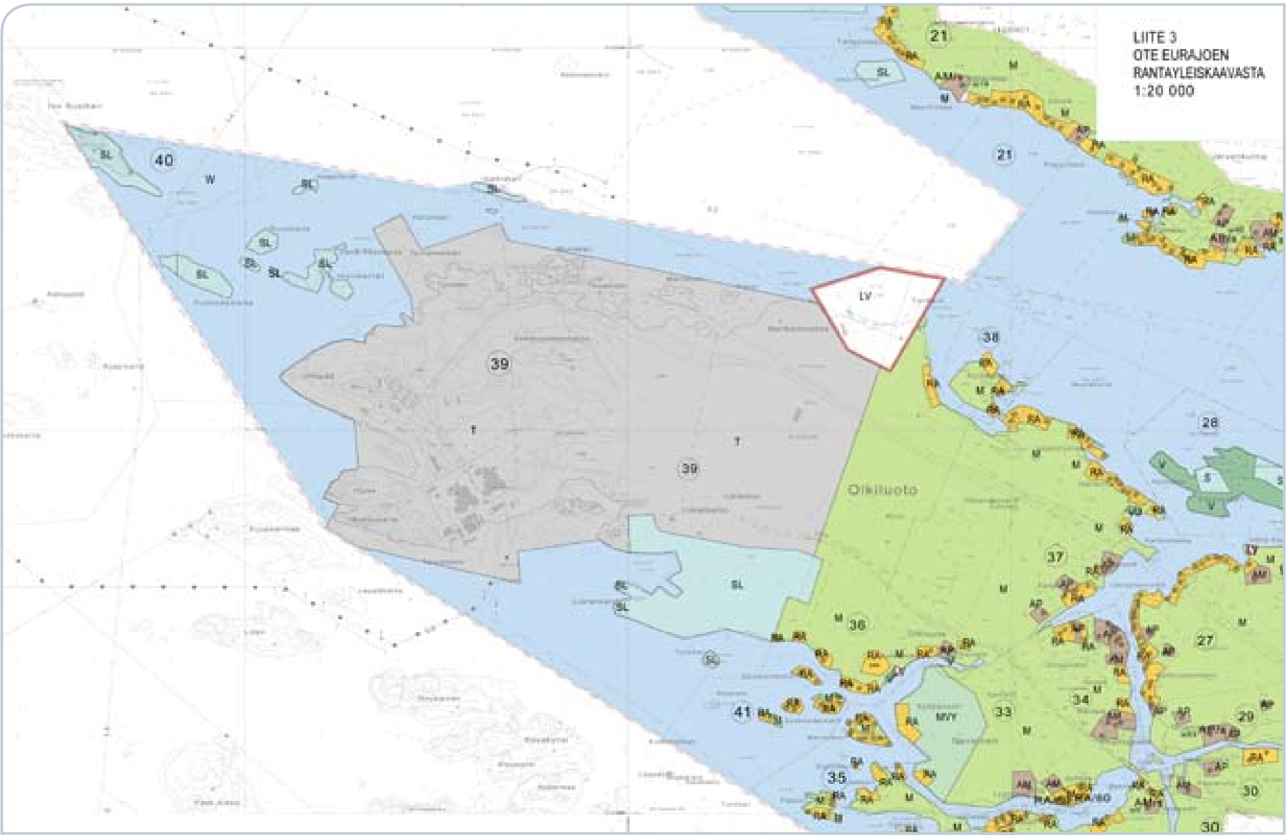


Figure 9-22 *Extract from the Eurajoki master shore plan. The options for the site of a new plant unit are designated as a zone for industrial and warehouse buildings (T).*



The partial master plan for the northern shores of Rauma ratified on 23 December 1999 is valid in the coastal areas of Rauma. With regard to the islands to the southwest and south of Olkiluoto, this plan designates Kuusisenmaa as an agricultural and forestry zone (M-1), while the southern bay is a boat harbour (LV-1). Leppäkarta is designated as a zone for holiday homes (RA). Lippo includes recreational zones (V), agricultural and forestry zones (M) and zones for holiday homes (RA).

Amendment to the partial master plan

The Olkiluoto partial master plan and an amendment to the partial master plan for the northern shores of Rauma are under preparation in the Olkiluoto area.

On 18 April 2006, the Municipal Board of Eurajoki decided that a legally binding partial master plan will be prepared for the Olkiluoto area. Within the municipality of Eurajoki, the partial master plan covers Olkiluoto, minor islands to its north and northwest (Kornamaa, Mäntykari, Munakari and approximately 20 smaller islands), and the waters surrounding them. The partial master plan will amend the Eurajoki master shore plan ratified on 25 October 2000 and the amendment to the master shore plan approved on 12 December 2005 (the area known as the accommodation village with its surroundings).

Simultaneously with the Olkiluoto partial master plan, an amendment to the partial master plan for the shores north of Rauma has been in preparation. Within the town of Rauma, the area covered by the plan includes the islands of Kuusisenmaa, Leppäkarta, Lippo and Vähä-Kaalonperä off Olkiluoto, as well as the waters surrounding these islands. The partial master plan is an amendment to the partial master plan for the northern shores of Rauma ratified on 23 December 1999.

The draft partial master plan of Olkiluoto was available for public viewing in accordance with Section 62 of the Land Use and Building Act from 21 February to 22 March 2007. The plan proposal was completed on 31 October 2007, and was available for public viewing from 13 November to 12 December 2007.

Several land use options were discussed during the preparation of the Olkiluoto partial master plan. The planning aims at a solution that realises the objectives set for a partial master plan in the best possible manner. The primary objective is to create, with regard to land use, the prerequisites for building the largest energy production site in Finland and a final disposal facility for spent nuclear fuel according to Finnish legislation and the requirements set for the safety of the operations. Special attention was paid to the road network, power line routes and cooling water arrangements.

The draft for the amended partial master plan for the northern shores of Rauma was also available for public viewing from 21 February to 22 March 2007. The plan proposal was completed on 31 October 2007, and will be available for public viewing during the first half of 2008.

Local plan and local shore plan

Local plans ratified in 1974 and 1997 are valid in the area of the existing nuclear power plant units. The power plant site is designated as a zone for industrial and warehouse buildings (T) allowed for nuclear power plants, other facilities and equipment intended for the production, distribution and transmission of power, as

Figure 9-24 *An extract from the partial master plan for the northern shores of Rauma.*

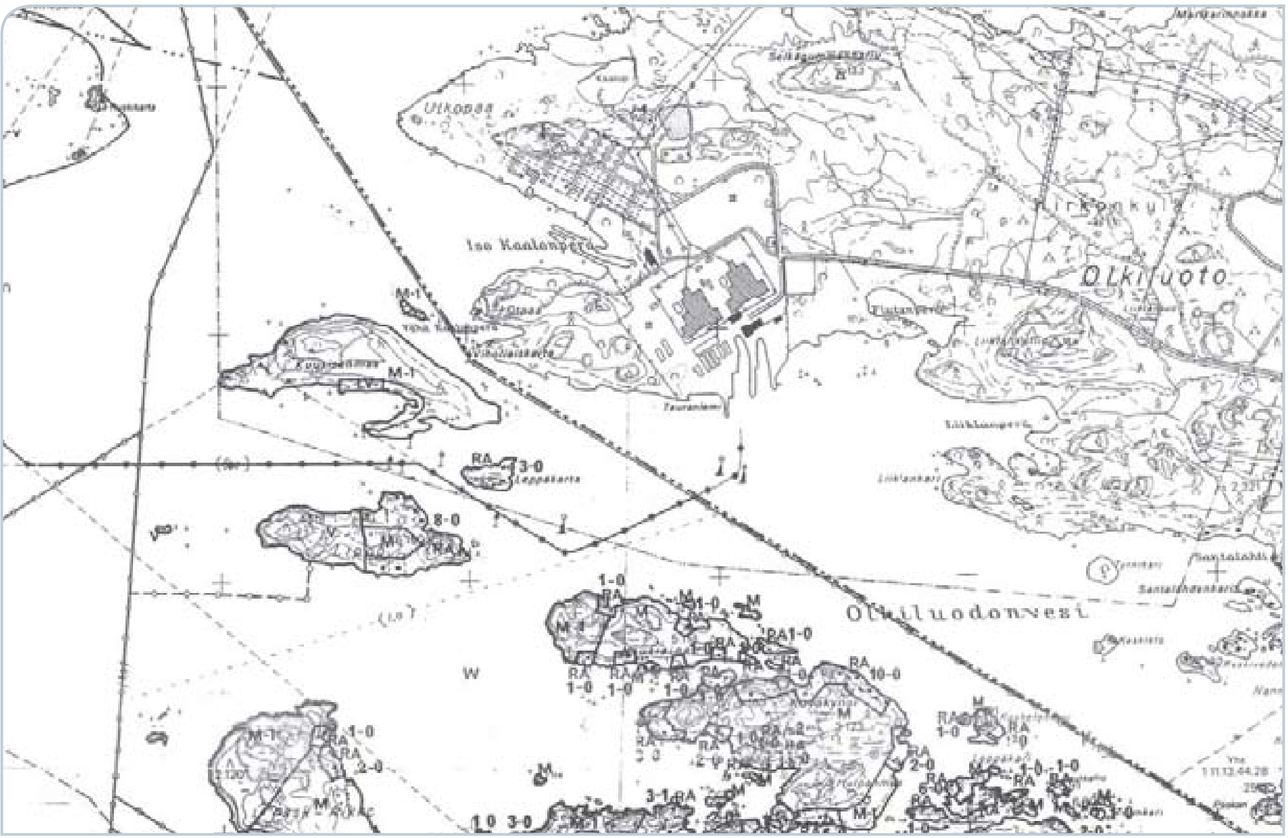


Figure 9-25 *An extract from the proposal for a change to the Olkiluoto partial master plan, 31.10.2007. In the proposed partial master plan for Olkiluoto, the options for the site of the new plant unit are located in a zone for energy supply (EN).*

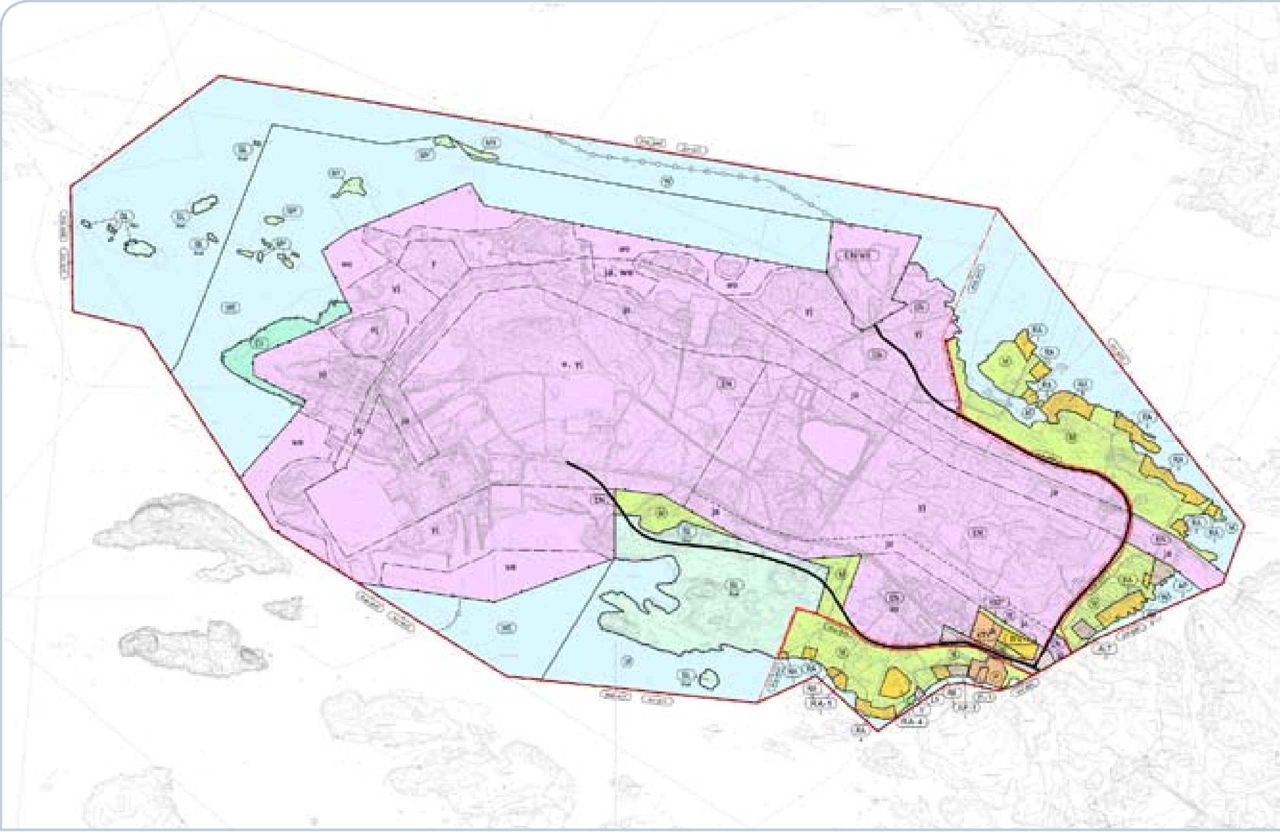
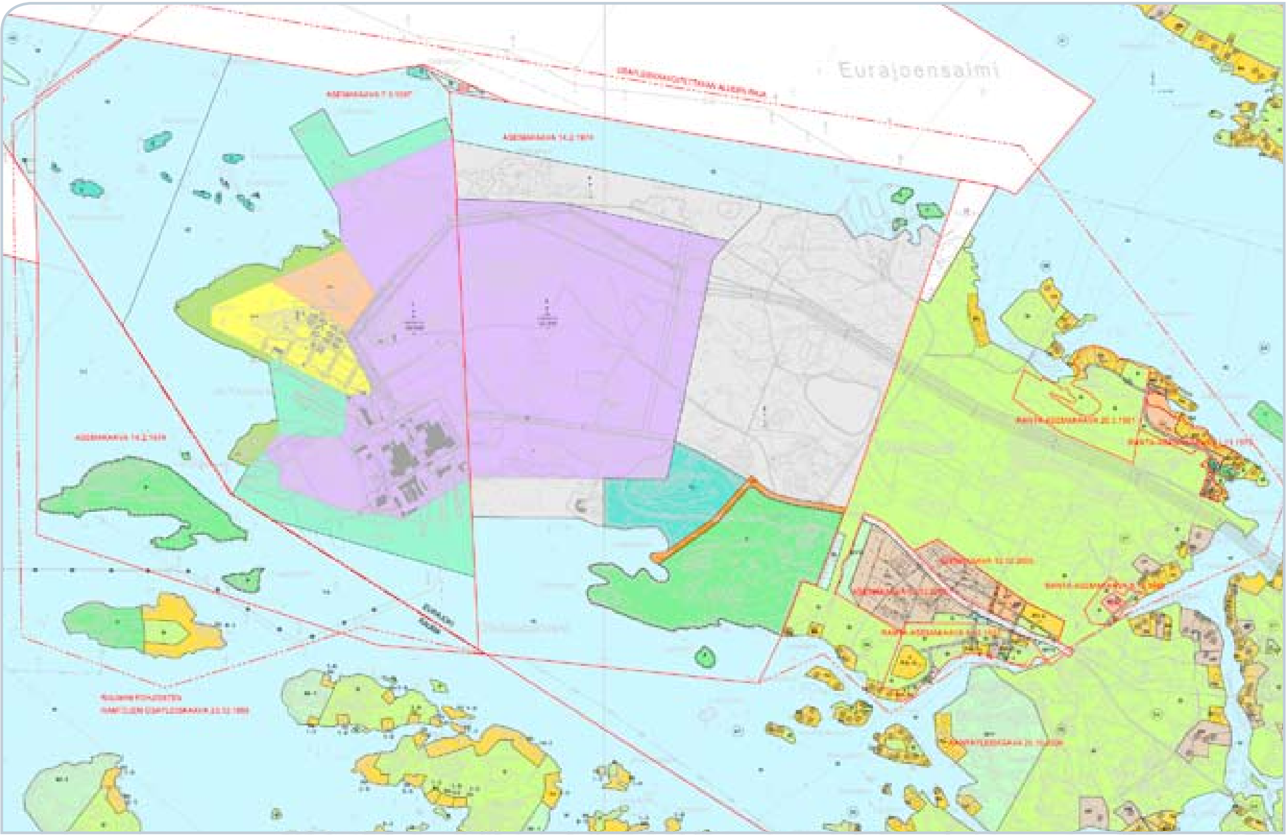


Figure 9-26 *Proposal for a partial master plan for the northern shores of Rauma 31.10.2007.*

Figure 9-27 *The status of local plans for the planned area of Olkiluoto and the northern shores of Rauma, with the power plant site designated as a zone for industrial and warehouse buildings (T).*



well as buildings, structures and equipment associated with these, unless otherwise restricted. The Liiklankari area is designated as a park (P) and a special zone (EL).

On 12 December 2005, Eurajoki municipal council approved two local plans defining a zone for accommodation buildings serving energy production (ASEN), a zone for office buildings (KTY), a zone for a caravan park serving energy production (RV-1EN), a tower zone (EMT), a protective green zone (EV), an agricultural and forestry zone (M), and an agricultural and forestry zone with special environmental values (MY/s) in the southeastern part of Olkiluoto. The plan defines an accommodation zone that must have capacity for seasonally accommodating 500 people. The area must also have connection points for temporary accommodation housing 500 people, 150 caravans and businesses serving the accommodation area (café, restaurant, grocery shop/kiosk, etc.). The project is closely linked to the construction of the third nuclear power plant unit in Olkiluoto (OL3), which started in 2005. The accommodation area and its facilities are needed for the construction workers and, in the future, for accommodating employees during annual maintenance outages, for example. The area partially replaces the accommodation area close to the power plants, the use of which will become more difficult with the construction of OL3.

There are three ratified local shore plans for the eastern parts of the Olkiluoto island, ratified on 11 November 1975, 20 March 1981 and 8 December 1992. The plans assign holiday homes to the shore area.

Amendment of the Olkiluoto local plan

Within the municipality of Eurajoki, the amendment of the local plan concerns Olkiluoto, minor islands to the north and northwest of it (Kornamaa, Mäntykari, Munakari and approximately 20 smaller islands), and the waters surrounding them. Within the town of Rauma, the area covered by the plan includes the islands of Kuusisenmaa, Leppäkarta and Vähä-Kaalonperä off Olkiluoto, as well as the waters surrounding these islands. The preparation of amendment process begun at the end of 2007.

9.5.3 The present landscape and cultural environment

Landscape

The Olkiluoto island is located in the municipality of Eurajoki on the coast of the Botnian sea area. Typical characteristics of the Botnian sea coast include capes pointing to the northwest, shallow bays between them and archipelago zones of a small area.

In the division of landscape regions, the Olkiluoto area belongs to coastal Satakunta. The region is characterised by low-lying terrain and the absence of strong profiles: in addition to rocky land, it includes glacial deposits, small areas of clay soil and ridge formations. The coast has long sheltered bays dominated by cane-grass that are turning to land due to land uplift at approximately seven millimetres per year.

The Olkiluoto island is approximately 6 kilometres long and 2.5 kilometres wide. The Botnian sea area opens to the west of the island, while its southern side abuts on the Rauma archipelago. The Lapinjoki river discharges to the east of Olkiluoto island, into a narrow inlet between Olkiluoto and Orjasaari. The Eurajoki river discharges into the Eurajoensalmi inlet north of the island.

Figure 9-28 *Olkiluoto island seen from the sea. The existing plant units OL1 and OL2 and the OL3 construction site on the right.*

The waterways separating Olkiluoto from the mainland are slowly closing up. The highest points of the Olkiluoto island are the Selkänummenharju ridge, approximately 15 metres above sea level, and the Liiklankallio clifftop, approximately 18 metres above sea level. The Olkiluoto landscape can be roughly divided into the following zones:

- the inland forest zone
- the shorelines: forest, part rocky
- the inhabited zone on the southern and eastern shores
- the industrial zone at the western end of the area (power plant site) and at the northern shore (the harbour).

The forest zone is divided by a wide power line clearing and the Olkiluodontie road. In the wooded inland zone there are operations related to the power plant, not visible in the overall landscape or to the roads. The most visible element of the wooded zone is the accommodation village on both sides of the road.

From the sea, Olkiluoto looks like a forest area with the following elements indicating power plant operations: the plant buildings with their vent stacks, the wind power station and the power lines, visible from a long distance. The industrial harbour with its cranes stands out from the wooded northern shoreline. *(Air-Ix Suunnittelu 2007.)*

Cultural history

Olkiluoto has mainly been a part of the Vuojoki estate. The central and western part of the island was uninhabited forest land, used as a pasture for the horses of the estate. On the eastern side, there were small farms owned by fishermen. These farms had forest pastures and small fields, which are still nearly the same size and have been continuously cultivated. There was no proper road to the island until the 1960s. The first phases of the Olkiluoto power plant were built in the 1970s. There are small fisher farms in the nearby islands, some of which have been pulled down and some extended and renovated as holiday homes. The oldest buildings on Olkiluoto were built in the first half of the 20th century. Most of the buildings date from the reconstruction period after the Second World War or from later periods. Holiday homes have been built since the 1960 and 1970s. *(Air-Ix Suunnittelu 2007.)*

There are no nationally or regionally valuable buildings or other objects of cultural history in the area *(National Board of Antiques 2007)*. No relics of antiquity are known in the Olkiluoto area *(Air-Ix Suunnittelu 2007)*.

9.5.4 Impact on land use

The Land Use and Building Act (132/1999) and Decree (895/1999) regulate the planning related to construction and the use of land. The provincial plan and master plan are general land use plans, used for long-term planning. A local plan is prepared for the detailed organisation of land use and for the building and development of an area. Buildings may not be constructed in the water-front in the shore area of the sea or a body of water without a local detailed plan (local shore plan) or a special master plan. When deciding about a land use plan and a construction permit, the authorities consider the special requirements pertaining to construction work on the nuclear power plant site and in its surroundings *(YVL guide 1.10.)*.

The new plant unit will be located on the Olkiluoto power plant site. In the current local plan, the area has been designated for industrial and warehouse buildings (T) and may be used for the construction of nuclear power plants and other facilities, equipment and components intended for power production, distribution and transmission, as well as accommodation and other buildings, constructions and equipment related to these. The actual nuclear power plant buildings will be located on zones indicated by the letter a.

The local plan also indicates water areas that may be filled or banked up and in which landing places, structures and equipment needed by the power plants may be built. The construction of a new plant unit complies with the currently valid local plan, and does not conflict with the partial master plan and local plan under preparation, or with any plan indications related to these.

The construction of the new unit requires some rearrangements in the plant area, for example, for the traffic routes. Also the choice of the cooling water discharge location causes some changes to the plant area. Discharging the cooling water at Tyrniemi (option B) disrupts the currently intact forest and shore zone.

The normal operation of the nuclear power plant or anticipated operational transients does not limit land

Figure 9-29 *Olkiluoto island seen from the sea. The photomontage shows the existing plant units OL1 and OL2, the OL3 plant unit currently under construction in its completed form and OL4 on the left.*

use off-site. In the environment surrounding the nuclear power plant, however, precautions in the form of land use and public protection plans shall be taken with a view to the possibility of a severe accident. This means, among other things, that in the plant's vicinity there may not be facilities or population centres where any necessary protective measures, such as sheltering indoors or evacuation, would be difficult to implement. In the plant's vicinity, no activities may be carried out that could pose an external threat to the plant.

A nuclear power plant site is defined as an area where only power plant related activities are allowed as a rule. A permit is required for entering the area and moving within it. The plant site extends to approximately one kilometre from the buildings. The plant site is surrounded by a protective zone extending to about five kilometres' distance from the facility. Land use restrictions are in force within the protective zone. Dense settlement and hospitals or facilities inhabited or visited by a considerable number of people are not allowed within the protective zone. The zone may not contain such significant productive activities that could be affected by an accident at the nuclear power plant. The number of permanent inhabitants should not be in excess of 200. The number of persons taking part in recreational activities may be higher, provided that an appropriate rescue plan can be drawn up for the area.

These limitations have been observed in the planning of the Olkiluoto area and in the preparation of the provincial plan. Locating a new plant unit within the five kilometre protective zone will cause no significant changes.

The permanent population of Olkiluoto island is very low. The nearest houses are located approximately three kilometres from the power plant site *(TVO 2004)*.

There are holiday homes on the Olkiluoto island and the nearby coastal areas and islands. Approximately 550 holiday homes are located within five kilometres of the power plant site. The nearest holiday homes are located on the northern coast of Olkiluoto (Munakari) and the Leppäkarta island, approximately one kilometre from the nuclear power plant units. Munakari and its cottages are owned by TVO and used for the recreation of TVO personnel. Leppäkarta is located to the southwest of the power plant. There is a high number of holiday homes within 1.5 to 2 kilometres, for example, on the islands Lippo, Nousiainen and Kovakynsi.

The power line's impact on land use is discussed in section 0.

9.5.5 Impact on the landscape and the built environment

The new power plant will be located within the Olkiluoto power plant site and will utilise the existing infrastructure of the area. There are two possibilities for the location of the new unit within the plant site. Both options are located to the north of the existing units.

The plant units already dominate the landscape of the area. The construction of the new unit will add another large building to the whole, but will not essentially alter the character of the area. When seen from the south from the sea or the islands, both location options are partly covered by the existing units. From the west, both options will add to the size and visibility of the power plant complex.

Placing the cooling water discharge structure at Tyrniemi (option B) would disrupt the intact north-eastern shore of Olkiluoto.

In the wider landscape, the tops of the reactor buildings and their vent stacks are visible far out to the sea. The new unit will add a fourth similar element to the complex. The impact of the new unit to the landscape and land use is illustrated by photographic montages presented in figures 9-28–9-31.

The construction of the new unit will increase the building stock of the power plant site. The construction of the new unit will have no other effect on the built environment in the area.

Figure 9-30 *A photographic montage of location option 1 (VE 1) with discharge location option A and intake location option C.*

Figure 9-31 *A photographic montage of location option 2 (VE 2) with discharge location option B and intake location option D.*

9.6 Impact on air quality and climate

The radioactive and other airborne emissions arising from the operation of the planned power plant have been presented and the impact on the environment and people assessed based on existing research findings.

In the nuclear power plant unit being assessed, the electricity production will not cause, apart from the production of back-up power, any flue gas releases and the positive impact on air quality results from the avoidance of release quantities equal to those arising from the production of a similar amount of electricity.

The avoided flue gas releases are estimated in chapter 11.2 by postulating that the amount of electricity equal to the electricity production volume of the nuclear power plant unit be produced with the average Nordic production structure and average release coefficients.

9.6.1 The current status of the climate and air quality

Weather conditions

Olkiluoto is located on the coast of the Botnian sea area in a maritime climate. A maritime climate is characterised by the stable of temperature conditions. In the spring, the temperature close to the coast is clearly lower than further inland. In the autumn, the warm sea evens out the daily temperature differences and there is almost no night frost. The winter in the Satakunta region is mild because Botnian sea remains open for almost the entire winter. The prevailing direction of the wind is from the southwest. Figure 9-32 presents the speed and direction distributions of the incoming wind directions at Olkiluoto in 2003, measured from the heights of 20 and 60 metres.

The annual precipitation at Olkiluoto varies between 400–700 mm. Table 9-5 presents the precipitation for Olkiluoto and the duration of rain in 2003–2005.

Month	Year			
	2003	2004	2005	2006
	Precipitation (mm) / duration (hours)			
1	30 / 115	27 / 113	66 / 133	17 / 50
2	12 / 80	23 / 66	29 / 93	9 / 72
3	15 / 39	16 / 56	4 / 19	19 / 79
4	20 / 64	7 / 16	19 / 38	58 / 102
5	79 / 103	28 / 57	30 / 59	67 / 57
6	37 / 36	39 / 47	60 / 53	22 / 25
7	27 / 14	84 / 69	69 / 35	10 / 11
8	49 / 46	61 / 51	155 / 67	32 / 26
9	19 / 27	85 / 96	51 / 45	71 / 41
10	41 / 77	29 / 46	53 / 49	124 / 124
11	36 / 99	38 / 59	95 / 143	63 / 126
12	44 / 114	69 / 87	21 / 87	95 / 99
Total	409 / 814	460 / 763	652 / 820	585 / 812

Table 9-5 *Precipitation (mm) and the duration of rain (hours) at Olkiluoto in 2003–2005.*

Air quality and fallout

Emissions to the atmosphere are minor in Eurajoki. The amount of emissions from smaller industrial plants, also known as point sources, as well as so-called area sources (detached houses, saunas, etc.) has not been assessed.

There is no air quality monitoring at Eurajoki. The nearest monitoring measurement point is in Rauma. Air quality is also monitored at the industrial locations of Harjavalta and Pori. Compared to the emissions in Pori and Harjavalta, the emissions of the Rauma region are minor.

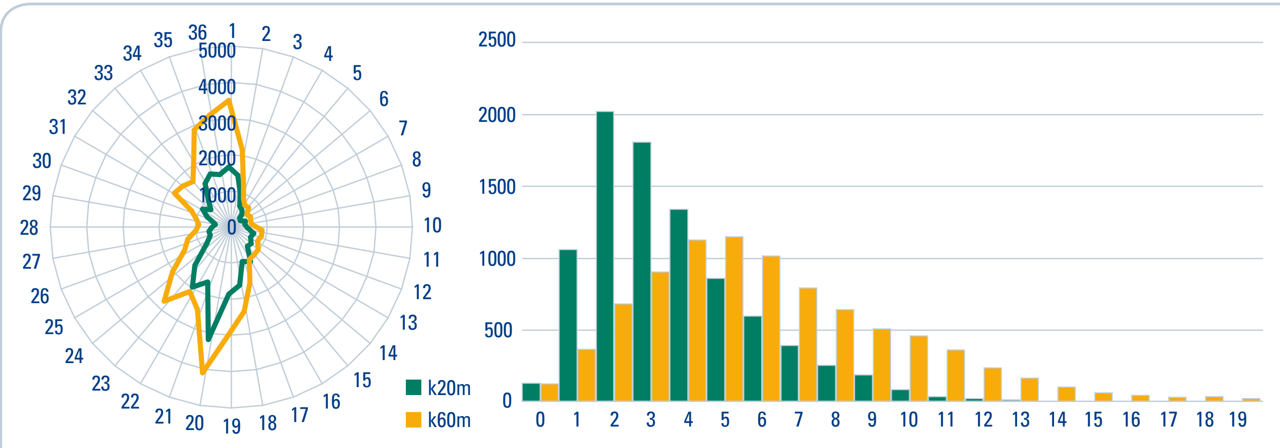
Measurements of fallout contained in rainwater, also known as wet fallout, have been conducted in Satakunta. The sulphate fallout has varied between 280 and 440 mg/m^2/year between 1992 and 1995. The nitrate nitrogen fallout has been 150 to 230 mg/m^2/year and the ammonium nitrogen fallout 60 to 190 mg/m^2/year *(Satakunta Regional Council 1998)*. The critical load for forest land is exceeded everywhere in Satakunta.

9.6.2 Radioactive releases into the atmosphere

The maximum allowable radioactive release into the environment has been defined so that the radiation dose to the population will not exceed 0.1 mSv per year. Releases may be emitted through the vent stack into the atmosphere or through the cooling water discharge opening into the sea.

The most common substances released into the atmosphere from light water reactors include noble gases generated in the fission reaction (xenon and krypton), gaseous activation products (mainly carbon 14), halogens

Figure 9-32 *Wind direction and speed distributions (incoming direction) at Olkiluoto in 2003, observed at 20 and 60 metres, speed average at 20 metres: 4.1 m/s, at 60 metres: 6.6 m/s.*



(iodines) and active substances in aerosol form. Most of the released radionuclides are very short-lived and can be detected only occasionally and only very close to the plant. In addition, radioactive noble gases are diluted in the atmosphere and do not settle on the ground. No radioactive substances originating from the nuclear power plant have been detected in the measurements of the nearby population *(Finnish Energy Industries Federation Finergy 2002)*.

For processing radioactive gases generated in the nuclear power plant, the principle of best available technology (BAT) is used. Radioactive gases generated in a nuclear power plant are collected, delayed to reduce radioactivity, and filtered. After filtering, the gases containing small amounts of radioactive substances are released through the vent stack. The releases contain noble gases, iodines, aerosols, tritium and carbon 14.

Radioactive releases may also be generated in the KPA Store. The releases take place through the KPA storage vent stack and have remained below the detection limit. VLJ repository causes no releases to the atmosphere.

In 2006, radioactive noble gas releases from the existing plant units were about 0.6 TBq, which is approximately 0.004 % of the authorised limit. Iodine releases into the atmosphere were approximately 0.2 GBq, which is approximately 0.1 % of authorised limit. Aerosol releases were approximately 31 MBq, tritium releases approximately 0.3 TBq and carbon-14 releases approximately 0.8 TBq. The table below presents the airborne releases of the existing plant units (OL1 and OL2) and an estimate of the releases from the OL3 unit under construction and the new OL4 unit.

The radioactive releases from TVO into the atmosphere are clearly within the limits set by the authorities. The releases are equal to a thousandth part of the set limits at most.

9.6.2.1 Impact of radioactive releases into the atmosphere

Radioactive substances released from the power plant and the KPA storage are carried onto ground or vegetation, into bodies of water and to biological populations, depending on weather conditions and the individual properties of each substance. In samples taken from the objects listed above, radioactive substances originating from the power plant can be occasionally detected among other radioactive substances, when sensitive methods of analysis are used.

The effects of radiation to living populations have been studied using several plant and animal species. The sensitivity to radiation varies greatly accordingly to species. Also, the knowledge of the sensitivity of species varies. Generally mammals are the most sensitive of animals, followed by birds, fish, reptiles and insects.

A survey of the condition of forests in the vicinity of the Olkiluoto power plant was conducted in 1992. Using experimental plots at various distances from the power plant site, the study aimed at finding out whether damage symptoms increase when approaching the power plant site. Various symptoms were observed in the forests in the vicinity of Olkiluoto, such as needle loss in conifer trees, typical in western Finland, particularly the coastal areas. Based on the survey, the health of the forests in the area was found to correspond to the average situation in the coastal areas of western Finland. *(Jussila et al. 1993.)*

Since there will be only minor radioactive releases from the new nuclear power plant unit during operation, they will not have any harmful effects on the natural environment. The impacts of these releases on people are discussed in section 0.

9.6.3 Other emissions into the atmosphere

Test runs of back-up power sources generate some carbon dioxide, nitrogen oxide, sulphur dioxide and particle emissions. The back-up heat boilers also generate minor emissions of a similar nature. The emissions from the boiler plant and the test runs of the reserve diesels of the plant units OL1 and OL2 generate an approximate annual total of 400 tonnes of carbon dioxide, one tonne of nitrogen oxides, 0.1 tonnes of sulphur dioxide and 0.5 tonnes of particles. The third plant unit under construction is estimated to double the emissions from the back-up power systems of OL1 and OL2. The test runs of the new, fourth unit's back-up power systems will create annual emissions roughly equal to those of the OL3 unit.

The back-up power systems of the new plant unit, such as the reserve diesels, will be normally be tested by operating them approximately 200 hours per year. The emissions from them and the back-up boiler will be minor and will have no significant impact on air quality or other effects. Even the possible production operation of the boiler plant or the reserve diesels will have no substantial effect on air quality.

***Table 9-6** Releases of radioactive substances from the existing plant units in 2006 (OL1 + OL2) and an estimate of the releases of the OL3 unit under construction and the new OL4 unit.*

Type of release	Releases in 2006 OL1+OL2 (TBq)	Estimated releases OL3 (TBq)	Estimated releases OL4 (TBq)
Noble gases (Kr-87 equivalent)	0.649	0.1 - 10	0.1 - 10
Iodines (I-131 equivalent)	0.00016	0.000001 - 0.001	0.000001 - 0.001
Aerosols	0.00004	0.000003 - 0.0003	0.000003 - 0.0003
Tritium	0.30	5 - 10	0.1 - 10
Carbon 14	0.77	0.3 - 0.7	0.3 - 0.7

9.7 Impacts on the water system and fishing industry

Model calculations on the dispersal of cooling water and an estimate of the impact of thermal load on the temperatures in the vicinity and the ice conditions in the different discharge point options have been prepared using a three-dimensional flow model developed at the Environmental Impact Assessment Centre of Finland Ltd (EIA Ltd). The detailed dispersal calculations, obtained as a result of the above, have been used as the basis of the impact assessments. The surveys have included existing cooling waters, cooling waters for OL3 under construction and cooling waters for the planned plant unit.

The waste water load and radioactive discharges to the sea occurring during the operation of the planned power plant unit have been described. The impacts of cooling and waste water on water quality and biology, as well as on the fish population and fishing industry, have been assessed based on the existing extensive research data and the results of the aforementioned dispersal model calculations.

9.7.1 Description and use of the water system

Olkiluoto is delimited by the Eurajoensalmi inlet of approximately 1.5 kilometres in width on the north side and the Olkiluodonvesi water area of approximately 3 kilometres in length and 0.7 to 1.0 kilometres in width on the south side. The Rauma archipelago begins on the south side of Olkiluodonvesi. The area west of Olkiluoto is a shallow coastal area with a relatively high number of small islands and islets. The Botnian sea area opens to the west of the islet zone.

To the west-southwest of the power plant site, there is the Kuusisenmaa island separated from Olkiluoto by a shallow inlet of approximately 0.2 to 0.3 kilometres in width. An island called Lippo is located south of Kuusisenmaa. A navigable passage to the power plant site's harbour quay runs between Kuusisenmaa and Lippo.

There are no lakes, rivers or brooks in the Olkiluoto area. The only lake on the island has dried up due to ditch drainage.

9.7.2 General description and hydrological information

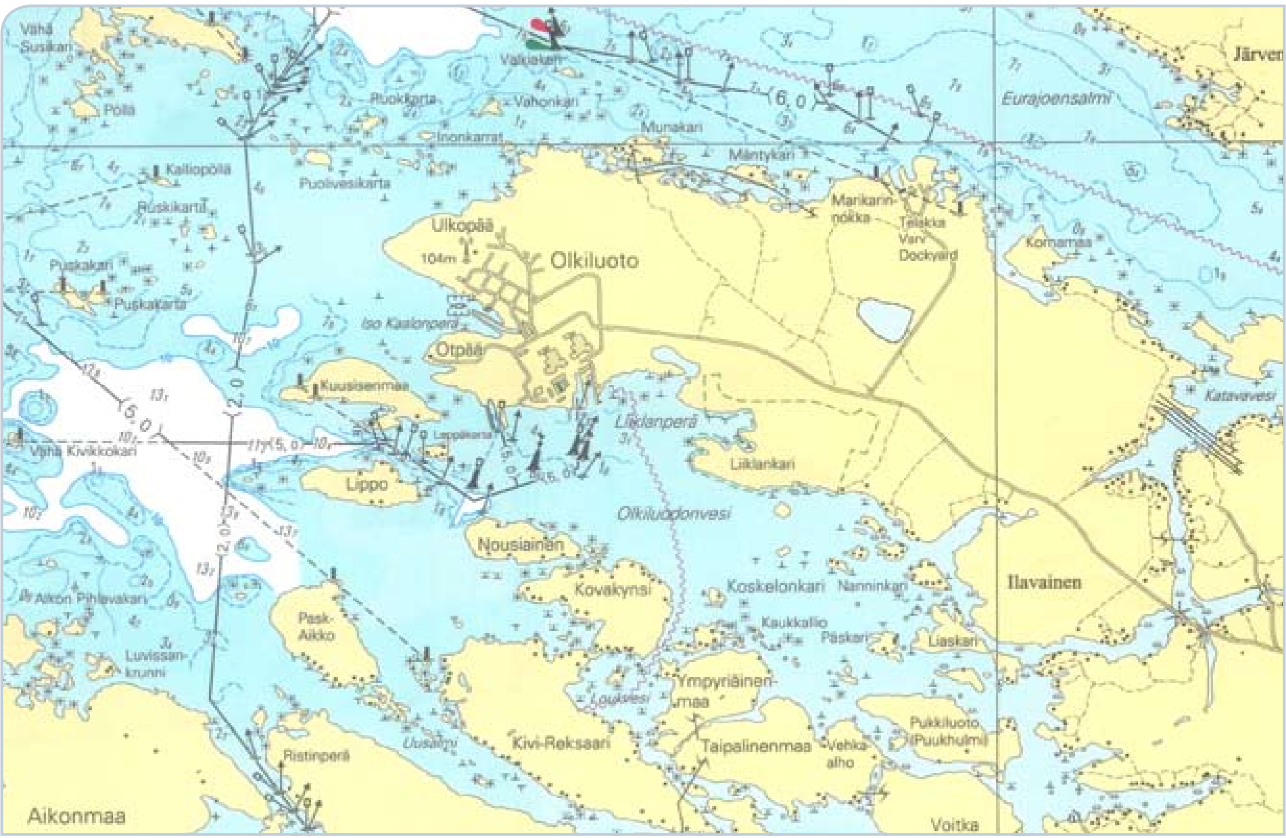
The surroundings of Olkiluoto are shallow coastal areas, with the exception of basins to the southwest and northwest of the island. The greatest depths are approximately 15 metres, and the average depth is less than 10 metres.

Botnian sea deepens fairly steadily when moving away from the coast. The average depth of 10 metres is usually reached at the outermost islands, the depth of 20 metres at approximately 10 to 20 kilometres from the mainland and the depth of 50 metres only at approximately 30 kilometres from the mainland.

Most of the waters near Olkiluoto do not have an actual topsoil layer; the sea bed is plain rock. Areas in which the topsoil is moraine are the second most common. The topsoil in Olkiluodonvesi and in the basin area west of Kuusisenmaa and Lippo is mostly muddy clay and other types of clay.

The sea around Olkiluoto is fairly open. The coast to the north of Olkiluoto has few islands. The conditions for water mixing and exchange are beneficial at the edge of

Figure 9-33 *Extract from nautical chart. The chart shows the passages leading to Olkiluoto island.*



the open sea. Due to the lack of archipelago, winds have a strong effect on the current conditions off Olkiluoto *(Turkki 2007)*.

The largest water systems in Southern Satakunta, Lapinjoki and Eurajoki, discharge into the sea area of Olkiluoto. The Lapinjoki river originates in the forest and swamp area west of Pyhäjärvi, flows through the municipalities of Lappi and Eurajoki, and discharges into Botnian sea at an inlet between Olkiluoto and Orjasaari. The catchment area of the Lapinjoki river is 462 km^2, the areal percentage of lakes is 4.2 and the mean discharge is 3.6 m^3/s *(Kirkkala & Oravainen 2005)*.

The Eurajoki river originates in the Pyhäjärvi lake within the municipality of Säkylä and flows through the municipalities of Eura, Kiukainen and Eurajoki to Botnian sea at the Eurajoensalmi inlet. The Köyliönjoki river coming from the Köyliönjärvi lake discharges into the Eurajoki river in Kiukainen, and the Juvanjoki river coming from the Turajärvi lake discharges into it in Eurajoki. There are three hydropower plants on the Eurajoki river. Water from the Eurajoki river is conducted through the Lapinjoki river to Rauma to provide a supply of water to the town of Rauma. The catchment area of the Eurajoki river is 1,336 km^2, the areal percentage of lakes is 13.3 and the mean discharge is 9.6 m^3/s *(Kirkkala & Oravainen 2005)*.

Currents

The surface current off Olkiluoto depends mostly on wind direction and velocity. The rivers Eurajoki and Lapinjoki that discharge fresh water into Eurajoensalmi and Olkiluodonvesi probably do not have any significant impact on currents near the western end of Olkiluoto.

The strongest continuous currents are found at the mouths of the cooling water intake channels and the discharge channel. At the mouth of the intake channels, the current flows from south to north, and at the mouth of the discharge channel, it flows towards the west. There is no substantial continuous cross current from the mouth of the discharge channel to the intake area. The reason for this is the suction caused by the relatively strong discharge current that attenuates the component directed from the south of the discharge area towards the intake area.

Winds affect the currents mainly in the cooling water discharge area and in the open areas surrounding it. The dominant winds between south and west contribute to turning the general direction of current from west to north. The current caused by coriolis force that is directed towards the north on the Finnish coast of Botnian sea also affects in the same direction. These factors affecting currents further reduce the possibility of cross currents between the discharge and intake areas.

In Olkiluodonvesi, winds do not substantially alter the currents caused by cooling water intake.

Sea level

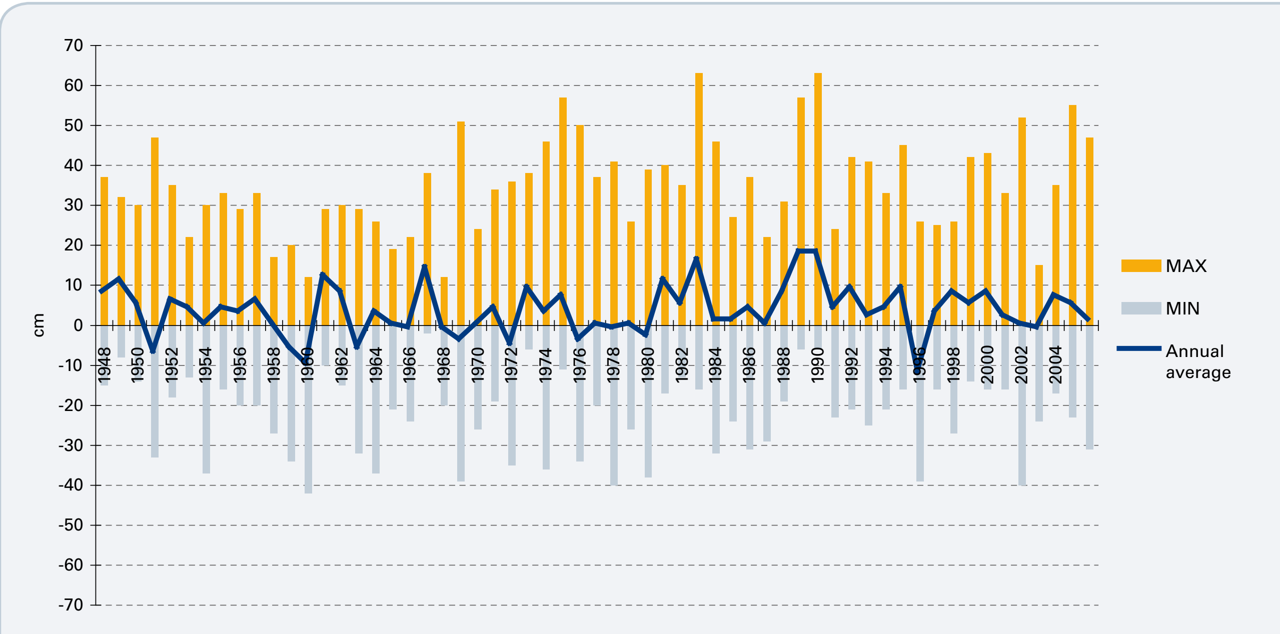
The variations in sea level off Olkiluoto are similar in magnitude to those off Rauma. Figure 9-34 illustrates sea levels as annual averages from 1948 to 2006 and the minimum and maximum levels in the sea area off Rauma.

9.7.3 Water quality, ice conditions and ecological condition of the sea area

The water quality, ecological condition and production in the sea around Olkiluoto are affected by the general condition of the coastal waters of Botnian sea, and nutrients and other substances carried by rivers. Local impacts are caused by increased temperature and changes in flow conditions due to cooling water from the nuclear power plant units, as well as the nutrient load of waste water conducted with the cooling water. *(Kirkkala & Turkki 2005.)*

Physical, chemical and biological monitoring of the waters around Olkiluoto has been conducted since 1979. The purpose of the monitoring is to survey the impact of cooling water from the Olkiluoto power plants on the

Figure 9-34 *Sea levels off Rauma in 1948–2006 as annual averages and minimum and maximum values (Source: Finnish Institute of Marine Research).*



quality and usability of the water in the surrounding sea area, as well as biological production. *(Turkki 2007.)*

Sea water warm-up

The existing nuclear power plant units at Olkiluoto, OL1 and OL2, take their cooling water, totalling approximately 60 m^3/s, from the shoreline of the Olkiluodonvesi sea area south of the island. The consumption of cooling water will increase by some 60 m^3/s when the OL3 plant unit is in operation. The cooling water is conducted back to the sea at the Iso Kaalonperä bay located at the western end of the island. The process of the existing plants increases the temperature of the cooling water by approximately 13 °C.

The increase in water temperature caused by cooling water varies by weather, season and the utilisation rate of the power plant. The cooling water mixes into the surface layer. The increase in seawater temperature due to cooling water is clear in the discharge area, and a slight increase in temperature can be perceived within a radius of 2 to 3 kilometres from the cooling water discharge point. *(Turkki 2007.)*

Ice conditions

Typical of open coast, the ice conditions on the Botnian sea coast are naturally quite unstable. Variation in winds and temperatures heavily affects freeze-up, break-up and the strength of ice. On average, permanent ice cover near the coast is created at the turn of December-January and breaks up in early April. The open sea around and off Olkiluoto remains unfrozen longer than more inward areas.

The discharge of cooling water to the west of Olkiluoto in winter creates an unfrozen area, the size and shape of which depend on the flow and weather conditions in the sea area, mainly the air temperature, wind direction and the ice conditions in Botnian sea. River waters flowing into the area may occasionally also have an impact on the behaviour of cooling water and thus the ice conditions.

The area of unfrozen sea and thin ice off Olkiluoto varies from a few square kilometres to 20 square kilometres. When the average temperature is 5 degrees below zero, the area is in the order of 10 to 14 km^2, and when it is 15 degrees below zero, the area is 3 to 6 km^2. The unfrozen area was approximately 4.5 km^2 at its smallest in 2006 *(Taivainen 2007)*.

Oxygen situation and nutrient concentrations

The oxygen situation in the sea area off Olkiluoto has usually been good. However, the oxygen situation may occasionally become impaired in the hypolimnium of basins if weather conditions are favourable for stratification. A clearly impaired oxygen situation in the hypolimnium has been observed only once in the 21st century (in August 2002) when the temperature of the hypolimnium was higher than normal.

The nutrient concentrations of water in the sea area off Olkiluoto have been characteristic of Botnian sea coastal waters and local variation in concentrations has been minor. However, currents, nutrients released from the shore zone and local wastewater loads occasionally increase the concentrations *(Kirkkala & Turkki 2005)*.

Table 9-7 *Limits for the eutrophication classes of water systems in accordance with literature. Sources: 1 = OECD 1982, 2 = Forsberg & Ryding 1980, 3 = Henriksen et al. 1997, 4 = general usability classification for sea water (www.ymparisto.fi).*

Eutrophication class/ usability class	Clorophyll-a µg /l				Total phosphorus µg /l			
source	1	2	4		1	2	3	4
very infertile / excellent	< 1	–	< 2		< 5	–	–	< 12
infertile / good	< 2,5	< 3	2 - 4		5 - 15	< 15	< 10	13 - 20
slightly eutrophic / satisfactory	2,5 - 8	3 - 7	4 - 12		15 - 50	15 - 25	10 - 35	20 - 40
eutrophic / passable	8 - 25	7 - 40	12 - 30		50 - 150	25 - 100	> 35	40 - 80
very eutrophic / poor	> 25	> 40	> 30		> 150	> 100		> 80

River water is a significant source of nutrient load in the area. The Eurajoki river brought 21,500 kg of phosphorus and 781,000 kg of nitrogen to the sea in 2006 *(Turkki 2007)*. Additional nutrients brought by the Lapinjoki river generally amount to approximately 30 % to 40 % of the quantity produced by the Eurajoki river. The burden from the Olkiluoto power plant, consisting of sanitary and laundry waste water and crayfish cultivation, totalled 35 kg of phosphorus and 2,560 kg of nitrogen *(Taivainen 2007)*.

Different categorisations with regard to the eutrophication of water systems have been presented in different contexts. The categorisations typically concern lake waters but are also applicable to coastal waters. In the 21st century, the concentration of a-chlorophyll in the sea area off Olkiluoto has been approximately 2 to 3 µg/l on average over the vegetation period, with the exception of the Eurajoensalmi inlet in which the average concentration of a-chlorophyll has been slightly higher. The concentrations of a-chlorophyll have been at the level of an infertile – slightly eutrophic water system, while the general class of usability with regard to the a-chlorophyll concentration has been good. Correspondingly, the total phosphorus concentration has been approximately 20 µg /l on average, which corresponds to the level of slightly eutrophic waters and is on the borderline of good and satisfactory in accordance with the general usability classification. The average nitrogen concentration in the sea area off Olkiluoto has been approximately 300 µg /l with the exception of the Eurajoensalmi inlet in which the concentration has occasionally been higher due to the impact of river water.

The nutrient concentrations in the sea area off Olkiluoto in the 21st century have been quite close to the background concentrations measured off Pyhäranta (2004–2006 winters total phosphorus 19 µg /l and total nitrogen 310 µg /l, 2000–2006 summers total phosphorus 16 µg /l and total nitrogen 280 µg /l, *Turkki 2007*).

Inorganic nitrogen has typically been abundant in the water in the beginning of the vegetation period, which means that basic production has been restricted by phosphorus. However, inorganic nitrogen is quickly exhausted, and during the vegetation period, production over the entire area has been jointly restricted – that is, the quantity of both of the main nutrients available to basic producers has been quite low. Local differences have otherwise been minor but the Eurajoensalmi inlet is clearly more phosphorus-restricted than other parts of the area, and phosphorus has often been the nutrient restricting production for almost the entire vegetation period due to relatively high concentrations of inorganic nitrogen.

Plankton production

Currents caused by cooling water from the Olkiluoto power plants and increased temperatures have affected phytoplankton production in a relatively small area *(Kirkkala & Turkki 2005)*. Due to the warming effect of cooling water, the vegetation period begins approximately one month earlier than in other coastal waters, and correspondingly lasts longer in the autumn. The extended vegetation period, particularly in the spring, has increased production. There has been slightly more blue-green algae in the cooling water intake and discharge areas compared to the other sea areas for a number of years, but the areas have not otherwise been distinguished from other observation points in terms of plankton algae *(Kirkkala & Turkki 2005)*.

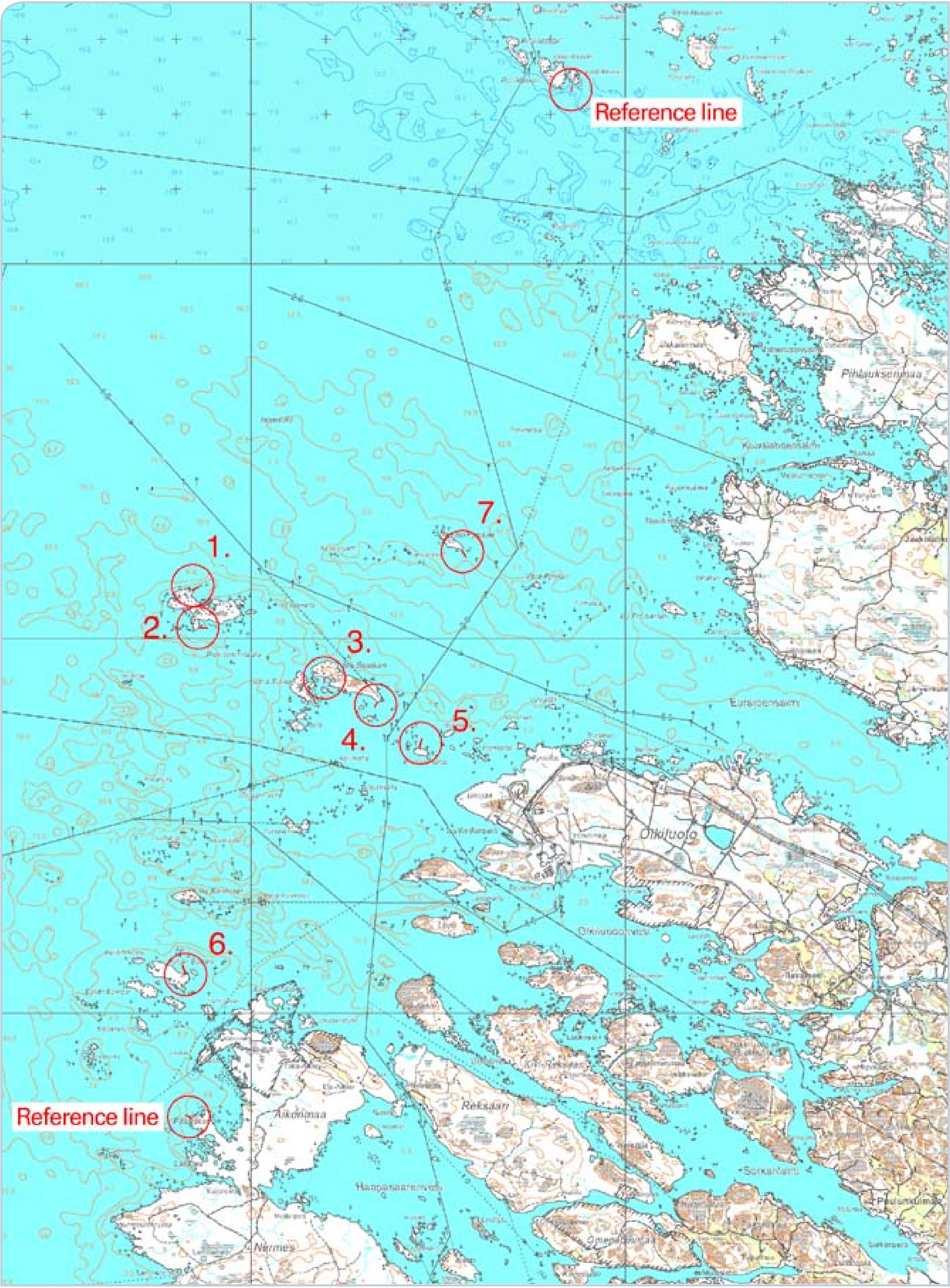
In the beginning of the vegetation period, diatoms typically constitute the majority of the phytoplankton biomass. Free nutrients are quickly bound to phytoplankton biomass during the so-called spring maximum of phytoplankton, after which the concentrations of inorganic nutrients in the water fall down. A reduced amount of nutrients leads to reduced phytoplankton production and reduced biomass. After the spring maximum, glaucophyta and crysophyta, which are smaller than diatoms, often become the dominant species in the algae community. Blue-green algae usually become more common in late summer.

The concentration of phytoplankton biomass over the entire vegetation period in the sea area off Olkiluoto has varied greatly (0.7 mg/l in 2005 and 1.8 mg/l in 2006, *Turkki 2007*), which is affected by factors such as weather conditions in the summer and the coincidence of sampling and the spring maximum of phytoplankton. All in all, the concentrations of phytoplankton biomass have mostly been at the level of slightly eutrophic waters. In the 21st century, the average phytoplankton biomass in the sea area off Olkiluoto in summer (12 June to 25 September) has been approximately 0.25 to 0.40 mg/l *(Turkki 2007)*. The highest concentrations have usually been measured in Olkiluodonvesi and the lowest ones north of the Puskakari rocks. The concentration of phytoplankton biomass near the cooling water discharge area off Kaalonperä has been on a par with the average.

According to studies, the basic production of phytoplankton near the cooling water discharge area off Kaalonperä has been approximately 20 % higher than to the southwest of the cooling water discharge area. Particularly in the spring, production near the cooling water discharge area has been clearly higher than to the southwest of Kuusinen. In 2006, for example, the difference in late April and early May was approximately 50 % to 70 %. *(Turkki 2007.)*

Over the long-term, the total quantity of phytoplankton in the sea area has increased, which has been affected by the general increase in eutrophication across the entire coastal area. The difference between biomasses off Kaalonperä and those in other sea areas has simultaneously diminished *(Turkki 2007)*.

Figure 9-35 *Map of the aquatic vegetation survey area. The figure illustrates the 7 surveyed vegetation lines and the southern and northern reference lines.*



Aquatic vegetation

Vegetation in the Olkiluoto sea area varies between a community dominated by algae on the hard sea bed in the outer archipelago and a community dominated by vascular plants on the soft sea bed of Olkiluodonvesi. In studies of aquatic vegetation, the impact of eutrophication has been visible within the area affected by power plant cooling waters. Among aquatic vegetation, macro-algae have suffered, with the exception of annual green and brown algae that are able to quickly utilise nutrients present in water. Vascular plants have benefited from the extended vegetation period and changes in the quality of the sea bed *(Kinnunen & Oulasvirta 2005)*. The greatest changes in aquatic vegetation have taken place quite soon after the discharge of cooling waters started *(Keskitalo & Ilus 1987)*. However, there have still been changes in vegetation and the quality of the sea bed in recent years *(Kinnunen & Oulasvirta 2005)*.

The discharge of cooling waters has increased the production of aquatic vegetation and algae in the area, which has resulted in increased sedimentation due to the decomposition of vegetation and algae. Increased sedimentation would seem to be restricted to a fairly small area near the discharge point for power plant cooling water. The increased quantity of loose sediment has deteriorated the preconditions for macro-algae growth. Bladder wrack and red algae in particular have declined and been replaced with annual filamentous algae. On the other hand, vascular plants have benefited from the changes in sea bed quality. Sago pondweed *(Potamogeton pectinatus)* and Eurasian water milfoil *(Myriophyllum spicatum)* in particular have proliferated. They have been found to best tolerate the thermal load caused by power plants. *(Keskitalo & Ilus 1987, Kinnunen & Oulasvirta 2005.)*

The development of eutrophication near the cooling water discharge area of the Olkiluoto power plant has continued in spite of balanced or reduced nutrient load because the vegetation period is longer in the area affected by the cooling water, and the cooling water also mixes the water mass and releases nutrients from the sediment into circulation. However, the eutrophication effect of cooling water extends only to the area maintained unfrozen by warm water during most winters *(Kinnunen & Oulasvirta 2005)*.

Because underwater biotopes are the primary target of the impact of warm water, permanent underwater vegetation lines were established in the coastal waters of islands and islets off Olkiluoto in the summer of 2007. The impact of cooling water on aquatic vegetation in the sea area has been monitored since the 1970s, most recently in 2004 *(Alleco Oy 2005)*. There are a total of seven vegetation lines located in the Natura 2000 area of the Rauma archipelago. Because one of the alternative discharge points for cooling water in the OL4 EIA procedure is located in Tyrniemi, the area subject to inventory was extended to the north, to Iso Pyrekari. After this rocky islet, the next Natura 2000 area to the north is the Luvia archipelago (FI0200074). There are no protected biotopes to the west after the Kalla islands. The southern reference area is the Pihlavakari vegetation line established in 2004, which is located approximately 5.5 kilometres southwest of the present cooling water discharge point. The northern reference line is located on the southern edge of the Luvia archipelago Natura area, approximately 9 kilometres from Olkiluoto. The surveys of aquatic vegetation were made using the line diving method. *(Ramboll Finland Oy 2007b.)*

According to the aquatic vegetation survey, changes caused by warm cooling waters from the nuclear power plant are clear in the vegetation line closest to the discharge point off the Iso Kaalonperänlahti bay, which is line number 5 at the shore of the Puolivesikarta island. Here the strong growth of filamentous algae and their almost complete coverage are indicators of the eutrophication of the shore area. The oxygen-free bottom of shallow waters is a consequence of the oxygen-consuming effect of loose algae mass that has drifted into the area in large quantities. Loose algae are apparently conducted to the area from the Iso Kaalonperänlahti bay with the flow of warm cooling water. At the eastern end of the Iso Susikari islet, line number 4, changes in vegetation towards a community of soft sea bed dominated by vascular plants can be seen. The species of hard sea bed have had to give way to vascular plants that are more tolerant to eutrophication. In the Iso Susikari inlet (line number 3), the results are mostly representative of the state of a shallow, sheltered and eutrophic inlet, and due to the lack of previous material, the effect of cooling water cannot be estimated.

The state of underwater vegetation in the sea area off Olkiluoto can be compared to the previous survey (2004) when two of the lines surveyed were the same as in 2007. The lines were number 4 located off Olkiluoto at the south-eastern shore of the Iso Susikari island and another line, the southern reference line, at the point of the Pihlavakari islet on the western side of the Nurmes island. The dominant species at the south-eastern line of Iso Susikari were similar to the survey three years ago. The vascular plants of soft sea bed were dominant among the flora. There had not been any significant changes at the line compared to the situation three years earlier. The southern reference line was still in better condition than the lines located closer to the nuclear power plant. The situation had also remained similar with regard to floral species.

No clear vegetation effects caused by cooling waters were observable at the other lines surveyed. However, the diversity of floral species was greater at the outer survey lines compared to nearby areas, and the dominant species were more often those of a hard sea bed that are more sensitive to the effects of eutrophication. An example of this is the rose-coloured alga *(Callithamnion roseum)* classified as a species to be observed, which was found at line 2 off the southern shore of the Kalla island but not at the other lines.

On the other hand, the erosive effect of the rough sea is naturally stronger in the outer archipelago, which favours plants that require hard sea bed. The species of soft sea bed thrive in more sheltered areas in the inner archipelago.

Similar to other outer lines, the floral species of the reference lines were more dominated by species of a hard sea bed but indications of the general eutrophication trend of the Baltic Sea were also observable there.

	Professional fishermen		Domestic fishermen		Total	
	kg	%	kg	%	kg	%
Salmon, trout	770	6	353	4	1,123	5
Whitefish	693	5	754	8	1,447	7
Baltic herring	900	7	816	9	1,716	8
Pike	1,496	12	1,445	16	2,941	13
Perch	6,031	47	2,314	26	8,345	38
Pike-perch	643	5	276	3	919	4
Burbot	641	5	246	3	887	4
Bream	608	5	938	10	1,546	7
Ide	1	0	175	2	176	1
Roach	1,036	8	911	10	1,947	9
Flounder	116	1	133	1	249	1
Others	16	0	684	8	700	3
Total	12,951	100	9,045	100	21,996	100
kg/household	2,590	..	65	..	..	..

Table 9-8 *Total fish catch (kg) in the sea area off Olkiluoto in 2005.*

Nutrients conducted by rivers discharging in the sea area under review contribute to the eutrophication of coastal waters. *(Ramboll Finland Oy 2007b.)*

Sea bed fauna

Dominant species of sea bed fauna off Olkiluoto in 2006 included Baltic tellin *(Macoma baltica)*, Jenkins' spire shell *(Potamopyrgus jenkinsi)*, the invasive species North American polychaete *(Marenzelleria viridis)* and few-bristled worms *(Oligochaeta) (Turkki 2007)*. The partial heterogeneity of the size distribution of Baltic tellin was an indication of disturbances in sea bed conditions, such as occasional oxygen depletion. Benthic amphipods *(Monoporeia affinis)*, which are typical of an undisturbed sea bed, have not been observed at all in samples between 2003 and 2006. They have been previously found sporadically. However, benthic amphipods have become extinct in large areas in the northern Baltic Sea and Botnian sea, which suggests that the changes in the population are connected with more extensive environmental changes and population fluctuations. The midge larva Chironomus plumosus, which is the type species in contaminated low-oxygen sea bed, was present in the cooling water discharge area off Kaalonperä only in small numbers. The composition of sea bed fauna and the growth of biomasses particularly with regard to Baltic tellin indicated an improved sea bed quality in recent years.

The biomass of sea bed fauna in the cooling water discharge area off Kaalonperä has clearly increased between 2004 and 2006 *(Turkki 2007)*. The biomass levels fell down in the late 1990s and remained low until 2003. Oxygen conditions in recent years have been better than before, which has been reflected in a gradual recovery of sea bed fauna *(Kirkkala & Turkki 2005)*. In several years, fairly large quantities of algal residue have been present at almost all observation points, forming an algal cover on the sea bed *(Turkki 2007)*. The decomposition of algal residue has caused at least occasional oxygen depletion in the water layer close to the bottom, and it is probable that the shellfish populations of some years have been destroyed due to lack of oxygen. Dead plankton and floral residue descend to the bottom, and strong currents carry them to separate basins in which they locally increase the amount of nutrition available to sea bed fauna. This sweeping effect of currents and the slight eutrophication of the sea area have caused variation in the quantity and biomass of sea bed fauna and occasional increases in species or groups benefiting from eutrophication *(Nereis, Macoma, Chironomus plumosus, Oligochaeta)* in the cooling water discharge area. The sea bed fauna community is characterised by increased instability and a tendency towards fairly rapid changes in species and biomass.

Radioactivity in the aquatic environment

Surveys conducted by the Radiation and Nuclear Safety Authority in accordance with the environmental radiation monitoring programme have measured minor concentrations of radioactive substances originating from the power plant in algae, sinking matter and shellfish, and sporadically very minor concentrations also in fishes. The proportion of natural radioactivity in the samples was substantially higher than that of radioactivity originating from the power plant. *(Taivainen 2007.)*

9.7.4 Fish and fishing

Fishery monitoring of the Olkiluoto nuclear power plant has been conducted in accordance with a programme prepared by Oy Vesi-Hydro Ab on 21 August 1995 and approved by the Turku Rural Economy District on 29 July 1996. The monitoring is a continuation of the previous studies of the basic condition and follow-up.

In the sea area off Olkiluoto, within a radius of some 5 to 6 km, there were 5 households engaged in professional fishing and approximately 140 households engaged in fishing for domestic use and recreation in 2005 *(Ramboll Finland Oy 2007c)*. Professional fishing nowadays constitutes mostly net fishing. Fyke net fishing for salmon and Baltic herring, fishing for whitefish at spawning and drift net fishing have declined and partly ceased in the area since the 1990s. Domestic and recreational fishing constitutes mostly net fishing. Active rod fishing is also carried out. Professional fishermen are active around the year but the emphasis is on the open water season between June and October. Domestic and recreational fishing focuses on the open water season between May and October. Fishing is carried out almost everywhere in the sea area off Olkiluoto. Sink gill nets are used in shallow and rocky areas. Fyke net fishing for salmon is carried out outside the archipelago to a minor extent. In winter, fishing in the unfrozen area caused by cooling water focuses mainly on net fishing for whitefish.

The total catch in the sea area off Olkiluoto in 2005 amounted to approximately 22 tonnes, consisting of perch 38 % and pike 13 % followed by whitefish, Baltic herring, bream and roach 7 % to 9 % each. The combined share of salmon and trout was 5 %. The economically most important species of catch were perch, salmon and trout, as well as whitefish and pike-perch. Professional fishing accounted for approximately 60 % of the total catch. The total catch per household was 2.6 tonnes on average for professional fishermen and 65 kg for domestic fishermen. *(Ramboll Finland Oy 2007c.)*

According to professional fishermen, seals are the greatest hindrance to fishing, and domestic fishermen also quote the contamination of fishing tackle and increased bottom flora in addition to seals (Ramboll Finland Oy 2007c).

The populations of the most important species of fish in the sea area off Olkiluoto can be considered good or moderate *(Ramboll Finland Oy 2007c)*. Baltic herring is mostly of a population spawning in the spring. The Baltic herring population has continuously been good but fishing has become unprofitable and almost nonexistent. Salmon is mostly found at the boundary of the shallow rocky zone and outside; its occurrence within the area affected by cooling water is minor. The salmon population is dependent on planting and its success. The trout population is also dependent on planting, and the population is quite weak. In the cold season, trout seeks its way to the area affected by cooling water, which has increased winter-time fishing. As the waters warm up in the spring, trout moves outwards to the sea. The whitefish populations in the area are mixed populations consisting of locally spawning rock whitefish and sea whitefish originating from planting. The whitefish population is fairly strong. The catch of whitefish off the power plant is quite good in the winter and spring. It is also caught across the entire sea area off Olkiluoto in late summer and autumn. Pike has previously been found mostly in the grassy areas of the Eurajoensalmi inlet and the mouth of the Lapinjoki river. It is currently also found in moderate numbers off the cooling water discharge point. The pike population in the area is fairly strong. The perch population in the area has strengthened and can be considered quite strong. The pike-perch population has improved as a result of planting since the 1990s and is presently satisfactory. Burbot is found in the winter mainly in the Eurajoensalmi inlet and in Olkiluodonvesi, but fishing is quite insignificant. Burbot moves to deeper and cooler waters in the outer sea for the summer. The average catch of burbot per fisherman has improved, and the burbot population can be considered normal. The roach population has constantly been abundant, and it has clearly been the dominant species in sample fishing.

9.7.5 Water requirements and supply to the Olkiluoto nuclear power plant

9.7.5.1 Fresh water supply

Fresh water required at the power plant site is taken from the lower course of the Eurajoki river, above the Tiironkoski rapids. The current average daily intake of fresh water from the Eurajoki river is 300 m^3. Approximately half of the water is used as tap water and the other half as process water, firefighting water and for other purposes.

The plant unit under construction (OL3) will increase the daily water requirement by approximately 210 m^3 during operation. The new plant unit (OL4) will increase the daily water requirement by approximately 200 to 400 m^3 during operation. Total water consumption during the construction of the new unit will amount to approximately 50 to 1,700 m^3 daily. Water consumption will be at its highest during the test runs of the power plant. Fresh water is used for producing demineralised water for the steam process, as well as tap water.

The fresh water required by the new plant unit will be supplied using arrangements constructed for the existing plant units. Preparations for water consumption during the operation and particularly the construction of the new unit have been made through Rauman Seudun Vesi Oy's water transfer project in which additional water will be taken to the Eurajoki river from the Kokemäenjoki river.

The raw water taken from the Eurajoki river is pumped through a pipeline of approximately 9 km in length to the Korvensuo basin on Olkiluoto. At Korvensuo, the water is treated in a filter and subsequently conducted to a storage basin constructed of earth. The capacity of the raw water basin has been increased during the construction of OL3 by making the banks higher. The increased capacity is approximately 140,000 m^3.

If considered necessary, the reliability of fresh water supply can be increased by constructing a new pipeline from the Eurajoki pumping station parallel to the existing raw water pipeline and a new storage basin parallel to the Korvensuo basin.

From the Korvensuo basin, water is pumped through a pipeline of approximately 2.6 km in length to a water treatment plant in the power plant area having a rated capacity of 90 m^3 per hour. The actual treatment at the water treatment plant is chemical precipitation. Furthermore, the pH value of the water is regulated as necessary using lye. The precipitate is mostly removed in a vertical clarifier. The clarified water is conducted through intermediate deacidification to active carbon filtration that removes the rest of the precipitate. The water is disinfected through the feed of hypochlorite.

The treated water is stored in two interconnected pools of 2,400 m^3 and 3,000 m^3 for firefighting water and clean water. Water is pumped from the pools to be used as necessary. Some of the water goes through a demineralisation plant and becomes process water, while some is used as tap water and firefighting water. Demineralisation is carried out using ion exchangers and a reverse osmosis filter used as an after-treatment unit. The capacity of the demineralisation plant is 45 m^3 per hour.

The treatment capacity of the new water treatment plant will also be sufficient for the needs of the new unit (OL4). The demineralisation plant will require an extension.

9.7.5.2 Cooling water intake

The power plant unit uses cooling water for cooling the turbine condensers. The existing nuclear power plant units at Olkiluoto, OL1 and OL2, take their cooling water, totalling approximately 60 m^3/s, from the shoreline of the Olkiluodonvesi sea area south to the plant site. The consumption of cooling water will increase by some 60 m^3/s when the OL3 plant unit is in operation. The new plant unit OL4 will require 40 to 60 m^3/s of sea water for cooling water. The maximum total cooling water requirement of the four plant units will be approximately 160 to 180 m^3/s. This EIA report reviews the intake of cooling water from two different locations. The cooling water for the new unit will be taken either from the east of the cooling water intake points for the existing plant units 1 and 2, or from the Eurajoensalmi inlet on the northern shore of Olkiluoto.

The length of the cooling water intake tunnel required by the new unit will be approximately 500 to 1,200 metres depending on the location of the plant unit.

The planning and construction of cooling water intake structures shall include preparations for phenomena that hamper the intake of cooling water, such as blockages caused by algae, other sea water contaminants or sub-cooled water. The cooling water is treated mechanically – that is, it flows through a coarse screen at the mouth of the cooling water channel and subsequently through a fine screen and travelling band screens at the pumping station. After this, the cooling water is pumped into the plant unit's condenser. The waste originating from the screens and travelling band screens is treated as required under licence in accordance with environmental and water law.

Sea water is used at the spent fuel storage facility to cool down water in the fuel storage pools. Cooling is carried out through heat exchangers. Sea water is supplied using a separate pumping station on the shore of Olkiluodonvesi. The cooling water system is designed for a flow rate of 0.06 m^3/s and a thermal power of 2.9 MW. The average cooling water flow in recent years has been approximately 0.035 m^3/s, while the average cooling power has been approximately 0.7 to 1.0 MW.

9.7.6 Effects of cooling water intake

Regardless of the location of the water intake point, the intake structure shall be designed so that the water flow rate outside the structure is as low as possible. This ensures that the intake of water will not cause danger to water traffic. The lowest possible flow rate will also reduce the amount of fishes and aquatic vegetation coming to the power plant.

Some amount of fishes will end up in the power plant with cooling water, mostly Baltic herring and smelt. Dead fishes are separated from the cooling water in screens and travelling band screens *(Teollisuuden Voima Oy 1999)*. The amount of fishes entering the power plant is reduced by putting barrier nets into the cooling water intake

Table 9-9 Cooling water flows of the existing plant units (OL1 and OL2) in 2006 and an estimate of the cooling water flows of the plant unit under construction (OL3) and the new plant unit (OL4).

Water fraction	OL1 + OL2 (actual 2006)	OL3 estimate	OL4 estimate	Total
Cooling water				
Volume million m³/year	1,810	1,730	1,100 - 1,810	4,640 - 5,350
Quantity of heat PJ/year	98.8 (27.4 TWh)	83	54 - 89	236 - 271

channels in the summer when the amount of fishes is the greatest. The amount of fishes entering the power plant is 2 to 10 kg daily and has not been observed to have any significant harmful impact on the fish populations in the area *(Teollisuuden Voima Oy 1999)*. The new plant unit will somewhat increase the amount of fishes entering the plant but is not expected to have any significant overall effect on the fish populations.

9.7.7 Discharge of cooling water into the sea

The power plant units use cooling water for cooling the turbine condensers. The process increases the temperature of the cooling water by 11 to 13 °C. Cooling water is conducted back to the sea at the Iso Kaalonperä bay, located to the west of the island, through a discharge tunnel and discharge channel.

Table 9-9 presents the cooling water flows of the existing two power plant units in 2006 and an estimate of the cooling water flows of the power plant unit under construction (OL3) and the new power plant unit (OL4).

There are two alternative arrangements for discharging the cooling water from the new unit. The different alternatives for discharge points are presented in Figure 9-38. In alternative A, the cooling water from the new unit will be discharged into the Iso Kaalonperä bay in connection with the discharge channel from the existing units. The length of the rock tunnel required for discharging the water will be 600 to 800 metres depending on the location of the plant unit.

In alternative B, the cooling water from the new unit will be discharged to the north of the existing discharge points through a discharge channel to be constructed to the southwest of Tyrniemi. The length of the discharge tunnel to be constructed will be 1,000 to 1,300 metres depending on the location of the plant unit. Furthermore, an alternative is assessed in which the northern bank of the discharge channel is extended, creating a dyke that will control the flows. The length of the dyke is 650 metres.

In both alternatives A and B, the inlet between Kuusisenmaa and Olkiluoto is closed with a dyke.

The cross-sectional area of the tunnels used for conducting cooling waters is approximately 50 m². This means that quarrying the tunnels will create 30,000 to 40,000 m³ of quarrying masses in alternative A or 50,000 to 65,000 m³ in alternative B depending on the location of the plant unit. The masses will be temporarily placed within the power plant area and used for earth construction work.

Cooling water that has flowed through the heat exchangers at the spent fuel storage facility is returned

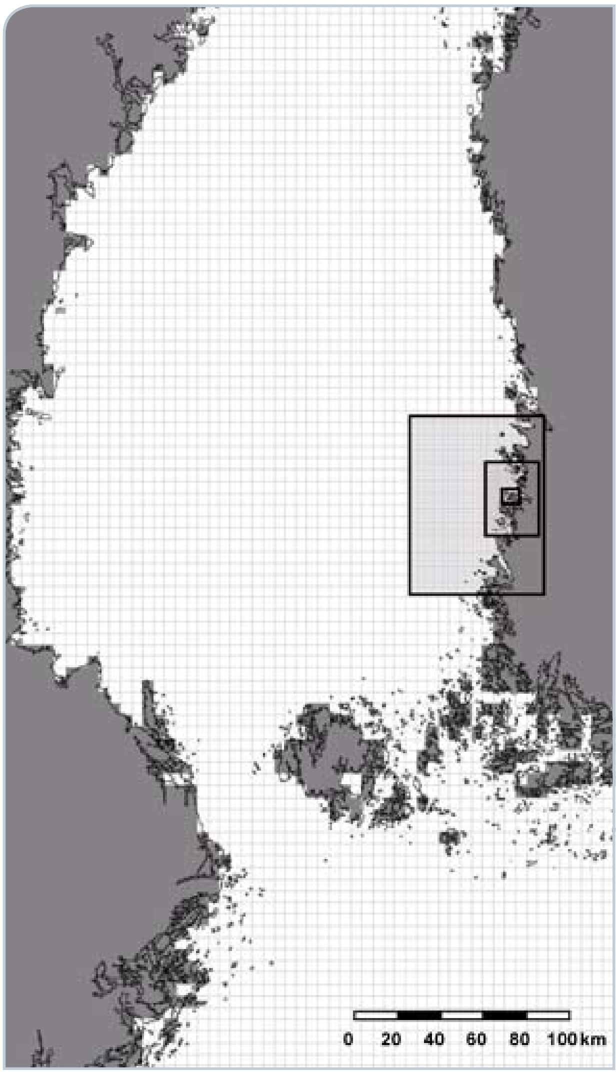


Figure 9-36 *Observation area for the water model. Precision of calculation is from the most extensive to the smallest 5 km, 1 km, 200 m, 40 m.*

to Olkiluodonvesi at the sea water pumping station. Spent fuel from the new power plant unit will somewhat increase the need for cooling water flow and cooling power.

9.7.8 Impacts of conducting cooling water to the sea

The impact of conducting cooling water to the sea has been studied through a three-dimensional flow model prepared for the sea area off Olkiluoto by YVA Oy *(Lauri 2007)*. The area near Olkiluoto has been modelled to a precision of 40 metres. In order to calculate boundary values, the coarsest grid in the model included the entire Botnian sea area to a precision of 5 kilometres.

In the model, the water system is examined in three dimensions – that is, the water is divided not only into longitudinal and lateral sections but also into vertical layers. In the depth direction, the model is divided into 16 levels of depth so that close to the surface, the thickness of a layer is 1 metre and increases with increased depth. The presently used model application was created on the basis of previous models prepared for the area off Olkiluoto by using a more precise calculation grid and more advanced methods of calculating turbulence and the migration of momentum.

The initial data for the model is meteorological data measured at the Olkiluoto meteorological station. The parameters for the model were set in accordance with the water area flow measurements of 1995 and the temperature measurements of 2003. Scenario calculations were carried out using information on the conditions in the summer of 2003 and the winter of 2002–2003. The model application for the area off Olkiluoto and the initial data are described in more detail in a separate report *(Lauri 2007)*.

Models are always simplifications of natural processes and phenomena and include errors dependent on the calculation method. The intention has been to minimise the embedded calculation error in the Olkiluoto model application but some tradeoffs have had to be made due to the optimisation of calculation time, for example. In the case of Olkiluoto, the model provides too high rather than too low values for water temperature *(Lauri 2007)*. A comparison of two different calculation situations reduces the significance of the error because the same error is included in both calculation cases. On the other hand, when observing temperatures of a certain calculation case calculated using the model, the embedded calculation error should be taken into account.

In spite of the above generalisations and uncertainty associated with calculations, even the results from the previous mathematical migration model created for the sea area off Olkiluoto in connection with the OL3 environmental impact assessment *(Teollisuuden Voima Oy 1999)* have been quite consistent with the results of observations in the sea area *(Turkki 2007)*.

The model allows the calculation of water temperature and ice conditions in the sea area off Olkiluoto. Other impacts of the new power plant unit on the condition of the sea area have been assessed on the basis of calculated temperature effects and other information available from the area.

The volume of cooling water used for modelling is 60 m^3/s for the new power plant unit (OL4) and 177.4 m^3/s for the units OL1 to OL4 in total. The quantity of heat conducted to the sea from the OL4 unit is 2,930 MW at maximum, and the quantity of heat conducted to the sea from the units OL1 to OL4 is 9,010 MW in total. Table 9-10 presents the thermal powers of the plant units conducted to the sea, cooling water flows and increases in temperature.

Table 9-10 *Thermal power of the plant units conducted to the sea, cooling water flows and increases in temperature used for modelling.*

Plant unit	OL1, OL2	OL3	OL4
Thermal power to the sea (MW)	2 x 1,670	2,740	2,930
Cooling water flow (m^3/s/unit)	2 x 30	57.4	60
Increase in temperature (°C)	13.3	11.4	11.7

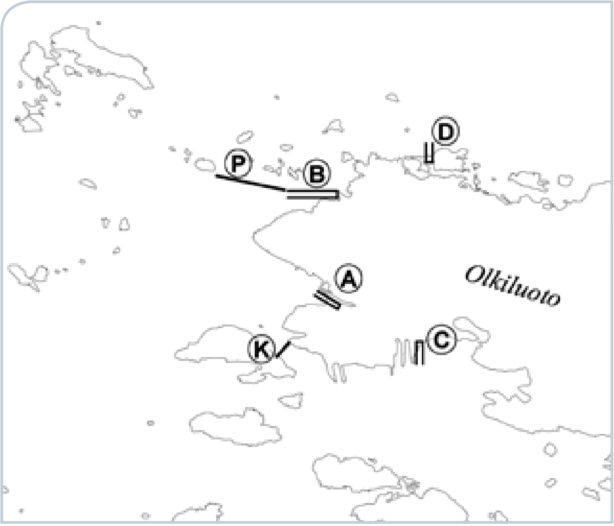


Figure 9-37 Cooling water intake and discharge points.

9.7.8.1 Impacts on sea water temperature

The cooling water intake and discharge points are shown on the map in Figure 9-37.

The cooling water intake and discharge points for the plant units OL1 to OL3 are constant. There are two alternatives for the cooling water discharge point for plant unit number 4:

A. Discharge point at the discharge point for units OL1 to OL3
B. Discharge point to the north of the discharge point for units OL1 to OL3

There are two alternatives for the cooling water intake point for plant unit number 4:

C. Intake point to the east of the intakes of the plant units OL1 and OL2
D. Intake point on the northern shore of Olkiluoto

Additional attributes include the following:

K. The inlet between Kuusisenmaa and Olkiluoto will be closed with a dyke.
P. The northern bank of the discharge channel B will be extended, creating a dyke that will control the flows. The length of the dyke is 650 metres.

The impact of the new power plant unit (OL4) on sea water temperature has been surveyed in five different situations (alternatives). The surveys have included existing cooling waters, cooling waters for OL3 under construction and cooling waters for the planned plant unit.

- 4CA = Intake from the south of Olkiluoto, discharge at the same location as units OL1–OL3
- 4CB = Intake from the south of Olkiluoto, discharge to the north of the discharge point for units OL1–OL3
- 4DA = Intake to the north of Olkiluoto, discharge at the same location as units OL1–OL3
- 4DB = Intake from the north of Olkiluoto, discharge to the north of the discharge point for units OL1–OL3
- 4DBP = Intake from the north of Olkiluoto, discharge to the north of the discharge point for units OL1–OL3; also the extension of the northern bank of the discharge channel creating a dyke that will control the flows.

All calculation cases make the assumption that the Kuusisenmaa inlet will be closed.

The series of figures 9-38 illustrates the increase in temperature due to cooling water in the surface layer for all alternatives in an example situation during the summer with wind blowing from the south. For comparison, the series of figures illustrates the situation corresponding to the zero option, with OL1, OL2 and OL3 in operation and the Kuusisenmaa inlet closed.

If OL4 cooling waters are to be discharged at the same location as cooling waters from the units OL1 to OL3, the warmed-up area will be expanded but its shape will remain approximately the same. If cooling waters from the new unit are to be discharged to the north of the existing discharge point, the thermal load will affect a new location and the area of warm water will be larger than if the discharge point was the same as that for units OL1 to OL3. Extension of the discharge channel bank will affect flows in the area and expand the warm water area.

Figure 9-39 illustrates an example of the impact of cooling water discharge on the temperatures of the surface layer of the sea area in a summertime example situation with a south wind.

Figure 9-39 An example of the increase of temperature caused by the cooling waters of units OL1 to OL4 in the surface layer in a summertime example situation with a south wind. In this situation, it is assumed that cooling water from the new unit will be discharged to the north of the existing discharge point (alternative 4CB).

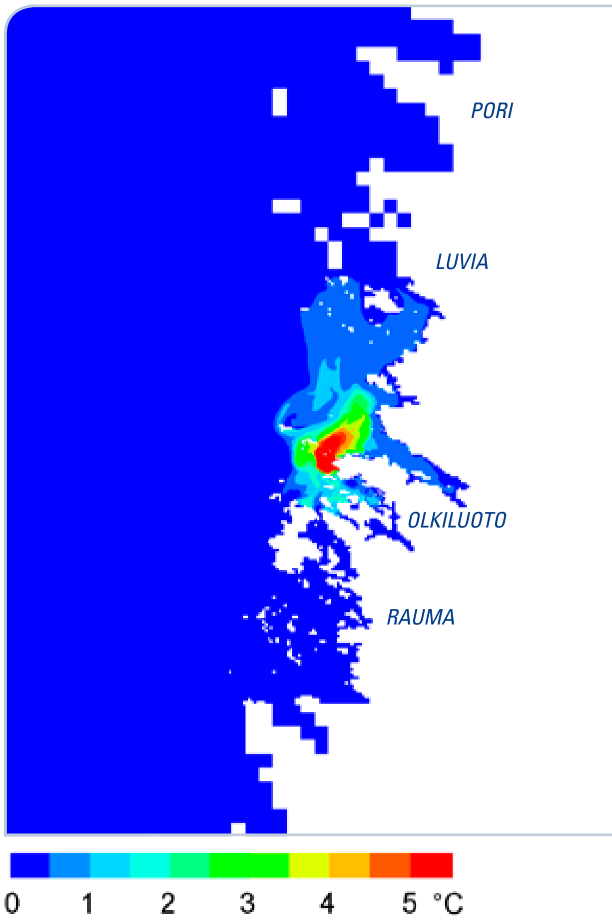


Figure 9-38 *The increase in temperature caused by cooling water in the surface layer in a summertime example situation with wind coming from the south, calculated using the model. Alternatives explained in the text.*

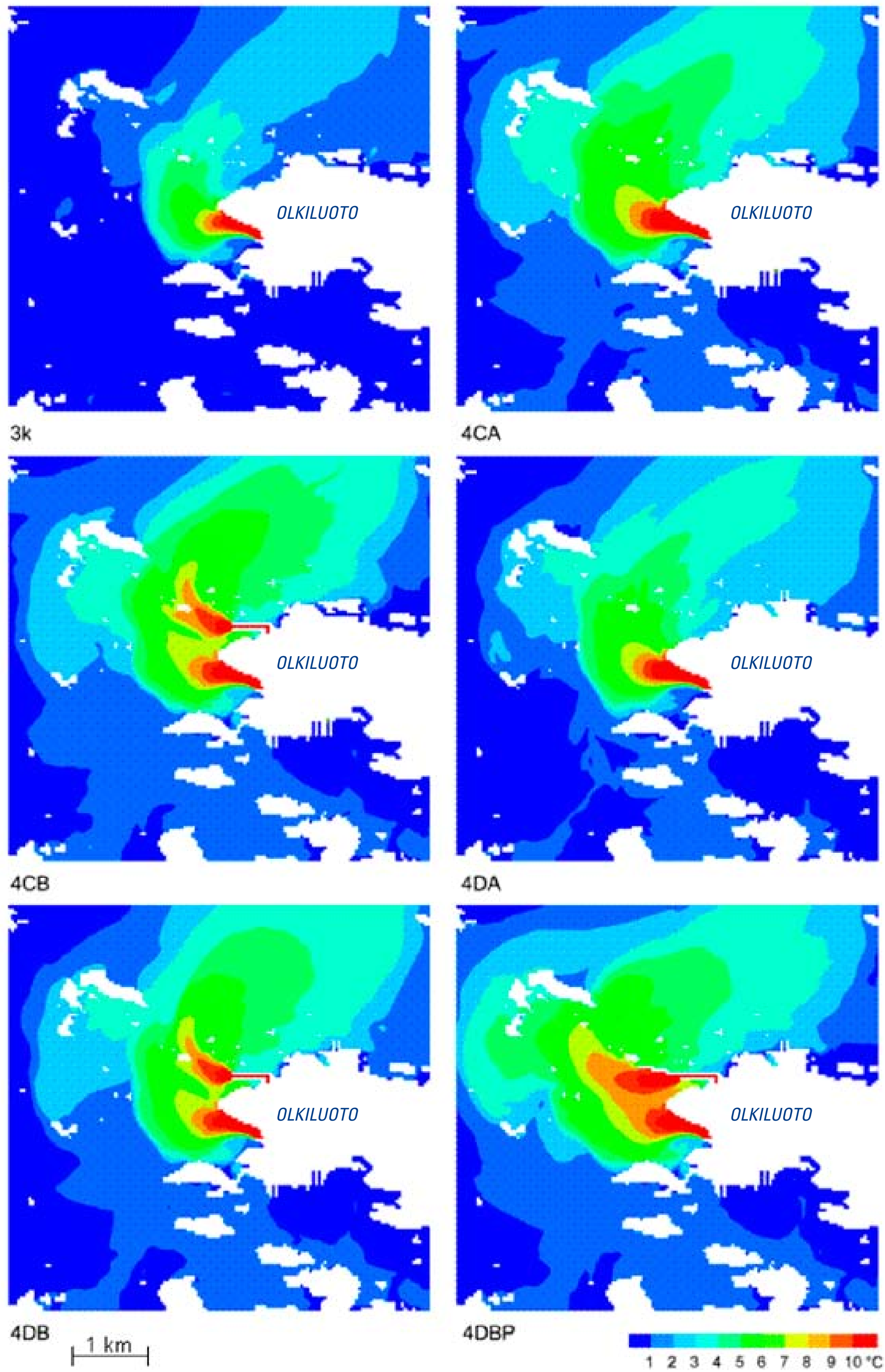


Figure 9-40 illustrates the areas warmed-up in summer with the different alternatives and wind from the south or north. The effect of weather on the extent of the warmed-up area is clearly greater than that of the difference between alternative discharge points. However, the warmed-up area is slightly larger in the alternative in which cooling water is discharged to the north of the discharge point for units 1 to 3 (discharge point B). Extension of the bank (alternative 4DBP) will further expand the warmed-up area.

According to the model calculation, the warming-up effect of cooling water in deeper water layers (2.5 metres of depth) remains minor in the present situation and with OL3 in operation, with the exception of the close surroundings of the discharge area. However, the commissioning of OL4 will increase the temperature effect at 2.5 metres of depth. The extent of the slightly warmed-up area (temperature increase approximately 3 to 5 °C) will increase particularly during a south wind. Extension of the bank at discharge point B will further increase the warm-up of water at 2.5 metres of depth during a north wind.

The warm-up is 1 to 3 °C in clearly more than half of the affected area in all of the surveyed alternatives. If cooling waters are discharged at the discharge point for units OL1 to OL3 during a south wind, the area warming-up more than 3 °C will be approximately one-third to one-fourth of the entire affected area. The difference between the alternatives will be smaller during a north wind. The area of surface water warming-up more than 5 °C is approximately 1.4 to 3.6 km² in the different alternatives during a south wind and 1.6 to 2.7 km² during a north wind. Deeper down, the area warming-up more than 5 °C is quite small.

The average temperature of incoming cooling water has been approximately 16 °C while the maximum temperature has been 24.7 °C *(Lauri 2007)*. The power plant warms-up the cooling water by approximately

Figure 9-40 *Areas of water warmed-up in summer in an example situation with wind from the south and north.*

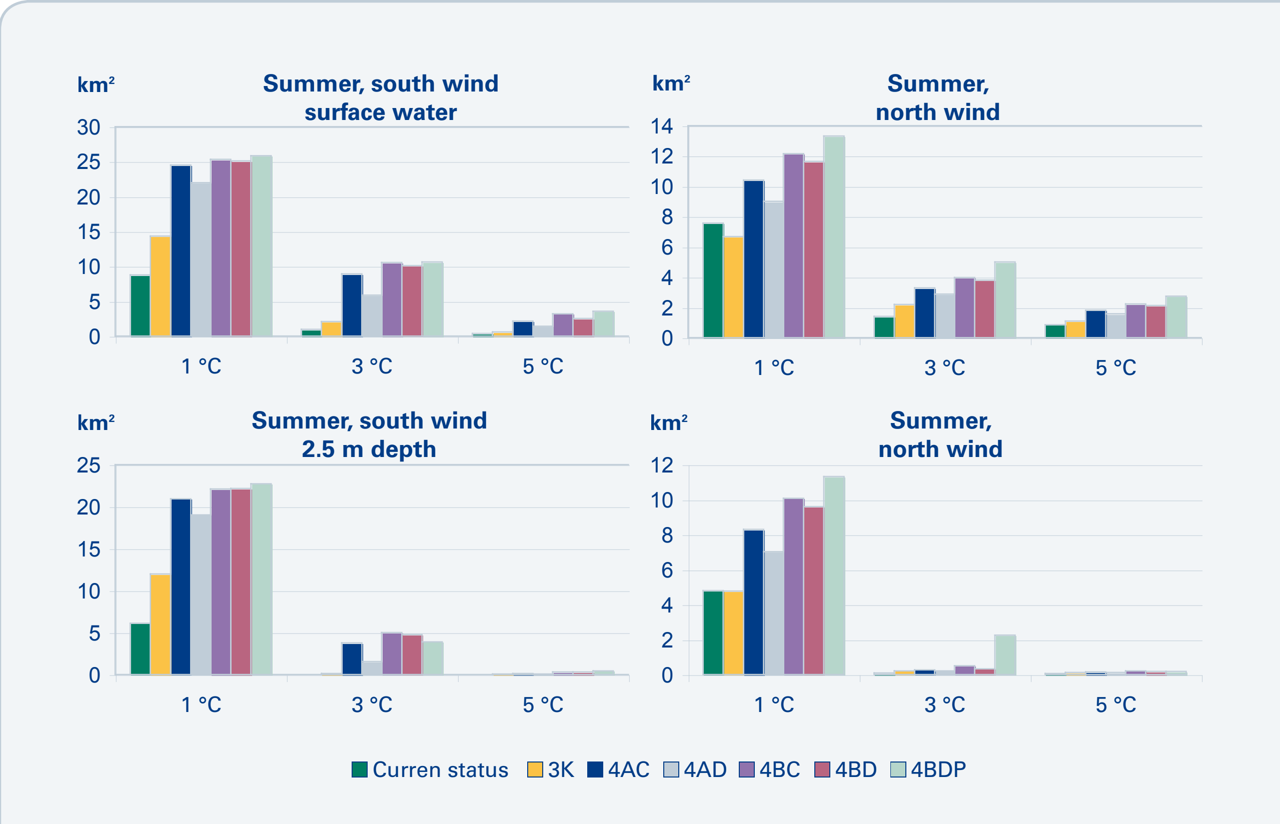
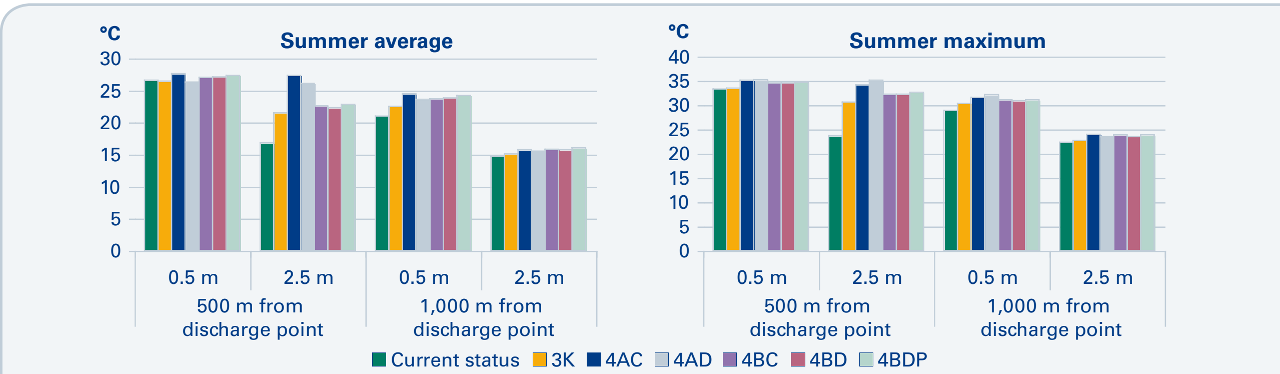


Figure 9-41 *Calculated temperatures off the existing cooling water discharge points in the present situation, with the OL3 unit in operation (zero option) and with the different alternatives of the OL4 unit in operation as an average over the summer. Alternatives explained in the text.*



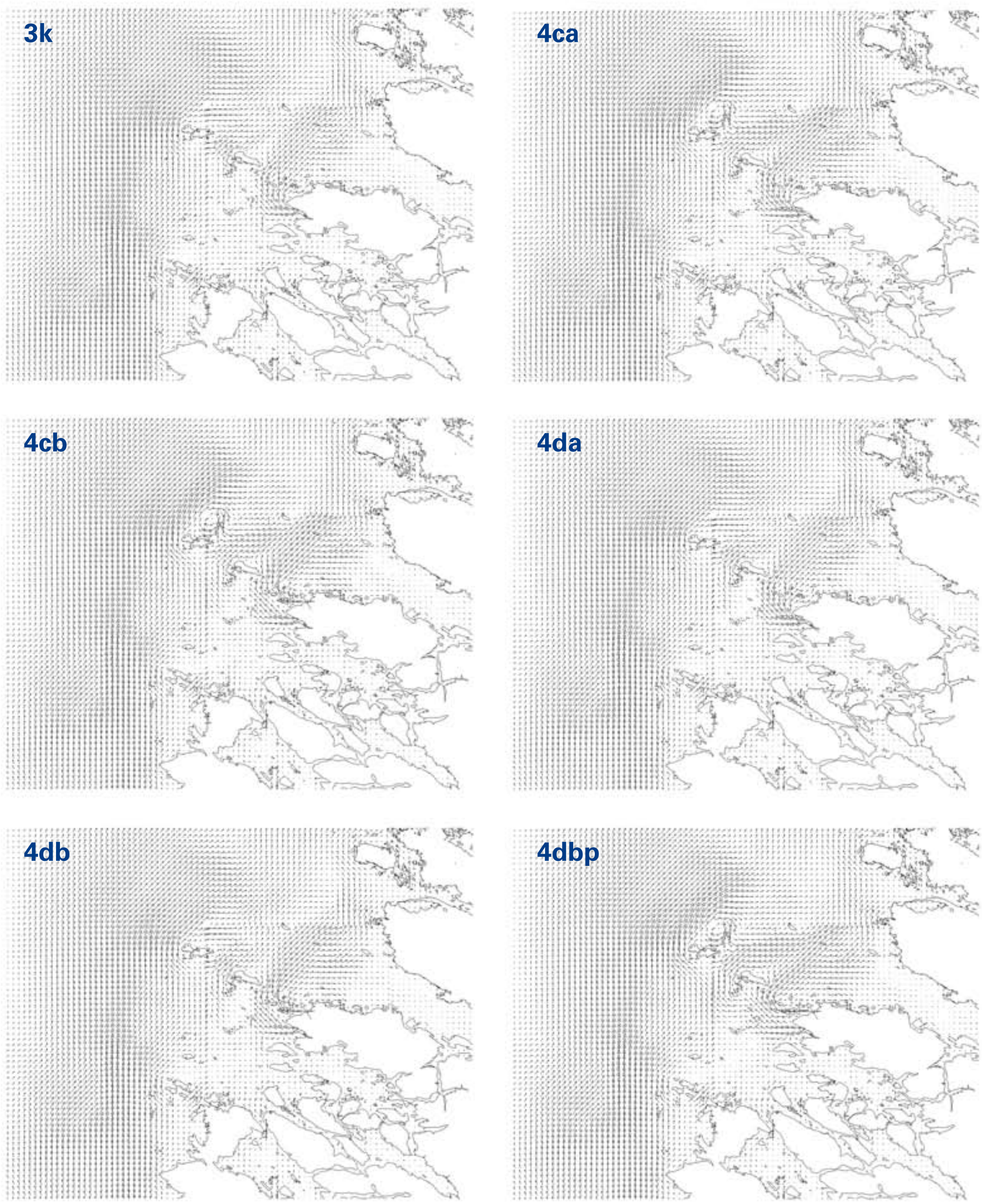
12 °C, meaning that the temperature of water discharged to the sea is approximately 28 °C, with a maximum of approximately 37 °C. Figure 9-41 represents a calculated average and maximum temperatures for the summer (31 May to 31 August) at approximate distances of 500 metres and 1 kilometre from the existing cooling water discharge point.

At approximately 500 metres from the discharge point, the temperature of surface water (0.5 metres) changes only slightly in comparison to the current situation. However, a water layer thicker than at present will warm-up particularly if the cooling waters from the new unit are conducted to the same discharge point as cooling waters from the units 1 to 3. The change in maximum temperatures at the surface layer can also be considered minor but the water will warm-up more clearly deeper down. Further outward, approximately 1 kilometre from the discharge point, the surface water will warm-up by approximately 2.5 to 3.5 °C compared to the present situation both as the summer average and in the maximum situation but the change close to the bottom will be quite minor.

In the winter, cooling water will be mixed in the surface layer of the sea water. After cooling down to a few degrees, the cooling water will dive below the colder epilimnion layer and settle in a layer of water corresponding to its density. In the present situation, the temperature increase caused by cooling water can be observed at a distance of 3 to 5 kilometres from the shore. In the cooling water discharge area, the temperature of the surface layer increases by 5 to 7 °C, and further out, it increases by 0.5 to 2.0 °C *(Kirkkala & Turkki 2005)*.

If the cooling water from the new power plant unit (OL4) is conducted to the same discharge point as that from the units OL1 to OL3, the volume of cooling water will increase but the temperature will not change. There will not be any change in temperature in the cooling water discharge area but a thicker water layer will warm-up as

Figure 9-42 *Surface flows in August for the zero option (3K) and the intake and discharge point alternatives for OL4 cooling waters in a south wind.*



the flow rate is higher. If the discharge point of the new power plant unit is to the north of the existing discharge point, the nearby affected area – that is, the area in which the temperature increases by some 5 to 7 °C – will expand to the north of the existing discharge point. In the winter, like in summer, the impact of cooling water is estimated to cover an area approximately 2.5 times larger than at present – that is, to a distance of approximately 7.5 to 12.5 kilometres from the discharge point.

9.7.8.2 Impact on currents

The series of figures 9-42 presents surface flow rates calculated using the model for all of the above alternatives. In prevailing south winds, there will be a current off the coast towards the north having a width of 2 to 5 kilometres. At Olkiluoto, the current will mostly flow to the west of Kalla but will partially branch at the inlets between Olkiluoto, Susikari and Kalla.

There are no substantial differences between the different calculation scenarios with the exception of alternative 4DBP in which the dyke will cause changes in the flow rates to the south of Susikari. The vortex shown in the images for scenarios 4CA, 4CB and 4DBP to the north of Kalla is located next to an angle point in the model grid and is probably at least partially caused by the calculation method.

9.7.8.3 Impact on the ice conditions and the formation of fog

The impact of the new power plant unit on the ice conditions were simulated in the situation of the winter season 2002–2003. According to the ice service of the Finnish Institute of Marine Research *(Kalliosaari 2003)*, the ice winter 2002–2003 was average in terms of ice areas. The winter deviated from the ordinary in that it started earlier than average, and the period of ice cover lasted longer than average. Freezing in Botnian sea started more than 3 weeks earlier than average. At the turn of the year, there was a frozen area 10 to 25 nautical miles wide in front of the coast in Botnian sea. Early January was cold, and on 7 January, almost all of Botnian sea was covered with ice. The weather became mild and windy in mid-January, and in Botnian sea the thin ice was compressed against the Finnish coast and formed a strong zone of packed ice in front of the coast. February started with a period of freezing and ice formed in all sea areas so that the Gulf of Bothnia was entirely covered with ice. The most extensive ice conditions of the winter were reached on 5 March. *(Kalliosaari 2003.)*

Alternative	Unfrozen area or weak ice km^2
present situation	3.54
OL3 in operation (zero option)	7.11
4CA	9.21
4CB	10.24
4DA	9.44
4DB	10.52
4DBP	10.73

Table 9-11 *Unfrozen area or area of weak ice (thickness less than 10 cm) in the conditions of the winter season 2002-2003 in the present situation, with OL3 in operation (zero option) and with different alternatives of OL4 in operation. Alternatives explained in the text.*

The size of the unfrozen area in the present situation, with OL3 in operation (the zero option) and with OL4 in operation with the different calculation alternatives is presented in Table 9-11.

If cooling water is conducted to the north of the existing discharge point, the unfrozen area or area of weak ice is approximately 1 km2 larger compared to the use of the same discharge point as for units OL1 to OL3. The unfrozen area or area of weak ice is approximately 3 times the size of the present situation and approximately 1.5 times the size of a situation with three power plant units in operation. The series of figures 9-43 presents the ice conditions corresponding to the zero option and the impact of the new unit with different alternatives of intake and discharge locations.

Even though this type of a model calculated for different alternatives in a constant situation is the most illustrative presentation of the change caused by the new unit in the ice conditions and the differences between the alternative intake and discharge points, one must keep in mind that in the real world, factors such as wind direction and velocity, currents in the sea area and temperature will have a substantial effect on the size and shape of the unfrozen area.

Fog is formed over the unfrozen sea area during cold and calm days of freezing temperatures. The fog over the unfrozen area off Olkiluoto does not cause any harm to sea or road traffic.

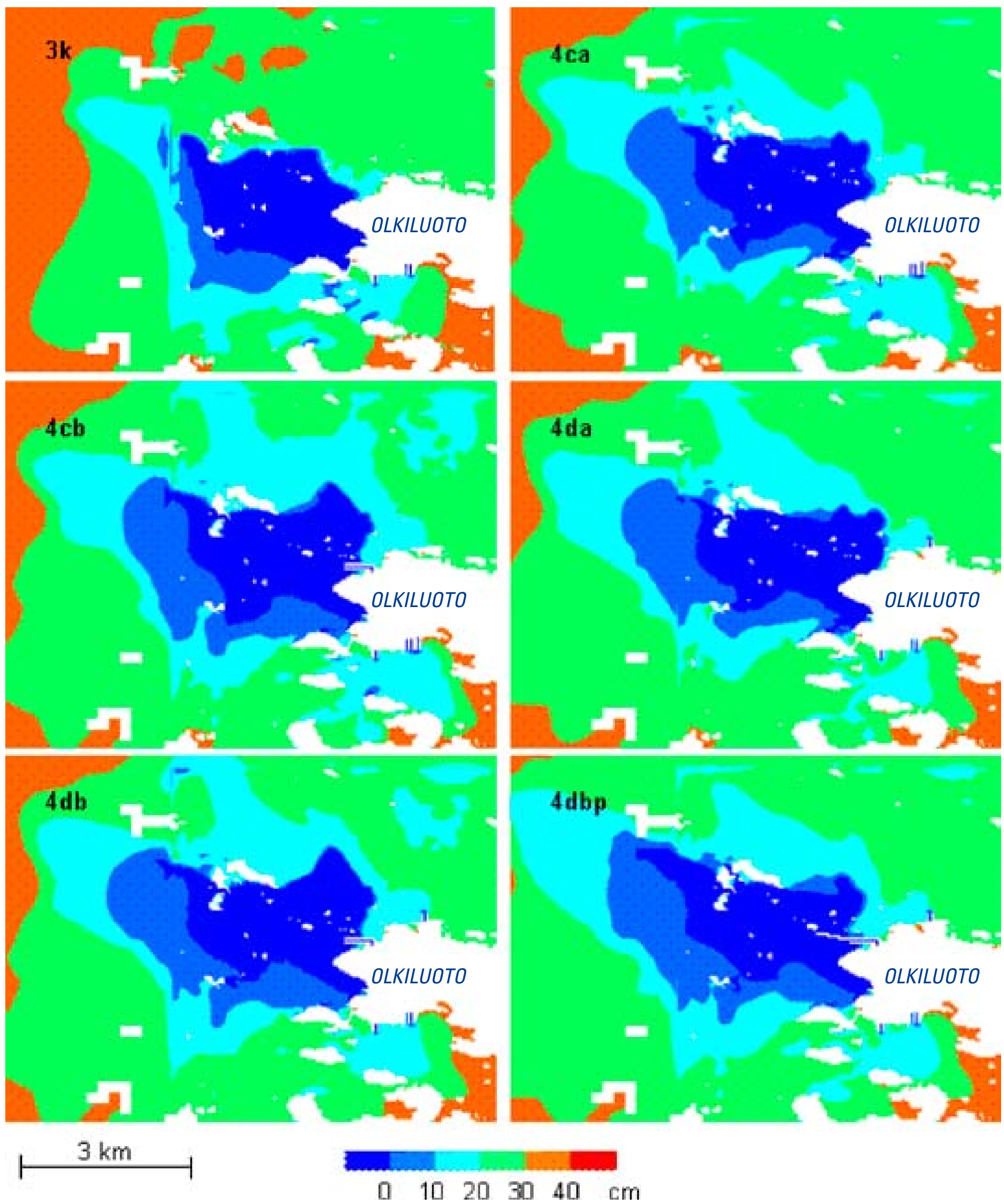
9.7.8.4 Impact on water quality and biology

With the new power plant unit in operation, the calculated maximum temperature at a distance of 500 metres from the discharge point is approximately 35 °C, and at a distance of 1 kilometre it is approximately 31 to 32 °C depending on the alternative under review.

In general, the increase in temperature due to the discharge of cooling water will speed up biological functions. Metabolism increases and the growth of organisms becomes faster if sufficient nutrition is available and the conditions are otherwise favourable. The vegetation period will become extended, and the increased temperature will usually improve the living conditions for plants in general. The changes are limited to areas in which the temperature is continuously more than 1 °C above the environment.

The differences in water temperature between the alternatives for discharge and intake are minor. Due to the minor temperature differences, the differences in water quality and the ecological condition of the discharge water system will also remain minor, due to which the differences between the alternatives have not been taken into account in the following unless differences in the variable in question can be observed between the alternatives.

Figure 9-43 *Ice conditions and ice thickness in the situation corresponding to the zero option (3k) and the impact of the new unit with different alternatives of intake and discharge locations.*



Water quality
Besides the heat load, cooling water does not cause any nutrient or oxygen-consuming load in the water system. The water quality to the south and north of Olkiluoto is similar to that in the discharge area, which means that the cooling water does not convey load from one point to another in either of the intake alternatives.

Cooling water warmer than the environment may increase the natural temperature stratification of the sea area, which was evident in the monitoring of waters around Olkiluoto in 2006 *(Turkki 2007)*.

The stratification of water can mainly affect the oxygen conditions in the hypolimnium and subsequently the other qualities of the hypolimnium. The oxygen conditions in the sea area off Olkiluoto have been good also close to the bottom and almost without exception, and the situation is not estimated to change substantially due to the increased thermal load.

Any decline or dissolution of temperature stratification close to the cooling water discharge area may slightly increase the nutrient concentrations in the epilimnion layer and subsequently basic production particularly in the beginning of the vegetation period. The difference in the quality of the epilimnion and hypolimnium at a distance of 1 kilometre from the discharge point has been estimated on the basis of water quality results. In the results, the concentrations of total phosphorus and ammonium nitrogen have often been higher in the hypolimnium than in the epilimnion during the spring.

Phytoplankton
OL4 will increase the thermal load on the sea but the temperature of cooling water will change only slightly. The changes in surface water temperature close to the cooling water discharge area will be small but the warm layer of water will become deeper particularly if cooling water from OL4 is to be discharged at the same point used for units OL1 to OL3. Increased cooling water volumes will increase the warmed-up area in all of the alternatives under review.

The impact of cooling water on phytoplankton production near the cooling water discharge area will remain roughly at the present level. Near the cooling water discharge area, temperature is not a factor restricting basic production during the vegetation period but the volume of production is mostly dependent on the availability of nutrients. However, the potential dissolution of temperature stratification and expedited decomposition due to the warm-up of the hypolimnium may speed up the circulation of nutrients during the vegetation period and thus increase phytoplankton production. However, the changes close to the cooling water discharge area during the vegetation period are estimated to remain minor. On the other hand, winter-time production in the unfrozen area can increase to some extent due to the warmed-up layer becoming deeper.

Impacts on phytoplankton production similar to the present ones will be observed in an area larger than previously. Compared to the present situation, the temperature will increase by more than 1 oC in an area of approximately 5 to 15 km^2 depending on the wind conditions. Phytoplankton production will increase in a corresponding area. In this area, the vegetation period will be extended and total production will increase. However, the changes in phytoplankton production in high summer are estimated to be minor because the availability of nutrients will restrict the increase in production.

In addition to increased phytoplankton production, changes in community structure may occur in the area affected by cooling water because different species of algae have different optimum temperatures *(Wetzel 1983)*. Changes in community structure have been observed in the discharge area for cooling water from Olkiluoto; for example, blue-green algae have been more common than in the comparison area *(Kirkkala & Turkki 2005)*. However, the occurrence of blue-green algae in the area has been relatively low. Blue-green algae are typically warm water species so it is probable that they will be found in the area affected by cooling water also in the future. The optimum temperature for several species of algae is close to 30 °C *(Wetzel 1983)*, which means that favourable conditions for several groups of algae can be found in the immediate vicinity of the cooling water discharge area. Power plant cooling waters have been conducted to the waters off Olkiluoto for approximately thirty years, which means that the algal community has had time to adopt to a temperature higher than the vicinity and no further changes in community structure are expected to occur due to cooling water but, similar to the changes in phytoplankton production, the impact will extend to a larger area.

Aquatic vegetation and macro-algae
Clear changes in vegetation have been observed close to the cooling water discharge area. Macro-algae have suffered, with the exception of annual filamentous green and brown algae. Vascular plants benefiting from the situation include particularly sago pondweed and Eurasian water milfoil, which can tolerate thermal load. All in all, vegetation has become less diverse and eutrophication has increased.

If cooling water from OL4 is to be conducted to the same discharge point as cooling water from units OL1 to OL3, the flow in the area will increase and the effect of ashing the bottom will expand to a larger area. On the other hand, if cooling water from OL4 is to be conducted to a new location, that area will also experience a ashing effect but due to the smaller volume of water, the impact will be smaller than in the present discharge area.

OL4 will increase the thermal load in the area and expand the area in which changes in aquatic vegetation will be observed. The extent to which changes in aquatic vegetation will be observed depends on the proportion of sea bed suitable for aquatic vegetation in the warmed-up area. In any case, vegetation will become less diverse, and production will increase over a larger area. According to a study on aquatic vegetation *(Kinnunen & Oulasvirta 2005)*, the impact of cooling water on aquatic vegetation would seem to extend to the area maintained unfrozen by warm water during most winters. The unfrozen area is estimated to increase almost threefold compared to the present situation when OL3 and OL4 are in operation *(Lauri 2007)*.

Increased production will result in increased volumes of decomposing organic mass. If accumulated in basins, increased organic matter may cause deterioration of the oxygen conditions in the hypolimnium of basins in a larger area than previously, and this will have an impact on the sea bed fauna.

Comb jelly

Comb jelly *(Mnemiopsis ledyi)* is an invasive species that was first observed in the Baltic Sea on the west coast of Sweden, in the Kattegat area and in southern Baltic Sea in the autumn of 2006. The species has spread rapidly, and in August 2007 it was found to be abundant in the deep areas of the Åland Sea and Botnian sea. The species originates in the east coast of North and South America and has spread to other regions in the ballast water of ships.

The comb jelly is a translucent jelly-like animal that is very adaptive. The species is known to appear at salt concentrations of ≤ 2 to 39 and temperatures of 0 to 32 °C *(Purcell et al. 2001)*. The salt concentration of the Baltic Sea is suitable for the species but it has been estimated that the cold winter season will limit its occurrence. However, during the summer of 2007 it was determined that the comb jelly is able to reproduce in the cold conditions of the Baltic Sea.

The comb jelly will not seek its way to the surface layer in the Baltic Sea but seems to favour the metalimnion of salinity or below it at a depth of approximately 80 to 110 metres. However, in its natural habitat on the west coast of the Atlantic and in the Black Sea, the species is mainly found in the surface layer *(Purcell et al. 2001)*.

The comb jelly is hermaphroditic and able to reproduce by division, which makes its reproduction very efficient in favourable conditions. One comb jelly will produce approximately 3,000 eggs per day if nutrition is abundant and the temperature is approximately 25 °C. Reproduction occurs at temperatures exceeding 12 °C *(Purcell et al. 2001)*.

The comb jelly preys efficiently on animal plankton, fish spawn and fry. In the Black Sea, for example, the invasive species has substantially changed the ecosystem and collapsed fish populations due to efficient reproduction and the lack of natural predators. The significance of the comb jelly in the food grid of the Baltic Sea remains unclear for the time being.

Cooling water from the Olkiluoto power plant locally increase water temperature. After the commissioning of OL4, the impact is estimated to extend to an area of approximately 25 km^2. Farther out, the impact of the power plant cannot be distinguished from natural variation. The greatest depths in the sea area off Olkiluoto are approximately 15 metres, and the average depth is less than 10 metres. The comb jelly has been found to live in the Baltic Sea at a depth of more than 80 metres at or below the metalimnion of salinity. On the other hand, the thermal load from the Olkiluoto power plant is directed mostly to the surface layer and, at the Baltic Sea scale, locally to the sea area off Olkiluoto, so the potential effect of the increased thermal load on the occurrence or reproduction of the comb jelly in the Baltic Sea is estimated to remain minor and cannot be separated from the impact of other factors. On the basis of the Black Sea example, the most important factor affecting the fluctuation of comb jelly populations is the lack or occurrence of natural predators in the area.

Hidrozoa

The Caspian colonial hydroid Cordylophora caspia is a novel species originating in the Black Sea – Caspian Sea area that settled in the Baltic Sea in the early 19th century. It is a brackish water species that tolerates a wide variation of salinity from fresh water up to approximately 15 ‰ of salt. The species is present in all of our coastal waters, mostly in the inner archipelago and sea inlets.

Hidrozoa growth identified as the Caspian colonial hydroid was observed in increasing numbers at the Olkiluoto nuclear power plant in late summer 2006. Inspections carried out during the annual outages of 2007 revealed that the hidrozoa had spread extensively to the sea water sections of heat exchangers at both plant units. The locations where the hidrozoa was found were surveyed, and the extent of occurrence was estimated. At several locations, the growth of hidrozoa was found to be abundant or very abundant and to have a deteriorating effect on the heat transfer ability of the heat exchangers. The Caspian colonial hydroid does not affect the safety or power of the plants.

The Southwest Finland Regional Environment Centre has approved an experiment on controlling the Caspian colonial hydroid through the chlorination of cooling water. The residual concentration of chlorine remains very low, and the addition of chemicals is not considered to cause danger of environmental pollution.

False dark mussel

The false dark mussel *(Mytilopsis leucophaeata)* is a species belonging to the family Dreissenidae having its original area of distribution in the Gulf of Mexico region in North America. It is found as an invasive species in Western Europe (Netherlands, Germany, France, Great Britain) and in the Black Sea and Caspian Sea areas. In the Baltic Sea, the species has previously only been observed in individual occurrences in Northern Germany.

In connection with environmental monitoring at the Loviisa power plant in 2003, intensive reproduction of mussels was observed in the cooling water discharge area. The false dark mussel is a brackish water species with its optimum salinity referenced at 1.4 to 12.7.

The extent of the false dark mussel occurrence in Finnish waters remains unclear. Because the false dark mussel originates from the borderline between the subtropical and temperate zones, it is possible that the presently observed occurrence is limited to areas with a higher sea water temperature than normal. *(Kainulainen 2006.)*

In September 2006, when inspecting a sea water sampling unit off the cooling water discharge channel at Olkiluoto, STUK employees detected small numbers of false dark mussels. If the mussels end up in the plant's heat exchangers, they may hinder their operation. TVO is monitoring the situation and has made preparations to control the false dark mussels.

Sea bed fauna
Through biological circulation, cooling waters have occasionally indirectly deteriorated the oxygen conditions in the hypolimnium and thus increased the instability of sea bed fauna communities and their susceptibility to fairly rapid changes in species and biomass. OL4 will not cause any substantial change in the present impact mechanisms but the affected area will be expanded. Locally increasing amounts of organic matter and slight eutrophication of the sea area will favour the reproduction of species or groups that benefit from eutrophication. Many species of fish feed on sea bed fauna but the impact of occasional declines in sea bed fauna on the nutrition conditions of fish will remain local.

9.7.8.5 Impacts on the fish population and fishing industry

Adaptation of fishes to different temperatures
Fishes can be roughly divided into cold water and warm water species *(Alabaster & Lloyd 1980)*. Cold water species include, among others, all of our salmonoids, ide, burbot and sculpins. Warm water species include most cyprinids, pike-perch, perch, pike and ruff. The optimum temperature for the growth of mature cold water fishes is 12 to 19 °C, and the lethal temperature is less than 28 °C *(Alabaster & Lloyd 1980)*. The optimum temperature for warm water species is more than 19 °C and the lethal temperature is more than 28 °C, for many species even more than 30 °C. Fishes are not tolerant of rapid changes in temperature. Fry are more sensitive than mature fishes, and rapid changes of 1.5 to 3.0 °C are harmful to fry *(Svobodá et al. 1993)*.

Changes in water temperature may change the time of spawning and affect the rate of spawn development. If the water is too warm, the fry may be hatched before their most important food, animal plankton, has sufficiently developed. On the other hand, a suitable increase in temperature may also improve the living conditions of fish species spawning in the spring in particular. When the water temperature exceeds the optimum temperature for the fish, the fish tend to reduce swimming and food intake. Prolonged exposure to high temperatures imposes stress on the fish and exposes them to diseases. The immune system of fishes is most efficient in water of approximately 15 °C *(Svobodá et al. 1993)*.

Fishes will actively seek their way to a suitable temperature, which means that they are usually able to avoid areas such as the cooling water discharge areas in which the temperature becomes too high.

Fish populations
In principle, a slight increase in water temperature, particularly if associated with increased eutrophication, will favour less valuable fish species spawning in the spring at the expense of more demanding species spawning in the autumn. However, local warm-up of surface water is not estimated to have any more extensive substantial harmful impact on the fish populations in the area because deeper water layers are cooler, and fishes can actively seek their way to a suitable temperature. In the summer, warm water fish species spawning in the spring will favour the area affected by cooling water, but in the winter, the area will also attract cold water species such as whitefish and trout.

Cooling water has no impact on the populations of migrant fish. The spawning areas of the local rock whitefish spawning in the autumn are mostly located away from the immediate discharge area close to the shore, which means that any harmful warm-up of the hypolimnium in potential spawning areas will be minor. Burbot, which spawns in the winter, does so most often in January-February at a depth of less than 3 metres *(Lehtonen 1989)*. The time of spawning depends on water temperature, and spawning usually occurs when the water temperature is at its minimum, with the optimum temperature at 0 to 3 °C *(Evropeitseva 1947)*. The optimum temperature for the development of spawn is 4 °C *(Jäger et al. 1981)*. An increased temperature may hamper the reproduction of burbot in the immediate vicinity of the discharge area but is not estimated to have any substantial effect on the burbot population in the area. This is also indicated by the results of fishery monitoring, according to which the burbot population in the area is normal *(Ramboll Finland Oy 2007c)*.

A suitable increase in temperature may advance the time of spawning and speed up the development of spawn and growth in the fry and mature stages, which may have a positive effect particularly on the populations of fishes spawning in the spring. For example, the early spawning of the Baltic herring and perch has been observed in cooling water discharge areas in Sweden *(Neuman & Andersson 1990)*. Indications of the early spawning of the Baltic herring have also been observed off Olkiluoto *(Vahteri 2000)*. In fairly enclosed cooling water discharge areas in Sweden, the growth of perch has been observed to improve clearly *(Sandström 1990, Neuman & Andersson 1990)*. The mixing of water masses in a fairly open sea area like Olkiluoto is more efficient, and the effect of increased temperature on the growth of fishes is smaller. The growth rate of perch was found to have improved somewhat in the cooling water discharge area compared to the surrounding sea in the 1990s *(Oy Vesi-Hydro Ab 1995)*, but in 2006, for example, the differences in perch growth in different areas were minor, and the material did not provide any indications of improved growth in the discharge area *(Ramboll Finland Oy 2007c)*.

The new power plant unit will expand the area affected by cooling water but the impact on fish populations will remain similar to the present. Increased temperature has different impacts on fish populations. When taking into account the migration of fishes, cooling water as a whole is not estimated to impose any substantial or extensive harmful effects on the fish populations of the area. However, in the long-term, increased temperature and its consequences will favour fish species spawning in the spring such as pike, perch, pike-perch, bream and roach.

Parasites
A high water temperature and extended warm period will expose fishes to different parasite attacks and diseases, which has been confirmed at fish hatcheries, for example. However, no direct parallels can be drawn between the conditions at sea and those at an engineered facility. No known parasite studies from the discharge areas of Finnish power plants have been published *(Fagerholm, H., Åbo Akademi University, oral information)*. Swedish

studies have not detected any differences between the occurrence of parasites in the warmed-up area and in a comparison area *(Höglund & Thulin 1988, Sandström & Svensson 1990)*.

Gas bubble disease

When the temperature of water increases, the amount of gas soluble in it decreases. The water may develop a supersaturated condition in which excessive atmospheric nitrogen or oxygen present in the water will form bubbles. Supersaturation of oxygen is also present naturally, particularly in eutrophic waters during maximums of phytoplankton production. When a fish moves from cold water to warm supersaturated water, bubbles may be formed in the tissue fluid, damaging or killing the fish. Gas bubble disease may occur in the immediate vicinity of cooling water discharge points.

Fishes are able to avoid supersaturated water to some extent *(Langford 1990)*. Furthermore, the depth of swimming – that is, environmental pressure – affects the release of gas. No harmful effects have been observed in the discharge areas of Finnish power plants, and the new power plant unit is not estimated to bring any substantial change.

Fishing

The new power plant unit will expand the area affected by cooling water but the impact on fishing will mainly remain similar to the present. If cooling water is discharged to the north of the existing discharge area, the affected area will expand from the present towards the north. Fishing in the sea area off Olkiluoto is presently done mostly with nets and rods. The most substantial impact of cooling water with regard to fishing takes place in the winter season when the area of unfrozen water and weak ice limits fishing from the ice. The Olkiluoto sea area, which faces the open Botnian sea, has naturally unstable ice conditions, and the cooling water from the existing units hamper its suitability for winter fishing. The new unit will expand the area of unfrozen water and weak ice from the present. As the opportunities for fishing from the ice are deteriorated, the opportunities for winter-time fishing in the unfrozen area are simultaneously improved. The unfrozen area attracts fish such as whitefish and trout in the winter.

In summer, the slight eutrophication of the sea area increases algal growth and consequently causes an increased build-up of slime in stationary fishing tackle, calling for more frequent cleaning. In the summer, salmonoids favouring cold water will avoid the area clearly affected by cooling water, and dominant species of fish in the area will be those of lower value that spawn in the spring and favour warm water. This may cause some increases in fishing distances in the summer, for example, with regard to whitefish. Cooling water and its consequences are not estimated to have any effect on the usability of fish.

9.7.8.6 Impact on the use of the water area

Weakened ice conditions due to the discharge of cooling water will limit operations on the ice, such as winter fishing, skiing, tour skating and access to cottages in the archipelago. The fourth power plant unit will expand the unfrozen area by approximately threefold compared to the present situation and by one-third compared to the situation when the third power plant unit is in operation. After the commissioning of the fourth power plant unit, the unfrozen area will extend outside of Iso Susikari. The ice conditions in Olkiluodonvesi will also deteriorate compared to the present situation. On the other hand, the unfrozen area will enable round-the-year boat access to some of the islands in the area, as well as winter fishing from open water.

In addition to the deteriorated ice conditions, the new power plant unit may increase eutrophication of the sea in a more extensive area. Eutrophication of shores, contamination of fishing tackle and increased murkiness of shore waters may deteriorate the conditions for fishing and recreation.

9.7.9 Waste water from Olkiluoto

Waste water generated at the power plant and on the site includes water from the raw water treatment and demineralisation plant, water from the liquid waste treatment plant, water used for flushing the travelling band screens, sanitary waste water and laundry waste water. The waste water is processed appropriately before being conducted to the sea.

Process waste water

The new plant unit has a designated treatment plant for liquid waste that processes all water coming from the so-called controlled area that may contain radioactive substances. The waters are treated mostly by filtration and evaporation to reduce radioactivity.

Process waste water that will be discharged into the water system after treatment (such as filtration, ion exchange, separation and evaporation) mainly includes filter rinsing and decantation water, floor cleaning water, sewage from the laboratory, neutralised waste water originating from decontamination, as well as laundry waste water. The radioactivity of water is measured before it is conducted to the cooling water discharge tunnel. Furthermore, the radiation level of the water in the discharge pipe is monitored by instruments that will automatically close the valves in the discharge pipe if there is excess radioactivity in the water. A collection sample is taken during outward pumping, and the concentrations and releases of radionuclides and total phosphorus are measured and determined.

The existing units (OL1 and OL2) generate approximately 70 m^3 of process waste water daily, the nuclear power plant unit under construction (OL3) is estimated to generate approximately 200 m^3 daily, and the new nuclear power plant unit is estimated to generate between 70 and 400 m^3 daily.

Waste water originating from the production of process water

The filter sludge liquor originating from the filtration of raw water at Korvensuo is conducted to an earth basin of 10,000 m^3 in which the sludge will be sedimented. The overflow from the basin is conducted through a secondary settlement basin of 0.6 hectares to an open

Table 9-12 Estimate of the volumes of waste water generated in the treatment of process waters at different stages of plant operation.

Operating condition of the nuclear power plant units	Sludge liquor from the filtration of raw water [m³/h]	Sludge liquor from settlement at water treatment plant [m³/h]	Water used for rinsing filters at water treatment plant [m³/day]
OL1/OL2	5	1	4
OL1/OL2/OL3 construction time	15 - 20	3 - 4	12 - 16
OL1/OL2/OL3 operation	8 - 13	2 - 3	6 - 10
OL1/OL2/OL3/OL4 construction time	25 - 35	5 - 7	20 - 28
OL1/OL2/OL3/OL4 operation	11 - 21	3 - 5	8 - 16

ditch and further to the sea in the Eurajoensalmi inlet to the east of Marikarinnokka (to the west of Kornamaa). The quality of the overflow water is similar to the raw water taken from the Eurajoki river, and it does not contain any significant amounts of residue from water treatment chemicals.

The settling section of the water treatment plant located at the power plant site produces sludge liquor and filter rinsing waters. Sludge liquor and rinsing waters having a pH of 5.5 to 6.5 are conducted to the cooling water discharge channel. Water that might contain oil is conducted through oil traps fitted with alarms. Table 9-12 presents an estimate of the volumes of waste water generated in the treatment of process waters at different stages of plant operation.

Waste water originating from the demineralisation plant

The ion exchangers of the demineralisation plant are revitalised using water with added sodium hydroxide or sulphuric acid. The acidic and alkaline waste water from revitalisation are conducted to a neutralisation pool. The waste water is neutralised to a pH range of 7 to 10 before being conducted into the cooling water discharge channel. The reject from the reverse osmosis device at the demineralisation plant is also conducted to the neutralisation pool. The waste water mainly contains salts generated in neutralisation.

The total volume of water is presently approximately 100 m³ weekly or an average of 15 m³ daily. The total daily volume of water will be 35 m³ once the unit under construction (OL3) is completed and 45 to 80 m³ once the new unit (OL4) is completed. The existing demineralisation plant will also serve the extension to the power plant (OL3) but the construction of OL4 will require a new demineralisation plant or an extension to the existing one.

Laundry waste water

Each power plant unit has a laundry of its own for laundering protective clothing such as overalls and shoe protectors used in the controlled area (area in which radioactive substances may be present). The laundries use low-phosphate detergents. The waste water from laundering, which is slightly radioactive, is mechanically decontaminated using nap collectors and centrifuges. The decontaminated waste water is conducted to the cooling water discharge tunnel together with cleaned process waste water.

The new plant unit will have a laundry of its own for laundering protective clothing used in the controlled area. The total volume of water from the existing units (OL1 and OL2) is approximately 1,000 m³ annually or an average of 3 m³ daily. The volume of waste water from the unit under construction (OL3) is estimated at 500 m³ annually. The new unit (OL4) will also generate approximately 500 m³ of laundry waste water annually. The laundry waste water is treated at the plant unit's liquid waste treatment plant. The waste water contains detergents used for laundering and contaminants discharged from the laundry. The phosphorus concentration in the waste water is low.

Water used for rinsing the screens and filters in cooling water systems

The matter collected in the fine screens and travelling band screens used for the treatment of cooling water (screenings) is rinsed off the screens using sea water. The screenings mainly consist of debris, algae, mussels and fish carried with the cooling water. Solid matter is separated from the rinsing water and treated as required under the power plant's environmental permit.

The rinsing water is conducted to the cooling water discharge system. The combined volume of rinsing water at the existing plant units (OL1 and OL2) is 160 m³ per hour at maximum and 80 m³ per hour on average (22 l/s). The amount of screenings for the two plant units (OL1 and OL2) is estimated to be 7 to 15 tonnes annually, approximately half of which is fishes.

The predicted cooling water flow for the plant unit under construction (OL3) and the new plant unit (OL4) is approximately 60 m³/s per unit at maximum - that is, in the same order as the combined flow of the existing units. It can thus be estimated that the volume of rinsing water for the fine screens and travelling band screens will be approximately equal to the total of the existing units – that is, approximately 160 m³ per hour at maximum and 80 m³ per hour on average.

The matter collected in the sieves of the cooling water system at the spent fuel storage is rinsed with sea water to the cooling water discharge pipe.

Waste water from the waste water treatment plant

Waste water from sanitary facilities and water from the washing and rinsing of floors on non-radioactive industrial premises is conducted to a biological-chemical waste water treatment plant located at the Olkiluoto plant site. The capacity of the treatment plant is approximately 100 m³ per hour, which is sufficient also for the treatment

Table 9-13 Volume of sanitary waste water during construction and operation of the units.

Operating condition of the nuclear power plant units	Volume of sanitary waste water m^3/day
OL1/2	100
OL1/2/3 construction time	190
OL1/2/3 operation	140
OL1/2/3/4 construction time	230
OL1/2/3/4 operation	180

of sanitary waste water generated at the new unit during the operating stage. A pumping station will be constructed in connection with the new unit for pumping waste water into the existing system.

The introduction of the new unit will increase the volume of sanitary waste water by approximately 40 m^3 daily. During the operation of the new unit (OL4), the four units combined will generate a total of 180 m^3 of sanitary waste water daily. Table 9-13 illustrates the volumes of sanitary waste water at the different stages of operating the units.

The load caused by waste water with regard to organic matter (BHK_{7ATU}) will amount to a total of 500 kg annually, phosphorus approximately 40 kg annually and nitrogen approximately 3,000 kg annually. The treated waste water is conducted through volume measurement to the cooling water discharge channel. The sludge generated in waste water treatment is pumped from the settlement basins through condensation basins to sludge basins and transported to the Rauma town waste water treatment plant for treatment.

Table 9-14 presents the waste water flows of the two existing power plant units in 2006 and an estimate of the waste water flows of the power plant unit under construction and the new power plant unit.

Rain water and foundation water

Rain water is conducted to the sea through the rain water drainage system. Some of the water is conducted to the cooling water discharge channel and some to Olkiluodonvesi to the west of the cooling water intake channels. Any rain water containing oil is treated in oil traps before being conducted to the drainage network.

The underdrains in the foundations of power plant buildings are conducted to the rain water drains through foundation water wells fitted with no-return valves.

The levels within the area are balanced so that not even in an exceptional flood situation will rain water flow to the floors or foundations of buildings but will be allowed to flow directly to the sea without causing any damage or harm.

9.7.10 Impacts of waste water

The waste water load discharged to the water system from the existing and planned nuclear power plant units at Olkiluoto is presented above. The volumes of waste water fractions are quite small, and therefore discharges to the sea are also minor. The most significant waste water fraction is sanitary waste water. When the fourth power plant unit is in operation, the total volume generated across the entire power plant site will be approximately 180 m^3 daily (2 l/s). The volume of sanitary waste water generated during the construction of the new power plant unit will be higher, approximately 230 m^3 daily. The volume of waste water is less than 0.01 % of the volume of cooling water used. Treated waste water is conducted to the sea together with cooling water, which means that dilution is already very efficient in the cooling water discharge channel. The dilution conditions in the discharge area are also good.

The impact of waste water discharges is quite minor also in the vicinity of the discharge area. The new power plant unit will increase the waste water load but its impact is estimated to remain small, and the impact cannot be separated from other factors affecting in the same direction, such as the effects of increased thermal load.

Table 9-14 Waste water flows of the existing plant units (OL1 and OL2) in 2006 and an estimate of the waste water flows of the plant unit under construction (OL3) and the new plant unit (OL4).

Water fraction	OL1 + OL2 (actual 2006)	OL3 estimate	OL4 estimate	Total
Sanitary waste water				
Volume m^3/year	70,795	15,000	15,000	100,800
Load				
BOD_7 kg/year	318	90	90	500
Total nitrogen kg/year	2,555	300	300	3,160
Total phosphorus kg/year	29	5	5	40

Table 9-15 Discharges of radioactive substances into water in 2006 (OL1+ OL2), an estimate of discharges from the new unit (OL3) and from the new unit (OL4).

Type of discharge	Discharge 2006 OL1 + OL2 (TBq)	Estimated discharge OL3 (TBq)	Estimated discharge OL4 (TBq)
Fission and activation products (excl. tritium)	0.0006	0.0003 - 0.03	0.0003 - 0.03
Tritium	2.46	20 - 30	0.3 - 30

Groundwater percolates into the VLJ cave. The groundwater collection system for the extension section will be connected to the existing collection system. The collected water is conducted to the sea through an open ditch. The radioactivity of the water is monitored at regular intervals. The water is clean bedrock groundwater, and its discharge does not have any harmful effects on the condition of the sea area.

9.7.11 Radioactive discharge into water

The tritium content of liquid effluents discharged into the sea in 2006, 2.5 TBq, is approximately 14 % of the annual discharge limit. The total activity of other nuclides discharged into the sea was 0.6 GBq or approximately 0.2 % of the plant-site specific discharge limit. Table 9-15 presents the discharges from the existing plant units (OL1 + OL2) into the sea, as well as an estimate of discharges from the unit under construction (OL3) and the new unit (OL4).

Discharges from spent fuel storage into the water are included in discharges from the existing plant units and are very low.

Radioactive substances discharged from the power plant into water are conveyed in the cooling water flow from which they end up in food chains or sink to the bottom. The behaviour of the substances is regulated by their biological, chemical and physical properties such as half-life. During the monitoring of the sea area described in more detail in Section 14.2.1, sensitive analysis methods are able to detect radioactive substances originating from the Olkiluoto power plant in algae and other aquatic vegetation, sea bed fauna, sinking matter and occasionally also in fishes. The amounts are smaller than those of natural radioactive substances.

Radioactive discharges during the operation of the new nuclear power plant unit are estimated to be minor and have no harmful effects on the aquatic environment. The impact of the discharges on humans is discussed in Section 9.11.1.

9.8 Impact on soil, bedrock and groundwater

The following is an assessment of the impacts on the soil and bedrock at the site location, and the interaction between them.

To assess the impacts on groundwater, the location of the power plant unit with respect to groundwater areas and the possible risks imposed on groundwaters due to construction and operation have been examined.

The available modelling data has been utilised in the assessment.

9.8.1 Geology and seismology in the Olkiluoto area

Soil, bedrock and groundwater

Extensive research of the bedrock such as quarrying, drilling and sounding has been and will be carried out at Olkiluoto particularly for the purpose of spent nuclear fuel disposal. The research investigates the properties of rock and the routes of groundwater flow and provides confirmation for the rock models in the Olkiluoto research area.

The main rock type in Olkiluoto bedrock is migmatite, which is a compound of gneiss and granite. The bedrock in the area is approximately 1,800 to 1,900 million years old. The soil on Olkiluoto is mainly rocky moraine. There are also thin layers of clay and peat at low-lying spots. The power plant site also includes filled areas.

The Olkiluoto island is quite flat, with no major differences in altitude. The earth surface on the Olkiluoto island is approximately 5 metres above sea level. The highest point of the island (Liiklankallio) is approximately 18 metres above sea level.

The soil layers in the sea bed are moraine, clay and sand.

The level of groundwater loosely follows the topography of the earth surface; in areas covered by moraine, the groundwater is at a depth of 1 to 2 metres, and at the shoreline, the groundwater level joins the sea water level. There are no classified groundwater areas in Olkiluoto, and the area is not significant for the procurement of water for communities. The island has 11 bored wells belonging to private owners, five of which are in continuous or recreational use. The nearest classified groundwater area is located in Kuivalahti, approximately 6 km northeast of the power plant.

Modelling

Posiva released a geological site model of Olkiluoto in early 2006. After the geological model was released, integration work to combine geological and hydrogeological data was initiated. As a result of this work, a hydrogeological structure model of Olkiluoto was completed in the autumn of 2006. In addition to said models, the hydrogeochemical and rock mechanical models were also updated in 2006.

The crucial objective of hydrogeological and hydrogeochemical site modelling is to combine hydrogeological material with groundwater chemical material and interpretations to achieve an unambiguous description of groundwater flow and geochemical development, as well as describe the most substantial characteristics of deep bedrock groundwater flow and chemistry in the Olkiluoto area before ONKALO is constructed. *(Posiva 2007b.)*

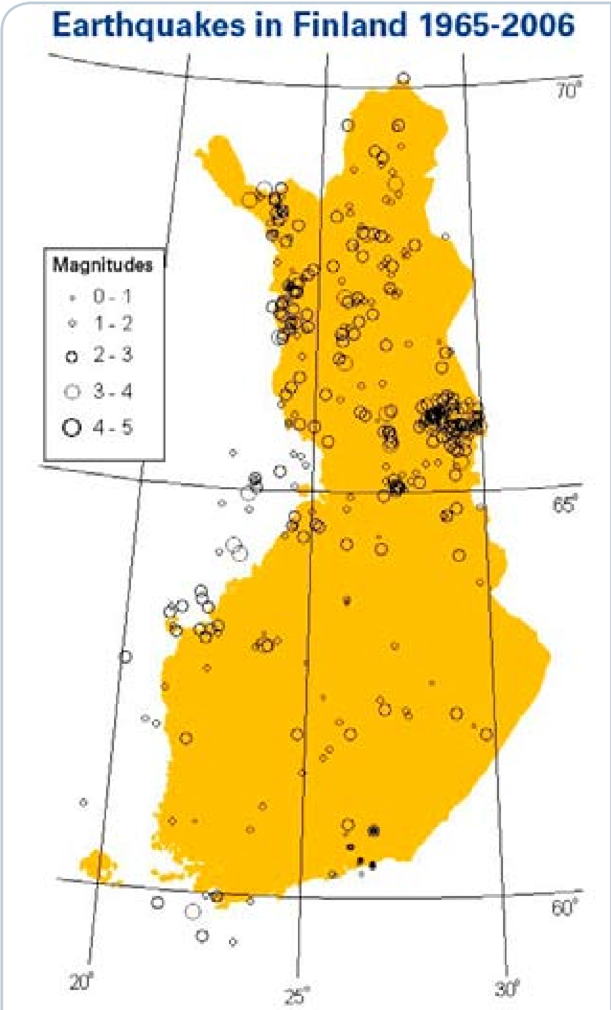
Seismology

Finnish bedrock belongs to the Precambrian Fennoscandian shield that is one of the seismically most stable areas in the world. However, there are tensions that may be discharged and cause weak earthquakes. These are often focused on weakness zones existing in the bedrock. 10 to 20 earthquakes occurring in Finland are registered each year. The earthquakes are relatively weak, having a magnitude of 1 to 4 (Richter). The most intense earthquake registered after 1965 occurred at Alajärvi on 17 February 1979. Its magnitude was determined at approximately 3.8. From 1977 to 2001, almost half of all earthquakes observed in Finland occurred in the Kuusamo region. There are known observations of earthquakes in Finland for almost 400 years. Occurrences of earthquakes in Finland from 1965 to 2006 are presented in Figure 9-44 *(University of Helsinki 2007)*.

In Finland, earthquakes are usually caused by tension arising from the widening of the mid-oceanic ridge in the North Atlantic. The Eurasian and North American plates diverge from each other by approximately 2 centimetres annually, which causes compression stress across entire Fennoscandia. The gradually accumulating stress exceeds the strength of the rock material at one point and is suddenly discharged as an earthquake. In this case, the parts of the bedrock surrounding the origin of the earthquake are moving in relation to each other. This movement usually occurs along existing faults in the crust. Other local reasons include uplift, which causes earthquakes mainly in the Gulf of Bothnia region. *(University of Helsinki 2007.)*

The bedrock of Olkiluoto has been studied in particular detail during recent years. Geological surveys have already proven that the bedrock is stable and that earthquakes affecting plant operation are nonexistent. The risks of a seismic accident at the Olkiluoto nuclear power plant have been assessed in the probabilistic safety analysis. *(EQE International Inc. 1997, ref. TVO 1997.)*

Figure 9-44 *Earthquakes in Finland from 1965 to 2006 (University of Helsinki 2007).*



9.8.2 Impact on soil, bedrock and groundwater

The foundations for the new plant unit will be built in a pit to be excavated in the surface section of bedrock. The bedrock at the existing VLJ cave will be excavated in connection with the extension of the VLJ cave. Excavation will affect internal tensions in the bedrock. The stability of the bedrock and the safety of the premises to be excavated will be ensured through structural means and continuous monitoring.

During the excavation work for the foundations of the power plant and the extension to the spent fuel interim storage facility (KPA Store), the extension of the VLJ Repository and the cooling water tunnels, bedrock groundwater will flow into the excavated premises. Groundwater will also percolate into the VLJ Repository during its operation. The quantity of water percolating into premises excavated in the rock will vary and depends on factors such as the size of the room, the tightness of the surrounding rock, the level and occurrence of groundwater, as well as any sealing actions carried out during excavation. This does not have any detrimental effect on the quality or quantity of groundwater at the power plant site or in the vicinity.

Discharges polluting the soil and groundwater at the power plant have been prevented using different types of structural solutions and sewage arrangements. The plant units are designed so that leak water and waste water from the process cannot come into contact with groundwater. Underground external structures are cast from waterproof concrete. Leak water, watering water and cleaning water are treated using separate leak collection and drainage systems. Sewage water from premises within the controlled area is collected using the controlled area floor drain system and treated mainly by evaporation. Floor water, watering and aeration water and sanitary water from other premises are collected using a separate sewage system and treated at a waste water treatment plant.

Leak water, watering water and cleaning water from the spent fuel storage facility are treated using separate leak collection and drainage systems. Contaminated and active filter rinsing water, leak water, watering and aeration water, as well as floor and cleaning water from the controlled area of the storage are pumped into the OL1 liquid waste treatment system. Any seawater leak and sprinkler water is conducted to the sea through the rain water drain system. The foundation water and leak water from the sea water pumping station is pumped directly into the sea. Water collected in the foundations of the storage building and its tunnels is conducted to the sea through the rain water drain system. Water can also be pumped into the controlled area floor drain system in case the foundation water is radioactive. The radioactivity of water is monitored by semi-annual sampling.

Diesel and heating oil tanks are surrounded by earthwork, and protective basins have been constructed. Rain water drainage from the earthwork goes through oil trap wells.

9.9 Impacts on flora and fauna

The project's direct and possible indirect impacts on vegetation and animal populations have been assessed by experts. On the basis of these results, the impacts of the alternatives for the project on biological diversity and interactions have been assessed.

9.9.1 Flora and fauna

The natural environment in the Olkiluoto area is heavily influenced and altered by human activities. Olkiluoto belongs to the Gulf of Bothnia coast, where land uplift is rapid, 5.35 - 0.25 mm/year. Low-lying terrain and rapid land uplift cause a change in flora when the habitat changes. The meadowy shores of land uplift areas are becoming swampy and are bordered by a bush zone consisting mainly of willow, buckthorn and myrtle. There is an alder zone between the bush and the forest, consisting almost exclusively of black alder in the Olkiluoto area.

In the geobotanic division of the regions, Olkiluoto belongs to the southern boreal zone and further to the anemone zone characterised by demanding forest plants such as hepatica and wood anemone. The coastal flora in the area is characterised by zonality that is constantly changing due to rapid land uplift. The zonality of flora is evident on the coast in that coastal forests are moister and more luxuriant than inland forests; when going inland, the forests become drier and more infertile, depending on the depth of groundwater. However, this zonality is not clear in Olkiluoto because differences in altitude within the island are minor and luxuriant habitats can be found both on the shores and inland. However, the most infertile habitats are clearly located at the highest points of the island.

In terms of natural conditions, the Olkiluoto area is a typical Southwestern Finland coastal area in which the species of flora and fauna and the soil are very similar to the surrounding areas. Unbuilt shores, particularly on the northern side, represent shore biotopes in a natural and often luxuriant state. Olkiluoto is quite abundant in species but few rare or endangered species have been observed. *(Insinööritoimisto Paavo Ristola Oy et al. 2007a.)*

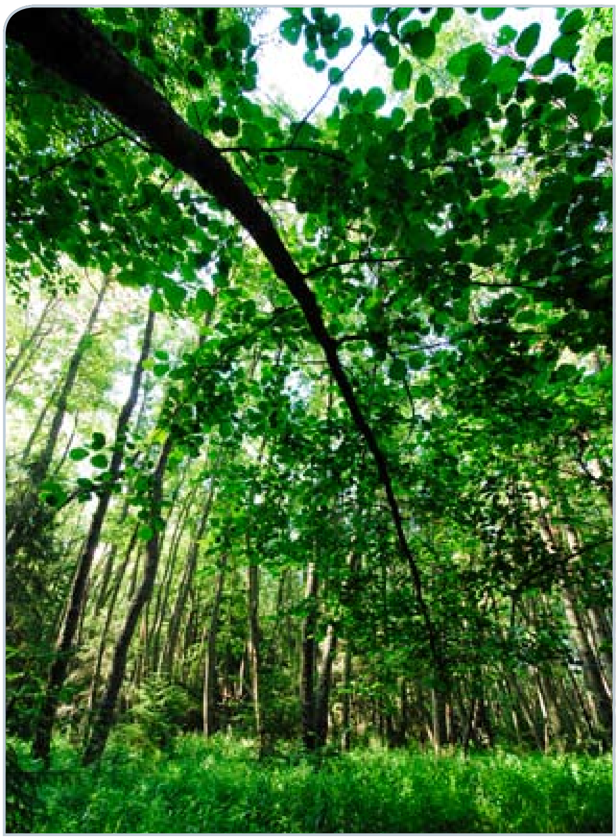
Forests

There are approximately 570 hectares of forests owned by TVO on Olkiluoto island outside the plant site; most of the forests (90 %) are heaths of the bilberry type (MT), wood sorrel type (OMT) or lingonberry type (VT). There are 22 hectares of swamps, 19 hectares of which are in productive forest use. The main species of tree in the young cultivated forests is pine, and in more mature forests it is spruce. Broadleaf trees (grey and black alder, silver and white birch, rowan and willows) grow mainly in a zone surrounding the island at the sea shore, and as undergrowth. The inland forests are dominated by pine; spruce copses are mainly located on the shores inside the black alder zone.

The Liiklankari nature conservation area is located on the southern shore of Olkiluoto island, in the immediate vicinity of the spent fuel disposal facility, approximately one kilometre southeast of the existing power plants. The Liiklankari forest is included in the old-growth forest conservation programme and established as a national nature conservation area. It also belongs to the Rauma archipelago area included in the Natura 2000 network.

Forests ready for felling represent 18 % of the total area. The small amount of private land, as well as forests administered by the Metsähallitus State Enterprise

outside the Natura zone, are in intensive forestry use and the area no longer has any mixed forests in a natural or near-natural state. The soil to the south of the island is clearly moister than to the north, which is evident as mild swamp formation and a higher number of vascular plants that tolerate or favour dampness. There are not many bushes in the forest, and most of the bush layer constitutes seedlings of the local tree species and juniper. The forests in productive use in the area are primarily free of rotten wood as well.



The rocky forests are characterised by their natural state. All rocky forests have open rock areas where lichen and low twigs grow. There are also peat-covered rocks, but their area is very small. Black alder grows as narrow strips on the shore, and, together with meadowsweet growing in the field layer, forms a zone surrounding the entire island. On the shores, common reed forms an unbroken belt around the island. Low-lying meadows are rare within the island; the reasons are the eutrophication of the Baltic Sea, spreading of human settlement and ditch drainage. *(Insinööritoimisto Paavo Ristola Oy et al. 2007a.)*

Swamps

The majority of swamps and peat-covered areas on Olkiluoto island have been drained, and the total area of swamps in a natural state is no more than 3.2 hectares. Some of these swamps in a natural state have disappeared following the completion of the forestry plan *(Latvajärvi et al. 2004)* due to the construction of the new accommodation village. Some of the swampy patterns are located on the sea shore and are excluded from forestry operations without any special measures because the forestry plan proposes that an untreated zone of 20 to 50 metres wide shall be left along the sea shore.

The locally most valuable swamp locations on Olkiluoto island are the paludified ponds in the northwestern corner of the island and a black alder swamp on the eastern shore of Flutanperä that has partially lost its natural state. A road to the Olkiluoto Visitor Centre leads through the black alder stand. There is an old ditch in the area and very little rotten wood; otherwise the area is in a natural state. The dominant species of the

field layer are meadowsweet, yellow loosestrife, marsh marigold, tufted hair grass and purple loosestrife.

The paludified ponds in the northwestern corner are infertile, so far almost treeless bogs. There are isthmuses of mineral soil between the ponds with spruce, black alder and birch. The ponds are paludified with moss of the species Sphagnum riparium; other common species include yellow loosestrife, marsh cinquefoil, bog arum, common reed, smallreed, reed mace, purple loosestrife, milk parsley, meadowsweet, bottle sedge and cotton grass. *(Insinööritoimisto Paavo Ristola Oy et al. 2007a.)*

Birdlife

According to a birdlife survey conducted on Olkiluoto island in 1997, the most common aquatic bird species is eider, and the rarest species observed at Olkiluoto is the greater scaup. Common shelduck, which is rare in Finland, and velvet scoter also nest in the Olkiluoto area. These observations have been described as valuable but not extraordinary. The most valuable part of Olkiluoto island in terms of aquatic birdlife is the northern shore. The island is neighboured by the Eurajoki river delta FINIBA area (Finnish Important Bird Areas 120075) at its northeastern corner.

Olkiluoto does not differ from surrounding areas with regard to ground birdlife; there are a lot of species but not many rarities. Like in the rest of the country, the most common species in the area are chaffinch and willow warbler. In addition to the observations referred to in the above, a grey-headed woodpecker (Picus canus, NT, a species listed in Annex I to the bird directive) was seen eating in an aspen tree in 2006 in connection with other surveys; however, the area is not suitable as a nesting biotope for the species as there are very few aspen trees of a small diameter in the Olkiluoto area and trees suitable for hole-nesting are almost nonexistent. *(Insinööritoimisto Paavo Ristola Oy et al. 2007a)*

An inventory of birdlife on the islets was taken in the summer of 2007 from a boat. Observations were made from the boat using binoculars. The birdlife in the area consisted of islet birds and seabirds typical of the Eurajoki sea area. The most valuable species found in the inventory were black-headed gull (VU), velvet scoter and Arctic skua. Furthermore, among the species listed in Annex I to the bird directive, common tern and Arctic tern were found nesting in the area. *(Loikkanen 2007.)*

Mammals

The data concerning the occurrence of mammals in the Olkiluoto area are based on active observation of animal tracks in winter, information received from hunting clubs and airborne survey data. The elk stock in Olkiluoto is estimated at 15 animals before the hunting season and 10 animals after the season. The white-tailed deer stock is estimated at 15 to 20 animals, and the roe deer stock at 10 animals. Other mammals common in the area include raccoon dog, fox, pine marten, mink, ermine, polecat, badger, hare, brown hare and rodents.

Insects

Inventories of the endangered (VU, vulnerable species) black Apollo butterfly, which is protected by law, were taken in the spring and summer of 2007. The inventory was associated with partial master planning in Olkiluoto. The black Apollo *(Parnassius mnemosyne)* is completely dependent on the spring corydalis *(Corydalis solida)*, which is the only food plant for its larvae. On the basis of inventory data acquired in 2007, observations in previous years and traces of larvae eating, it can be noted that the eastern/northeastern part of Olkiluoto island is most probably a black Apollo habitat and that the area belongs to a larger metapopulation with subareas on Olkiluoto island and its immediate vicinity. *(Ramboll 2007.)*

9.9.2 Impacts on flora and fauna

The impacts of the nuclear power plant project on flora and fauna are primarily related to the land areas required for buildings and structures, as well as the construction work. There will be no significant impact during the operation of the new unit.

The alternative sites for the unit are located to the north of the existing plant units. The new unit with support functions will require approximately 4 to 6 hectares of space. The area is waste land with seedlings and some forest. The area is surrounded by roads traversing the power plant area.

The planned cooling water intake location C is located next to the cooling water intake for the OL1 and OL2 units. The other alternative cooling water intake location D is located to the north of Olkiluoto. Vegetation and trees will be removed from the shore for the construction of the cooling water channel.

There are two alternative locations for the discharge of cooling water. In alternative A, discharge will take place into the Iso Kaalonperä bay, which means that the construction of the cooling water channel will not substantially change the existing shore zone. In alternative B, the cooling water from the new unit will be discharged to the northern shore of Olkiluoto island through a discharge channel to be constructed to the southwest of Tyrniemi. The forest and shore area extending from the outer cape to the east of Tyrniemi is characterised by a long unbuilt shoreline, luxuriant forests in an almost natural state and representative shore biotopes. The area is considered to be the most significant part of Olkiluoto in terms of its natural values. The construction of a cooling water discharge point in this area will break the consistency of the shoreline. Birdlife in the area will also be disturbed during construction.

The area does not have any very important habitats referred to in the Forest Act, the Water Act or the Nature Conservation Act that should be taken into account. The endangered plants found in the area are species dependent on brackish water that will move to new habitats as a consequence of land uplift. The species of birds found in the area are also common, with the exception of a few rare aquatic birds. In addition to the Liiklankari Natura area, valuable natural sites include the Tyrniemi forest area as well as some islands in the vicinity of Olkiluoto island that have no holiday homes but have retained their tree stands and have primarily landscape value. The treeless islets in the archipelago are also important for birds and therefore constitute habitats worth conserving. Conservation of these sites is sought through appropriate markings in the land use plan.

The spring corydalis, which is the only food plant for black Apollo larvae, is found in the eastern and northeastern parts of Olkiluoto island, and the construction of a new nuclear power plant unit will not affect its occurrence.

With regard to an inventory of flying squirrels *(Pteromys volans)* taken in 2006, it can be noted that Olkiluoto island only contains a biotope suitable for the species in the southern part of the area with the Liiklankari old-growth forest and other patterns with mixed tree species and spruce-dominated parts of regeneration maturity. No flying squirrel droppings or trees used for hole-nesting have been found in the area. It is very improbable that the area would be a passageway for the species because there are practically no connections with surrounding forests.

The impact of radioactive releases on organisms

It can be stated on the basis of the maximum activity concentrations observed in conjunction with the environmental monitoring of present plant units, when the contribution of fallout from other sources is taken into account, that there is a high probability that the radioactive releases caused by the operation of a nuclear plant representing the present state of technology will not cause any impacts on the animal and plant populations on the Olkiluoto plant site. The assessment was made using a method developed in the ERICA project of the European Commission *(Beresford et al 2007). (Ikonen, A. 2008.)*

9.10 Impacts on biological diversity and objects of protection

The question of whether the project, either individually or in combination with other projects and plans, is likely to have a significant adverse effect on the ecological values that serve as the conservation basis of the nearest Natura areas has been reviewed in this section. On the basis of the review, it has been decided whether a Natura assessment pursuant to Section 65 the Nature Conservation Act will be carried out.

9.10.1 Present state of protection areas in the vicinity of Olkiluoto

Natura areas

In relation to the Olkiluoto power plant, the nearest area belonging to the Natura 2000 network is the Rauma archipelago (FI0200073). The site is included in the Natura 2000 network as an SCI area (Sites of Community Importance, included in the Natura 2000 network by virtue of the nature directive). The area extends to 5,350 hectares and comprises 15 different biotopes in total. The nearest sites belonging to this area are located approximately one kilometre from the power plant.

The conservation area nearest to the Olkiluoto power plant site is the Liiklankari nature conservation area located on the southern shore of Olkiluoto island, in the immediate vicinity of the spent fuel disposal facility, approximately one kilometre southeast of the existing power plants. The Liiklankari forest is included in the old-growth forest conservation programme and established as a national nature conservation area. It also belongs to the Rauma archipelago area included in the Natura 2000 network.

The Metsähallitus State Enterprise conducted a biotope inventory of the Liiklankari area in accordance with the nature directive in the summer of 2006. With regard to biotopes listed in Annex I to the nature directive, boreal natural forests are found in the Liiklankari Natura area. The biotope belongs to the priority biotopes, the conservation of which is of primary importance. A survey of the Liiklankari area identified flood plains and swamps with trees as new biotopes in the area.

According to present information, no species listed in Annexes II and IV to the nature directive are found in the Liiklankari conservation area. Grey seal is the only species listed in Annex II to the nature directive that is found in the Rauma archipelago Natura area. No observations of species listed in Annex II to the nature directive, such as flying squirrel, were made in the Liiklankari area. The Rauma archipelago Natura area has no other species requiring strict protection listed in Annex IV of the nature directive.

Surveys/preliminary reviews of certain groups of species were carried out in the Liiklankari area in the autumn of 2006. The groups of species studied were bryophytes, shelf fungi, beetles and macrofungi. No species listed in Annex II to the nature directive, nationally or regionally endangered species, or species to be observed were found in the area. Among the indicator species for boreal forest, two occurrences of goblin's gold were found. One observation was made of Phellinus ferrogineofuscus, which is a species to be observed (NT). Other notable shelf fungi included Asterodon ferroginosus, Leptoporus mollis, Phellinus chrysoloma, Phellinus nigrolimitatus, Phellinus viticola and Postia leucomallella. A noteworthy species of macrofungus found in the area was Lactarius scrobiculatus. Ganoderma lucidum has also been found in the area. *(Insinööritoimisto Paavo Ristola Oy 2006b.)*

The outer archipelago north of Rauma, including the Susikari, Kalla and Bokreivi islands, belongs to the shore conservation programme. These areas also belong to the Natura 2000 area of the Rauma archipelago. The area has sparsely located small isolated rocks and two larger, almost treeless, islands close to the open sea. The area is a representative archipelago and landscape entity. It is significant as a breeding ground for animals and a resting stop for migratory birds.

The Omenapuumaa nature conservation area in the inner archipelago and the Särkänhuivi cape has regional conservation value. Omenapuumaa also belongs to the Natura 2000 network of areas. The luxuriant grove island of Omenapuumaa is located in the Rauma archipelago, approximately five kilometres south of Olkiluoto. The nature on Omenapuumaa is a very variable labyrinth

of broken landscape patterns. The central parts of the area are quite infertile coniferous forest but the edges, particularly along the southern shore, are luxuriant shore groves. There are remnants of grove meadows also in the central part as a consequence of grazing in the past. Noble broad-leaved trees were once planted in the area and are now very large. The vegetation close to the shore is black alder, and farther up, it becomes a grove of the hepatica and wood-sorrel type that is being taken over by spruce and is abundant with Solomon's seal. A rarity growing in the area is cowslip, possibly in its northern most habitat. The low, narrow, long and curved cape of Särkänhuivi is the outermost tip of the Irjanteenharju ridge that protrudes into the sea. The ridge of the cape has a road along its entire length, and, with the exception of the end, there are holiday homes in the area.

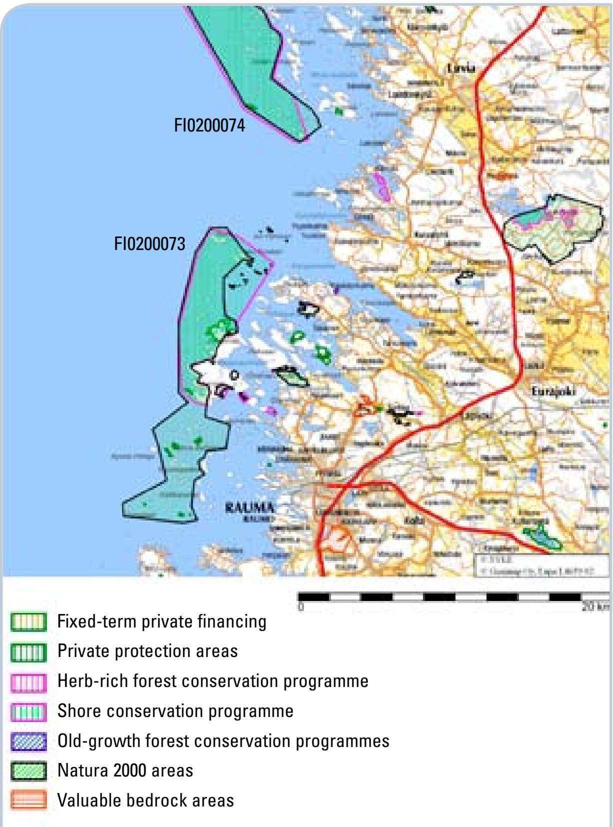
The Luvia archipelago area (FI0200074), belonging to the Natura 2000 network, is located approximately nine kilometres north of Olkiluoto. The site is included in the Natura 2000 network as an SCI area (Sites of Community Importance, included in the Natura 2000 network by virtue of the nature directive) and an SPA area (included in the Natura 2000 network by virtue of the nature directive). The Luvia outer archipelago represents the island nature of Satakunta in its most diverse form. The area has more than 60 islands and islets of at least one hectare, as well as several small islets and rocks.

Other valuable natural sites near Olkiluoto that have national conservation value include the Pyrekari islets and Kaunissaari island. The Pyrekari islets are located to the north of Olkiluoto, approximately four kilometres from the power plant site. The Pyrekari islets are rocky small outer islets with endangered plant species. They also serve as an educational site. Kaunissaari island to the east of Olkiluoto island is a site of cultural history.

The Kalattila grove has local conservation value. The Kalattila grove has peculiar luxuriant grove vegetation typical of the northern Rauma archipelago *(Satakunta Regional Council 1996)*.

According to the new Government programme (19 April 2007), the possibilities for establishing a national park in Botnian sea will be investigated. The planned core of the park would include the chain of outermost islands in the sea areas of Pyhäanta, Rauma, Eurajoki and Luvia, as well as the versatile inner Rauma archipelago. Furthermore, a few islands off Säppi in Luvia belong to the territory of the city of Pori. Kaunissaari in Eurajoki is also a specialty as it is located in the inner archipelago; it is not only a valuable natural and historic site but also a backpackers' base for exploring the outer archipelago. The Botnian sea national park is one of the spearhead projects of the Satakunta Regional Council. The objective is backed not only by nature conservation but also support from the tourism industry.

Figure 9-45 *Conservation sites and areas around Olkiluoto.*



9.10.2 Impacts on biodiversity

Biodiversity, which refers to the biological diversity of nature, is usually divided into the diversity of ecosystems and biotopes (types of habitat), the diversity of species, and the genetic diversity of species and populations. This diversity is considered an important factor for the adaptation of nature to environmental changes.

The changing and loss of habitats is the most significant threat to biodiversity. Changes in habitats are usually harmful to biological diversity even though the impact of man has also improved the diversity of Finnish nature. The fundamental issue in protecting biological diversity is how to maintain species or their separate populations in a reproductive state. The upkeep of biological diversity is also an important objective of the Nature Conservation Act (1096/96) that entered into force at the beginning of 1997.

The new unit will be located tightly integrated with the existing power plant site, which means that direct impacts on biodiversity will be limited to the use of the required unbuilt areas. In the vicinity of a nuclear power plant, indirect impacts, such as the impact due to releases into the atmosphere or water, are limited to changes in the aquatic environment due to the discharge of cooling water.

The cooling water load of the new unit may cause changes in the species composition of populations and vegetation in the discharge area and the ratios of abundance of different species within a maximum of a few kilometres from the cooling water discharge point. The impact of warm cooling water on aquatic vegetation can be observed in the vicinity of the Susikari islet located approximately three kilometres from the current cooling water discharge point that belongs to the Natura network. These changes are relatively minor, and the contribution of the new power plant unit is not easily distinguishable from the complex of other factors affecting the variation and development of vegetation. The impact cannot be considered to substantially deteriorate natural values in the area.

The construction of the new plant unit will not have any impact on other conservation areas in the vicinity of Olkiluoto. Nor is the construction of the new plant unit estimated to have any detrimental impact on the living conditions of endangered species in the immediate vicinity of Olkiluoto.

9.10.3 Impacts on Natura areas

Sea area

The potential impacts of OL3 currently under construction at Olkiluoto with regard to the Rauma archipelago Natura 2000 area were examined in connection with the OL3 environmental impact assessment *(TVO 1999)*. The impacts were subsequently assessed in more detail *(Insinööritoimisto Paavo Ristola Oy 2001a and b)*. The reports state that the ramifications of OL3 cannot be considered significant with regard to the protection of natural values within the scope of Natura. The Southwest Finland Regional Environment Centre has also stated in its statement on 26 June 2001 that the OL3 construction project will probably not have any significantly adverse effect on the natural values of the Natura area in the Rauma archipelago.

The impacts of four power plant units on the Rauma archipelago Natura 2000 area were assessed in a separate Natura requirement assessment *(Ramboll 2007d)*. In practice, only the marine and coastal biotopes of the Natura area (8 in total) can be affected by the operation of the nuclear power plant. The impact mechanism is through warmed-up cooling water. In the outer archipelago, this concerns rocky shores and islets typical of the area (reefs, rocky shores, islands and islets in the outer archipelago). The other biotopes (7) are located on the mainland or on islands – that is, in locations where warmed-up seawater will not cause any changes or impacts.

With the new power plant unit (OL4) in operation, the area affected by cooling water within which the surface water layer will warm up by two or three degrees will increase two- to fivefold compared to a situation with three plant units in operation (the zero option). This means that the area affected by a slight increase in temperature will include new islands and islets belonging to the Natura area. Depending on the alternative chosen for the discharge point, the area affected by the greatest temperature increase close to the tip of Olkiluoto will expand to new underwater Natura objects in the vicinity.

Depending on the alternatives chosen for the intake and discharge points, the area affected by cooling water will also expand to the outermost islands, islets and rocks in the outer archipelago off Olkiluoto. These areas typically have no sheltered bays or inlets that would provide favourable conditions for a clear increase in vegetation. On the basis of a map survey and field observations, such environments can mainly be found on the shores of Iso and Vähä Susikari, as well as the Kalla island and smaller islands surrounding these. The areas are included in the scope of Natura protection.

In the coastal waters of the Susikari island group located nearest to the discharge point, the surface temperature of seawater is estimated to increase by a maximum of five degrees while the increase in the zero option is in the order of one degree. Because the impact of cooling water already extends to this location, the change in temperature may gradually increase the populations of species that thrive best in the new conditions. If bladder wrack is present on the same rocky shores, it is possible that these populations will gradually decline due to the increasing growth of algae on the surface. An important habitat for many species will thus be destroyed. Increased organic matter will sink to the bottom when dead, and the conditions for vegetation and sea bed organisms will become unfavourable. This will be reflected in the impoverishment and decreased diversity of species.

The results of model examination in a situation with four plant units suggest that the area with clearly detectable changes in underwater vegetation within shore zones caused by cooling water will probably extend to the level of the Kalla island. The development of vegetation in the coastal waters of the Kalla island, which will be a new introduction to the area affected by a temperature increase of a few degrees, can be estimated to be similar to the development in the Susikari area by now. Similar changes can also be expected farther south in the Natura area which, according to the results from the model, would seem to be affected by seawater warm-up of a couple of degrees in certain wind conditions. In the example cases presented in Figures 9-48 and 9-49, the proportion of this affected area compared to the entire water area included in Natura (5,090 ha) would be 7 % to 4 % on average (surface water layer and 2.5 m layer). During a south wind, the impact will be focused in the vicinity of the Susikari group of islands. Depending on the alternative, seawater temperature at this location may increase by several degrees in a water layer of 2.5 m thickness. *(Ramboll 2007d.)*

Figures 9-46 to 9-49 present the limits of the Rauma archipelago Natura 2000 area and the spreading of cooling water into the area in surface water and at a depth of 2.5 metres in different north and south wind conditions during the operation of OL4. The intake of cooling water takes place at point C, which is to the east of the intakes of the OL1 and OL2 plant units. The discharge of cooling water takes place at point B off Tyrniemi.

Based on the results of a model examination, with four plant units operating at Olkiluoto, the area of unfrozen sea belonging to the Natura area would be approximately 5 km^2. Over time, the impacts of warmed-up water will be most distinguishable in this area due to factors such as an extended vegetation period. This area represents approximately 10 % of the entire Rauma archipelago Natura 2000 area.

Fish

The rocks around the islands and islets of the outer archipelago are a breeding ground for several species of fish (such as Baltic herring and whitefish). The areas closest to Olkiluoto island already belong to the scope of impact of seawater that has warmed up by several degrees. Follow-up studies have not detected any decline in fish populations. On the contrary, the growth rate of perch has been found to have improved somewhat in the cooling water discharge area.

On the basis of the above, it is not probable that the conditions in the spawning and feeding areas of fish would become unfavourable even in the new situation. This would require the intense eutrophication of the sea bed with the consequential adverse phenomena (silting of the bottom, consumption of oxygen, etc.). In the open sea area, the mixing effect of winds and currents will prevent such a situation from developing. On the contrary, a slight increase in vegetation may improve the nutritional situation for fish at the fry stage. Furthermore, the optimum temperature for the fry of many species is higher than that of mature fish. For this reason, in most cases the young stages of fish in particular will benefit from the warm-up of seawater. In the area with no ice or weak ice, the water will be warmer than in other parts of the coast earlier in the spring. This will advance the spawning of fish species that spawn in the spring and summer, as well as the hatching of fry. At the same time, the first growth period will be extended and the probability of survival of the fry will improve as they will have time to grow larger than normal before the winter. *(Ramboll 2007d.)*

Conclusions

As a conclusion, it can be stated that the commissioning of the new plant unit will intensify the development of eutrophication primarily in the northern part of the Rauma archipelago, within the underwater biotopes located nearest to Olkiluoto. Furthermore, the area of less severe impacts can become extended farther west. On

Figure 9-46 *Limits of the Rauma archipelago Natura 2000 area and the spreading of cooling water in surface water during a south wind, cooling water intake at point C and discharge at point B.*

Figure 9-47 *Limits of the Rauma archipelago Natura 2000 area and the spreading of cooling water at a depth of 2.5 metres during a south wind, cooling water intake at point C and discharge at point B.*

the basis of area ratios, the impact over the entire Natura area would remain on quite a smallscale. It must also be noted that in this location, parts of the protected biotope are already included in the area affected by warm cooling water in the situation corresponding to OL3.

Increased eutrophication to some degree may become evident in the central part of the Natura area. The probability of such an impact, the rate of change and its significance will be reduced by the fact that the prevailing direction of current off the coast of Botnian sea is from the south to the north. Furthermore, during the open water season, the most common direction of wind is from the south and southwest, which means that no increase of temperature will take place in this section.

On the basis of the information available at present, it is not probable that the consequences of the project in relation to the entire Natura area would be so significant and extensive that they would endanger the favourable level of protection of the underwater biotope under examination. Therefore an assessment procedure according to Section 65 of the Nature Conservation Act is not deemed necessary.

The above assessment of the project's environmental impacts includes uncertainty due to the lack of information concerning the underwater biotopes (reefs) of the Rauma archipelago Natura 2000 area, their representativeness and their locations in the sea area in question. Furthermore, inventory data concerning the vegetation and populations of underwater rocky shores has only been available for some locations off Olkiluoto and reference areas. Even in these areas, the composition of water species dependent on algal populations, for example, has not been studied in more detail.

Due to the lack of inventory data, there is no information concerning the potential occurrence of rose-coloured alga belonging to red algae and classified as a species to be observed, which was found at diving line 2 of the Kalla island in the summer of 2007, and in other parts of the Natura area. Therefore it is impossible to state with certainty if a potential decline in the occurrence would be significant for the entire Natura area. On the other hand, the Web pages of the environmental administration state that the species is present in the sea area under examination and that it is not endangered there. *(Ramboll 2007d.)*

Liiklankari conservation area

The Natura biotopes of the Liiklankari conservation area were examined in inventories completed in 2006. For the purpose of impact assessment, surveys of species (beetles, shelf fungi, bryophytes and macrofungi) were conducted in the autumn of 2006. The outcome of the Natura assessment is that the projects made possible at Olkiluoto through master planning will have no substantial impact on the values for which the Liiklankari area was included in the Rauma archipelago area belonging to the Natura 2000 conservation programme. The actions will not have any substantial impact on the preservation of a favourable level of protection in the network of old-growth forests in Southern Finland. *(Insinööritoimisto Paavo Ristola 2007b.)*

Figure 9-48 *Limits of the Rauma archipelago Natura 2000 area and the spreading of cooling water in surface water during a north wind, cooling water intake at point C and discharge at point B.*

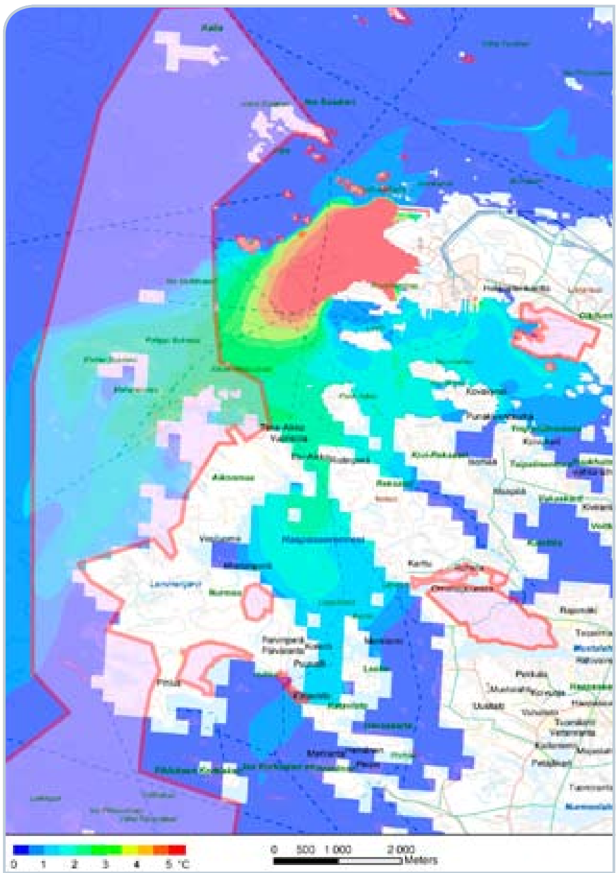


Figure 9-49 *Limits of the Rauma archipelago Natura 2000 area and the spreading of cooling water at a depth of 2.5 metres during a north wind, cooling water intake at point C and discharge at point B.*

9.11 Impacts on people and society

This section has assessed the impacts of the alternatives on people's health, comfort and living conditions. Impacts on people and society are caused by changes in land use, landscape impacts, radioactive releases, impacts on water, impacts on traffic, traffic safety, impacts on the economy and employment, as well as noise. The starting point has been the present state of the area and the change imposed on it by the project. The focus areas of the assessment were selected based on the feedback received from the residents and commuters of the area. The interaction and feedback taking place in the audit group, the resident survey and the discussion meetings, as well as the information obtained from various interest groups and the media, has served as a tool for assessing the project's impact on people.

In the assessment of social impacts, the main focus has been on the neighbouring regions of Olkiluoto – that is, Eurajoki and Rauma. The impacts on the regional structure and regional economy have also been examined in the whole Satakunta area at the broadest.

The impacts on people's health and comfort have been assessed using the human impact assessment guidelines prepared by Stakes, the National Research and Development Centre for Welfare and Health (www.stakes.fi). The guidebook on the application of the Finnish law on EIA in the assessment of health and social impacts, published by the Ministry of Social Affairs and Health *(Ministry of Social Affairs and Health 1999)*, has also been utilised in the assessment.

9.11.1 People and communities in the vicinity of Olkiluoto

The population of Olkiluoto island is very low. The nearest houses are located approximately three kilometres from the power plant site. There are approximately 70 permanent residents within five kilometres of the power plant. Settlement is located mainly to the east and southeast of the power plant. The distribution of population in the vicinity of Olkiluoto in 2002 is presented in Figure 9-50.

The coastal areas and islands near Olkiluoto have a lot of holiday homes. There are approximately 550 holiday homes within five kilometres of the power plant site. The nearest holiday homes are located on the northern coast of Olkiluoto (Munakari), approximately one kilometre from the nuclear power plant units. Munakari and its cottages are owned by TVO and used for the recreation of TVO personnel. The nearest holiday homes in the south-southwest sector are located on Leppäkarta island approximately one kilometre from the power plant. There are a high number of holiday homes within 1.5 to 2 kilometres, for example, on the islands Lippo, Nousiainen and Kovakynsi.

The population of the Rauma economic zone was approximately 59,000 at the end of 2006. Population by municipality was as follows: Rauma approximately 37,000, Eura approximately 9,400, Eurajoki approximately 5,800, Kiukainen approximately 3,400 and Lappi approximately 3,200. Compared to 1980, the population of the economic zone has declined by some 3,500 people. Unlike the other municipalities, the population of Eurajoki increased by

Figure 9-50 *Distribution of population in the vicinity of Olkiluoto in 2002.*

120. According to the population forecast, the population of the economic zone will continue to decline. The population of Luvia, which is a neighbouring municipality to Eurajoki, was approximately 3,300 at the end of 2006, while the population of Nakkila was approximately 5,800. Pori, which is located 50 kilometres by road from Olkiluoto, had an approximate population of 76,200.

The unemployment rate was 9.6 % in the Rauma region and 12.7 % in the Pori region in 2006. The unemployment rate in Eurajoki was 8.9 %, which was on par with the national level. The unemployment rate in the entire province of Satakunta was 11.6 %. The unemployment rates were clearly lower compared to the situation ten years earlier. The unemployment rates in 1997 were: Rauma region 18.2 %, Pori region 21.1 %, Eurajoki 16.6 % and Satakunta 19.0 %. Heavy fluctuation of the employment rate is typical of Satakunta. Due to the economic structure of Satakunta, the cycles of the global economy and production arrangements made by international companies are heavily reflected on the region's industry and its subcontracting chains.

The distribution of sectors providing employment for the residents of Eurajoki in 2005 was: primary production 10.4 %, secondary production 49.5 %, services 36 % and other sectors 4.1 %. The distribution in the Rauma region was: primary production 4.5 %, secondary production 40.6 %, services 49.1 % and other sectors 5.8 %. Half of the residents of Eurajoki commute out of the municipality, for example, to Rauma and Pori. The majority of employees commuting into Eurajoki live in Rauma but, all in all, employees come from a very large area.

The most important agricultural land near Olkiluoto is located 20 to 40 km east and 25 to 35 km northeast of the power plant. There are a few market gardens approximately 10 km from the power plant producing vegetables primarily for the Rauma region. The nearest dairy is located in Pori, approximately 35 km away. There are three milk-producing farms within 10 km of the nuclear power plant and dozens more within a radius of 40 km.

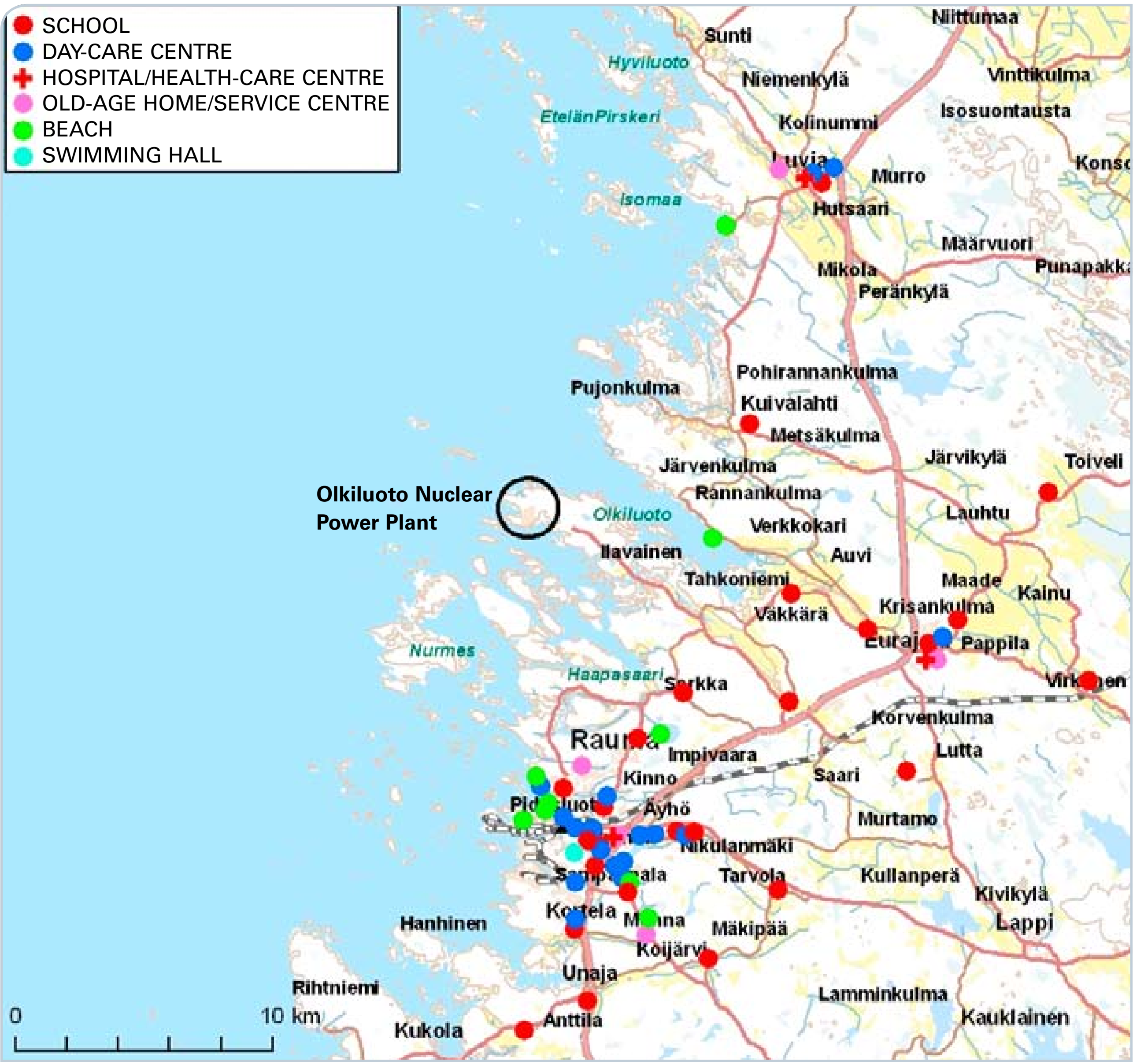


Figure 9-51 Schools, day-care centres, hospitals and health-care centres, old-age homes and service centres, beaches and swimming halls located in the vicinity of the power plant.

TVO is the largest employer in Eurajoki. The company has approximately 660 permanent employees in Olkiluoto. TVO has a substantial direct and indirect effect in Satakunta and particularly in the Rauma region. In 2006, 59 % of TVO's employees working in Olkiluoto lived in Rauma, 19 % in Eurajoki, 8 % in Pori and 14 % in other municipalities. The power plant's support services employ an additional 200 to 250 people on the payrolls of other enterprises. 800 to 1,500 people work at the power plant during annual outages. OL3 will have a maximum of about 3,500 employees during construction and approximately 200 to 300 after completion.

There are four schools within 10 km of the nuclear power plant. The schools are primary schools and the pupils are 7 to 13 years of age. Schools, day-care centres and hospitals in the vicinity of the power plant are presented in Figure 9-51.

9.11.2 Present radiation situation

The area covered by the current environmental radiation monitoring programme of the Olkiluoto power plant has been used as the observed area for the impact of radioactive releases. This supervised area for normal operation, approved by the authorities, has measurement and sampling points that are used for supervising and taking samples from, for example, air, soil, wild plants, grazing grass, milk, garden and agricultural products, domestic water, landfill site, seawater, water plants, sea bed fauna, fishes, sinking matter, and bottom sediment. The distance of sampling points from the power plant varies according to the supervised object. Samples from rainwater, for example, are taken within a distance of 0 to 10 km from the power plant, while grain is sampled within a maximum distance of 20 km and beef at a maximum distance of 40 km. However, the monitoring programme mainly focuses on distances of less than 15 km from the power plant. Monitoring is carried out in accordance with the radiation control programme for the surroundings of the power plant, and the results are reported to the Radiation and Nuclear Safety Authority.

Radioactive substances originating from the Olkiluoto power plant are detected relatively rarely in samples taken from the ground environment. A few observations are made each year in air and fallout samples but the concentrations have only been in the order of one thousandth of natural activity at maximum. In the immediate vicinity of the power plant, small amounts of radioactive substances originating from the power plant are regularly observed in aquatic samples, such as algae, aquatic vegetation, sea bed fauna and sinking matter, but the concentrations have been insignificant both for humans and nature.

Observations of radioactive substances in food samples have been rare. Radioactive substances originating from the Olkiluoto power plant have never been detected in samples of milk, crops and meat during the entire operating history of the power plant.

A total of 301 samples were taken from the vicinity of the Olkiluoto nuclear power plant in 2006. Radioactive substances originating from the Olkiluoto nuclear power plant were detected in a total of 25 samples taken from aquatic vegetation, sinking matter, sea bed fauna, seawater and air. The concentrations found in all of the samples were minor and had no significance to radiation exposure. *(Isaksson 2007.)*

Annual radiation doses to the environment are calculated on the basis of radioactive releases from the power plant. The calculating models account for the spreading of radioactive substances in the atmosphere and waters, as well as accumulation phenomena in different food chains. The calculation of radiation doses to people resident near the plant accounts for the means by which they utilise the environment surrounding the power plant for purposes such as agriculture, recreation and fishing in order to be able to determine the radiation doses imposed on people through different routes of origin. The radiation dose to nearby residents due to atmospheric and aquatic releases in 2006 was approximately 0.27 µSv/inhabitant. The allowed maximum annual dose caused by releases from Olkiluoto is 100 µSv. It can be noted for comparison that the average dose received by each Finn from background radiation is approximately 3,700 µSv annually.

The environmental radiation caused by the nuclear power plant is very minor in comparison to natural background radiation. However, environmental monitoring measures can be used to monitor the occurrence of radioactive substances originating from the nuclear power plant in the environment because they can be distinguished from natural radioactive substances and those originating from other sources of releases.

The radiation doses of everyone who worked at Olkiluoto nuclear power plant in 2006 were below the 50 mSv annual limit. The highest individual dose incurred at Olkiluoto nuclear power plant was 12.2 mSv. The collective radiation dose of employees at OL1 was 1.88 manSv, at OL2 0.33 manSv, totalling 2.20 manSv. Individual radiation doses in 2002–2006 were below the 100 mSv dose limit determined for any period of five years. *(Kainulainen 2007.)*

Ten continuous-operation radiation dose rate measurement stations for external radiation measurement in the vicinity are located approximately five kilometres from the nuclear power plants, and four similar measurement stations are located less than one kilometre from the plants. The measurement data from these stations are transferred to the power plant and to the national radiation-monitoring network. Furthermore, there are 11 separately read dosimeters in the vicinity. There were no changes in external radiation in 2006 that would have exceeded the normal variation in natural background radiation. *(Isaksson 2007.)*

9.11.3 Health impacts and risks

9.11.3.1 General categorisation of health impacts

The health impacts of radiation can be divided into two main categories: direct and random impacts. Direct impacts arise from extensive cell damage caused by a very large radiation dose. Random impacts refer to impacts with randomly varying occurrence between different people due to differences between the exposed individuals, for example. The probability of a random impact such as cancer increases with increased radiation dose but the severity is independent of the dose. A direct impact such as cataract or skin damage will only arise after the radiation dose exceeds a certain threshold, and the severity of the impact increases with an increased dose. *(Paile 2002, STUK 2005.)*

The health impacts of radiation can be roughly estimated through radiation doses. The following presents general background information on the health impacts of small as well as large radiation doses. The health impacts of operating a fourth nuclear power plant unit at Olkiluoto will be addressed in the final part. Health impacts in accident situations are discussed in Chapter 10

Cancer

An increased risk of cancer is the most important impact of radiation doses and has been known for the longest time. Exposure to radiation increases the probability of cancer but radiation does not necessarily cause cancer, not even in large doses. The probability of getting cancer due to radiation is minor at small radiation doses. As the radiation dose increases, the probability of cancer increases but its severity does not increase *(Paile 2002, STUK 2007k, UNSCEAR 1993, 2000)*.

Attempts have been made to determine the average magnitude of cancer risk related to radiation exposure through statistical studies. The estimates concerning cancer risk are based on follow-up studies of groups exposed to radiation. Such groups include the survivors of the atomic bombs at Hiroshima and Nagasaki, people exposed in connection with the medical use of radiation, people exposed in their occupations, and people exposed to an environmental radiation level higher than normal. *(Paile 2002, STUK 2007l, UNSCEAR 2000.)*

Even though the risks associated with large radiation doses and the health impacts of large doses are known fairly well, the assessment of cancer risk caused by small doses based on the impact of large doses involves several factors of uncertainty and assumptions. Risk assessments are rendered difficult by the fact that at small doses, the impacts of radiation are hard to distinguish from the impacts of other factors. Cancer will only occur several years after exposure to radiation, the occurrence of cancer is affected by several other factors as well, and all of the factors and their impact mechanisms are not known yet *(Paile 2002, UNSCEAR 2000)*.

Even though studies have not proven with certainty that very small radiation doses would cause cancer, the risk of cancer cannot be completely excluded. In accordance with the precautionary principle, radiation protection makes the safety assumption that the probability of cancer is directly proportional to the radiation dose – that is, there is no threshold value below which there would be no harmful effects. The ICRP, International Commission on Radiological Protection, uses a risk factor of 5 %/Sv for lethal cancer at small doses and small dose rates. In this case, it is assumed that among 20,000 people who all have received a dose of 1 mSv, there would be one radiation-induced lethal case of cancer *(ICRP 2007, ICRP 1991, Paile 2002, UNSCEAR 2000)*.

Cancer potentially caused by small radiation doses cannot be observed in the population in practice because cancer is such a common disease. Approximately 20,000 people fall ill with cancer every year in Finland. Natural radiation may be a contributing factor to approximately 500 cases of cancer death annually in Finland *(STUK 2007l)*.

Genetic impacts

Radiation is suspected to cause genetic impacts. Even though genetic impacts caused by cancer have been proven in animal experiments, no such impacts have been observed in any group of people exposed to radiation. No increased hereditable health impacts have been observed even in the descendants of the victims of the atomic bombings at Hiroshima and Nagasaki *(Paile 2002, STUK 2002, UNSCEAR 2000)*.

Direct impacts

Direct impacts occur when an individual gets a very high dose of radiation within a short period. Direct impacts are nonexistent below a certain dose level known as the threshold value but above the threshold, the severity of impacts increases with the dose. The threshold value for direct impacts is 500 mSv for full-body exposure. Examples of the direct health impacts of radiation include skin damage, sterility, grey cataract, kidney disease, pneumonia and foetal damage. The direct impacts of a large acute full-body dose also include radiation sickness and, in the worst case, death. Radiation sickness is possible if an individual receives a radiation dose exceeding 1,000 mSv within a short period. A radiation dose of 4,000 mSv is dangerous to life but proper treatment can save the victim. Elsewhere in the world, direct impacts of radiation have mostly occurred in connection with the Hiroshima and Nagasaki nuclear bombings, among plant personnel and firemen involved in the Chernobyl nuclear accident, as well as in situations in which people have inadvertently handled powerful radiation sources manufactured for industrial or medical use *(Paile 2002, STUK 2002, STUK 2005, STUK 2007m)*.

9.11.3.2 Comparison data concerning radiation sources and doses in Finland

The following is a report on radiation doses in Finland for comparison.

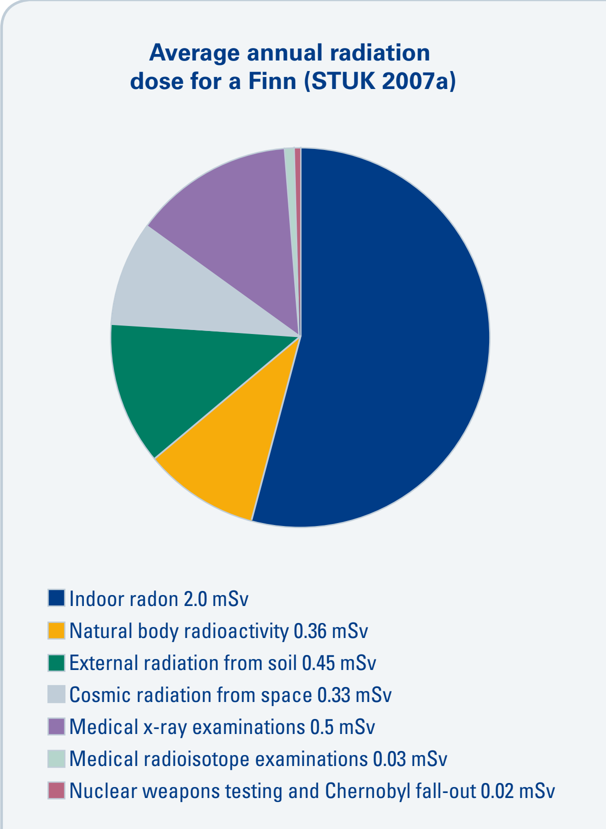


Figure 9-52 *Average annual radiation dose for a Finn.*

The average annual radiation dose to each Finn is approximately 3.7 mSv. Finns receive radiation mostly from the nature and the medical use of radiation. Approximately half of each Finn's radiation dose, or some 2 mSv, originates from radon contained in indoor air. The average annual dose caused by external radiation from the soil and construction materials is 0.5 mSv per each Finn. People are exposed to cosmic radiation everywhere, on aircraft more than on the surface of Earth. Each Finn receives an annual dose of approximately 0.3 mSv from cosmic radiation. People also eat, drink and breathe natural radioactive substances. Natural radioactive substances contained in the body cause an average annual internal dose of 0.4 mSv for each Finn. The Chernobyl fallout is estimated to cause an annual radiation dose of approximately 0.02 mSv *(STUK 2007a and 2007b)*.

The radiation dose originating in natural background radiation varies by region. There is great regional variation in the radon concentration in indoor air. Finns receive their largest radiation dose from radon contained in indoor air. There are approximately 70,000 dwellings in Finland with a radon concentration exceeding the maximum of 400 Bq/m^3. Living in a dwelling that has a radon concentration equal to the maximum of 400 Bq/m^3 causes an annual dose of approximately 7 mSv. The radiation dose caused by external radiation from the soil and buildings varies from between 0.2 and 1 mSv/year in different locations within Finland. Aircrews receive an additional radiation dose of approximately 2 mSv per year from cosmic radiation *(STUK 2007b, 2007c, 2007d, 2007e and 2007f)*.

Radiation is also caused by human activity. The medical use of radiation causes approximately one-eighth

(0.5 mSv) of the annual average radiation dose of Finns. The Chernobyl fallout is still increasing the radiation dose of Finns but the quantity is less than one hundredth (0.02 mSv) of the annual average dose. The radiation dose imposed by existing Finnish nuclear power plants on the most exposed group in the vicinity of the power plants is less than one thousandth of the annual average dose of Finns *(STUK 2007b, 2007g)*.

The radiation dose caused by the utilisation of radiation in Finland originates almost entirely in the medical use of radiation. Each year, approximately 4.2 million X-ray examinations, approximately 1.3 million conventional dental X-rays and almost 200,000 dental panorama X-rays are carried out in Finland. When the radiation doses imposed on patients by various kinds of X-ray examinations are divided among all Finns, the average annual dose comes to approximately 0.5 mSv. The average radiation dose from all X-ray examinations is approximately 0.6 mSv per examination *(STUK 2007a, 2007h)*.

The maximum limit for radiation dose originating from releases during the operation of a nuclear power plant is set at 0.1 mSv per year (Government Decision 395/91). In every year of operation, the radiation doses caused by releases from the Olkiluoto nuclear power plant have been only a fraction of the limit. Releases from the power plant to the atmosphere and water caused a radiation dose of approximately 0.0003 mSv to nearby residents belonging to the most exposed group of population in 2006.

9.11.3.3 Health impacts during the operation of the fourth nuclear power plant unit

The radiation dose caused by releases from the planned fourth unit of the Olkiluoto nuclear power plant to nearby residents is estimated to be about 0.3 µSv or 0.0003 mSv annually, which is in the same order of magnitude as the dose caused by the existing units at Olkiluoto (OL1 and OL2). After the completion of the new unit and the third unit currently under construction, the radiation dose caused by releases from the operation of the Olkiluoto nuclear power plant (OL1, OL2, OL3 and OL4) to a member of the most exposed group of population will thus be about 1 µSv or 0.001 mSv per year.

The dose imposed by the fourth nuclear power plant unit on nearby residents will be less than one hundredth of the radiation dose limit set for the operations of the nuclear power plant and less than one thousandth of the average radiation dose received by each Finn. The dose is so small that it does not have any direct impact on human health. The radiation dose causes an extremely small increase in the risk of cancer and genetic damage. One can summarise that the amounts of radioactive materials discharged from the fourth power plant unit at Olkiluoto into the environment are so minor that they do not have any significance on human health.

The collective radiation dose of nuclear power plant employees is materially accumulated during annual outages, and a substantial part of the practical work is carried out by external contractors. The development of working procedures and the order of tasks has led to a reduction in radiation doses.

9.11.4 Impacts on employment and the regional structure and economy

Employment impacts

The most substantial parts of the nuclear power plant investment constitute earth construction, the construction of power plant buildings and the procurement of equipment. The construction of the power plant unit is estimated to take 6 to 8 years.

Table 9-16 *Examples of radiation doses (STUK 2007a, 2007c, 2007g, 2007h, 2007i, 2007j, Government Decision 395/91, TVO 2007).*

Dose	Description
6000 mSv	Probably lethal if acute
1000 mSv	Symptoms of radiation sickness (such as fatigue and nausea) will start to occur if the dose is incurred within less than 24 hours
100 mSv	Maximum allowed five-year dose in radiation work
14 mSv	Annual dose incurred by people living in indoor air with a radon concentration exceeding 800 Bq/m³ (there are approximately 19,000 dwellings in Finland exceeding this value)
12 mSv	Computer tomography (CT scan) of the abdomen
4 mSv	Average annual radiation dose of each Finn
2 mSv	Typical annual dose received by an aircrew member from cosmic radiation
1 mSv	Average annual dose from the consumption of water from drilled wells
0,5 mSv	Average annual dose received by a Finn from external radiation originating in the soil
0,4 mSv	Average annual dose caused by natural radioactive substances contained in the body
0,1 mSv	Dose imposed on the patient by a single X-ray examination of the lungs
0,1 mSv	Maximum allowed annual radiation dose from the releases of a nuclear power plant to an individual living in the vicinity
0,02 mSv	Average annual dose received by present-day Finns from the fallout caused by the Chernobyl accident
0,01 mSv	Dose imposed on the patient by a single dental X-ray examination
0,0003 mSv	Dose imposed by releases from the Olkiluoto nuclear power plant (OL1 and OL2) on members of the most exposed group of population living in the vicinity in 2006

The employment effect of building a new nuclear power plant unit is substantial. The project requires construction labour and construction site services, as well as special expertise and specialty manufacturing both in Finland and abroad. According to TVO's estimate, the domestic content of the power plant unit will be 35 % to 45 %. The proportion of foreign procurement is high because the supplier of the plant unit is foreign. Due to the scale of the project, Finnish contractors may also have to employ foreign labour.

Domestic procurement concerns all of Finland but the project is of particular importance to the nearby region. In addition to the provision of labour, the most substantial economic effects in Eurajoki and in the regions of Rauma and Pori arise from services required by the construction site, as well as subcontracting work. The construction site needs experienced employees. Enterprises in the nearby regions are in a good position to offer contracts for the construction site based on their location and experience of previous projects. All in all, a substantial quantity of high-quality technical deliveries such as electrical supplies, metal products, machinery and equipment will be procured from Finnish industry. The proportion of design and expert services is also substantial.

The new nuclear power plant unit is expected to have a direct employment effect of 12,000 to 15,000 man-years in Finland. The indirect employment effect in Finland is expected to be 10,000 to 13,000 man-years. The construction of the new nuclear power plant unit is expected to have a total employment effect of approximately 22,000 to 28,000 man-years in Finland.

The project's employment effects in foreign countries exceed the effects in Finland. However, in practice, a substantial proportion of the foreign work will be carried out in Olkiluoto. The foreign plant supplier's operations on site will have economic effects through factors such as the demand for construction site services, short- and long-term accommodations for foreign employees and trade in consumer goods.

The labour requirement of the plant construction site will vary through the different stages of construction and installation work. During the first two years, the number of employees at the construction site will be from a few hundred to one thousand. After this, the number will vary between 1,000 and 3,500 people. The intensive period of construction and installation will last for approximately four years.

The fourth nuclear power plant unit will require an operating staff of approximately 150, and the increased need for outsourced services will correspond to the work input of approximately 250 people. Annual outages of the fourth plant unit will require external staff of approximately 500 to 1,000 people. Because the same employees can be used for the maintenance of the three other plant units, the duration of employment during the maintenance period will be extended. The annual value of maintenance investments at the fourth plant unit will be € 20 million on average.

Impacts on municipal tax income

The construction of the fourth nuclear power plant unit at Olkiluoto will increase the weight of the production sector, which is already substantial in the income flows of the public economy in Eurajoki and the regions of Rauma and Pori. The effects during operation are also sustainable in the long term.

The construction of the new nuclear power plant unit will increase the real estate tax income of Eurajoki municipality by an average of € 3 million annually. The increase in real estate tax income will begin during construction and continue for the entire service life of the plant unit.

The increase in permanent employment due to additional nuclear power plant operating staff will

Direct and indirect employment effects during the construction stage	man-years
Machinery and equipment	5,900 - 7,600
Construction work	3,600 - 4,700
Project and services	2,300 - 3,000
Indirect effects	10,400 - 13,300
Total	22,000 - 28,000
Employment effects during operation	**people**
Operating staff	150
Outsourced services	100
Total	250
Annual outages lasting from 1 to 3 weeks	500 - 1,000

Table 9-17 *Employment effects of investments made in Finland in connection with the fourth nuclear power plant unit at Olkiluoto, as well as employment effects during operation.*

Figure 9-53 *Annual number of employees at the OL4 construction site (estimate).*

increase municipal tax income from wages and salaries by approximately € 1 to € 1.5 million annually. Furthermore, tax income will increase as there will be more staff providing outsourced services. The increase in tax income will concern the municipalities in which the operating staff of the new plant unit live, mostly in Eurajoki, Rauma and Pori. However, the balancing of state subsidies may reduce the benefits of increased tax income.

At the stage of constructing the plant unit, tax income will increase as enterprises in the region gain more business and provide employment in connection with services to the construction site. The accommodation of employees coming to the construction site from elsewhere, as well as their purchasing power, will also provide employment. This may create several dozen jobs in the municipalities of Satakunta where construction site employees live.

Other impacts

The construction of a new nuclear power plant unit will maintain the jobs created in the region due to the construction of the third nuclear power plant unit at Olkiluoto in sectors such as construction, construction site services, accommodation, retail trade and services. Furthermore, the procurement of external services to the nuclear power plant that will be further intensified in the operating stage is significant for local business and employment in the long term. Business benefits will continue and increase particularly in Eurajoki and in the regions of Rauma and Pori. The effects will help in balancing the employment situation in the regions that is otherwise variable.

Accommodations during the construction of the fourth power plant unit will not require additional capacity as the capacity and arrangements created for the needs of the previous construction site can be utilised. Employees living in the region with their families for a longer period during construction can use the services (such as accommodation arrangements, day care, schools and health services) created during the previous construction project, taking the international aspects into account. There are existing models also for recruitment and the provision of official services for Finnish and foreign labour alike.

9.11.5 Impacts on living standards, comfort and recreational opportunities

A resident survey and thematic interviews were carried out to investigate the attitudes of nearby residents towards the project and to support the assessment of social impacts.

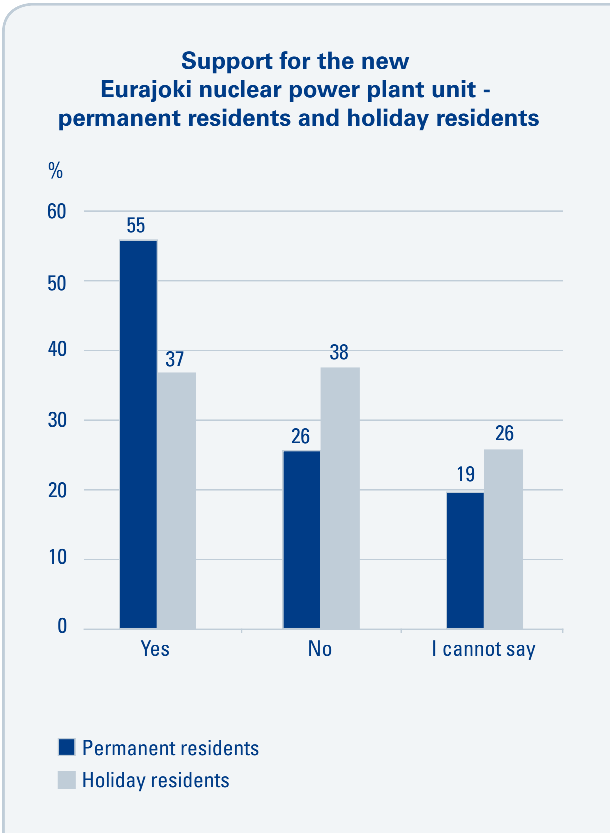
Resident survey

The purpose of the resident survey was to promote interaction by providing the organisation responsible for the project of the project with information about the residents' attitudes towards the project and, conversely, by providing the residents with information about the project and its impact on their living environment. Information about the project and its environmental impacts, and on the EIA procedure in general were sent along with the resident survey. The resident survey was conducted in September and October 2007 through a mailed form. A total of 1,184 survey forms were sent to residents or holiday home owners in Eurajoki and Rauma. Among others, the survey was sent to all households located within an approximate radius of five kilometres from the Olkiluoto power plant and the owners of holiday homes within the same radius. A total of 483 responses were received, resulting in a response rate of 40.8 %. The resident survey form is included in Appendix 3.

In the form of an open questionnaire, the respondents were provided the opportunity to indicate areas of which they would like to receive additional information. Permanent residents were concerned with the increase in cooling water and its impacts, as well as the possibilities to conduct cooling water further away from the existing discharge point. The impacts on water were of a general concern because holiday residents also asked for information about the alternative cooling water intake and discharge points. Holiday residents also requested information on further planning, protection zones and the duration of actual impacts.

General attitudes towards the project were fairly positive or neutral but there was some degree of fear. Women had a more critical and negative attitude towards the impacts and were less supportive of the project compared to men. Holiday residents were more negative towards the project than permanent residents. 55 % of all respondents supported the construction of a new nuclear power plant unit in Eurajoki. Support has declined by 13 percentage points compared to the previous resident survey of 1999.

Figure 9-54 *Support for the nuclear power plant unit, permanent residents and holiday residents.*



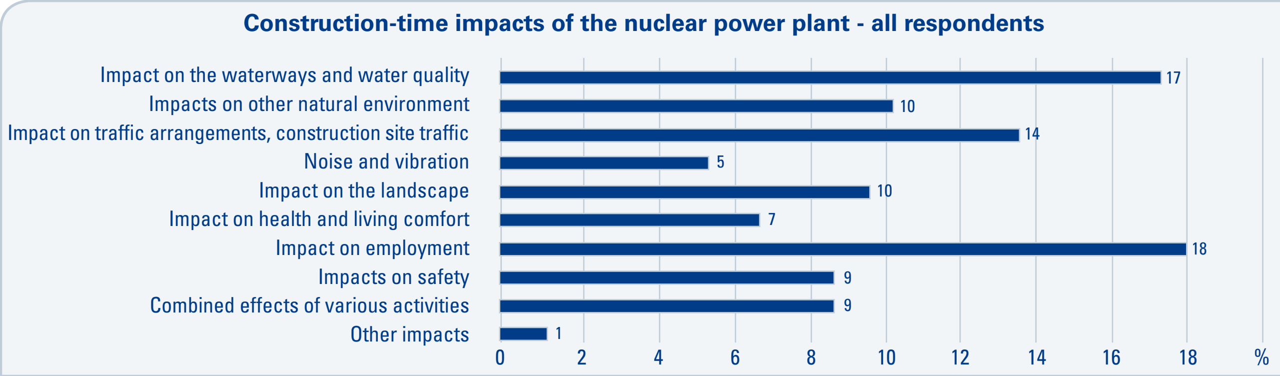


Figure 9-55 *Most considerable environmental impacts during the construction of the nuclear power plant project.*

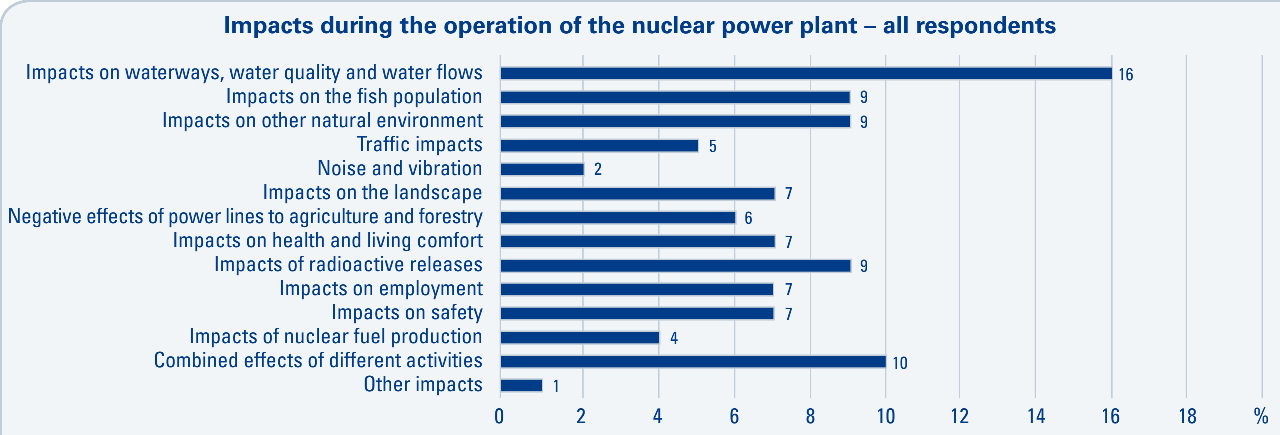


Figure 9-56 *Most considerable environmental impacts during the normal operation of the nuclear power plant.*

Support for the project was greater among permanent residents than holiday residents: 55 % of permanent residents and 37 % of holiday residents supported the project. 26 % of permanent residents and 38 % of holiday residents opposed the construction of a new nuclear power plant unit in Eurajoki. Almost one-fifth of permanent residents (19 %) and more than one-fourth of holiday residents (26 %) were unable to provide an opinion. 55 % of men and 36 % of women supported the project. 27 % of men and 35 % of women opposed the project. Almost one-fifth (18 %) of men and more than a quarter (29 %) of women were unable to provide an opinion. The proportion of uncertain opinions was therefore substantial in all groups of respondents.

Most of the respondents had the opinion that the project will not hamper the comfort of living in their area but some respondents estimated that this will happen. Holiday residents had a more negative idea of the impact on comfort.

Slightly more than half of all respondents (53 %) estimated that the project will not affect recreational opportunities. Less than 10 % of the respondents expected positive effects, while almost one-third of the respondents estimated that the effects on recreational opportunities will be negative. The effects were most often estimated to concern fishing. In addition to fishing, the respondents thought that the project will have a negative impact on boating. Compared to permanent residents, holiday residents were more often of the opinion that the impacts on recreational opportunities will be negative. The project was generally not considered to affect traffic connections and routes.

The new nuclear power plant unit was generally not estimated to increase a desire to move out of the region. 16 % of permanent residents and 27 % of holiday residents estimated that the desire to move will increase if the project is realised. The project was not expected to affect the value of permanent dwellings but the value of holiday homes was suspected to decline.

The employment effects during construction were considered to be of great importance. Women had the most positive idea of the employment effects during construction. The employment effects during operation were not estimated to be as significant as the effects during construction but more than 40 % of men and more than 50 % of women still considered them significant.

The most substantial risk factor associated with the new nuclear power plant unit was considered to be an accident leading to a radioactive discharge. The disposal of nuclear waste and external threats such as terrorism were also considered substantial risk factors.

Most considerable environmental impacts

The respondents were also requested to name the three most considerable environmental impacts during the construction and during the normal operation of the new nuclear power plant unit. The most considerable environmental impacts during construction were considered to be the employment effects, impact on the waterways and the quality of water, as well as the impact on traffic arrangements. The impacts on the landscape and safety were also considered significant.

The most considerable environmental impacts during normal operation were considered to be the impact on the waterways and the quality of water, as well as the joint impacts of operations. The impact on fish and other natural environment, as well as the impact of radioactive releases, were also considered significant.

At the end of the survey form, there were two open questions asking the respondents to identify issues that they would like to see being considered in the environmental impact assessment of the nuclear power plant project and in the design of the new nuclear power plant unit. In the open question concerning environmental impact assessment, permanent residents and holiday residents alike emphasised two groups of issues – safety and impacts on the waterways. Information was requested on issues such as how close to the power plant can you safely live or spend your leisure time. Some of the respondents to the open question on environmental impact assessment also indicated their negative opinion on the construction of the new power plant. On the other hand, the project also received support, and the existing infrastructure of Olkiluoto was seen as an advantage.

It was requested that the practical utilisation of cooling water be taken into account in the design of the new nuclear power plant unit. Issues identified as design considerations for the nuclear power plant unit also included releases and safety. More active communication about these issues was desired. Holiday residents requested that in connection with the design of the nuclear power plant unit, particular attention should be paid to traffic arrangements and the avoidance of unreasonable restrictions or trouble to nearby properties. The safety of pedestrians and bicyclists should be improved, and it was suggested that the harbour road be relocated farther away from the holiday homes on the northern side of Olkiluoto. In the plant unit design stage, solutions should be found for conserving the surrounding nature and natural balance to the best extent possible.

Small group interviews

The group interviews were held in Olkiluoto on 16 October 2007. Participants invited to the first event included professional and recreational fishermen from the vicinity, a representative of a nature conservation organisation, public officials and representatives from forestry societies. The attendance totalled 14 people. In the first group

Table 9-18 *Summary of the social impact assessment. (CO = impacts during construction, OP = impacts during normal operation, X refers to impacts existing during both construction and normal operation.)*

Changes imposed by the project on the social environment	Great	Moderate	Small	Uncertain
POPULATION				
Number, composition	CO	OP		
Diversity of population structure	CO		OP	
Change from the viewpoint of special population groups (those in a poor position, the elderly, the disabled and children)			X	
SOCIOECONOMIC CONDITIONS				
Employment/unemployment	X			
conomic structure and finances	X			
Financial circumstances and structure		X		
Cost of living			X	
Values, norms, behaviour			OP	CO
Quality of living, lifestyle			X	
Positions and interrelationships of population groups				CO
ACCESSIBILITY OF SERVICES				
Private and public service structure		X		
Accessibility			X	
INVOLVEMENT (INTERACTION, INFLUENCE, AVAILABILITY OF INFORMATION, MOBILITY)				
Social relationships			X	
Involvement in decision-making and influence			X	
Availability of information, communication connections			X	
Traffic and mobility opportunities (work, services, pedestrian and bicycle traffic)			X	
REGION				
Regional identity, identification				X
Public image of the region	X			
Safety				X
Comfort of living, inspiration and recreational opportunities		X		
Residents' relationship with nature		X		

interview the discussion focused on the project's water system impacts, fishing and ecological values.

Participants invited to the second event included representatives from nearby village committees, entrepreneurs and parties involved in regional development. The second small group meeting was attended by six people. Above all, the meeting discussed the impacts of the new power plant unit on the region's image, regional development and the social and cultural impacts of the project.

The group interviews were carried out as free-form thematic interviews. At the beginning of the event, a representative from the party responsible for the project briefly explained the background of the project, after which the EIA consultant gave a brief presentation of the alternatives being assessed, the impact assessment methods and the preliminary results of the impact assessment. After this, the representative from the party responsible for the project left the event, and the group interview was conducted as a free-form half-structured thematic interview in which the interviewer guided the discussion on the basis of an interview framework prepared in advance. The interviewees were provided with the opportunity to tell about their opinions and the impacts they considered important.

The summary table 9-18 presents a compiled assessment of the social impacts of expansion of the Olkiluoto nuclear power plant. Crucial initial data for the assessment included the group interviews conducted in the autumn of 2007 and the extensive resident survey in Eurajoki and Rauma.

Impacts on the number and composition of population in Eurajoki and the Rauma region will be great during the nuclear power plant construction stage. Impacts on the number of population will be smaller during operation but the development of nuclear power plant operations will contribute to maintaining and increasing energy sector employment in Eurajoki. This will have a favourable effect on population development in the region.

The realisation of the fourth plant unit will have a great positive effect on employment in the region. In addition to direct employment effects, jobs will probably be created in the service sector. The effects on the economy and commercial life in the region's municipalities will be positive. Employment opportunities will improve, which will have a favourable effect on the residents' opportunities to receive income. The framework for developing public and private services will improve. The employment effects were seen as positive in the group interviews as well as in the resident survey.

The impacts on social conditions in Eurajoki and the relationships between different population groups (in this case, people of different nationalities) depend on the domestic content of the potential fourth nuclear power plant unit and the extent to which any foreign construction site employees will adapt to the local conditions, values and norms. Systematic work to develop recreational opportunities for foreigners has already been found necessary during the construction of Olkiluoto 3. Internationalisation was experienced as positive development.

The construction of the fourth plant unit will have a positive effect on the public image of Eurajoki. The project will reinforce the municipal image as "the most electric municipality in Finland". The present level of interaction and communication was considered to be good and sufficient.

Normal operation of the fourth plant unit will not affect the safety of the region. Most residents of Eurajoki consider nuclear power plants to be safe and reliable. Some of the respondents to the resident survey were concerned about the impact of radioactive releases and accident situations. Women in particular emphasised the safety and health impacts. The general attitude towards the project was fairly positive or neutral.

The impacts on the living comfort and recreational opportunities in the area are mostly dependent on the impacts of the increased thermal load imposed by cooling water on the Olkiluoto sea area. On the basis of the resident survey and the group interviews, the most negative impact of the fourth plant unit was considered to be the impact on the water system. The warm-up of seawater was considered to affect water quality, fish and ice conditions in the area. Ramifications were identified as the deterioration of ice, diminishing fish populations, declining opportunities for fishing, eutrophication of shores and increased difficulty of access to the islands off Olkiluoto during the winter.

9.12 Impacts of the decommissioning and dismantling of the power plant unit

Different dismantling phases and their durations, the types of waste generated and the methods used for their treatment, as well as the environmental impacts relating to them, will be presented with regard to the dismantling of the power plant unit. The dismantling of the power plant unit will be subject to a separate EIA procedure that will be carried out at the appropriate time.

The planned technical service life of the new plant unit is approximately 60 years. If the plant is commissioned in 2018, decommissioning would start around 2080. According to the Nuclear Energy Act, the licensee of a nuclear power plant is responsible for its decommissioning. In order to fulfil this obligation, the party obliged for arranging waste management must provide a description of the decommissioning methods and schedule, as well as the storage and disposal of dismantling waste.

During the operation of a nuclear power plant unit, some of the structures and equipment become radioactive. After the operation of the power plants ceases, all radioactive components will be dismantled. In accordance with TVO's plans, the new plant unit and the existing units at Olkiluoto will be dismantled in connection with decommissioning in a way that will eliminate the need for subsequent radiation monitoring. Because Olkiluoto has been in industrial use for a long time and houses many structures required for industrial operations, such as roads and the harbour, it will be suitable as an industrial area also in the future.

Dismantling is carried out with a delay – that is, the plant unit will be dismantled approximately 30 years after the end of operation. This period will allow radioactivity to decline to a fraction of the original, which will facilitate the final dismantling work and reduce the radiation dose of the dismantling staff. The plant can also be dismantled immediately after operation period. In this case, components with the highest radioactivity must be handled with remote-controlled equipment. Normal technical procedures are more extensively applicable to delayed dismantling.

For the purpose of dismantling, a decommissioning plan shall be prepared in order to ensure that the radioactive components of the plant will not impose a hazard on the environment. The principles applicable to dismantling are the same as those for the existing Olkiluoto plant units. The dismantling plan will be defined in more detail at regular intervals. The decommissioning plans for the nuclear power plants were most recently updated in 2003, and the next review will be carried out by the end of 2008.

In the first stage of decommissioning, fuel, radioactive waste and other loose highly radioactive material will be removed from the plant. The plant's process systems will be sealed so that radioactive substances on their inner surfaces cannot spread to the plant premises. This stage usually lasts for a few years. With regard to dismantling costs and safety, it is preferable that the plant be kept in this state for a few decades.

Activated dismantling waste will originate from the reactor pressure vessel, its internals and other components in the immediate vicinity of the pressure vessel. The most radioactive parts of the dismantling waste generated after the operated period of the new power plant unit will be stored in the power plant's fuel pool or moved to the pools of the spent fuel storage facility for subsequent disposal together with spent nuclear fuel. Some of the plant unit's components will be replaced during operation. Such components include, for example, used fuel channels, control rods, core instruments, core lattices and other components from the inside of the reactor pressure vessel. They will be stored in the fuel pools or moved to the pools of the spent fuel storage facility for subsequent disposal in connection with the dismantling of the entire plant unit. The total amount of such waste generated during the service life of the plant unit will be approximately 200 to 300 tonnes, requiring a volume of 800 to 1,000 m^3.

Not all parts of a nuclear power plant are radioactive. Dismantling waste can be categorised as conventional dismantling waste, low-level and intermediate-level dismantled waste and activated dismantled waste.

Intermediate-level dismantled waste consists of waste arising from the disassembly of the process system, such as piping, pumps and valves. Low-level dismantled waste arises from some concrete and steel structures, for example. According to the present plan, the intermediate- and low-level waste from decommissioning and the used reactor internals accumulated during the operation of the power plant will be disposed of in an extension to the VLJ Repository. The total volume of radioactive dismantling waste from the plant unit will be approximately 10,000 m^3.

Other nuclear facilities, such as temporary waste storage facilities, will be decommissioned similarly to the power plants. The dismantling of these other nuclear facilities is facilitated by the fact that they have no components activated by neutron radiation comparable to the reactor pressure vessel and nearby structures, which means that their activity levels are lower and the amount of radioactive material is smaller.

Dust, noise and vibration will be generated during the different stages of dismantling. Traffic and the number of heavy vehicles will increase during dismantling. Radioactive releases during dismantling are smaller than during the operation of the power plant *(TVO 1999)*.

The funds required for decommissioning must be collected in advance and paid to the State Nuclear Waste Management Fund. These requirements have been applied to the existing plant units at Olkiluoto and Loviisa, and they will naturally be applicable to the new nuclear power plant unit as well.

9.13 Impacts of associated projects

9.13.1 Connection to the national grid and the production of reserve power

The new nuclear power plant unit will require reinforcements to the power transmission system. According to the Electricity Market Act, Fingrid Oyj has an obligation of developing the national grid and carries the system responsibility. On the basis of this, Fingrid Oyj will take care of the required reinforcements to the national grid and the sufficiency of the required disturbance capacity. According to preliminary reports, one or two new connecting lines from the power plant to the grid at Rauma will be required, depending on the size of the power plant unit. The regional transmission capacity from Rauma to other parts of the national grid must also be reinforced. No more new power transmission lines can be placed into the same line corridor as existing lines but a new area must be reserved for power lines going out of OL4. The new power line route must be dimensioned to allow for the construction of two 400 kV power transmission lines. The impact of the power line corridor will extend to an area of at least 62 metres in width so that the open area will be 42 metres wide and there will be edge areas of 10 metres on both sides within which the growth of trees is limited. *(Air-Ix Suunnittelu 2007.)*

A terrain corridor for new power transmission lines is reserved in the Olkiluoto partial master plan in the southern part of the island, to the north of the accommodation village and the Liiklankari conservation area. The power line area is currently unbuilt and does not include any objects of significant natural value.

The construction of a power line is usually considered to be a disadvantage close to settlements. There are no residences or holiday homes in the immediate vicinity of power lines in Olkiluoto.

A power line is an element that is visible in the landscape. The aesthetic disadvantage of power lines can be experienced strongly in the immediate vicinity of the power line corridor. One of the technical requirements for electrical structures is that they must not disturb the environment. Corona discharges occasionally occurring on the surface of conductors or insulators (chirping sound) can be disturbing and cause radio interference. The objective is to prevent the disturbance through power line structures such as the use of three partial phase conductors. Corona discharges may occur at the voltage level of 400 kV in damp weather.

9.13.2 Disposal of spent nuclear fuel

The amount, as well as the storage method and time, of the spent fuel generated by the new power plant unit have been described. In the description of environmental impacts, the material concerning the disposal of spent fuel prepared by Posiva Oy in 1999 in connection with the respective EIA procedure, as well as subsequent reviews, has been utilised. The environmental impacts of spent fuel are described in Chapter 9.2.2.2.

9.13.3 New road traffic connections

The new power plant unit will increase the volume of traffic to Olkiluoto during the construction phase in particular. The increase in traffic volumes may require refurbishing road 2176 between Lapijoki and Olkiluoto.

In the partial master plan proposal for Olkiluoto (31 October 2007), a new road connection will be routed through the Liiklankari conservation area from the south side of the energy supply area directly to the present gate of the power plant site. The present road will remain in use, leading to the accommodation village from which it will continue as an internal road connection within the energy supply area. The partial master plan proposal also contains another road connection to the harbour along the eastern and northern borders of the energy supply area.

The road is located and planned so that according to a separate assessment, its construction and use will not substantially deteriorate the natural values subject to protection through the inclusion of the Liiklankari area in the Natura 2000 network *(Insinööritoimisto Paavo Ristola Oy 2006b)*.

The possible detrimental effects arising from the increased traffic volumes, as well as the options for mitigating them, are described in Chapter 13.1.1.

9.14 Impacts on the energy market

The purpose of the new nuclear power plant unit is to increase the production capacity for base-load power. The construction of a nuclear power plant unit will also improve Finland's independence of foreign electricity and increase supply in the electricity market. A nuclear power plant is characterised by stable production costs, which means that the project will improve the predictability of the electricity market.

9.15 Security of maintenance and supply

The sufficiency of electrical production capacity and the reliability of fuel deliveries are the most crucial issues related to the security of energy supply. Problems can arise in very exceptional situations of the world economy or in political crises.

There are no problems with the availability of nuclear fuel during normal times. The nuclear reactor is only loaded approximately once a year and individual fuel elements can remain in the reactor for several years. Nuclear power plant units usually purchase an annual load of fuel at each time and store the fuel at the power plant. Therefore the power plant may have a quantity of fuel sufficient for electricity production over several months or maybe more than a year.

10 Nuclear safety and the impacts of exceptional situations and accidents

This chapter discusses the environmental impact of exceptional and accident situations based on the safety analyses and accident modelling assessments prepared for the current power plant units, as well as on the requirements imposed on the new unit. The ramifications of exceptional situations have been assessed based on extensive research data on the health and environmental impacts of radiation. In addition to the above, the advancement of the safety of nuclear power plants has also been considered.

The report presents various types of accidents causing different kinds of radioactive releases and describes the extent of the respective affected areas and, by virtue of examples, the impact of releases on people and nature.

The safety assessments carried out for the purpose of applying for a construction and operating license pursuant to the Nuclear Energy Act, as well as other types of surveillance, have also been described.

To provide for the occurrence of accidents, the current Olkiluoto power plant has been allotted a protective zone extending to 5–7 km from the power plant in land use planning, as well as an emergency planning zone of rescue operations comprising the areas of Eurajoki, Luvia and Rauma. The preparation for exceptional situations at the new plant unit and the environmental impacts of such situations have been examined in the entire Baltic Sea region but primarily on the basis of the above division of areas.

10.1 Safety requirements

According to the Nuclear Energy Act, the design, construction and operation of a nuclear power plant must be safe and shall not cause injury to people or damage to the environment or property. The safety objective can be considered achieved when the risk caused by releases from normal operations and potential accidents represents a very small increase in the total risk imposed on people by other functions of society and natural dangers.

The principle of decision-making and the licensing system under the Nuclear Energy Act is that the assessment of safety shall continue and estimates shall be made more specific for the entire duration of the procedure. Final safety assessments shall only be made at the operating licence stage.

At the stage of applying for a decision in principle, the Radiation and Nuclear Safety Authority is responsible for preparing a preliminary safety assessment of the application. The safety assessment shall deal with the possibilities of fulfilling the requirements set in the Nuclear Energy Act and Decree, as well as Government Decisions issued by virtue of Section 81 of the Nuclear Energy Act. When preparing the safety assessment, the Radiation and Nuclear Safety Authority shall request opinions from the Advisory Committee on Nuclear Safety and, to the extent necessary, also from other expert organisations. The Advisory Committee on Nuclear Safety is an expert body operating in connection with the Radiation and Nuclear Safety Authority. Its members are appointed by the Government for three-year terms each time. The members of the Advisory Committee represent a high standard of expertise in nuclear safety. In its safety assessment, the Radiation and Nuclear Safety Authority shall indicate if any issues have been revealed that would suggest a lack of sufficient prerequisites for constructing the nuclear facility in compliance with legislation.

The Radiation and Nuclear Safety Authority shall issue a statement on the construction licence application and attach a safety assessment to the statement. When preparing the safety assessment, the Radiation and Nuclear Safety Authority shall request opinions from the Advisory Committee on Nuclear Safety and, to the extent necessary, also from other expert organisations. In its safety assessment, the Radiation and Nuclear Safety Authority shall present an opinion on whether the statutory requirements have been fulfilled.

General regulations concerning the safety of nuclear power plants are prescribed in Government Decision 395/1991. The Government Decision will be replaced by a corresponding Government Decree that was at the draft stage when the EIA report was completed. Corresponding decisions have also been issued on the emergency preparedness and physical protection of nuclear power plants, as well as the disposal of reactor waste and the safety of disposal (GD 395/91, GD 396/91, GD 397/91). These decisions will also be replaced by Government Decrees. Detailed safety requirements are presented in the YVL guides published by the Radiation and Nuclear Safety Authority. They constitute a comprehensive set of regulations that specifies the level of safety required from nuclear power plants in Finland.

In addition to requirements related to safety design, the YVL guides present procedures to be observed with regard to the procurement of plant equipment, for example. According to the basic principles of the YVL guides, an alternative procedure proposed by the licensee can be approved to replace a procedure specified in the guides if the licensee is able to prove that the level of safety intended in the guides will be achieved.

The requirements for a new nuclear power plant differ from the requirements observed in the design of existing plants. They have a more systematic approach to the opportunities of eliminating safety-endangering factors that have become known on the basis of new information obtained during the course of 30 years. The most substantial additional information relates to the possibility of preventing the discharge of radioactive substances into the environment even if the actual reactor would become severely damaged. With regard to this, the safety requirements applicable to the new plant are clearly stricter than the requirements that were applied during the construction of existing plants. During the service life of existing Finnish nuclear power plants, modifications have been made to improve safety, aiming for the level of safety required of a new plant.

10.2 Implementing the safety requirements at the new nuclear power plant unit

In accordance with the Nuclear Energy Act, the starting point for the design, construction and operation of a nuclear power plant is that the plant must be safe and it shall not cause injury to people or damage to the environment or property. This is complied with through precautionary measures in the design, construction and operation of the plant, functions protecting the plant in cases of disturbance and damage, and as functions mitigating the consequences of accidents.

The design, construction and operation of the nuclear power plant shall be implemented in accordance with the Government Decision on the general regulations for the safety of nuclear power plants (GD 395/91). The arrangements to prevent unlawful actions against the nuclear power plant shall be implemented in accordance with the Government Decision on the general regulations for the physical protection of nuclear power plants (GD 396/91), and the arrangements to limit nuclear damage within the nuclear power plant and its area shall be implemented in accordance with the Government Decision on the general regulations for emergency response arrangements at nuclear power plants (GD 397/91). This will be complied with by extending the emergency response arrangements of the existing plant units to cover the new plant unit. The design of the plant unit shall also observe the most recent international safety recommendations. Essential sets of requirements include the European Utility Requirements (EUR) specified by European power companies. The power plant unit's compliance with the requirements set in the YVL guides is proven by means of safety analyses that examine the behaviour of the plant unit in disturbances and accidents.

10.2.1 Multi-layered defence in depth principle of safety

The high level of safety of the planned nuclear power plant unit is based on the defence in depth principle. The defence in depth principle refers to ensuring the safety of a nuclear power plant by preventing the harmful effects of damage and radiation through successive and mutually redundant functions and structural levels. All functions significant to safety shall be backed up by several redundant systems and devices, and the design of all equipment and functions shall observe a high level of quality requirements and sufficient safety margins. The starting point is that a severe accident cannot be caused solely by operating error or equipment failure even if several devices fail simultaneously.

The first level of protection constitutes the prevention of operational transients and accidents in advance. In relation to this, proven or otherwise carefully examined high-quality technology shall be employed in design, construction and operation. The safety culture for the operations is also at a high level. The second level of protection constitutes systems by means of which operational transients and accidents can be quickly and reliably detected, and the aggravation of any event can be prevented. The third level of protection mitigates the consequences of accidents through efficient technical and administrative arrangements. In preparation for accident situations, the plant has a designated emergency organisation, and its operations and the functionality of emergency preparedness plans are tested in annual emergency drills carried out together with rescue authorities.

According to the defence in depth principle, accidents are prevented through sound design, a high level of quality and diligence of operating activities. Should a disturbance or accident take place despite this, it can be controlled by safety systems. Should this also fail, the environmental impacts of the accident shall be mitigated as efficiently as possible.

10.2.2 Multiple barriers

The starting point for nuclear power plant design is that no significant amounts of radioactive substances shall be discharged into the environment as a consequence of potential disturbances or accidents. The dispersion of radioactive substances into the environment is prevented by multiple successive barriers. These include the ceramic structure of the fuel pellets, the gas-tight cladding of the fuel bundles, the reactor pressure vessel, the gas-tight and pressure-proof containment and the surrounding reactor building. Only the simultaneous failure of several barriers can lead to the dispersion of radioactive substances into the environment.

To prepare for the failure of equipment used in normal operation, the plant shall be equipped with safety systems consisting of several redundant subsystems. Therefore the failure of one subsystem does not prevent the appropriate safety function. Subsystems are implemented using different operating principles and structural arrangements in order to prevent the simultaneous failure of all subsystems due to a similar fault. Systems used for normal operation as well as safety systems are designed so that they will assume a safe state in the case of failure. As a precaution for external impacts and fire, the subsystems are located separately from each other to prevent the simultaneous failure of all subsystems.

The automatic start-up of safety functions is designed so that operating personnel will be allowed at least 30 minutes to consider their actions. The inherent properties of a light water reactor make an uncontrolled increase in power or an explosion-like reaction impossible – in other words, an event such as the loss of coolant will cause the reactor to shut down by itself. The plant shall be designed to tolerate failures and incorrect operating actions.

10.2.3 Precautions for external hazards

The design of the new plant unit allows it to endure extreme weather conditions that are estimated to be very rare or improbable at the site, including high and low temperatures, wind, snow load, sea water level, ice conditions and thunder. Furthermore, the possibility of an earthquake is taken into account in the design of plant components important to safety.

The plant unit site is located far away from significant roads and air traffic routes. However, the plant unit design takes an aeroplane crash or other external impact into account. The plant unit shall be implemented so that an aeroplane crash or other external impact will not cause any damage that could immediately discharge a significant amount of radioactive substances into the environment. Precautions for external threats arising from terrorism or other illegal activity are taken through comprehensive security arrangements.

10.2.4 Precautions for severe accidents

The design of the new nuclear power plant shall include precautions for extensive reactor core damage, also

known as a severe accident. The requirement applies primarily to the design of the containment because a severe accident means that the integrity of the inner barriers (fuel cladding, primary circuit) will be lost.

The successful control of a severe accident calls for a strategy that gives due consideration to the specific features of the plant and the phenomena threatening the containment building. Such a strategy must define sound methods for preventing or controlling the energetic phenomena related to the development of the accident (e.g. hydrogen burn, high-pressure melt eruption, energetic molten core-coolant interaction). Additionally, the strategy must ensure the cooling of the molten core and the removal of residual heat from the containment building in such a way that the containment building remains intact during the accident and for a long time thereafter.

The systems designed for controlling severe accidents must perform their functions even if any single piece of equipment in the system fails. The systems to be designed for controlling severe accidents must be independent of other safety systems. A severe accident must be controllable in all operational states of the nuclear power plant, not only during power operation but also during shutdowns.

10.2.5 Safety analyses

The safety features of a nuclear power plant shall be proven through detailed analyses. The safety analyses constitute a foundation, using which the authorities will form their opinion on the plant's ability to recover from different situations of damage and disturbances. The safety analyses are presented to the authorities in connection with the plant's preliminary safety analysis report when applying to the Government for a construction licence. The final safety analysis report supplements the safety analyses with the effects of details associated with the construction of the plant. The final safety analysis report will be presented to the authorities when applying to the Government for an operating licence.

The analyses to justify the technical solutions for a nuclear power plant unit must assess the discharges of radioactive substances in anticipated operational transients and accidents in accordance with YVL Guide 2.2. Furthermore, analyses shall be made for the planning of emergency preparedness arrangements, and preparations shall be made to assess the spreading of radioactive substances in real-time during an accident situation in accordance with YVL Guide 7.4.

10.2.6 Regulatory control

In Finland, all operations associated with the production of nuclear energy are subject to permit. In addition to safety supervision, nuclear facilities and the use of nuclear materials are supervised to prevent misuse. The operation of nuclear power plants is continuously supervised in accordance with the Nuclear Energy Act and the Nuclear Energy Decree. Authorities supervise the operation of plant units in accordance with strict guidelines. According to the Nuclear Energy Act, the control and supervision of the nuclear energy sector in Finland is the ultimate responsibility of the Ministry of Trade and Industry, the tasks of which transferred to the Ministry of Employment and the Economy as of 1 January 2008.

The Radiation and Nuclear Safety Authority is responsible for supervising the operation and safety of nuclear energy. TVO provides regular reports of its operations to the Radiation and Nuclear Safety Authority. Through the licensing process (see Section 5), the Radiation and Nuclear Safety Authority ensures that safety requirements are taken into account in the design, construction and operation of a plant. The Radiation and Nuclear Safety Authority supervises the fulfilment of safety requirements during design, construction, staff training, plant operation and decommissioning. Nuclear fuel is also controlled by the International Atomic Energy Agency (IAEA) and the European Atomic Energy Community (Euratom).

10.3 Rating of accidents

The International Atomic Energy Agency (IAEA) has specified a severity scale for events at nuclear facilities called the INES (Internatio¬nal Nuclear Event Scale). The INES scale was developed in international cooperation between the International Atomic Energy Agency (IAEA) and the Organisation for Economic Co-operation and Development (OECD). The work has also involved experts from several countries. The INES scale was taken into trial use in 1990. The scale was approved for official use at nuclear power plants in 1992 and at other nuclear facilities in 1994. The scale is used in 60 countries.

The scale includes seven ratings, the lowest three levels describing events endangering safety and the highest levels 4 to 7 describing accidents. Furthermore, Level 0 is used for events that are not significant to safety. The scale and the ratings of some example events are described in Appendix 2.

The worst light water reactor accident occurred in 1979 at the Three Mile Island (TMI) nuclear power plant in the United States. The accident involved the partial meltdown of the reactor core. On the basis of impacts internal to the plant, the accident is rated at Level 5. The containment prevented substantial discharges of radioactive substances into the environment, and the radiation impacts were minor. The radiation dose to the most exposed resident in the vicinity was less than 1 mSv, which is approximately a quarter of the average annual radiation dose of each Finn (Eisenbud 1989).

The worst nuclear power plant accident of all time occurred in Chernobyl in the Soviet Union (now Ukraine) in 1986. The nuclear power plant's reactor disintegrated by explosion when the chain reaction producing power got out of control. The accident is rated at INES Level 7 and caused extensive environmental impacts. A Chernobyl-type accident is not possible in the light water reactor planned for Olkiluoto that is of a completely different structure compared to the graphite reactor of Chernobyl.

Events at Finnish nuclear power plants have never exceeded Level 2.

10.4 Impacts of accidents

In order to prevent accidents and mitigate their consequences, safety principles and regulations are observed in the design, construction and operation of the plant unit.

The postulated accidents that serve as a basis for the design of the plant unit examine, among other things, situations where a leak develops in the reactor cooling system and the safety systems operate as designed. In these accident situations, there is no need to impose any restrictions on living and the use of foodstuffs in the vicinity or any other restrictions. The radiation dose caused to the nearby population may not exceed the limit for a postulated accident specified in GD 395/91, which is 5 mSv. The limit concerns the dose accumulated by an individual during a period of one year from the accident. The dose limit corresponds to the dose received by an average Finn from other sources over a period of just over a year. If the average Finn receives a dose corresponding to the limit for a postulated accident once in his life, his lifetime radiation burden increases by approximately 2%. The change is minor in comparison with the variations in the lifetime dose from natural radioactivity in different regions of Finland.

In the case of a severe accident, it is assumed that the safety systems of the plant are not operational in a situation caused by a reactor system leak or some other damage. This may lead to severe damage to the reactor core, releasing a major part of the radioactive materials in the fuel into the containment building. According to the design requirements, the containment building must keep the amount of radioactivity discharged into the environment below the limit specified in GD 395/91. The prescribed limit is such that even in the case of a severe accident, the discharge does not cause immediate health hazards to the surrounding population or any long-term restrictions to the use of large areas of land. The health impacts of radiation are described in more detail in Section 9.11.3, Health impacts and risks.

In connection with the application for a construction licence and an operating licence, detailed analyses are used to prove that the plant fulfils the requirements set for accident situations in GD 395/91. This also includes proving the fact that the possibility of exceeding the limit for a severe accident is extremely minor. *(TVO 2004.)*

10.4.1 Requirements applicable to exceptional situations in Finland

The Government Decision (GD 395/91) on the general regulations for the safety of nuclear power plants gives definitions for exceptional situations and sets limits for the radiation exposure of the surrounding population and the discharges of radioactive substances. GD 395/91 will be replaced by a corresponding Government Decree that is at the draft stage at the time of this writing. The following definition of exceptional situations and limits is in accordance with the draft Decree. The limits for an anticipated operational transient, postulated accident and severe accident correspond to the limits in GD 395/91.

In accordance with the limits set in GD 395/91, an operational transient would probably be rated at INES Level 2, a postulated accident at Level 4 and a severe accident at Level 6.

Anticipated operational transient

An anticipated operational transient refers to a deviation from normal operational conditions milder than an accident, which can be expected to occur once or several times during any period of a hundred operating years. The limit for the annual dose of an individual in the population arising as a result of an anticipated operational transient is 0.1 mSv.

Postulated accident and the extension of postulated accidents

Postulated accident refers to an event which serves as a design basis for the engineered safety systems of a nuclear power plant. The nuclear power plant shall withstand a postulated accident without severe fuel damage. In the draft decree, postulated accidents are grouped into two classes based on their frequency:

i) Class 1 postulated accidents, which can be expected to occur less than once over a period of one hundred reactor-years but at least once within a thousand years.
ii) Class 2 postulated accidents, which can be expected to occur less than once over a period of a thousand reactor-years.

The extension of postulated accidents refers to an event in which a common-cause failure or a complex combination of failures occurring in the engineered safety systems are related to the initiating event of an operational transient or accident. The nuclear power plant shall withstand an extension of postulated accidents without severe fuel damage.

Postulated accidents and events handled as extensions of postulated accidents shall not result in a discharge of radioactive materials so large that extensive measures should be taken in the plant's vicinity to limit the radiation exposure of the population.

The limit for the annual dose of an individual in the population arising as a result of a postulated accident is:

- for Class 1 postulated accidents 1 mSv
- for Class 2 postulated accidents 5 mSv
- for an extension of postulated accidents 20 mSv.

Severe accident

Severe accident refers to an emergency in which a considerable part of the fuel in the reactor is damaged. The limit for the discharge of radioactive materials arising from a severe accident is a discharge that causes neither acute harmful health effects to the population in the vicinity of the nuclear power plant nor any long-term restrictions on the use of extensive areas of land and water.

The requirement concerning long-term effects is fulfilled if the possibility that, in connection with a severe accident, the atmospheric release of caesium-137 exceeding 100 TBq is extremely small.

According to the Radiation and Nuclear Safety Authority guide YVL 2.8, the expectation value for reactor core damage must be below 10–5/year. All cases of reactor core damage do not cause a major discharge of radioactivity, which means that the probability of such a discharge is even lower. According to the same guideline, the expectation value for the frequency of a discharge exceeding the above limit for a severe accident must be lower than 5 x 10–7/year.

10.4.2 Severe accident

Definition of accident situation

The discharge of long-lived radioactive substances from a severe accident is assumed to be 100 TBq Cs-137 and a corresponding proportion of other isotopes of caesium. For comparison, it can be noted that some radiotherapy devices used in hospitals have a caesium-137 radiation source that is of the same order of magnitude, 100 TBq. On the basis of accident analysis results (such as U.S. Nuclear Regulatory Commission 1990), the discharge of radioactive iodine is assumed to be 1,500 TBq of iodine-131 and a corresponding proportion of other isotopes of iodine.

Furthermore, it is assumed that all of the radioactive noble gases will be discharged into the environment. On the basis of accident analyses, the significance of isotopes other than caesium, iodine and noble gases is smaller, and no substantial amounts are expected in the discharge. The discharge is expected to begin 24 hours after the initiator of the accident in accordance with a requirement in the EUR document (EUR 1995) and last for one hour, during which no change in wind direction is assumed. If the duration of the discharge was longer, the greatest radiation doses would be lower than specified below due to longer-term changes in wind direction but, on the other hand, radiation doses would be incurred across a wider area. The initial altitude of the discharge plume is assumed to be 100 metres.

Computer programs developed for the purpose have been used for estimating the radiation doses incurred by nearby residents due to the discharge (Rossi et al. 1993, Saikkonen 1992). The doses presented in Table 10-1 have been calculated with the assumption that the discharge will take place during such weather conditions and such a season that the doses would be lower than the specified value with a probability of 95 %. The radiation dose for the longest distances has been extrapolated using results presented in the publication *(Nordlund et al. 1985)*.

In Table 10-1, the radiation dose is divided into two parts due to the great difference in the rates of dose accumulation. The first-day dose originates mostly from the discharge plume floating in the air. Subsequent to this, the radiation dose will mostly be accumulated from fallout radiation and through foodstuffs. The calculation of the 50-year radiation dose assumes that the person will live at the same location for the entire period. This is also true at a distance of one kilometre, which is within the power plant site. The nearest holiday homes are located at an approximate distance of two kilometres, with permanent residences a bit farther. At distances of 10 km and more, it is assumed that all food will be produced on location. The consumption of food from outside the fallout area would reduce the radiation doses. For comparison, it can be noted that the average Finn normally receives a radiation dose of 200 mSv over 50 years.

The radiation doses incurred in the vicinity during the first 24 hours have also been illustrated in Figure

Table 10-1 *Radiation doses to the most exposed residents in the vicinity in case no population protection measures are taken.*

Distance from the power plant (km)	Radiation dose during the first 24 hours (mSv)	Radiation dose accumulated over 50 years subsequent to the first 24 hours (mSv)
1	200	300
3	70	200
10	20	70
30	6	20
100	2	4
300	0.6	1
1000	0.2	0.3

10-1, which represents a map of areas in which the dose would exceed 50 mSv or 10 mSv.

However, in the case of accident, protective measures would be taken. They would substantially reduce the radiation doses exceeding 20 mSv in the table.

The accident would not cause any immediate health impacts to nearby residents.

Protective measures

The IAEA recommends the following indicative levels for taking action to protect the population against the impacts of radiation *(IAEA 2002, IAEA 1996)*:

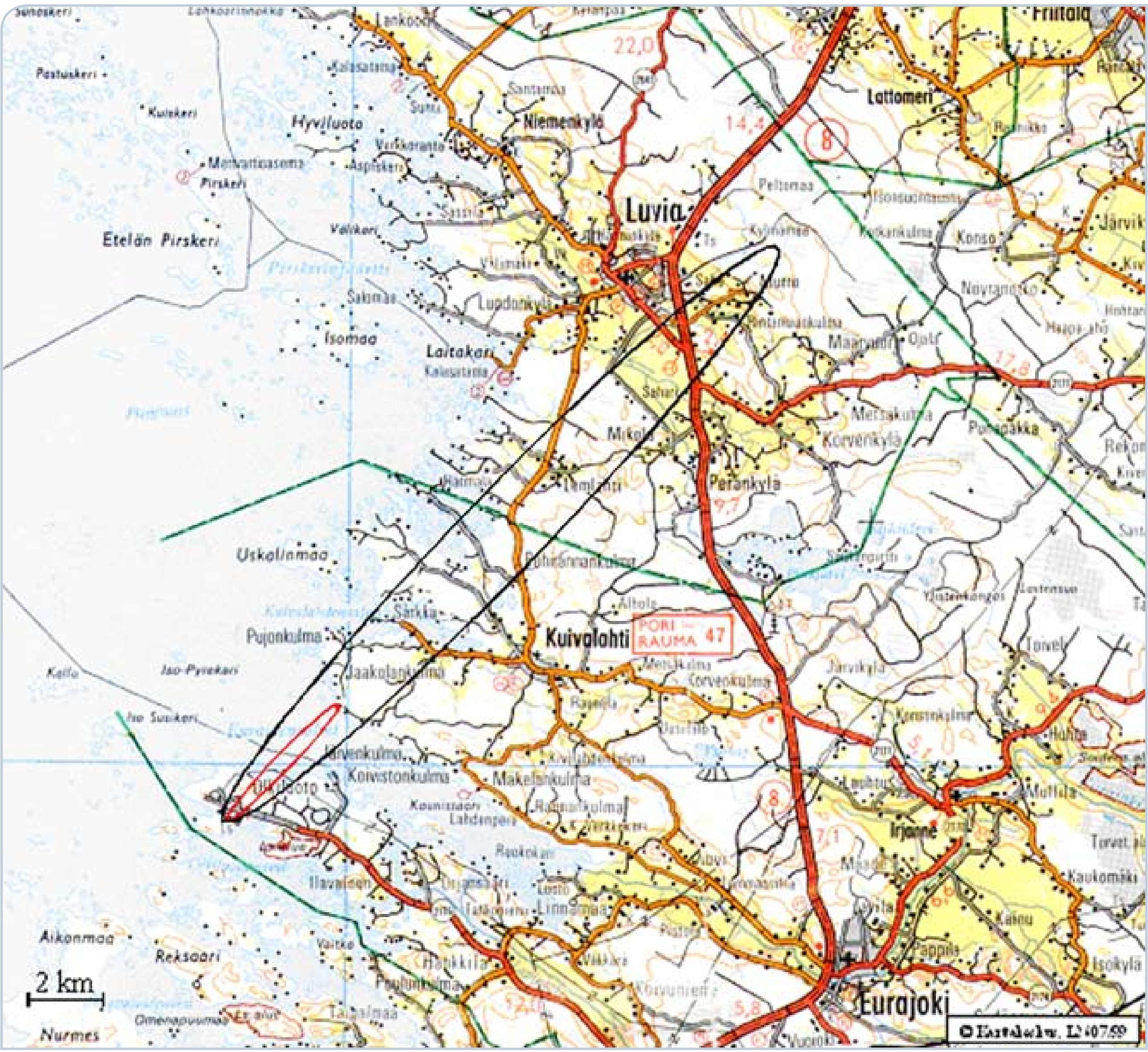
- taking shelter indoors: 10 mSv of avertable dose in a period of no more than two days
- temporary evacuation: 50 mSv of avertable dose in a period of no more than one week
- consumption of iodine tablets: avertable dose to the thyroid 100 mGy, dose to the thyroid of a child 10 mGy *(STUK 2001)*
- permanent evacuation: 30 mSv of avertable dose in a period of one month.

The indicative level for action refers to a radiation dose that can be justifiably and reasonably averted through the protective action in question – in other words, the protective action does not cause greater harm than the radiation dose averted through it.

In the situation examined here, temporary evacuation would be justified up to a distance of five kilometres in the direction of spreading of the discharge, taking shelter indoors would be justified up to approximately ten kilometres and the administration of iodine tablets to children would be justified up to a few dozens of kilometres. The soil would be contaminated beyond the limits for human habitation for a period longer than one year up to a maximum distance of a few kilometres.

Radiation doses can also be reduced by restricting the use of foodstuffs containing radioactive substances. Indicative levels for action have also been specified for such countermeasures (IAEA 2002, IAEA 1996). The radiation doses caused by the consumption of foodstuffs corresponding to these action levels are small in comparison to the avertable doses listed above.

Figure 10-1 *Radiation doses caused by the accident under review during the first 24 hours without protective measures in the vicinity of Olkiluoto with a southwesterly wind. The red line represents the area within which the doses incurred exceed 50 mSv, and the black line represents the area within which the doses incurred exceed 10 mSv.*



Radioactive iodine would be introduced from foodstuffs particularly through milk. During the Windscale graphite reactor accident in England in 1957, the amount of iodine discharged into the environment was roughly equal to the amount examined here *(UNSCEAR 1993)*. On the basis of experience from Windscale, it can be estimated that the distribution of any milk produced would be prohibited within an area roughly corresponding to the route of the discharge plume and having a maximum length of one hundred kilometres. Depending on the weather conditions and season during the discharge, the length of the area might be only a fraction of this.

The half-life of the most important isotope of iodine, I-131, is eight days, which means that its activity will be reduced to 1/200th in two months. Therefore the restrictions concerning milk need not be in force for any longer than this. It would not be necessary to destroy the milk; it could be processed into products with a long shelf life, and the radioactive iodine would decay during storage. Restrictions on the use of other foodstuffs due to iodine would be required within a substantially smaller area.

Long-lived radioactive substances, particularly caesium-137, which has a half-life of 30 years, could impose the need for long-term restrictions on the use of foodstuffs produced in the fallout area. The extent of the area subject to restrictions would depend on the weather conditions during the accident. According to migration model studies (Suolanen 1992 and 1994), in the case examined here, the use of some agricultural products such as milk and beef during the first year could be restricted to a maximum distance of a few dozen kilometres, with a smaller restricted area applicable to most other agricultural products. Long-term restrictions would be required to a distance of less than ten kilometres, and restrictions concerning crops, for example, would not be required at all.

Accident impacts on organisms

Assuming fallout in keeping with the accident situation specified above and estimating its impacts on living organisms, we can state that there is very little evidence to suggest that the fallout would cause any detrimental effects to even the most fragile plant or animal populations inside the plant perimeter. The radiation exposure of organisms has been estimated using a method developed in the ERICA project if the European Commission *(Beresford et al 2007, Ikonen, A. 2008)*.

10.4.3 Accidents associated with the intermediate storage and disposal of spent fuel and the treatment and disposal of reactor waste and decommissioning waste

Spent fuel is located in KPA Store completely below ground level and is protected well from any external impacts. The safety analysis report for KPA Store addresses different types of accident situations, among which the falling of an open fuel transport cask and disintegration of spent fuel in the cask is estimated to be a situation that would cause the largest radiation dose to nearby residents. The environmental radiation doses arising from such a very improbable accident would remain below 5 mSv, which is the limit set for postulated accidents in the general regulations for nuclear power plant safety (GD 395/91). The upcoming extension to the KPA Store will not change the situation.

Accidents associated with the disposal of spent fuel have been addressed in an EIA report concerning the disposal of spent fuel *(Posiva 1999)*. The consequences of the most severe accidents associated with the disposal of spent fuel are minor compared to the consequences of a severe reactor accident.

The radioactivity contained in operating waste and decommissioning waste from the power plant units is not in an easily releasable form, and the amount of activity is very small compared to that contained in nuclear fuel. In the disposal facility (the VLJ Repository and its future extensions), the waste is inside the bedrock, well protected from external impacts. The safety analysis report for the VLJ Repository addresses different accident situations, among which the situation that would cause the largest radiation dose to nearby residents is estimated to be the complete combustion of the most radioactive waste load allowed on its way to the repository. The environmental radiation doses arising from such a very improbable accident would remain below 5 mSv, which is the limit set for accident conditions considered possible (GD 398/91). Upcoming extensions to the VLJ Repository will not change the situation.

10.5 Civil defence

The TVO plant site is surrounded by a protective zone extending to approximately five kilometres from the plant. The protective zone includes Olkiluoto island and a few smaller islands in the vicinity of Olkiluoto. The zone includes approximately 33 residential buildings intended for permanent use. There are approximately 550 holiday homes within the zone. The emergency planning zone extending to approximately 20 km from the plant extends to the municipalities of Eurajoki, Rauma and Luvia. There are approximately 46,000 inhabitants in the zone.

To prepare for accident situations, TVO has established and trained an emergency organisation responsible for necessary action within the power plant site. TVO's emergency preparedness arrangements would be extended to cover the new plant unit in accordance with the existing principles.

Rescue service authorities within the area have arrangements in place for providing instructions to nearby residents and arranging any protective actions required in case of an accident. Protective actions have been planned for in advance for the emergency planning zone including Eurajoki, Luvia and Rauma. Drills are arranged regularly to ensure that the actions and plans of the rescue service authorities and TVO are mutually compatible in accident situations.

By virtue of the Nuclear Liability Act, TVO as the operator of the nuclear facilities is liable to compensate for damages incurred to outsiders due to accidents. TVO has an insurance policy for the existing nuclear power plant units in accordance with the Nuclear Liability Act. In compliance with the Act, similar nuclear liability insurance will also be extended to the new plant unit.

10.6 Chemical accidents

Other environmental accidents that may occur at the new unit are mainly accidents caused by the environmental discharge of oils and chemicals. The risks of such accidents are also taken into account starting from the plant unit design stage.

Most of the chemicals stored at the power plant are used in auxiliary processes such as the processing of water. Chemicals are also used for purposes such as the decontamination of primary circuit equipment and pipelines, as well as fuels. Chemicals used in substantial amounts include, for example, hydrazine, sulphuric acid, sodium hypochlorite, sodium hydroxide or lye, as well as oils. The design, construction and operation of discharge equipment, storage and transport pipelines for these substances make preparations for disturbances and accidents.

The Safety Technology Authority TUKES supervises the handling and storage of hazardous chemicals at the plants operating in Olkiluoto. The commissioning of the OL3 plant will increase the processing of hydrazine, which is categorised as highly toxic, to such amounts that oblige the power plant to carry out a safety assessment. The safety assessment shall describe the major accident risks caused by hazardous chemicals and associated precautions. OL4 will be included in the safety assessment.

Storage tanks for chemicals and other chemical storage facilities shall be constructed in accordance with the requirements of the Chemicals Act, regulations enacted by virtue of it and SFS standards. The storage of chemicals complies with the valid procedures of licensing and notification that aim to ensure the safety of the use and storage of chemicals both for the environment and for the employees.

Automatic alarms and supervision instructions ensure that no uncontrolled or undetected leaks may arise. Sewerage is designed so that any leaks can be caught in shielding pools, sludge or oil trap wells or a neutralising tank. Training for power plant personnel and instructions for the prevention of environmental and material damage ensure a high standard of managing chemical accident risks.

Furthermore, risk analyses for the OL4 plant unit shall be prepared in a manner approved by the authorities pursuant to the obligations of both environmental and chemical legislation, reporting the probabilities of risks imposed by hazardous materials on the environment, people and property, the magnitudes and mechanisms of potential damage, as well as the functionality of the risk management system and organisation at the power plants.

The risk of harmful amounts of chemicals or oils being discharged into the water, atmosphere or soil is minor.

10.7 Potential phenomena caused by climate change and associated preparations

Potential phenomena caused by climate change and associated preparations are examined as exceptional situations. Changes in sea level, snowstorms and other potential conditions have been taken into account. The EIA report provides a general assessment of what events may arise from climate change and the impact they may have on the Olkiluoto nuclear power plant. The impacts are examined on the basis of the existing assessments.

10.7.1 Phenomena caused by climate change

The most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC) states that warming is an undisputed fact. The average temperature of Earth has increased by 0.74 degrees during the last century. Measurements have also indicated increases in sea level and reductions in ice and snow cover. Warming is very probably primarily caused by the acceleration of the global greenhouse effect.

Even though the acceleration of the greenhouse effect is an apparent physical fact, there is no absolute certainty on how much it will ultimately impact on the climate in different parts of the world. Global uncertainty is caused by factors such as aerosols and clouds, as well as potential changes in regional oceanic currents.

In accordance with most recent climate scenarios, the average temperature of Earth will increase by 1.1 to 6.4 degrees by 2100 compared to the average temperature from 1980 to 1999. Precipitation will also change; it will be increased close to the poles and reduced in many regions that are already suffering from drought. *(IPCC 2007.)*

The climate of Finland has warmed up by approximately 0.7 °C in the 20th century. Changes in the Finnish climate are expected to continue, and they may

be accelerated over the upcoming decades. Differences between the climatic impacts of alternative releases scenarios will only become apparent after 2050. On average, the climate in Finland is expected to warm up and become more humid in all seasons. Rainstorms will become more intense and constitute a larger proportion of total precipitation in summer. The snow cover will be reduced more in the south than in the north. The occurrence of ground frost will be reduced, and the frost-free season will be extended. The number of hot days (maximum temperature exceeding 25 °C) will increase *(Carter 2007)*. Climate change will result in increased floods and periods of drought also in Finland. Intensive increases in sea level can also cause an increasing amount of damage *(Finnish Environment Institute 2007)*.

In 2003, Posiva commissioned a study from the Finnish Meteorological Institute on changes in the climate in the Olkiluoto area in upcoming centuries *(Ruosteenoja 2003)*. The research report presents climate change scenarios for the Olkiluoto area for the years 2010 to 2350. Changes that have occurred during this century were assessed on the basis of calculations made using climate models. All of the three models studied predict that the temperature will increase during the current century. Precipitation is predicted to increase in the autumn and winter but in other seasons the results of the models were conflicting. The average winter temperature in 2070–2099 is predicted to be 3.8 °C to 10.4 °C above the basic period (1961–1990), while the summer temperature would increase by 1.6 °C to 5.6 °C. Precipitation in the winter months would increase by 5 % to 81 %. With regard to changes in relative atmospheric humidity, results were only available from one model. The model predicted that humidity will decline in all other seasons except winter *(Ruosteenoja 2003)*.

The assessment of climate in 2100 – 2350 made the assumption that the increase in atmospheric carbon dioxide concentration will stop at some stage and that the concentration will remain constant after that. The climate change estimates for this period are mostly indicative *(Ruosteenoja 2003)*.

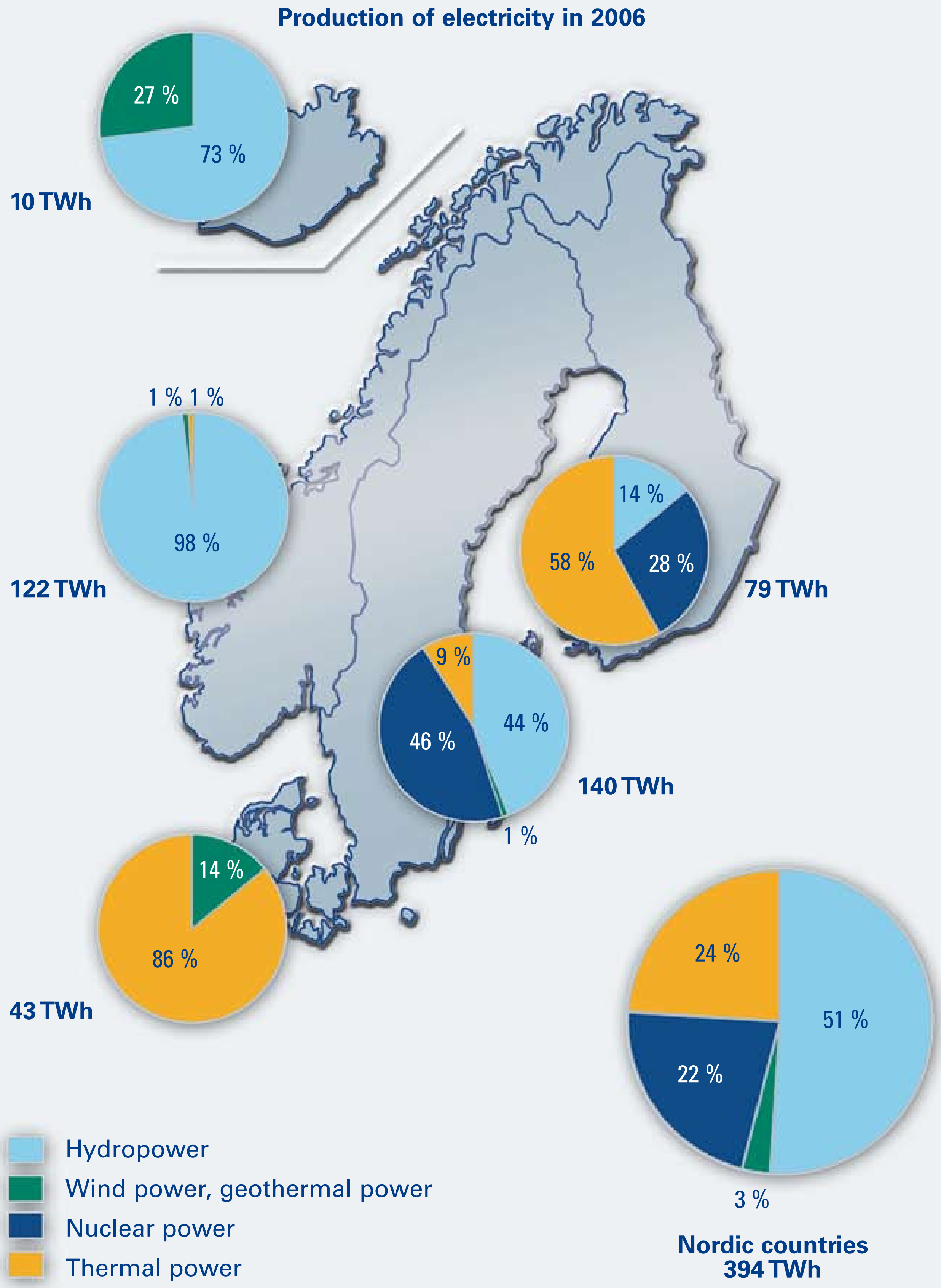
In addition to the estimates of climate change, the report presents a short assessment of increase in the sea level based on a literature survey. The predicted increase in sea level varies greatly between different model calculations. *(Ruosteenoja 2003.)*

10.7.2 Preparations for phenomena caused by climate change

The existing power plant units at Olkiluoto have been constructed so that the water level may increase to as high as 3.5 metres. Land uplift at Olkiluoto amounts to 68 cm in a century. It is very improbable that the increase in sea level would exceed the land uplift rate during the operation of the OL4 plant unit. *(Ruosteenoja 2003)*. An increased sea level will not be able to prevent access to the plant site.

The design of the nuclear power plant unit makes preparations for intense weather phenomena (snowstorms, storms, etc.) and increased temperature. Due to preparations for aircraft collisions and earthquakes, the structures are already very rigid. The plant has versatile options for producing backup power in case of the loss of the external grid.

11 Impacts of the zero option



Source: Nordel Annual Report 2006

The zero option is the non-implementation of the project. This means that the condition of the environment and the impact of environmental loads correspond to the situation in which OL3 has been commissioned.

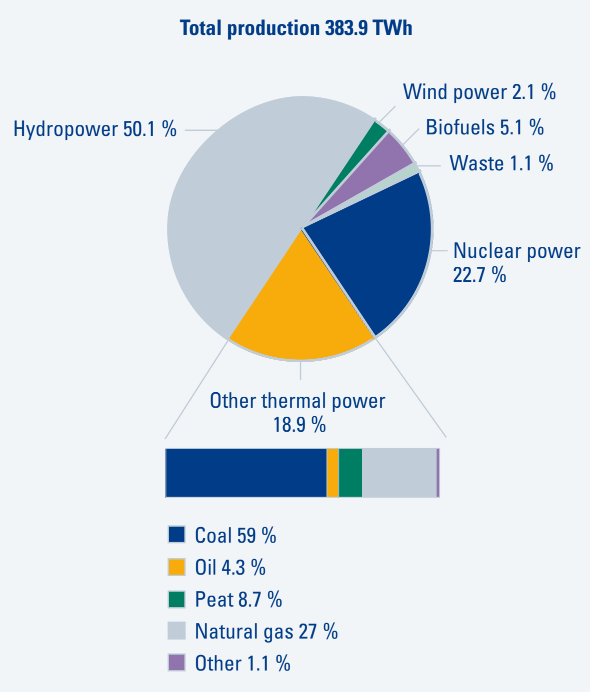
The zero option would mean that operations at the Olkiluoto power plant would cease earlier than in the main option – that is, after the decommissioning of the existing units and OL3 under construction. Furthermore, the social and economic impacts of the project will not be realised in the zero option.

It is assumed that in the zero option, TVO's shareholders will cover their electricity requirements from the Nordic electricity market. This requires that there is production and transmission capacity available in the market. This section assesses the environmental impacts in a situation where the estimated power production of OL4 would be produced in accordance with the present average Nordic electrical production structure.

The assessment is based on today's best available information on Nordic electrical production and its specific emissions. The fourth nuclear power plant unit at Olkiluoto is scheduled to be started in the end of 2010s, at which time the Nordic electrical production structure may be different from the present. There are many uncertainties associated with the electrical production structure in the future (new power plants, new environmental norms, new energy production technologies, opening of the electricity market to form a single pan-European market area, etc.). Due to the uncertainties, the EIA report is limited to examining the environmental impacts that would be caused if the estimated electrical production of OL4 was produced in accordance with the present average Nordic electrical production structure. The near-term outlook for the development of different forms of production in the Nordic electricity market has also been described.

The assessment of environmental impacts in the zero option has considered two estimates for the annual production of the fourth unit at Olkiluoto, 8 TWh (lower estimate) and 14 TWh (upper estimate).

***Figure 11-1** Distribution of electricity production in the Nordic countries in 2006 (Nordel 2006).*



11.1 The Nordic electricity market

Finland, Sweden, Norway and Denmark constitute a common Nordic electricity market area created during the last ten years as the countries have opened their electricity markets to open competition. In 2006, these four countries produced a total of 383.9 TWh of electricity. Hydropower accounted for slightly over half of the production, totalling 192.5 TWh. The production of nuclear power in Finland and Sweden totalled 87 TWh, and other conventional thermal power within Sweden, Finland and Denmark covered 96.6 TWh of the total demand. The production of wind power in the Nordic electricity market area in 2006 totalled 8 TWh, with more than 75 % produced in Denmark. Figure 11-1 presents the distribution of Nordic electricity production between different forms of production and the fuel-specific proportions of other thermal power production. *(Nordel 2006.)*

The price of electricity is determined on the Nordic electricity exchange Nordpool on the basis of demand and supply and the price of Nordic incremental production. Figure 11-2 illustrates price formation and the order of operating plants in a free electricity market. Figure 11-2 illustrates the average electricity production structure in an average year and the incremental costs of production covering electricity production in Sweden, Finland and Norway.

As illustrated by the figure, the production costs of hydropower are the lowest in comparison to other forms of production. The next form of electricity production in the order of operation is nuclear power, which has production costs slightly higher than hydropower. Next in the line are industrial combined heat and power (CHP) and district heat production. The costs of CHP production depend on the fuel and the type of power plant. The production of condensing power alone is usually more expensive than CHP. Condensing power is typically produced from coal and natural gas but in Finland and Sweden, peat, biofuels and waste are also used as fuel for condensing power to some extent.

The price of electricity will always be determined by demand and supply in accordance with the operating order curve. The addition of a new nuclear power plant unit will increase the share of nuclear power production on the incremental cost curve and, according to demand, forms of production that are more expensive on the production cost curve will be dropped from production.

Emissions trading influences the price of electricity and the order of operating the plants as illustrated in Figure 11-2. The area shaded in grey represents the increase in electricity production costs at an emissions right price of €20/tCO_2. The price impact of emissions rights is naturally greatest on forms of production that create a lot of carbon dioxide emissions. With the exception of backup power, nuclear power production does not generate greenhouse gas emissions, which means that emissions trading does not impose additional costs on nuclear power production. Figure 11-2 illustrates the impact of emissions trading on the price level for electricity in an example case in which the total annual demand for electricity is assumed to be approximately 400 TWh.

The electricity production system consists of power plants with different properties. The continuous production of base-load power takes place at power plants having low variable costs and, correspondingly, high fixed costs. On the other hand, short-term load peaks are covered by plants having low fixed costs and, correspondingly, high variable costs. A substantial part of consumption fluctuation at the daily level is covered by hydropower and imports. The share of thermal power (electricity produced by combustion, not wind, hydro or nuclear power) in the balancing of production is fairly small.

Existing hydropower offers limited possibilities for regulation, which means that the increased need for power must be covered by imports and thermal power.

In terms of its cost structure and purpose, a nuclear power plant is a typical base-load plant with a long operating life, and its construction is not feasible for covering peaks in consumption. The choice of a form of production for base-load power does not have an immediate effect on the demand for and choice of regulating power. Technically a nuclear power plant can participate in regulation, however. This is already being done in some countries such as France and Belgium where nuclear power has a large share of electricity production.

11.2 Other energy production alternatives

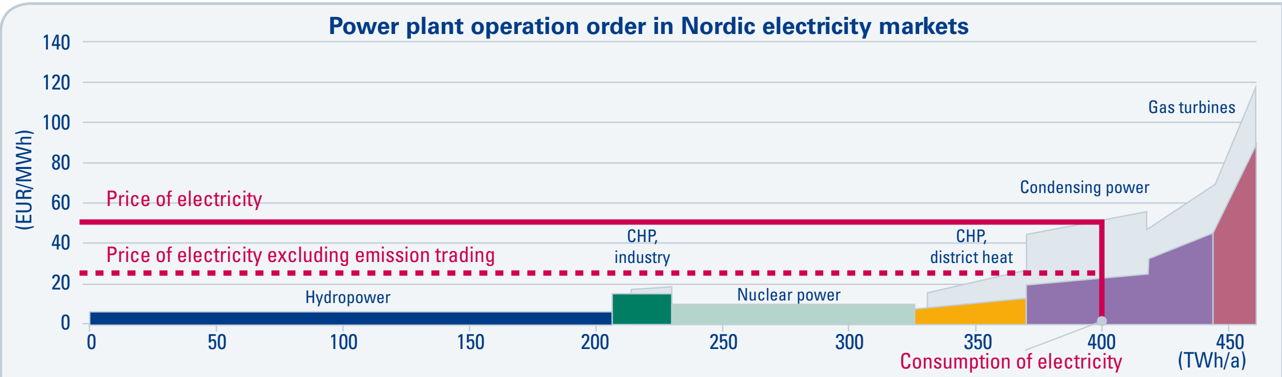
The following is a brief examination of different forms of energy production within the Nordic electricity market, their present state and the production structure in the future.

11.2.1 Development outlook for different forms of energy production in the Nordic electricity market

11.2.1.1 Hydropower

The production of hydropower dominates the average Nordic production of electricity. More than 50 % of total electricity production was produced by hydropower in 2006. The share of hydropower in proportion to total production is 99 % in Norway, approximately half in Sweden and about 15 % in Finland. There are almost 200 hydropower plants in Finland with a total power of approximately 2,800 MWe, which means that the average power of a hydropower plant is approximately 15 MWe.

__Figure 11-2__ Determination of electricity price in the Nordic electricity market. The area shaded in grey represents the increase in electricity production costs at an emissions right price of €20/tCO2.



The production of hydropower is sensitive to precipitation, and the volume of water in the reservoirs dictates the available annual production capacity particularly in Norway and Sweden, as well as the direction and volume of annual net exports and imports between the Nordic countries. In dry years, such as 1996, 2002 and 2006, Norway and Sweden had to resort to electricity imports to cover their consumption. Electricity is imported to the Nordic electricity market area through transmission connections from Russia, Germany, Poland, and since 2006 also from Estonia. In dry years, condensing power produced in Finland and Denmark is exported to Norway and Sweden, and correspondingly, in wet years, electricity produced by hydropower is imported from Norway and Sweden to Finland and Denmark.

No major changes in Nordic hydropower production capacity are expected until 2025. Rapids and waterfalls not yet used for the production of hydropower are almost all protected by law. Political acceptance will only be granted to new small-scale hydropower plants. The general estimate is that some new hydropower capacity will be obtained through the construction of more small-scale hydropower plants and the renovation and modernisation of existing hydropower plants.

11.2.1.2 Other thermal power

Other thermal electricity production is either condensing production or combined heat and power (CHP) production.

The production of condensing power based on fossil fuels occupies a substantial position in Finland and Denmark with regard to price formation in the Nordic electricity market. In a normal or dry year, condensing power production is the most expensive form available in terms of production costs and will thus determine the margin price for electricity. Condensing power is usually coal condensate but the share of peat-based condensing production is also substantial in Finland.

There is condensing production capacity in Sweden but a major part of it is out of operation. It will take months if not years to get the capacity into use. The volume of condensing production is not expected to increase in Sweden or Finland in the near future, with the exception of additional condensing capacity built in connection with CHP production. There are plans to build some new gas-based condensing production in Norway.

In a condensing power plant, the steam turbine is used to produce electricity only, which means that a substantial

share of the energy contained in the fuel (50 % to 60 %) is wasted in the cooling water because condensing heat has a low thermal value and there is no use for it.

Combined heat and power production (CHP) is in widespread use in industrial energy production and district heating production in Finland and increasingly also in Sweden. The amount of CHP-produced electricity depends on the thermal loads of industry and heating. In Finland, the greatest thermal loads have been utilised in combined production. The combined production capacity increases slowly with the modernisation of equipment, which typically increases the construction degree of the plants (electrical output in proportion to thermal power). However, combined production is always linked to the thermal load and thus cannot be freely regulated similarly to other power production.

The efficiency of a power plant in combined heat and power production is substantially higher but a prerequisite for electricity production is that the plant must be able to supply district heating and industrial steam. In Finland, all large-scale thermal potential has already been utilised.

11.2.1.3 Bioenergy

Bioenergy has a significant role in the achievement of the EU's additional objective for renewable energy. The EU is committed to increasing the share of renewable energy from the present 7 % of total energy consumption to 20 % by 2020.

The share of electricity production based on biomass and peat in the Nordic electricity market was approximately 6.7 % of the total production in 2006. A total of 19.6 TWh was produced from biomass and 6.3 TWh from peat. 98 % of the peat-based production was produced in Finland, with Sweden accounting for the rest, less than 2 %. Finland and Sweden accounted for 94 % of the biomass-based electricity production.

The green electricity certificate system used in Sweden increases the demand for bioenergy. Currently, the planned capacity increases up to 2010 will not be sufficient to cover the increasing demand. However, the construction of additional capacity to fill the deficit is being planned. Swedish authorities are developing the green electricity certificate system so that the construction of new capacity would be based on market terms. The plans call for an increase in green power production by 17 TWh from the level of 2002 until 2016. In addition

to bioenergy, the green energy certificate system includes wind power, hydropower, solar power, geothermal power and peat-based CHP.

In Sweden, most biomass have been used in the separate production of heat. The use of biomass is increasing mostly due to new CHP plant investments. In Finland, a major part of biomass is utilised in large CHP power plants operated by industry and communities. Particularly in community production, the primary fuel for large plants is peat, and biomass is increasingly used in accordance with its availability. The use of biomass will increase in the future primarily through an increased proportion of biomass and through plant investments that replace other fuels. There is growth potential in forest processed chips (incl. tree stubs). However, the volume of forest industry by-products will not increase but may even decline.

The primary factor restricting the increased use of biomass is the availability of biomass for energy utilities. If new subsidies are introduced for the energy use of biomass, supply will increase. As a consequence, raw material used by the forest industry may be directed to combustion instead of processing. In terms of the national economy, the further processing of wood is more beneficial than combustion.

11.2.1.4 Wind power

The production of wind power in the Nordic countries is expected to substantially increase in the next few years. The share of wind power in 2006 was 2.1 % of Nordic electricity production (8 TWh), with more than 75 % produced in Denmark.

During past years, the activity of wind power construction has greatly varied between the Nordic countries. Denmark is a global pioneer that already produces approximately one-fifth of its electricity by wind power. Sweden has also been fairly active. Sweden operates a green electricity certificate system through which wind power producers may receive additional subsidies for their production; this has clearly resulted in some concrete projects.

Norway is one of the best countries in the world in terms of wind conditions but the political desire to promote wind power has not been too active. There have been large projects in development but only a few have reached the implementation stage. It is expected that additional capacity will be built in Norway in the future.

In Finland, wind power has received little subsidies in the past years compared to biomass power plants. A new wind power subsidy based on the supply tariff has

been planned in Finland, and this could encourage the additional construction of wind power in the future.

Due to the different history and different periods of wind power use, the average size of wind power plants varies by country. Old turbines bring the average size of Swedish and Danish turbines down even though the turbines in new wind power parks have had capacities of 1 to 2 MW for years.

Wind power plants are expected to become more common fairly rapidly during the next five years. According to an estimate, more than 4,700 MW of new wind power plants will be built in the Nordic countries within the next five years (http://www.btm.dk/world-index.htm). The unit size in most projects will be in the order of 2 to 3 MW but turbines of approximately 1 MW will always have their own substantial market.

The temporal distribution of electricity production by wind power is less balanced than that of thermal power plants or nuclear power because the production of wind power depends on wind conditions. To provide for a constant need for electricity, wind power will require backup power also in normal conditions (such as hydropower, gas turbines and condensing power plants).

11.2.2 Environmental load of Nordic electricity production

As environmental impacts of Nordic electricity production, the emissions of sulphur dioxide, nitrogen oxides, carbon dioxide and particles have been examined with the help of a characteristic emissions calculation for Nordic electricity production.

The local impacts of Nordic energy production depend on the form of production and focus on the locations where energy is produced. Any global impacts will naturally also affect the Eurajoki area.

Emissions into the atmosphere

Because it is difficult to accurately estimate the production structure in the Nordic electricity market in the end of 2010s, the environmental impacts are assessed in a situation where the planned electrical production capacity of OL4 would be replaced with production from the present average Nordic production capacity. Table 11-1 illustrates the emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X) and carbon dioxide (CO_2) in such a situation, assuming that the electrical production of the nuclear power plant will be 8 TWh (lower estimate of the production of a fourth unit in Olkiluoto) or 14 TWh (upper estimate of the production of a fourth unit in Olkiluoto).

When calculating the emissions of sulphur dioxide, nitrogen oxides and carbon dioxide, an average emissions coefficient weighted by production volumes in Finland, Sweden, Denmark and Norway has been calculated for each emissions component according to information from year 2005 *(Eurprog 2005)*.

The combustion of coal, oil, peat, biomass and waste also generates particle emissions. Table 11-2 illustrates the estimated particle emissions when production volumes of 8 TWh and 14 TWh are replaced in accordance with the average Nordic distribution of production in 2006. The emissions coefficients are the limits for particle emissions specified in the Waste Combustion Decree (362/2003) and the Decree applicable to combustion plants exceeding 50 MW (1017/2002).

With the exception of backup power, a nuclear power plant does not produce any emissions of sulphur dioxide, nitrogen oxides, carbon dioxide or particles.

Table 11-1 Estimated emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and carbon dioxide (CO_2) for the zero option in a situation where the annual production of OL4 would be replaced in accordance with the average Nordic distribution of electrical production in 2005 (Eurprog 2005).

						Emissions avoided	
	Finland kg/MWh	Sweden kg/MWh	Norway kg/MWh	Denmark kg/MWh	Production-weighted kg/MWh	8 TWh production, t/a	14 TWh production, t/a
CO_2	258.34	19.73	5.61	552.49	115,73	**925,818**	**1,620,182**
SO_2	0.37	0.04	0.03	0.50	0.15	**1,189**	**2,080**
NO_x	0.47	0.03	0.01	1.22	0.23	**1,828**	**3,199**

Table 11-2 Estimated particle emissions in a situation where the annual production of OL4 would be replaced in accordance with the average Nordic electricity production distribution in 2006.

					Emissions avoided	
	Production 2006, TWh	Efficiency of power production	Characteristic emissions coefficient, mg/MJ_{fuel}	Share of total production 2006	8 TWh production, t/a	14 TWh production, t/a
Coal	42.9	45 %	17.5	11.2 %	125.1	219.0
Oil	3.1	45 %	15.0	0.8 %	7.8	13.6
Peat	6.3	42 %	17.5	1.6 %	19.7	34.5
Natural gas	19.6	57 %	1.5	5.1 %	3.9	6.8
Biofuels	19.5	42 %	17.5	5.1 %	60.9	106.7
Waste	4.2	42 %	3.7	1.1 %	2.8	4.9
					220	385

12 Comparison of alternatives and an assessment of the significance of environmental impacts

Environmental impacts have been examined through comparing the changes caused by the implementation of the project with the present situation. The significance of the impacts has been assessed on the basis of the magnitude of change and by comparing the impacts of future operations with the limits set for radioactive radiation, environmental quality standards and the present situation in the area. Particular emphasis has been given to investigating and describing those impacts that are considered important on the basis of feedback received during the EIA procedure, as well as the social impacts of the project.

The impacts of different alternatives of implementation have been compared by means of a qualitative comparison table. The major environmental impacts of the project – positive, negative and neutral alike – have been recorded in this table in an illustrative and uniform manner. The environmental feasibility of the alternatives has also been assessed in this connection.

Factors essential to the significance of impacts are:

- territorial extent of the impact
- target of the impact and its sensitivity to changes
- significance of the target of impact
- reversibility or permanence of the impact
- intensity of the impact and magnitude of the resulting change
- fears and uncertainties associated with the impact
- different views on the significance of the impact.

The environmental impact assessment has been carried out by analysing information that describes the current state of the environment in the area and by preparing expert assessments based on experience and research results from similar projects, model calculations and photomontages of the impacts of future operations. The environmental impacts have subsequently been examined by comparing the changes caused by the implementation of the alternatives with the zero option.

12.1 Summary of impacts

The impacts examined in the summaries presented in the following tables are divided in accordance with the different functions of the project and the focus of impacts. A more detailed estimate of the impacts for different alternatives is presented in Section 9.

12.2 Comparison between alternatives

The following sub-alternatives exist for the implementation of a new nuclear power plant unit at Olkiluoto:

- boiling water or pressurised water reactor plant
- electrical output approximately 1,000 to 1,800 MW
- two alternative sites at Olkiluoto, Alternative 1 and Alternative 2
- two alternative locations for cooling water discharge, A and B
- two alternative locations for cooling water intake, C and D.

The following is a brief description of the differences in environmental impacts between these sub-alternatives.

12.2.1 Plant type

The new unit will be either a boiling water reactor plant or a pressurised water reactor plant. The requirements concerning nuclear safety are practically the same for all plant types, which means that the chosen plant type is of no significance in that regard. Also, the plant types that come into question do not significantly differ from each other with regard to radioactive discharges.

12.2.2 Size of the power plant unit

The electrical output of the new unit will be approximately 1,000 to 1,800 MW depending on the choice of plant type and manufacturer.

In practice, the only environmental load factor that will substantially change in direct proportion to power is the amount of heat conducted to the sea and, correspondingly, the volume of cooling water required. At the lower limit of the power range, the need for cooling water is approximately 40 m^3/s. At the upper limit, the corresponding value is approximately 60 m^3/s.

In this EIA report, the estimates concerning the impact of cooling water are presented on the basis of the cooling water consumption of a 1,800 MW unit – that is, a flow of approximately 60 m^3/s. If the flow is 40 m^3/s corresponding to 1,000 MW of power, the warmed-up area and the area of unfrozen water or weak ice will diminish almost in direct proportion. However, variation due to weather conditions will remain greater than the change in warm-up impacts. In other words, the most extensive warmed-up areas at a flow of 40 m^3/s can be larger than the smallest warmed-up areas at a flow of 60 m^3/s.

The biological impacts arising from warming are smaller and also controlled by many other factors, which means that they will not change in direct proportion to the load. The area within which vegetation will become more abundant will be somewhat smaller at a flow of 40 m^3/s compared to the larger flow. With regard to other biological impacts, there will probably be no difference visible in follow-up studies.

Table 12-1 Impacts of the new power plant unit on the natural environment.

	Soil, groundwater, ground flora and fauna	Air quality	Water quality, biological state, fish
Construction stage	• the impacts of construction work and land use are restricted to the existing power plant site and its vicinity • the extension to the VLJ cave will not cause any detrimental changes in the state of the bedrock or groundwater	• dust and vehicle emissions from the work site: temporary impact limited to the work site area	• water construction work required for the cooling water passages will cause temporary murkiness of water close to the work areas • the waste water load will be increased slightly for the duration of construction
Power plant operating stage			
Nuclear fuel procurement	• Most impacts will arise from the production of raw uranium, or enriched uranium, which contains 60 % to 85 % uranium oxide • The fuel is transported in safe containers as oxide or salt in accordance with internationally agreed safety regulations.		
Radioactive releases	• no harmful impact	• no harmful impact	• no harmful impact
Cooling and waste water discharges	• not applicable	• not applicable	• the area warming up by more than 1 °C will increase approximately 1.5-fold compared to the zero option • differences in water temperature between the alternatives for discharge and intake are minor • the unfrozen area or area of weak ice will increase approximately 1.5-fold • no harmful impact on water quality • the vegetation period will be extended and the total production increased in the area within which the temperature is continuously more than 1 °C above the environment • other biological impacts are minor • impacts on fish populations are similar to at present • when taking into account the migration of fishes, cooling water as a whole is not estimated to impose any substantial or extensive harmful effects on the fish populations of the area • in the long term, increased temperature and its consequences will favour fish species spawning in the spring • impacts on fishing are minor • the increased nutrient load on the sea caused by waste water is minor: no harmful impact
Low- and intermediate-level operating waste	• no harmful impact on groundwater, no impact on nature above the ground	• not applicable	• groundwater percolating into the cave will be pumped into the sea through monitoring and processing as necessary: no harmful impact
Conventional and hazardous waste	• no harmful impacts when handled properly and placed correctly	• not applicable	• no harmful impact
Traffic	• no harmful impact	• the significance of emissions from commuter traffic is minor	• not applicable
Noise	• not applicable	• not applicable	• not applicable
Power line	• a new area must be reserved for power transmission lines out of OL4 • the terrain corridor reserved for the transmission line area in the partial master plan is located in the southern part of the island, to the north of the accommodation village and the Liiklankari conservation area. The power line area is currently unbuilt and does not include any objects of significant natural value.	• not applicable	• not applicable

Table 12-2 Impacts of the new nuclear power plant unit on the built environment and population.

	Health, living conditions and comfort, habitation and leisure time	Landscape, land use, community structure	Employment, business, economy
Construction stage	• the volume of traffic will be substantial during construction: impact on traffic safety, noise and dust impacts will be increased primarily around road number 2176	• no impact on land use outside the site	• substantial employment effect at the construction stage • increases the demand and supply of services • increases municipal tax income
Power plant operating stage	• no significant change to the present situation	• no significant change to the present landscape	• employment effect • increases municipal tax income
Radioactive releases	• no health impacts	• not applicable	• not applicable
Cooling and waste water discharges	• weakened ice conditions will limit access to the ice and fishing from the ice • opportunities for using the unfrozen area for winter fishing and boat access to islands will be improved	• not applicable	• no harmful impact
Low- and intermediate-level operating waste	• no harmful impact	• no harmful impact	• the extension to the VLJ cave will increase employment, otherwise no impact
Conventional and hazardous waste	• no impact when handled properly and placed correctly	• no impact	• no impact
Traffic	• minor increase in commuting traffic	• no harmful impact	• no impact
Noise	• the noise levels will remain below the guideline values at the nearest permanent and recreational residences in the day and night • the completion of OL4 at alternative site 1 will increase the noise level at the nearest holiday home on Leppäkarta island by approximately 1 dB compared to the zero option • alternative site 2 does not have any practical difference compared to alternative 1 in terms of noise impacts on Leppäkarta island.	• not applicable	• not applicable
Power line	• no impact	• the terrain corridor reserved for the new transmission line area in the partial master plan is located in the southern part of the island, to the north of the accommodation village and the Liiklankari conservation area.	• no impact

The impact of the size of plant on radioactive discharges is minor. The size of the plant will have some effect on the quantities of materials to be transported during construction and use, the quantities of waste generated, the number of employees and thus the volume of commuter traffic, as well as the economic impacts of the project. The size of the power plant may also affect the number of power transmission lines required.

12.2.3 Alternative locations in Olkiluoto

There are two alternative sites for the new plant unit in Olkiluoto. Alternative 1 is located to the north of the existing units, and Alternative 2 is located to the northeast of Alternative 1.

The new unit will add a fourth element of a similar type to the existing power plant complex, which means that the change in the landscape will be relatively small. The magnitude of the change to the present landscape will depend on the direction of viewing.

Alternative 1 is located closer to the western shore, while Alternative 2 is located closer to the northern shore. The location of the power plant unit in the area does not impose any principal restrictions on the choice of cooling water discharge point.

With regard to environmental impacts, the differences between the alternative locations are minor, and the location can be chosen primarily on other grounds.

12.2.4 Cooling water solutions

Several alternatives were examined for the intake and discharge of cooling water.

The cooling water for the new unit will be taken either from the east of the cooling water intake points for the existing plant units 1 and 2, or from the Eurajoensalmi inlet on the northern shore of Olkiluoto.

According to cooling water modelling concerning the locations of intake and discharge for the fourth unit, an intake point on the northern shore of Olkiluoto (point D) was slightly more favourable with regard to intake temperatures compared to an intake location east of the present intake points (point C). Locating the discharge point in parallel to the existing discharge point (point A) resulted in slightly lower intake temperatures at different calculation alternatives compared to the location on the northwestern shore of Olkiluoto (point B).

In alternative A, the greatest thermal load and initial erosion due to additional flow will focus on the existing discharge area, the Iso Kaalonperä bay.

In alternative B, the cooling water from the new unit will be discharged to the northern shore of Olkiluoto island through a discharge tunnel to be constructed to the southwest of Tyrniemi. In this alternative, the warming-up of the sea and the deterioration of ice in the winter would be focused farther north in an area not presently impacted. This alternative would bring a new zone of seabed into the scope of the erosion impact caused by cooling water discharge. The cooling water discharge structure would break off a previously untouched shore zone.

There are some differences in the amounts of masses generated in the tunnel excavation work required by the alternatives but this does not create a significant difference in terms of environmental impact.

In cooling water modelling, locating the discharge for the fourth unit at point B slightly increased the size of the unfrozen area compared to discharge point A.

With regard to environmental impacts related to sea water warm-up, the differences between the alternative cooling water intake and discharge locations are small compared to the impact of variation in weather conditions. On average, the size of the warmed-up area and the area unfrozen in winter is directly proportional to the thermal power conducted into the sea. The size and shape of these areas vary greatly on the basis of weather conditions.

12.3 Uncertainties in environmental impact assessment

The available environmental data and the assessment of impacts always involve assumptions and generalizations. Furthermore, the available technical data is very preliminary at this stage. Lack of sufficient data may cause uncertainty and inaccuracy in the assessment work.

During the assessment work, the potential uncertainty factors have been identified as comprehensively as possible and their impact on the reliability of impact assessments has been considered. These issues have been described in the assessment report.

12.4 Report on the feasibility of the alternatives

The fundamentals of nuclear safety and the possibility and consequences of a severe nuclear accident have been addressed above in Section 10. An explosive event arising from an uncontrolled increase in power is impossible in a light water reactor due to structural reasons. An accident leading to severe reactor core damage would require the simultaneous failure of multiple safety systems and several incorrect actions by operating personnel.

The EIA report does not take a stand on the acceptability of severe accident risk from an individual's viewpoint on ethical or other personal grounds. However, the aim of the report has been to present reference data associated with the probability of a severe accident and its consequences as clearly as possible in order to allow the reader to use them to form an opinion.

When handled appropriately, the spent fuel and other radioactive waste from the new unit will not cause harmful impacts on the environment or people.

In summary, it can be stated that the environmental impact assessment did not find any adverse environmental impacts of such significance arising from the construction or operation of the nuclear power plant that they could not be accepted or mitigated to an acceptable level.

13 Prevention and mitigation of impacts

The possibilities for preventing or mitigating the adverse impacts of the project, and its associated projects, by means of design or implementation have been investigated during the assessment work.

13.1 Construction stage

The adverse biological impacts due to the murkiness of water close to the work areas can be minimised by scheduling the water construction work called for by the cooling water passages required for the new unit to the biologically inactive season – that is, late autumn or winter.

The harmful impact caused by construction-time noise and other disturbance near the power plant can be mitigated by scheduling any particularly noisy or disturbing operations to weekdays and daytime. Furthermore, advance information on the schedule and duration of such operations can be provided to nearby residents and holiday home owners. Noise from the crushing of blasted stone can be reduced by using acoustically screened crushing stations.

Dust emissions from the work site can be reduced by means such as paving the permanent roads in the area, reducing the speed limits on dirt roads and work sites, as well as cleaning or sprinkling the roads regularly.

With regard to waste management, the objective is to reduce the quantity of waste and promote waste recovery. For the purpose of collecting hazardous waste from the work site, appropriate collection facilities and storage facilities for hazardous materials (gases, flammable liquids, toxic substances) will be designated. A typical storage facility fulfilling the requirements is a steel container with a sufficient catchment basin. Storage facilities and containers shall be fitted with markings compliant with the regulations.

Social impacts during construction can be balanced by distributing the accommodation facilities for out-of-towners involved in the construction work to Eurajoki, Rauma and other nearby municipalities in addition to Olkiluoto. Furthermore, sufficient accommodation facilities and recreational opportunities for construction employees shall be arranged at Olkiluoto, and guidelines shall be provided for recreation in permitted areas.

13.1.1 Traffic and transportation during construction

The inconvenience caused by construction-time traffic and transportation in the nearby region can be reduced by directing traffic to highway 8 and Olkiluodontie, not through Sorkka or Linnamaa. Furthermore, the shifts of construction employees can be scheduled so that they do not coincide with the beginning and end of the school day in Lapijoki and Sorkka. Construction employees can also be provided with information concerning problem spots on the road, for example, thus influencing compliance with speed limits. Communication of information about public transport routes and schedules and the interadaptation of schedules and construction site hours will contribute to reducing traffic. To the extent possible, heavy traffic will be scheduled on weekdays between 7 am and 9 pm. Sufficient winter-time cleaning and anti-skid treatment of the transport routes in Olkiluoto and the construction site will reduce the risk of accidents.

Development needs and plans concerning the traffic system

The capacity of the intersection of Olkiluodontie and highway 8 is almost fully utilised at present. During rush hours, the speed limit in the intersection area has had to be reduced from 80 km/h to 60 km/h. This will also impose pressure on the smoothness of traffic during potential construction work. The overall development survey for highway 8 concerning the years 2010–2020, which is currently underway in the Turku road district, includes a planned pedestrian and bicycle route between the Olkiluoto intersection and Eurajoki. The road development projects planned in the overall development survey will improve traffic safety, smoothness and the functionality of intersections on the highway section.

The aim of the Olkiluoto partial master plan is to implement the traffic arrangements so that the smoothness of traffic and the safety of the nuclear facility area can be maintained at a high level in spite of the expanding and increasing plant operations *(Insinööritoimisto Paavo Ristola 2007b)*.

According to the proposed partial master plan, the construction of a graded interchange at highway 8 shall be considered as the volume of traffic to Olkiluoto increases further. A graded interchange would improve the smoothness and safety of traffic.

The new road connection presented in the proposed partial master plan to the south of the present entrance road to the power plant site and a new road connection to the harbour that would diverge from the entrance road earlier would reduce the volume of traffic in the Posiva area and accommodation village areas to a fraction of the present, which would improve the smoothness and safety of traffic in the Olkiluoto area.

13.1.2 Impact of construction on the operating safety of the existing units

The area of the units in operation is appropriately enclosed by a fence that prevents unauthorised access. Construction will not endanger the operating safety of the operating units.

13.2 Operating stage of the power plant unit

13.2.1 Landscape impacts

The impact of the new unit on the landscape can be mitigated by choosing surface materials and colours similar to the existing units. The vicinity of the new unit can be landscaped.

13.2.2 Discharges of radioactive substances and nuclear safety

Even though the discharges of radioactive substances during the operation of a nuclear power plant are minor, power plants are continuously involved in development and reforms aimed to further reduce the discharges. For example, radioactive discharges from the Olkiluoto 1 and 2 plant units into water have been reduced through technical and procedural reforms.

Safety aspects attributable to nuclear power plants are described in Section 10.

13.2.3 Mitigating the impacts of waste water

Waste water generated at the power plant shall be treated by mechanical, chemical or biological means or combinations of these depending on the quality of the waste water. The volume of waste water generated shall be minimised through water use planning and recycling.

13.2.4 Cooling water intake

Cooling water intake structures shall be designed so that the water flow rate outside the structure is as low as possible. This ensures that the intake of water will not cause danger to water traffic. A low flow rate will also reduce the amount of fishes and aquatic vegetation coming to the power plant, which will decrease contamination of the screens and travelling band screens within the cooling water cleaning system. Nets fitted at the mouth of intake channels will prevent fish from being carried by cooling water. The nets are kept in place from May through to June and also during other times if it is found that substantial amounts of fish are entering the system.

13.2.5 Remote cooling water intake and discharge

The cooling water flow model has not examined options for remote cooling water intake and discharge because they would be located within the Rauma archipelago Natura area off Olkiluoto.

Remote intake

A remote cooling water intake could be located deeper than a local intake, which would provide slightly cooler water in the summer and correspondingly reduce the temperature of the OL4 discharge. However, the

difference would be smaller than the cooling water warm-up at OL4. The difference in sea water temperature in the Natura area due to the difference between remote and local intakes would be fractional. The energy required for the pumping of cooling water will increase in proportion to the length of the tunnel. The pumping energy is converted into waste heat going into the sea. Shells and aquatic vegetation would accumulate in the intake tunnel and be difficult to remove. Furthermore, this would create a new area with the sea bed in an unnatural state.

Remote discharge

The remote discharge option for cooling water – that is, using a tunnel to conduct the water farther out from the scope of the Natura area – is directed to the northwest of Olkiluoto, between the Natura areas of the Rauma northern archipelago and the Luvia archipelago.

The discharge opening of the tunnel could be behind the shallows approximately four kilometres away at Kallio-Hyörtti-Lännenkivet-Iso Pyrekari. This solution would not significantly improve the situation in the Natura areas. During unfavourable wind conditions, warm water will affect the Natura area. Furthermore, this would create a new area with the sea bed in an unnatural state.

Impacts of the construction of a remote intake and discharge

The harmful environmental impacts of the construction of a remote intake and discharge (dredging of the intake and discharge point, deposition of the dredging matter, excavation of the intake and discharge opening and the tunnel, as well as deposition of the rock material) would exceed those of a local intake. Furthermore, this would create a new area with the sea bed in an unnatural state. In order to eliminate the risk of collapse, the tunnel will require more reinforcements as its length increases. A longer tunnel will also require a larger surge basin.

Regardless of the reinforcement actions required, the quality of the rock plays an important role in tunnel construction with regard to the permanence of tunnel structures and the operation of the cooling water tunnels. The geology to the north of Olkiluoto island suggests the presence of a weak area in the northwest-southeast direction along the route of the potential discharge tunnel, the penetration of which would impose difficulties on the implementation.

13.2.6 Tower cooling

An alternative to direct water system cooling is the use of cooling towers that will discharge the excess thermal load primarily directly into the atmosphere. The thermal load on the water system is small. Cooling towers are quite a common solution in Central Europe, for example, where the water resources of plants located inland are often quite limited (rivers, groundwater), and the combined production of power and heat is not as common as in Finland.

Winter conditions, for example, can cause problems to an indirect cooling system. Because approximately one per cent of the cooled water flow is evaporated into the cooled air flow, fog will be formed in connection with the air exhaust particularly at low outdoor temperatures. Depending on the conditions, the phenomenon can be quite intense and cause icing in nearby areas as the fog lands on surfaces. The blowers in the cooling towers will also generate some noise, while water system cooling does not cause any noise carried outside the plant. Cooling towers operating without blowers are substantially higher than power plant buildings and thus have a substantial landscape impact.

The amount of electrical output produced depends on factors such as the temperature of cooling water used for condensing the steam conducted to the turbine. The colder the cooling water, the higher the power obtained from the turbine. The most substantial disadvantage of indirect cooling is that it is not as efficient as direct cooling. This hampers the efficiency of the power plant, which causes a financial loss and increases the quantity of nuclear waste per unit of electricity produced. The power requirement of the cooling tower pumps and optional blowers will also reduce the amount of electrical energy obtained from the plant.

In summary, it can be stated that there are no techno-economically feasible or environmentally justifiable alternatives for direct water system cooling.

13.2.7 Utilisation of cooling water

The cooling water from the existing nuclear power plant units, totalling approximately 60 m^3/s, is conducted directly to the sea through a discharge channel. The commissioning of OL3 currently under construction will double the need for cooling water. The fourth power plant unit will increase the total cooling water requirement to approximately 180 m^3/s.

The cooling water is taken from the sea and warms up in the condensers by approximately 12 °C. Thus the temperature of the discharge water varies roughly between 15 and 30 °C depending on the season. The total thermal power condensed in the sea is substantial but its utilisation is difficult due to the low temperature of the discharge water. In order to utilise the heat in the cooling water in a district heating system, for example, the water temperature should be at least 80 °C.

The existing power plant units and the third unit under construction have a single-stage turbine condensing system. It would be theoretically possible to design a dual-stage condensing system for the fourth

power plant unit. In this case, the condensing water from the first stage would be at a high temperature, allowing the utilisation of the condensing heat. However, this alternative is not realistic for OL4 because there is no suitable thermal load in the vicinity. The existing district heating load can be supplied by existing thermal plants, and there is no industry in the area that would require plenty of new heat production. The district heating load in the area is not expected to increase substantially in the near future as this would require the construction of a large and densely populated residential area.

Because the cooling water is sea water, it is not suitable for the irrigation of agricultural areas due to its salt content. However, low-temperature cooling water could be used for heating greenhouses, for example; in such a solution, the water is conducted to greenhouses and releases heat and humidity when flowing through. The cooled water is conducted back to the sea through a discharge channel. However, to be profitable, such a solution would require large greenhouses, and there are no such facilities near the power plant.

Fish or crayfish farms would be a potential application for salty warm water. However, no large-scale fish farming is carried out near the power plant at present.

All in all, the heat consumption of these operations is so minor in relation to the available thermal load that the resulting reduction would not be significant to the thermal load conducted to the water system. Furthermore, the water impacts of some of these forms of heat utilisation, such as large-scale fish farming, could be more harmful than the impacts of the heat that would not need to be conducted to the water system. In addition to minor environmental advantages or even disadvantages, the fact that it is uneconomical is a problem with the small-scale utilisation of heat.

The disadvantages of cooling water discharged into the sea include that the warm discharge water will keep the vicinity of the discharge point unfrozen in winter. If there was a water area in the vicinity that would benefit from the lack of ice, it would be reasonable to examine the possibilities of discharging at least some of the water into such an area. An example of such a water area could be a harbour. However, there are no large harbours near Olkiluoto. The nearest large harbour is located in Rauma, more than 20 km from the power plant.

There are currently no other feasible possibilities for utilising the heat contained in the cooling water that would improve the condition of the sea outside Olkiluoto. TVO is open to any proposals regarding extensive utilisation of the cooling water heat.

13.2.8 Nuclear waste management

Nuclear waste generated at the plant is handled appropriately. Spent fuel is kept in intermediate storage at the plant until disposal in Finnish bedrock begins. Liquid low- and intermediate-level waste is either dried or solidified. The disposal of low- and intermediate-level waste is implemented through an extension to the disposal facility located at the power plant site.

13.2.9 Waste management

Foul smells from the landfill shall be prevented through compacting and covering the waste. Harm caused by particles and microbes in the landfill area shall be mitigated through covering the waste. Dust formation shall be prevented through covering the waste and sprinkling or salting the roads as necessary. Harm caused by a closed landfill shall be mitigated through measures such as using a gas collection system to prevent the discharge of landfill gas directly into the atmosphere, a tight surface structure in the fill area and bio-filters.

13.2.10 Noise impacts

Noise during the operation of the power plant can be mitigated to a level compliant with official guidelines concerning occupational safety and environmental noise levels.

The construction technology and materials used in the plant building will efficiently attenuate noise from machinery and equipment. Furthermore, noise sources can be isolated by protective housings or fitting them with mufflers as necessary. Vibration can be attenuated by placing vibrating equipment on flexible platforms.

13.2.11 Impact of the transport, use and storage of chemicals and oils

Precautions have been taken for disturbances and accidents associated with the handling and storage of chemicals through sewerage, shielding pools and automatic alarms, as well as operating plans and instructions. Applicable safety guidelines and regulations are observed in the transportation of chemicals. The risk of discharges of harmful amounts of these substances into the water or soil during operation or an accident is minor.

Comprehensive safety instructions shall be prepared for the plant, addressing the control and prevention of chemical accidents. Plant personnel will be trained on the safe use of chemicals. Accidents associated with the storage and with handling of chemicals are improbable. Any leaks will be stopped and minimised by structural means, eliminating the discharge of any significant amounts of harmful chemicals into the environment.

Any leaks can be caught in shielding pools, sludge or oil trap wells or a neutralising tank. Training provided to personnel working on the power plant site shall pay special attention to minimising the occupational safety and environmental risks of chemicals.

13.3 Accident situations

The design of the power plant includes preparation for disturbances and accidents. The prevention of accidents is a commanding principle in all operations at the plant. The safety aspects of a nuclear power plant, as well as measures aimed at preventing accidents and mitigating their consequences are addressed in Chapter 10 of the report.

13.4 Dismantling stage

Only a few nuclear power plants have been completely dismantled in the world so far. Before the dismantling of the new unit, the existing units at Olkiluoto and many other nuclear power plants currently in operation around the world will be decommissioned. The experience and research data gained from the decommissioning of these plant units will be utilised when preparing a decommissioning plan for the new unit and updating it at regular intervals. The dismantling of the plant unit is subject to a separate EIA procedure.

14 Environmental impact monitoring programme

Environmental legislation requires that the parties responsible for projects and activities having an environmental impact monitor these impacts. In case of nuclear power plants, monitoring is also required by the regulations and guidelines issued pursuant to the Nuclear Power Act.

The legally binding obligations regarding monitoring are laid out in the conditions for the various permits concerning the project. Typically, the permit conditions prescribe that the environmental impacts of the project must be monitored in compliance with the monitoring programmes approved by public authorities. The monitoring programmes are drawn up, after obtaining positive decisions on the permits, in co-operation with public authorities, and the programmes specify the details of the monitoring of loading and environment to be carried out and the reports to be submitted.

The environmental impacts monitoring programme is a plan regarding the collection of information at regular intervals of environmental loading, impacts and changes caused by the project in its affected area. The monitoring aims at:

- producing information on environmental loading and impacts caused by the power plant
- investigating which changes to the state of the environment are caused by the operation of the power plant and which are caused by other factors
- investigating how the results of the environmental impact prediction and assessment methods correspond with reality
- investigating how the measures for mitigating adverse impacts have succeeded
- enabling the required measures if unforeseen adverse impacts occur.

The monitoring results are reported at regular intervals which vary with the monitored subject from some months to a year. The reports are sent to the proprietor of operations and to the relevant authorities.

Even though the detailed environmental monitoring programmes are only drawn up after the permits have been granted, the main contents of environmental monitoring can, however, be presented in this EIA report because the impacts of the new nuclear power plant unit planned for Olkiluoto would be monitored according to the same principles that are observed when monitoring the impacts of the present units.

14.1 Environmental management system of the Olkiluoto power plant

An environmental management system in TVO has been certified to comply with the requirements of international standard ISO 14001:2004. In addition, the Olkiluoto power plant is the only Finnish energy producer to hold the EU Directive (761/2001) based EMAS registration (FI-000039). EMAS (the Eco-Management and Audit Scheme) is a voluntary environmental system intended for private and public sector companies and organisations. The environmental system is the organisation's environmental management tool that allows environmental issues to be systematically taken into account in all operations. EMAS organisations commit to adhering to environmental legislation, continually improving their standard of environmental protection and issuing public reports concerning their environmental issues. The new plant will be operated in compliance with the principles of environmental systems.

14.2 Monitoring of load

14.2.1 Radioactive releases

For radioactive substances, the main object of environmental monitoring is that of releases. The releases of radioactive substances from nuclear power plants and spent fuel repositories originate from the handling and processing systems for waters and gases containing radioactive materials. The monitoring of releases into the air and water covers all such systems that contain or may contain radioactive materials. The releases into nature occurring after processing are monitored by sampling and continuous measurements. The measurements provide information on the quantities of released radioactive materials and help ensure that the set release limits are not exceeded. The methods of monitoring and reporting of radioactive releases, as well as those deployed in the quality control of monitoring operations, have all been approved by the Radiation and Nuclear Safety Authority.

Releases of radioactive materials from the nuclear power plant take place through monitored release routes. The gaseous releases are emitted in a centralised manner through the vent stack of the plant. The vent stack has a set of sampling equipment through which part of the exhausted gases travel. The solid particles contained in the sample flow are caught in the sampling filter that is

changed and analysed at regular intervals. The level of radioactivity of gaseous substances is measured using a continuously operating radioactivity meter. Samples are also taken of the gas at regular intervals for isotope-specific analysis. A similar sampling procedure is also used to monitor the radioactivity of waste waters discharged from the plant to waterways.

The doses caused by the releases cannot be directly measured in the environment, as they are very minor compared to natural background radiation and its variations. The amounts of radioactivity caused by releases are monitored by means of an environmental radiation monitoring programme that includes, for example, measurements of the radioactivity in more than 300 environmental samples each year.

14.2.2 Cooling water

The flow rate and inlet and discharge temperatures of cooling water are monitored using continuous measurements. The results are recorded in a computer as hourly and daily averages. The electrical output and thermal power readings of the plant units, serving as the basis for calculating the annual heat load, are recorded continually in a computer. The temperatures outside the discharge point are monitored continuously.

There is no continuous temperature monitoring for the discharge area of the KPA store. The thermal effects of cooling water are monitored in conjunction with monitoring the seawater temperatures.

14.2.3 Waste waters from the laundry

The waste water originating from the monitored area is collected in tanks. The plant laboratory measures the level of radioactivity in the water and clears it for pumping out if the level is acceptably low. In conjunction with discharging the water into the sea, a collective sample is taken for release measurements. The detergent-related loading of waterways is calculated on the basis of the phosphate content of the discharge water, measured by the plant laboratory.

14.2.4 Waste water treatment plant

A water laboratory operating under official supervision monitors the discharges from the waste water treatment plant four times a year. Automatic sampling equipment is used to take 24-hour collective samples proportional to the flow rates of waste water entering and leaving the treatment plant. The samples are analysed for the following: pH, BOD_{7ATU} value, COD_{cr} value, total nitrogen, ammonium nitrogen (outgoing water), total phosphorus, soluble phosphorus (outgoing water), solids, total aluminium (outgoing water).

In addition, the laboratory of the power plant operates an intensified weekly releases monitoring scheme. The incoming waste water is analysed for: pH, total phosphorus, COD_{cr} value. The outgoing waste water is analysed for: pH, total phosphorus, total aluminium, solids, COD_{cr} value. A monthly summary report is drawn up for the water treatment systems of the power plant, containing among other things the average and maximum values of the above parameters in the outgoing waste water.

The daily routine monitoring includes the following: volume of water treated, any bypasses taking place at the treatment plant or sewage network, chemical dosing (flow meter readings), depth of visibility on sedimentation. In addition, the following measurements are made when required, however, at least once a week: temperature of incoming and outgoing waste water, pH of incoming and outgoing waste water.

In addition to the above, monthly routine monitoring includes the following: consumption of chemicals, volume of removed slurry, consumption of electricity.

Daily records are kept for the operation of the waste water treatment plant.

14.2.5 Monitoring of groundwater conditions

The impacts during the construction and operation of the final repository of operating waste on the flow, pressure and quality of groundwater are systematically monitored both from the construction engineering and environmental points of view.

14.2.6 Waste records

Records are kept in compliance with the Waste Act regarding the type, quantity and treatment of the waste materials generated at the power plant. For ordinary waste, the records are kept in compliance with the environmental permits of the power plant and its landfill. For radioactive waste, the records are kept in compliance with the regulations issued by the Radiation and Nuclear Safety Authority.

14.2.7 Monitoring of noise levels

After the completion of the new unit, noise level measurements will be carried out in the areas surrounding the power plant. The purpose of the measurements is to ensure that the noise generated by the power plant complies with the guide limits issued by public authorities and with the design guide values.

14.2.8 Boiler plant and reserve power diesel engines

The operating condition of the burner, blower and control system is checked in the monthly trial start-up of the boiler plant. The parameters measured daily during normal operation are fuel consumption, boiler temperature and pressure, as well as the temperature and carbon dioxide (CO_2) content of exhaust gas. The parameters measured in conjunction with burner maintenance (when required) are residual oxygen (O_2), carbon dioxide (CO_2) and darkness/Bacharach scale reading of soot content.

A sample is taken monthly of the boiler water for determining its hydrazine content, conductivity, pH, chloride content and fluoride content.

The emissions from the boiler plant and reserve power diesel engines (carbon dioxide, particles, sulphur dioxide, nitrogen oxides) are calculated on the basis of the material balances of fuel consumed annually. The carbon dioxide emission details submitted to the Energy Market Authority will be verified by a third party.

14.3 Monitoring of impacts

14.3.1 Environmental radiation monitoring

The purpose of environmental radiation monitoring around Olkiluoto is to determine the radiation load caused to the environment and people by the radioactive releases from the nuclear power plant. The environmental radiation monitoring around Olkiluoto began in 1977.

External radiation is measured continuously. Continuously operating radiation dose meters have been placed both on the power plant site and at a radius of some five kilometres from the power plant. Ten meters are connected to the nationwide radiation monitoring network, the readings of which are available in real-time to, among others, the Ministry of the Interior and the Radiation and Nuclear Safety Authority.

Air and the particles contained in it are also monitored using continuous sampling. Fallout is measured in rain water.

Soil samples are taken as part of surveys carried out every four years. Samples are also taken at the same time as mushrooms and berries growing in the forest. Samples are taken annually during the growth season of natural plants, polytrichtum moss, reindeer-lichen and pine needles. Samples are also taken of grazing grass during the growth season at distances of 0–10 km from the power plant.

Of human food, samples are taken of milk, tap water, wheat, rye, lettuce, blackcurrant and beef. The sources of the samples are chosen so that they provide comprehensive coverage of the routes through which people may receive radioactive substances in food. The samples are taken at distances ranging from 0 to 40 km from the power plant.

In the sea environment, samples are taken of water and different plants including kelp and green algae. Of sea bottom fauna, samples are taken of Baltic tellin and blue mussel. The fish sample species include Baltic herring, pike, perch and roach. Samples are also taken of sediment materials and bottom sediments.

Every year, more than 300 samples are taken from the environment for radiation monitoring. Whole-body scans are also carried out for a group of people selected from those living near the power plant.

In addition to the radiation monitoring programme, radiation dose calculations are carried out using mathematical models. The models are based on measured data on emissions and the circumstances in which they spread. By comparing these dose calculations and the results obtained in the radiation monitoring programme, it is possible to verify and develop mathematical models for calculating the spreading of releases and the resulting doses.

The monitoring programme is reviewed from time to time on the basis of accumulated information. The current radiation monitoring programme will also be reviewed after building the new unit to ensure that it reflects the new situations. The programme is approved by the Radiation and Nuclear Safety Authority.

14.3.2 Monitoring of the aquatic environment

The monitoring of the aquatic environment involves monitoring the impacts of discharging cooling and waste waters on the state of the sea. The monitoring covers physical phenomena in the sea and monitoring of the water quality, as well as monitoring the biological state of the sea.

The monitoring of physical phenomena includes the monitoring of temperatures in the sea area by continuous metering and survey-type studies, as well as the monitoring of ice conditions. Monitoring the water quality involves an extensive monitoring scheme for parameters indicating the state of the aquatic environment, such as acidity, oxygen content, buffering capacity, electrical conductivity and salinity, colour, cloudiness and depth of clear visibility, as well as nutrient and solid materials contents. The physico-chemical analyses are carried out by a water laboratory operating under official supervision. The analyses are carried out using approved standard assay methods.

The biological state of the sea is monitored, among others, by determining the basic production rate and species distribution of plant plankton, through studies investigating the flora and abundance of aquatic plants, as well as through studies of bottom fauna. Analyses regarding the eutrophication rate are carried out by a water laboratory operating under official supervision. The analyses are carried out using approved standard methods.

The loading and aquatic environment monitoring programme is reviewed from time to time as new information is obtained or circumstances change. The programme will also be reviewed to correspond to the new situation when the new plant unit is commissioned. Loading and aquatic environment monitoring is carried out in the manner approved by the regional environmental authority, the Southwest Finland Regional Environment Centre.

Observations regarding the ice situation are made during the winter months every 1 to 3 weeks depending on the winter. An ice observation map is drawn up of the area, showing the edge of solid ice, sludge zones and pack ice zones, as well as the fragmentation and drifting of ice. Warnings to the general public will be published in local newspapers for the area of ice weakened by cooling water. Signposts warning of weak ice will be located by the roads leading to the area.

14.3.3 Fishery monitoring programme

The impacts of discharging the cooling and waste waters on fishes, fishing and catches in the sea areas surrounding Olkiluoto are monitored in accordance with the fishery monitoring programme. The fishery monitoring programme typically includes determinations of the age and growth of fish specimens, fishing questionnaires and interviews with professional, recreational and home use fishermen, as well as accounts based on detailed records kept by fishermen.

The fishery monitoring programme is also reviewed as new information is obtained or the circumstances change, for example, in conjunction with commissioning the new plant unit. Fishery monitoring is carried out in the manner approved by the regional fishery authority, the Fishing Industry Unit of Southwest Finland Employment and Economic Development Centre.

14.3.4 Monitoring of social impacts

Co-operation with interest groups is an important part of the normal operations of any modern company that cares for environmental issues. Through the open exchange of information with interest groups, organisation responsible for the project can obtain information on the impacts of the projects and on the means available for mitigating or preventing them. The connections established with the participating interest groups during the EIA procedure can serve as channels for interaction. TVO also has regular meetings with representatives of Eurajoki and its neighbouring municipalities.

The indirect and direct impacts of the project on employment and businesses can be of interest not only to TVO but also to municipal or regional Employment and Economic Development Centres.

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KAUPPA- JA TEOLLISUUS-MINISTERIÖ

Ministry of Trade and Industry, Finland

STATEMENT

Dnro 5/815/2007

28.9.2007

Teollisuuden Voima Oy

ENVIRONMENTAL IMPACT ASSESSMENT PROGRAMME FOR THE OLKILUOTO 4 NUCLEAR POWER PLANT UNIT; STATEMENT BY THE CONTACT AUTHORITY

On 31 May 2007, Teollisuuden Voima Oy (TVO) submitted an environmental impact assessment programme (the EIA programme) to the Ministry of Trade and Industry (MTI) in accordance with the environmental assessment procedure (hereinafter the EIA procedure), pursuant to the Environmental Impact Assessment Act (468/1994; EIA Act), on the fourth unit of the Olkiluoto nuclear power plant and the related projects. Prepared by the organisation responsible for the project, the EIA programme presents a plan for the necessary studies and implementation of the EIA procedure. The EIA programme also includes a description of the present state of the environment in the area likely to be affected.

Pursuant to the EIA Act, the MTI will act as the contact authority in the EIA procedure.

A public notice announcing the launch of the EIA procedure was published on 8 and 9 June 2007 in the following newspapers: *Helsingin Sanomat*, *Hufvudstadsbladet*, *Turun Sanomat*, *Satakunnan Kansa*, *Uusi Rauma* and *Länsi-Suomi*. The public notice and the assessment programme can be found on the MTI's website at www.ktm.fi

Members of the public were able to view the assessment programme between 12 June and 31 August 2007 in the local government offices of Eurajoki, Eura, Kiukainen, Lappi, Luvia and Nakkila and in the environmental office in Rauma. The Ministry organised a public meeting to discuss the project on 13 June 2007.

The comments and opinions invited and presented on the assessment programme are described in Chapter 3.

The Espoo Convention (67/1997) will be applied to the assessment of the project's cross-border environmental impacts. The parties to the Espoo Convention have the right to participate in the EIA procedure. The Ministry of the Environment is responsible for the practical arrangements for conducting the international hearing. The Ministry of the Environment has notified the following countries of the project: Sweden, Denmark, Norway, Germany, Poland, Lithuania, Latvia, Estonia and Russia.

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1 Project information

Organisation responsible for the project

The organisation responsible for the project is TVO, which holds the operating licences for the two present units in the Olkiluoto nuclear power plant until 2018. In addition, TVO is currently constructing the Olkiluoto 3 plant unit, for which the Government issued a construction licence in 2005. According to the information TVO has received from the project contractor, it has been estimated that the unit's completion will take place in 2011.

Project and its alternatives

TVO is exploring opportunities to expand a nuclear power plant, located on the island of Olkiluoto in the Eurajoki municipality, with a fourth unit. The purpose of the project is to increase power production capacity, both to satisfy demand and replace capacity about to be withdrawn from the market.

The electrical output of the planned unit will range from 1,000 to 1,800 megawatts and the thermal power from 2,800 to 4,600 megawatts. A pressurised water reactor and a boiling water reactor are both being considered. The Olkiluoto 4 unit is designed as a base-load power plant and, excluding an annual service shutdown, it will run continuously throughout the year. The unit has an estimated technical life cycle of approximately 60 years.

The project includes the intermediate onsite storage of spent nuclear fuel generated by the new unit, and the treatment and disposal of low- and intermediate level radioactive waste. The implementation of power transmission to the national grid is also included in the project.

A situation in which the Olkiluoto 4 project would not be implemented is regarded as a zero option. TVO would not consider building another type of power plant in the Olkiluoto plot instead of the new nuclear power plant unit, and the area would remain unused for the time being. The zero option assesses the environmental impacts caused by generating the electricity corresponding to the plant unit's production using the average Nordic power production structure.

The limitation of the alternatives is made on the basis of the importance of utilising existing infrastructure in nuclear plant projects.

According to TVO's plans, the construction of the nuclear power plant would take around 4 to 6 years, and its timing would be approximately between 2013 and 2018.

2 Licensing of nuclear facilities

Pursuant to the Nuclear Energy Act, the decision-making and licensing system is based on a principle whereby safety is continuously reviewed, the assessments being further defined throughout the procedure so that the final safety assessments are only made at the operating licensing stage.

2.1 Environmental impact assessment

TVO will draw up an EIA report based on the assessment programme and the contact authority's statement, followed by a public hearing on the EIA report. The responsible organisation estimates that the EIA report will be finished by early 2008.

The EIA procedure constitutes part of the safety and environmental impact assessment for nuclear power plants laid down in a decision-in-principle pursuant to the Nuclear Energy Act (990/1987).

2.2 Decision-in-principle

The planned nuclear power unit complies with the definition of a nuclear power plant of considerable general significance, as laid down in the Nuclear Energy Act, requiring the Government's project-specific decision-in-principle on whether the construction project is in line with the overall interests of society. In accordance with the Nuclear Energy Decree (161/1988), the decision-in-principle shall include an EIA report complying with the Environmental Impact Assessment Act. The scope of the project, outlined in the application for the decision-in-principle, may not exceed that described in the EIA report.

The application for the decision-in-principle is not solely based on the material provided by the applicant. The authorities will acquire supplementary reports, both those required pursuant to the Nuclear Energy Decree and other reports deemed necessary, providing a broader analysis of the project. In preparation for the processing of the application, the MTI will obtain a statement from the council of the local authority intended to be the site of the facility, and from its neighbouring local authorities, the Ministry of the Environment and other authorities, as laid down in the Nuclear Energy Decree. In addition, the MTI will obtain a preliminary safety assessment from the Radiation and Nuclear Safety Authority (STUK).

The MTI will provide local authorities, residents and municipalities in the immediate vicinity of the facility with an opportunity to express their opinions in writing before the decision-in-principle is made. The Ministry will arrange a meeting, where the public will have the opportunity to express its opinions verbally or in writing. These responses will be submitted to the Government.

Pursuant to the Nuclear Energy Act, before making the decision-in-principle, the Government shall ascertain whether the municipality where it is planned that the nuclear facility will be located (Eurajoki) is in favour of the facility, and that no facts indicating a lack of sufficient prerequisites for constructing and using a nuclear facility in a safe manner and not causing injury to people, or damage to the environment or property, have arisen in the statement from STUK or elsewhere during the processing of the application. The

Government's decision-in-principle shall be forwarded, without delay, to Parliament for perusal. Parliament may reverse the decision-in-principle or decide that it should remain in force as such.

2.3 Construction licence

The actual licensing procedure follows the Government's decision-in-principle. Construction of the nuclear power plant requires a licence issued by the Government, stating that the construction project is in line with the overall interests of society. Furthermore, sufficient safety, protection of workers, the population's safety and environmental protection measures must have been taken into account appropriately when planning the operations, and the location of the nuclear facility must be appropriate with respect to the safety of said operations.

A hearing procedure involving municipalities, authorities and citizens will be established during the application process for the construction licence.

2.4 Operating licence

Operation of a nuclear power plant requires a licence issued by the Government. In order to receive a licence, the operation of the nuclear facility must be arranged so that it is in line with the overall interests of society, and so that the protection of workers, safety and environmental protection have been taken into account as appropriate.

A hearing procedure involving municipalities, authorities and citizens will be established during the application process of the operating licence.

3 Summary of comments and opinions

The following organisations were invited to comment on the assessment programme:

Ministry of the Environment, Ministry of the Interior, Ministry of Social Affairs and Health, Ministry of Defence, Ministry of Finance, Ministry of Transport and Communications, Ministry of Labour, Ministry of Agriculture and Forestry, Ministry for Foreign Affairs, State Provincial Office of Western Finland, Satakuntaliitto, Western Finland Environmental Permit Authority, Finnish Environment Institute, Radiation and Nuclear Safety Authority, Safety Technology Authority, Satakunta T&E Centre, South-western Finland T&E Centre, Occupational Safety and Health Inspectorate of Turku and Pori, Regional Environment Centre of Southwest Finland, Municipality of Eurajoki, Municipality of Eura, Municipality of Kiukainen, Municipality of Lappi, Municipality of Luvia, Municipality of Nakkila, City of Rauma, Satakunta Rescue Service, Confederation of Unions for Professional and Managerial Staff in Finland (AKAVA), Confederation of Finnish Industries EK, Finnish Energy Industries, Greenpeace, Central Union of Agricultural Producers and Forest Owners, Central Organisation of Finnish Trade Unions, Finnish Association for Nature Conservation, Federation of Finnish Enterprises, Central Union of Swedish-speaking Agricultural Producers in Finland, Finnish Confederation of Salaried Employees, WWF, Fingrid Oyj, Posiva Ltd and Advisory Committee on Nuclear Energy.

Comments were not received from the following organisations: Ministry of Defence, Ministry for Foreign Affairs, Western Finland Environmental Permit Authority, Finnish Environment Institute and Municipality of Kiukainen.

In the assessment procedure with respect to cross-border environmental impacts, the Ministry of the Environment notified the authorities of the following countries: Swedish Environmental Protection Agency (Sweden), Ministry of the Environment (Denmark), Ministry of the Environment (Norway), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany), Ministry of the Environment (Poland), Ministry of the Environment (Lithuania), Ministry of the Environment (Latvia), Ministry of the Environment (Estonia), Ministry of Natural Resources (Russia).

Sweden, Norway and Estonia participate in the EIA procedure and have commented on the EIA programme. Lithuania will participate in the EIA procedure but has not commented on the EIA programme. Russia will participate in the EIA procedure but has not commented on the EIA programme, submitting its comment at a later date, when it will be delivered to the responsible organisation. Latvia has replied to the Ministry of the Environment that it will not participate in the EIA procedure. The Ministry of the Environment has not received replies from Denmark, Germany or Poland. If any of the potential participants in the cross-border procedure submit a comment, it will be delivered to the organisation responsible for the project.

Comments invited by the MTI

According to the statement submitted by the Ministry of the Environment, the assessment programme generally describes matters laid down in Section 9 of the Government Decree on the environmental assessment procedure (713/2006). However, the Ministry considers the programme to be a general description and deficient in parts.

In the summary of its statement, the Ministry of the Environment advises that the EIA report on the planned nuclear facility should provide further details of the following matters in particular:

- Main alternatives to the project with sub-alternatives and, in conjunction with the zero option, opportunities to increase the efficiency of power consumption;

- Nuclear safety of the project and its impact on the current arrangements for nuclear waste management at Olkiluoto;

- Relationship with, and the interrelated and combined effects of the project under review (the Olkiluoto 3 unit currently under construction) with respect to, Posiva's nuclear fuel disposal facility;

- Limitations of the project and any associated projects, such as fuel sourcing, power transmission and demand for back-up power; and
- Impacts of cooling water on the state of the sea, taking into account the effects of Olkiluoto 3.

The Ministry of the Environment stresses the importance of making both the EIA report and the contact authority's respective statement available, when comments will be invited on a potential decision-in-principle.

According to *the Ministry of the Interior*, the EIA programme has been comprehensively prepared and the Ministry's Department for Rescue Services does not have any major suggestions for changes at this stage of the project. However, the Department for Rescue Services deems important the cooperation between local rescue services and any related parties, and the organisations implementing the EIA programme. The programme should include an assessment of the potential impact on rescue services.

The Ministry of Social Affairs and Health finds the EIA programme appropriate and comprehensive, with adequate consideration having been paid to potential risks, both direct and indirect, to the population's health and alternative risks.

The Ministry of Finance finds no cause to criticise the content of the EIA programme. However, the Ministry draws attention to the social significance of the project, and to implementing an assessment of economic, social and environmental impacts from the perspective of society in general during the decision-in-principal stage. The Ministry points out that the planners are able to assess how demand for electricity could be met if the nuclear plant unit is not built.

The Ministry of Transport and Communications maintains that particular attention should be paid to defining the observed area in the impact assessment, and the junction of road 2176 and highway 8. The report on the overall development of highway 8 between 2010 and 2020 should be taken into account in the studies and the EIA report.

The Ministry of Labour maintains that it is important to provide a detailed assessment of the project's impact on employment, both during the construction and the operational stage. A potential estimate of the availability of skilled labour may prove significant to the organisation implementing the project, since insufficient workforce may have an effect on the implementation schedule.

The Ministry of Labour further notes that, although the organisation implementing the project is not required to provide an impact assessment on improving energy efficiency and conservation at this stage, these will be assessed later by the Government, Parliament and other parties during the potential licensing of the project. The long-term strategy for the climate and energy policy, currently under preparation by the ministerial working group, will have an effect on the wide-scale social assessment of the project.

The Ministry of Agriculture and Forestry finds no cause to criticise the EIA programme in respect of its own sector. However, the Ministry maintains that problems relating to climate change, such as extreme weather conditions, may increase in the future. Since the planned facility is located on the coast, the EIA should take into account the potential increase in sea level changes and the impact of sea water warming on biological production, which may also present new challenges to the safe and uninterrupted operation of the facility.

According to *the Advisory Committee on Nuclear Energy*, the scope of the programme is appropriate. After the assessments described in the programme have been completed, sufficient basic data will be available for making the decision-in-principle. However, the Committee finds it critical that the EIA report should not simply repeat the content of previous EIAs but take into account changes in the operational environment to an appropriate degree. For example, the ICRP's new guidelines on radiological protection, currently at the drafting stage, should be taken into consideration wherever possible, since they involve an assessment of radiation doses affecting both human and other populations. Since considering the impact of climate change is vital, the EIA report should provide a description of how to prepare for and adapt to climate change.

The Radiation and Nuclear Safety Authority (STUK) maintains that the EIA report should prescribe the key grounds and objectives for planning the limitation of emissions of radioactive substances and environmental impacts, as well as an assessment of the possibilities of meeting the safety requirements in force.

The programme describes guidelines for analysing the environmental impacts of possible radioactive emissions in emergency situations. The EIA report should include a clear summary of the basis for such an analysis and describe, in an appropriate manner, the potential cross-border environmental impacts of radioactive substances.

The EIA report should account for and describe more precisely the intake and discharge of cooling water in the facility, including any possible remote intake and discharge options. A comprehensive dispersion calculation for waterways should cover the seasons and a range of weather conditions.

STUK also points out that in section 6.1.1 it is stated that the protection zone was created for the impact of spent nuclear fuel, while in reality it is being used for preparing for emergency situations caused by the reactor.

The State Provincial Office of Western Finland finds that the assessment programme has been appropriately prepared; the suggestions for impact assessments on human health, living conditions and the attractiveness of living environment cover various aspects to a sufficient extent.

According to *the Regional Environment Centre of Southwest Finland*, the assessment programme is very clear and illustrative. The project and the alternatives have been presented and defined clearly in such a way that the environmental impacts caused by the project can be studied.

The Centre considers the two options covering the construction sites for the unit in Olkiluoto and the two alternative intake and drainage sites for cooling water sufficient for a project such as this. Energy conservation, the option excluded at this stage, will be considered in a review of the importance of the nuclear power plant to Finland's energy supply, supporting the Government's decision-in-principle. However, since energy conservation is linked not only to the zero option but also to the purpose and justification of the project, it would be appropriate to present and investigate it at the EIA stage as part of the national energy supply review.

The Centre also considers it important that the utilisation of condensation heat be covered in the options. These should include utilisation of condensation heat fully, to a large extent, partly and not at all (the current model).

In the waterways impact assessment, the impact of cooling and sewage water on water quality, biology, fish stocks and the fishing industry are assessed on the basis of existing studies and dispersion models. The impact of Olkiluoto 3 should be included in these calculations. The assessment report should include more specific information on the applied knowledge and research methodologies in order to provide the best possible transparency and to allow verification of the conclusions drawn from the assessment results.

According to the Centre, the EIA programme does not show what kind of flow and water quality modelling will be used in the impact assessment. The Authority considers the local model inappropriate for the purposes of investigating the project's impact to a sufficient degree. Flow and water quality modelling should be directly linked to the Bothnian Sea and the Baltic Sea. The project's importance to the eutrophication of the Baltic Sea and to the survival of newcomer species should also be considered. The effects from the mitigation of damage caused by newcomer species, such as the eradication of hydrozoans in the current power plant's cooling system through chlorination, must be taken into account in the impact assessment.

The Safety Technology Authority has no comments on the EIA programme, although it notes that the programme does not include information on the hazardous chemicals used in the operation of Olkiluoto 4.

The Occupational Safety and Health Inspectorate of Turku and Pori has no comments on the EIA programme.

Satakunta T&E Centre finds the EIA programme comprehensive on the whole. However, the T&E Centre finds it important that the impact of cooling water on the sea areas adjacent to Olkiluoto and in the Bothnian Sea be satisfactorily assessed. Problems caused by climate change, such as sea level changes and more frequent exceptional weather conditions, should be taken into account.

Satakuntaliitto finds the EIA programme comprehensive, with the planned assessments creating solid ground for drawing up the EIA report and decision-making. On the basis of the approved regional plan and other similar plans, Satakuntaliitto states that it finds no cause to criticise the EIA programme. Currently preparing a provincial plan to replace the present regional plan, Satakuntaliitto points out the long-term development needs with respect to land use, the need for and presentation of power transmission in this EIA and the dispersion calculations for cooling water.

The South-western Finland T&E Centre finds no cause to comment on the EIA programme with regard to impacts on humans and society, the regional structure and economy, and transport. Instead, it considers that, with regard to certain impacts, the EIA programme remains rather superficial, for example regarding the effects of cooling water on the fishing industry. The T&E Centre also notes that there is no previous assessment of what would happen if fish entered the Olkiluoto power plant with cooling water, and considers that this eventuality should be investigated alongside the current EIA.

The Municipality of Eurajoki finds no cause to criticise the EIA programme. However, Eurajoki considers it important that a detailed study of the impact of cooling water on the immediate vicinity of the drainage area and on the wider marine area near Olkiluoto be conducted. Eurajoki also finds it vital that an EIA procedure for power transmission would be conducted alongside the Olkiluoto 4 EIA in the future.

According to *the Municipality of Eura*, the EIA programme is fairly successful in its comprehensive description of the natural environment and land use solutions in the area. Monitoring and research reports concerning the natural environment, including the aquatic ecology, are comprehensive. However, Eura finds that the techno-economic scope of the programme is too narrowly defined. For example, the residents' questionnaire targeted stakeholder groups only in the neighbouring areas. It further finds the method of limiting power transmission questionable.

The Municipality of Lappi maintains that, without question, the entire EIA process should be extended to a wider area, covering the neighbouring municipalities of Eurajoki. The environmental impact of power transmission lines should be reviewed during this EIA process, not leaving this to a separate EIA procedure. The assessment of traffic arrangements should take into account road 2070 between Lappi and Eurajoki.

The Municipality of Luvia finds that the key environmental impacts, likely to be caused by the different implementation options, are observed in the EIA programme. However, Luvia emphasises that the EIA must include model calculations for the dispersion of cooling water, the estimated effects of the thermal load on sea water temperatures and ice conditions in the nearby areas, and the assessment of changes to the sea currents in the area.

The Municipality of Nakkila states that the EIA programme provides reasonable prerequisites for reviewing the environmental impact of the fourth plant unit. However, the assessment of producing and transporting nuclear fuel is insufficiently presented by a responsible nuclear energy company like TVO. The EIA report must clearly show that Finland does not import nuclear fuel produced or concentrated in questionable conditions with regard to occupational health and safety or environmental protection. Nakkila regards the review of emergency situations as superficial, and suggests that consideration be given to extending the emergency planning zone.

The City of Rauma emphasises the impact of the thermal load on the sea, created by the current and the planned facilities. The assessment report should show the effects in a situation where heat created in the production process is cooled using a different technique, not causing a thermal load on the sea. The report should also consider the effects of climate change on the operation and environmental impact of the nuclear power plant.

Satakunta Rescue Service finds that Chapter 7 of the EIA programme provides good grounds for assessing the environmental impact in the assessment report. The Rescue Service considers the current protection zone and the division into emergency planning zones as functional, but points out that if the picture of the risks involved changes in the EIA process from its current state, the division into emergency zones should be reassessed. In addition, the Rescue Service suggests that a representative from Satakunta Rescue Service be invited to the current EIA monitoring group at TVO.

The Confederation of Finnish Industries EK finds the assessment programme comprehensive.

Finnish Energy Industries consider the EIA programme comprehensive, and also note the project's social significance.

Greenpeace states that the environmental impacts of the entire production chain of nuclear fuel should be considered as environmental impacts of the project. It further maintains that the effects of a serious nuclear emergency should be considered as potential environmental effects. The EIA report should mention that the potential environmental impacts of such an emergency would last for hundreds of thousands of years, the nuclear waste finally ending up in ground water or on the surface.

The zero option should include a scenario whereby Finnish energy needs are met by sustainable energy solutions without increasing the use or import of nuclear energy and fossil fuels. This option should be based on the expectation that electricity consumption will decrease as the consequence of a determined energy policy.

WWF suggests that the EIA programme should give equal weight to different options, which can satisfy the need for, and objectives of, the project. These options should particularly include an increase in energy efficiency and the use of renewable sources of energy. The assessment should mention how different views, such as those of citizens and organisations, have been considered when the options were formed.

WWF maintains that the impact assessment should be enhanced by considering the entire life cycle of the project, including the environmental impact of processing and transporting uranium. The environmental impact of construction should be assessed with regard to using natural resources and creating emissions.

WWF also suggests providing more detailed information on the assessment of environmental impacts, such as on the Natura area and people, the affected area and the effects of emergencies. WWF notes that up-to-date data should be used in the assessment.

The Central Union of Agricultural Producers and Forest Owners finds communication and interaction important, maintaining that the communication and participation plan presented in the EIA programme provides a solid base for interaction. Residents, land owners, stakeholder groups and other potentially affected groups in the area should be heard and their views taken into account.

The Union suggests that attention should be paid to the indirect effects of the project, such as the planned power transmission structures. The Union also remarks on the project's social significance and the need to review questions relating to the energy policy in the decision making process.

The Central Organisation of Finnish Trade Unions considers uninterrupted operation and safety in all circumstance to be the key points of the assessment. The assessment should take into account the experiences accumulated from Olkiluoto 3, the latest international data on the safety of nuclear power plants and STUK's views as a whole. All in all, the organisation finds the assessment programme sufficient.

The Confederation of Unions for Professional and Managerial Staff in Finland (AKAVA) presents the organisation's general energy and climate policies, and AKAVA's member organisations point out the social significance of nuclear power as part of these policies.

AKAVA proposes that the reviewed options include the utilisation and profitability of condensation heat (The Finnish Medical Association) as well as energy conservation, either in the EIA or before the prospective licensing decision on the construction of the nuclear unit (The Finnish Union of Environmental Professionals and the Trade Union of Education in Finland).

In the main, the assessment programme is considered appropriate and comprehensive. However, AKAVA proposes providing additional information with regard to the impact assessment. Although the safe final disposal of nuclear waste is a key question in the nuclear power industry, the utilisation of waste may present a future option for energy production (The Finnish Medical Association). Unexpected emergencies and exceptional situations should include changes in the environment, threats caused by human activities and securing basic energy production in unexpected situations. It should be determined which factors with a detrimental effect on the environment should be excluded from the zero option (The Finnish Union of Environmental Professionals).

The Finnish Association for Nature Conservation maintains that the need for the project should be justified to a sufficient extent in the assessment programme. Energy conservation and renewable sources of energy should be reviewed as options.

The Association maintains that the impact assessment should be enhanced by considering the entire life cycle of the project, including the environmental impact of processing and transporting uranium, the decommissioning of facilities, nuclear waste management and transport. Combined effects should be reviewed in addition to the environmental impact of the project, including the effects of the current units at Olkiluoto in different situations (life cycles, decommissioning).

Environmental changes, which may have an effect on the project, should also be considered. Particular attention should be paid to the exposure of local residents to airborne radioactive isotopes, the potential risk of concentrated isotopes in species in the terrestrial environment through emissions, and the volume and specification of isotopes discharged into the aquatic environment of the Bothnian Sea.

The Federation of Finnish Enterprises states that the EIA programme has been appropriately drawn up, covering all key aspects of assessment to a sufficient extent.

The Federation would find it reasonable to review a zero option, in which emissions of different power production methods are assessed. This would provide an estimate of the actual alternatives to the power plant.

The Finnish Confederation of Salaried Employees finds no cause to criticise the EIA programme.

Fingrid Oyj has investigated the possibilities of connecting the Olkiluoto 4 unit to the national grid and the necessary reinforcement of the grid on the basis of data on the facility. The necessary reinforcements of the grid are included in the long-term development plan of the national grid and also form part of the preparations for a provincial plan. Fingrid Oyj has commenced its investigations for establishing power line routes. The environmental impacts of these changes will be assessed in a separate EIA procedure.

Posiva Oy finds no cause to criticise the EIA programme.

Sweden's environmental authority, *Naturvårdsverket,* considers the EIA programme sufficient on the whole. The main impacts will be on the sea, and data on these is gathered under the environmental monitoring programmes of the current facilities. The EIA programme is also considered appropriate by Sweden's nuclear safety authority, *Statens Kärnkraftinspektion*. It finds the impact assessment of the normal use of the power plant particularly comprehensive.

Comments invited by the Swedish environmental authority emphasise the assessment of radioactive emissions from several perspectives. Particular attention should be paid to the potential long-range transportation of radioactive emissions and the related preparations, technologies to reduce emissions and mitigating the potential harmful effects. The impact of emissions on the environment and industries should be assessed, e.g. fish stocks and fishing. The authority notes that it would be prudent to assess the combined impacts of the planned unit and the current units on the radioactivity of the Baltic Sea.

It suggests that the impact assessment could be enhanced by examining the whole life cycle of the project and assessing the environmental effects due to the production of nuclear fuel and spent nuclear fuel.

The comments draw attention to the lack or deficient handling of a zero option, with particular mention of the lack of alternative means of power production.

In *Norway*, *the Ministry of the Environment* acts as the environmental authority. It emphasises the assessment of reactor safety, emergency situations, unexpected events and radioactive emissions. It would be prudent to describe the plans and monitoring systems for emergencies and exceptional situations.

Comments invited by the Norwegian environmental authority also emphasise the assessment of radioactive emissions from several perspectives. Particular attention should be paid to the potential long-range transportation of radioactive emissions and the related preparations, and mitigating the potential harmful effects. The impact of emissions on the environment and industries should be assessed, e.g. vegetation, animals, reindeer husbandry and recreational use.

Acting as the environmental authority, *the Estonian Ministry of the Environment* stresses the description of cross-border emergencies from several perspectives. The description should identify any impacts requiring protection from radiation, and the methods of informing neighbouring countries in emergencies.

The authority notes that it would be prudent to assess the combined impacts of the planned and the current units.

Other comments and opinions

This summary introduces issues and views that have been presented or highlighted in other comments or opinions. A total of 18 other comments or views were submitted. Eight of these were from organisations and ten from private persons (four individuals).

The following organisations presented a comment or opinion: Women Against Nuclear Power, Finnish Youth for Nuclear Energy, Women for Peace in Finland and Amandamij (joint comment), Raumanmeri Fishing Area, The Swedish NGO Office for Nuclear Waste Review (MKG), the Reseau Sortir du nucleaire network, the Sorkan osakaskunta partners and the Edelleen ei ydinvoimaa popular movement against nuclear energy.

Several comments suggest that the environmental impact assessment should be enhanced by considering the entire life cycle of the project, including the environmental impact of processing and transporting uranium, the decommissioning of facilities, nuclear waste management and transport.

The comments also mention the project's social significance and address the need to assess other alternative means of energy production. Several opinions do not present views relating to the EIA programme in addition to the aforementioned comments but either oppose or support the use of nuclear energy in general.

Raumanmeri Fishing Area considers it important that the dispersion and impacts of cooling waters from Olkiluoto be assessed using an up-to-date calculation model, which can be more extensively linked to the flow conditions of the Bothnian Sea. Impacts on fish stocks and the area's fishing industry should be estimated on the basis of these assessments. The potential increase in the number of newcomer species (such as Mytilopsis leucophaeata, the false dark mussel) to the area due to the effects of cooling waters should also be assessed.

The Sorkan osakaskunta partners suggest that the discharge of cooling water from the planned fourth power plant unit should be run via the north of the island of Olkiluoto in order to mitigate the detrimental load on the islands.

4 Contact authority's statement

The Ministry of Trade and Industry states that the EIA programme for the Olkiluoto 4 nuclear power plant unit meets the content requirements of EIA legislation and has been handled in the manner required by the legislation. The comments submitted consider the programme to be appropriate, in the main, and quite comprehensive.

However, attention should be paid to the following issues in the investigations and the drafting of the assessment report. The organisation responsible for the project should also account for the additional questions, notes and views presented in the comments and opinions, answering as many of them as possible in the assessment report.

4.1 Project description and the alternatives

The assessment programme presents a summary of the power range and potential types of the planned power plant, including the operational principles of the boiling water reactor and the pressurised water reactor.

In the Ministry's view, the EIA report should include a review of current nuclear power plants on the market which are suitable for the project under review. Similarly, the safety planning criteria for the prospective plant must be presented with respect to the limitation of emissions of radioactive substances and environmental impacts, alongside an assessment of the feasibility of meeting the safety requirements in force. The Ministry suggests that for the purposes of communicating the project it may prove advantageous to include a short description of the cost structure of the project and its alternatives in the assessment report.

The assessment programme briefly describes the zero option, considering the environmental impacts caused by generating the electricity corresponding to the plant unit's production using the average Nordic power production structure.

The programme further proposes that energy conservation should not be analysed as an alternative, since the organisation responsible for the project does not have access to any energy conservation means that would allow the replacement of the quantity of electricity produced by the nuclear power plant. It is also noted in the programme that the MTI must submit a review of the importance of the nuclear power plant to Finland's energy supply to the Government, in order to enable the Government to make its decision-in-principle. The Ministry agrees that national reviews of the energy economy fall under the remit of the organisation responsible for the project. Should these reviews be necessary to support decision-making, they will be drawn up by the central government.

However, in addition to the aforementioned review, several comments propose assessments of conservation and the more efficient use of energy. The Ministry maintains that the organisation responsible for the project is a company that generates power only for its shareholders. Therefore, it cannot access any significant means of energy conservation or efficiency.

The Ministry also notes that the report on the importance of a new nuclear power plant or power plants to the national energy supply, supporting the Government's decision-making with regard to reaching the decision-in-principle, will include information on energy conservation and efficiency. However, this perspective will cover the Finnish energy supply as a whole and thus could not be applied to the issue of replacing the power plant under review. The Ministry points out that the Government is currently preparing a long-term climate and energy strategy.

The Ministry recommends that the assessment report briefly introduce the energy efficiency and conservation efforts undertaken by the applicant.

4.2 Impacts and the assessment

In the EIA programme, the impact of cooling and sewage water on water quality, biology, fish stocks and the fishing industry are assessed on the basis of existing studies and the results of dispersion model calculations. The area under more detailed review under the modelling covers 12 x 12 square kilometres to the fore of Olkiluoto. The possibilities of utilising cooling waters will also be assessed.

Several comments remark on the significant impact of cooling water on the state of the marine environment around the power plant, suggesting that the assessment be extended further to the Bothnian Sea and the Baltic Sea. The effect of warming on the fishing industry is mentioned in several comments.

The Ministry is of the view that the impacts of cooling waters form the most significant environmental impact during normal plant operation. Therefore, when analysing the environmental impacts of sea water warming, any background material available must be utilised extensively and the analyses must be linked on a wider scale to the state of the Bothnian Sea and the Baltic Sea. Uncertainties in calculation results must be illustrated clearly. Also, the alternatives for cooling water intake and drainage options must be presented clearly, and any possibilities for remote intake and drainage must be examined.

The calculations for cooling water should be presented in a conservative way and so that thermal stress caused by all four units is taken into account. In addition, the need for a Natura review pursuant to Section 65 of the Nature Conservation Act should be considered (concerning the Natura area FI0200073).

Olkiluoto is an area undergoing major changes. According to the current plans, the Olkiluoto 3 unit, now under construction, should be operational by 2011. In addition, Posiva is building an underground research facility, ONKALO, intended to form part of the final disposal facility for spent nuclear fuel. At this rate, Posiva expects to apply for a construction licence for a used fuel disposal facility by the end of 2012. The final disposal is planned to begin in 2020. In addition, TVO has plans to expand the intermediate storage facility for used fuel, and possibly also the final disposal facility for waste produced by the power plants.

The MTI emphasises that, in the EIA report, the interrelationships between Olkiluoto 3, ONKALO/final disposal facility, Olkiluoto 4 and other planned projects (such as schedules, environmental impacts during the construction and operational phases, the need for licensing in accordance with the Nuclaer Energy Act, traffic volumes and safety) should be explained in an illustrative way so that a clear overall picture can be formed of the state of, and changes to, Olkiluoto.

The new recommendations for radiation protection, published in October 2007 by the International Commission on Radiological Protection (ICRP), will be taken into account when assessing the impacts on vegetation and animals.

A new nuclear unit would require improved power transmission. Fingrid Oyj has investigated how the Olkiluoto 4 unit could be connected to the national grid, and examined the reinforcement of the grid based on information received from TVO on the facilities.

The necessary reinforcement in connecting the power plant to the grid, and elsewhere in the national grid, has been taken into account in the provincial planning, carried out in partnership with the regional councils alongside land use planning. The company has commenced the preliminary planning of necessary power lines, and will launch an environmental impact assessment of the power lines during 2007–2009. In its own EIA report, TVO is obligated to provide information on the environmental impact of the required power transmission in the Olkiluoto area.

Assessing the impacts of exceptional and emergency situations must not be limited to the exclusion area or the emergency planning zone for rescue operations. The Ministry is of the view that the EIA report must present various emergency scenarios involving radioactive emissions and, with the help of illustrative examples, should describe the extent of the affected zones and the impacts of emissions on people and the environment.

The assessment may use the classification system (INES) of the International Atomic Energy Agency (IAEA), and the EIA report must present a clear summary of the basis used in the review. The assessment must also include a review of the possible environmental impact of radioactive substances on the states around the Baltic Sea and on Norway.

As exceptional situations, any eventual phenomena caused by climate change and the related preparations to cope with such phenomena must be examined (changes in sea level and other exceptional weather phenomena).

In the assessment of the environmental impact on transport, particular attention should be paid to defining the observed area in order to include the traffic arrangements for the junction of road 2176 and highway 8. The combined effects of other projects under construction or at the planning stage should be included in the assessment.

With regard to the socio-economic review of the EIA procedure, a detailed assessment should be provided of the project's impact on employment, both during the construction and operational stage of the power plant.

According to the EIA programme, the organisation responsible for the project will examine the environmental impacts of nuclear fuel production and transport, including mining, concentration and fuel manufacturing. The environmental impact assessment is based on existing studies. Some comments point out that the environmental impacts of the entire production chain of nuclear fuel should be considered environmental impacts of the project. The Ministry finds it reasonable that the organisation responsible for the project should examine the environmental impacts of the entire fuel supply chain in general and, additionally, the company's opportunities to influence this chain.

According to the EIA programme, the report will describe the quantity, quality and treatment of ordinary, hazardous and radioactive waste generated at the plant unit, and assess the related environmental impacts. The environmental impacts of the disposal of spent nuclear fuel have been described using the results of the EIA procedure carried out by Posiva Oy in 1999, and the studies carried out thereafter. In the comments, grounds are presented for assessing the environmental impact of nuclear waste management using the latest data. The Ministry finds the plan proposed by the organisation responsible for the project to be appropriate, and points out that the latest available data must be quoted in the assessment.

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

4.3 Plans for the assessment procedure and participation

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

When the assessment report is finalised, the MTI will publish a public notice, make the report available, and invite various authorities to comment on the report. The statement on the EIA report, prepared by the MTI in its capacity as a contact authority, will be delivered to the municipalities in the affected area and to the appropriate authorities.

4.4 Assessment report

Pursuant to the Nuclear Energy Act, submitting an application to the Government for a decision-in-principle is possible before the contact authority has published a statement on the EIA report.

In its comment, the Ministry of the Environment stresses that when comments are invited on a prospective decision-in-principle, both the EIA report and the contact authority's respective statement must be made available.

The MTI does not consider it appropriate that an EIA report and an application for a decision-in-principle be presented for comments at the same time, since they relate to the same project. The Ministry hopes that the contact authority is able to submit the EIA report for comments and provide the contact authority's statement before the application for a decision-in-principle is presented to the Government.

5 COMMUNICATING THE STATEMENT

The MTI will deliver the EIA statement to those authorities which have submitted comments. The statement will also be available on the Internet at www.ktm.fi

The Ministry will send copies of the comments and opinions concerning the assessment programme to the organisation responsible for the project. All comments and opinions received by the Ministry are published on the Internet.

The original documents will be stored in the Ministry's archives.

Mauri Pekkarinen
Minister of Trade and Industry

Jorma Aurela
Senior Engineer

For information — Authorities which have submitted comments

International nuclear event scale

The International Nuclear Event Scale (INES) is used to illustrate the significance of events from the point of nuclear and radiation safety. The scale is intended to communicate nuclear plant events to the public. The scale was designed jointly by the Nuclear Energy Agency (NEA) of the OECD and the International Atomic Energy Agency (IAEA). In Finland, the events are classified by the Radiation and Nuclear Safety Authority.

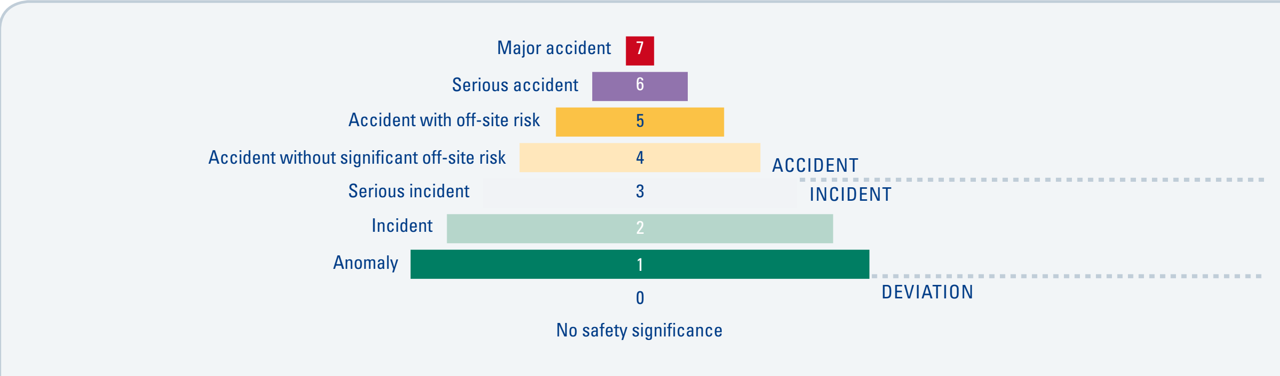

***Figure 1** Levels of severity in the INES scale.*

EVENTS AND INCIDENTS

Level and characterisation

INES 0 – Deviation; an event with so little bearing on safety that it cannot be placed on the actual scale

The event has no bearing on nuclear safety, but the public authority (STUK) considers it to be noteworthy and of general interest. The event is appropriately managed with the help of available instructions and plans. Level 0 events include, for example, the quick shutdown of the reactor (reactor trip) where all plant systems operate in the situation as planned.

INES 1 – Anomaly; an exceptional event affecting safety

Such deviations in the operation of equipment or the plant that do not compromise safety but nevertheless indicate that there are defects in safety-related factors. Such deviations can be caused by equipment faults, errors in use or defective procedures.

Level 1 incidents include, for example, the rupture of a small pipe in the reactor coolant system when all safeguard systems provided for the eventuality of such a rupture operate as planned. Level 1 incidents may also include the failure of several redundant parts of some safety system even if that safety system was not required in the actual situation.

INES 2 – Incident; a significant event affecting safety

Faults or deviations which, in spite of not having a direct impact on plant safety, may result in a review of safety-related factors.

An event resulting in a dose to a worker exceeding a statutory dose limit. An event which leads to the release of significant quantities of radioactive materials inside the plant in areas not expecting these by design. The contaminated areas must be cleaned before they are used again.

INES 3 – Serious incident; a serious event affecting safety

External releases of radioactive materials exceeding the limits set by public authorities. The external releases result in the persons living in the vicinity of the plant and being most exposed receiving a radiation dose of less than one millisievert. Protective measures are not required outside the plant.

High level of radiation in the plant or the contamination of plant facilities as a result of equipment faults or operating errors. Plant workers receive radiation doses exceeding the statutory limits (individual doses in excess of 50 millisieverts).

Incidents in which a further failure of safety systems could lead to accident conditions, or a situation in which safety systems would be unable to prevent an accident if an incident requiring that safety system were to occur. .

ACCIDENTS

Level and characterisation

INES 4 – Accident; an accident without significant off-site risk.

The external releases of radioactive materials result in the persons living in the vicinity of the plant and being most exposed receiving a radiation dose in the order of more than one millisievert. Such a release may result in a need to take off-site protective actions such as local food control.

Significant damage to the installation. Examples of such accidents include a partial core melt-down in a power reactor and comparable events at non-reactor installations. The accident may result in a long interruption in plant operations.

Irradiation of one or more workers resulting in an overexposure where a high probability of early death occurs.

INES 5 – Accident with off-site risk

The external release of radioactive material (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerels of iodine-131). Such a release would result in the partial implementation of countermeasures to lessen the likelihood of health effects.

Severe damage to the installation. This may involve severe damage to a large fraction of the core of a power reactor, a major uncontrolled power increase (a criticality accident), or a major fire or explosion releasing large quantities of radioactivity within the installation

INES 6 – Serious accident

The external release of radioactive material (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerels of iodine-131). Such a release would be likely to result in the full implementation of countermeasures to limit serious health effects.

INES 7 – Major accident

The external release of a large fraction of the radioactive material in a large facility. This would typically involve a mixture of short- and long-lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands of terabecquerels of iodine-131). Such a release may result in acute health effects, delayed health effects over a wide area and possibly involving more than one country, as well as long-term environmental consequences.

Examples of nuclear plant incidents and accidents

Olkiluoto

A fire occurred in the switchgear building of Olkiluoto 2 in 1991. As a result, the plant unit lost its connection to the external electricity grid. The unit had to rely on electricity produced by four diesel-powered reserve generators for 7 hours. The incident revealed defects in ensuring external power supply. On this basis, the rating of the event is Level 2.

Loviisa

The feedwater system pipe in the secondary circuit of Loviisa 2 ruptured in 1993 while the plant unit was operating at full power. The rupture was caused by erosion corrosion of the pipe. During the situation, the reactor operator rapidly took the correct route of action, and the leak was stopped in nine minutes. There had been a similar rupture of feedwater pipe at Loviisa 1 in 1991. After the event at Loviisa 1, the monitoring of pipe systems condition was enhanced. Despite the actions taken, erosion corrosion caused a pipe rupture at Loviisa 2. The event was rated as Level 2. As permitted by the rules, the classification was increased by one class because the event had recurred.

Vandellos

In 1989, a fire broke out at the Vandellos nuclear power plant in Spain. The incident did not result in a release of radioactive materials, nor was there damage to the fuel rods or contamination on-site. Several safety-ensuring systems were damaged in the fire which is why the event is classified as Level 3.

Saint Laurent

In 1980, a loose metal sheet in the reactor structures at the gas-cooled nuclear power plant in Saint Laurent, France, blocked the coolant flow for two fuel bundles. This resulted in serious damage to the fuel. However, there were no external releases of radioactive materials. On the basis of the on-site impact, the rating of the accident is Level 4.

Three Mile Island

The 1979 accident at Three Mile Island in the United States was a case of a relief valve jamming open resulting in the loss of so much coolant that the reactor dried, overheated and partially melted. Plenty of radioactive materials were released inside the plant, but the off-site release was very limited, which is why the accident did not cause any significant radiation impact externally. On the basis of the on-site impact, the rating of the accident is Level 5.

Windscale

The 1957 fire at the air-cooled graphite reactor pile at Windscale (now Sellafield) facility in the United Kingdom involved the external release of radioactive fission products. On the basis of the off-site impact, the rating of the accident is Level 5. The consumption of milk was banned for 25–44 days in an area spanning some 500 km^2 around the plant.

Kyshtym

The 1957 accident at the Kyshtym reprocessing plant in the Soviet Union (now in Russia) involving the explosion of a tank containing highly radioactive liquid waste led to an off-site release of radioactive materials. An area of 17 km^2 had fallout of about 100 MBq Sr-90/m^2 and an area of 300 by 50 km had fallout of more than 4 kBq/m^2. Emergency measures including the evacuation of the population were taken to limit health effects. On the basis of the off-site impact, the rating of the accident is Level 6.

Chernobyl

The reactor of the Chernobyl nuclear plant in the Soviet Union (now in the Ukraine) was destroyed in an explosion-like accident in 1986. The total destruction of the reactor resulted in an extensive release of radioactive materials, and more than 30 plant workers died as a result of the injuries they sustained in the accident. Large areas in the Ukraine, Belorussia and Russia were contaminated. On the basis of the off-site impact, the rating of the accident is Level 7. The population had to be evacuated from an area spanning some 30 km from the plant. Limitations were imposed on the use of foodstuffs in several European countries at distances of up to 1,000 km away from the plant.

Resident survey form

Teollisuuden Voima Oy

Extension of the Olkiluoto nuclear power plant by a fourth unit, environmental impact assessment

RESIDENT SURVEY

A list of questions related to the potential impact of the project is shown below. Please circle one statement or assumption that best agrees with your opinion. If you want, you can supplement your answers in writing on the reverse side or on a separate sheet to be attached to the reply. All replies will be processed anonymously and in confidence.

We ask you to kindly return the completed survey form in the enclosed prepaid reply envelope as soon as possible, but not later than 4 October 2007.

Background details

1. Gender of the respondent
   a. female
   b. male

2. Age of the respondent
   a. 18 - 30
   b. 31 - 50
   c. 51 - 65
   d. over 65 years

3. My residence near the Olkiluoto power plant is
   a. a permanent residence
   b. a holiday residence

4. The distance between the residence and Olkiluoto power plant is
   a. less than 5 km
   b. 5 - 10 km
   c. 10 - 30 km
   d. more than 30 km

   The distance between the holiday residence and Olkiluoto power plant is
   a. less than 3 km
   b. 3 - 5 km
   c. 5 - 10 km
   d. more than 10 km

5. The type of house I live in is
   a. multi-storey building
   b. terraced/semi-detached house
   c. detached house
   d. agricultural/forestry farm
   other (please specify) ______________________________

6. I have lived in my present residence for
   a. less than a year
   b. 1 - 3 years
   c. 4 - 9 years
   d. 10 - 15 years
   e. more than 15 years

   I have been using my holiday residence for
   a. less than a year
   b. 1 - 3 years
   c. 4 - 9 years
   d. 10 - 15 years
   e. more than 15 years

7. I have lived in my present municipality of residence for
   a. less than a year
   b. 1 - 3 years
   c. 4 - 9 years
   d. 10 - 15 years
   e. more than 15 years

8. My present position is primarily in one of the following categories:
   a. salaried employee
   b. professional craftsman
   c. farmer
   d. other entrepreneur (please specify) ____________________
   e. pensioner
   f. student
   g. parent staying at home
   h. unemployed
   i. other (please specify) ____________________

Availability of information

9. Have you received sufficient information on the new nuclear power plant project (Olkiluoto 4) and the associated EIA procedure?
   a. I have not heard or read anything about the nuclear power plant project before this survey
   b. I have heard or read something about the proposed nuclear power plant
   c. I have been reasonably well informed about the nuclear power plant project
   d. I have been sufficiently informed about the nuclear power plant project
   e. Too much information has been provided regarding the project

10. The information I have received regarding the project has been
   a. Competent and comprehensible
   b. Of ordinary standard
   c. Of poor standard (please specify how/why) ____________________
   d. I cannot say

11. Which issues would you like further information on?

____

____

____

Comfort, recreation and living conditions

12. How would you rate your own living environment
    1. At the moment
        a. very comfortable
        b. comfortable
        c. not very comfortable
        d. very uncomfortable
        e. I cannot say

    2. After the fourth nuclear power plant has been built
        a. very comfortable
        b. comfortable
        c. not very comfortable
        d. very uncomfortable
        e. I cannot say

13. What has been the impact on your living comfort by the existing nuclear power plant?

____

____

____

14. What do you think the effect of the fourth nuclear power plant will be on the traffic connections and routes you use?
    a. very positive
    b. positive
    c. no effect
    d. rather negative
    e. very negative
    f. I cannot say

15. What do you think the effect of the fourth nuclear power plant unit will be on your recreational or pastime possibilities or other leisure activities?
    a. very positive
    b. positive
    c. no effect
    d. rather negative
    e. very negative
    f. I cannot say

    Which recreational/pastime/leisure activity do you think the new nuclear power plant unit will affect (such as fishing, boating, berry picking, general outdoor recreation, etc.)?

    ____

16. If the fourth nuclear power plant unit is implemented, do you think that will affect your family's willingness to move away from the area?
    a. it will increase the need to move away
    b. it will reduce the need to move
    c. no effect on the need to move
    d. I cannot say

17. What do you think the effect of the fourth nuclear power plant will be on local property values?
    1. Regarding the value of your permanent residence
        a. the value of your residence will increase
        b. the value of your residence will decrease
        c. no significant change
        d. I cannot say
    2. Regarding the value of your holiday residence
        a. the value of your holiday residence will increase
        b. the value of your holiday residence will decrease
        c. no significant change
        d. I cannot say

18. How significant do you rate the employment-improving effects of the fourth nuclear power plant unit?
    1. During construction
        a. very considerable
        b. rather considerable
        c. rather small
        d. very small
        e. none
    2. When the fourth nuclear power plant is in operation
        a. very considerable
        b. rather considerable
        c. rather small
        d. very small
        e. none

19. If you are an entrepreneur, how do you think the fourth nuclear power plant unit will affect your business?

    a. positively. How? ______________________________

    ____

    b. negatively. How? ______________________________

    ____

    c. no significant effect.

20. Are you in favour of the new nuclear power plant project at Eurajoki?
    a. yes
    b. no
    c. I cannot say

Most considerable environmental impacts

21. Which do you consider the most considerable risk factor regarding the fourth nuclear power plant unit?
    a. accident at the power plant resulting in radioactive releases
    b. dismantling of the power plant after it has been decommissioned
    c. final repository of nuclear waste
    d. nuclear fuel transports
    e. external threats
    f. other (please specify)

    ____

    ____

22. The construction phase of the fourth nuclear power plant unit will take about five years. If the fourth nuclear power plant unit is built, which do you consider the most significant impacts during the construction phase? Please number three alternatives in their relative order of importance as follows: 1 = most significant, 2 = second-most significant and 3 = third-most significant.

    ____ impacts on waterways and water quality
    ____ impacts on other natural environment
    ____ impacts on traffic arrangements and the construction site traffic
    ____ noise and vibration
    ____ impact on the landscape
    ____ impacts on health and living comfort
    ____ impacts on employment
    ____ impacts on safety
    ____ combined effects of different activities
    ____ other impacts (please specify)

    ____

    ____

23. If the fourth nuclear power plant unit is built, which do you consider the most significant impacts during the operation of the nuclear power plant unit? Please number three alternatives in their relative order of importance as follows: 1 = most significant, 2 = second-most significant and 3 = third-most significant.

    ____ impacts on waterways, water quality and water flows
    ____ impacts on the fish population
    ____ impacts on other natural environments
    ____ traffic impact
    ____ noise and vibration
    ____ impact on the landscape
    ____ negative effects of power lines to agriculture and forestry
    ____ impacts on health and living comfort
    ____ impacts of radioactive releases
    ____ impacts on employment
    ____ impacts on safety
    ____ impacts of nuclear fuel production
    ____ combined effects of different activities
    ____ other impacts (please specify)

    ____

    ____

Other issues

24. How, in your opinion, should the electricity corresponding to the generation capacity of the fourth nuclear power plant unit be produced?
    a. by building a nuclear power plant in Olkiluoto
    b. by building a nuclear power plant in some other location in Finland
    c. by building a power plant using fossil fuels (coal, natural gas, peat) in the municipality/neighbouring areas of Eurajoki
    d. by building a power plant using fossil fuels (coal, natural gas, peat) in some other location in Finland
    e. by building a power plant using bio-fuels in the municipality/neighbouring areas of Eurajoki
    f. by building a power plant using bio-fuels in some other location in Finland
    g. by building a power plant using waste materials as fuel in the municipality/neighbouring areas of Eurajoki
    h. by building a power plant using waste materials as fuel in some other location in Finland
    i. by building additional hydroelectric power generating capacity in Finland
    j. by building wind power plants and/or solar energy plants
    k. by purchasing electricity from abroad. Where from? ______________________________
    l. the consumption of electricity should be reduced by an amount equal to the production of the new nuclear power plant unit
    m. other (please specify) ______________________________

25. Which factors would you like to see taken into account when assessing the environmental impacts of the nuclear power plant project (Olkiluoto 4)?

____
____
____
____

26. If the nuclear power plant project (Olkiluoto 4) is implemented, which factors would you like to see taken into account when planning/designing the nuclear power plant?

____
____
____
____

Thank You for your reply!

TVO

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