Environmental impact assessment report | December 2024

EXTENDING THE SERVICE LIFE OF THE OLKILUOTO 1 AND OLKILUOTO 2 PLANT UNITS AND UPRATING THEIR THERMAL POWER

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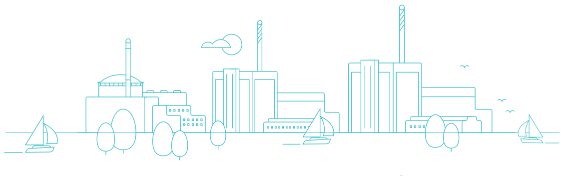
Translations Alasin Media Oy

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

Content

Summary



Project owner and location of project area

The project owner for the EIA procedure is Teollisuuden Voima Oyj (TVO). TVO produces zero-carbon energy domestically, all year round and regardless of the weather at Olkiluoto in Eurajoki by using three nuclear power plant units: Olkiluoto 1 (OL1), Olkiluoto 2 (OL2) and Olkiluoto 3 (OL3). In 2023, the combined electricity output of the plant units OL1, OL2 and OL3 was 24.67 terawatt hours (TWh). This corresponded to approximately 31% of the electricity produced in Finland. TVO has been generating electricity for its owners safely and reliably for more than 45 years.

The Olkiluoto nuclear power plant area owned by TVO is located in the municipality of Eurajoki, on Olkiluoto Island. Generally speaking, the Olkiluoto power plant area refers to the area which houses TVO's plant units OL1, OL2 and OL3 and Posiva's encapsulation plant and disposal facility for spent nuclear fuel. Within the power plant area, the plant units are located inside a site area limited to the western part of the island which also contains facilities, equipment and functions related to the plant units; these include the interim storage for spent fuel (KPA storage) and the interim storage facilities for very low, low and intermediate-level operating waste (HMAJ, MAJ and KAJ storages). The proposed project alternatives do not require new space reservations in the power plant area; any modifications will be implemented within the existing, constructed power plant area.

Project background, alternatives being considered and schedule

As part of service life management for the Olkiluoto nuclear power plant, TVO is analysing the possibility of extending the service life of the OL1 and OL2 plant units and uprating their thermal power.

The OL1 and OL2 plant units are identical boiling water reactors that were commissioned in 1978 (OL1) and 1980 (OL2). They have been generating electricity for the good of Finnish society for more than 40 years already. At the time of commissioning, the thermal power of the plant units' reactors was 2,000 MW, from which it has been uprated to the current 2,500 MW in two stages: in 1984 and between 1994 and 1998. Correspondingly, the nominal (net) electrical power of the plant units has increased from the original 660 MW to 840 MW. As a result of the turbine plant modernisations carried out in 2005–2006 and 2010–2012 and the improvement in efficiency, the current nominal value for electrical power is 890 MW. In 2023, the annual electricity production of the plant units was 14.29 TWh in total, corresponding to approximately 18% of the electricity consumption in Finland. Since the early 1990s, the capacity factors for OL1 and OL2 have been around 90%. High capacity factors indicate that the plant units operate reliably. During their years of operation, the plant units have been modernised in many ways through annual servicing, while also improving their safety. Due to significant investments, the power plant units remain in excellent operating condition. As a result, it has been possible to extend the service life of the plant units from 40 years to 60 years, and their current operating licences are in force until the end of 2038.

The currently examined project involves analysing the possible extension of the service life of the plant units until 2048 or, alternatively, until 2058. Alongside the service life extension, a power uprating of the plant units is examined where the starting point is an increase in the reactor's thermal power by 10% to 2,750 MW. This corresponds to increasing the plant units' nominal electrical power output from the current 890 MW to 970 MW. The total additional electricity generated by the OL1 and OL2 plant units each year would be approximately 1,200,000 MWh, roughly equivalent to the annual consumption in a city the size of Jyväskylä or Kuopio.

In the environmental impact assessment procedure, the implementation alternatives being examined for the project are continuing the operation of the OL1 and OL2 plant units at the current power level until 2048 or 2058 (VE1) and continuing the operation at an uprated power level until 2048 or 2058 (VE2). In the zero alternative, the operation of the plant units will continue until the expiration of the valid operating licences in 2038 (VE0).

Project description

The enclosed tables (Table 1; Table 2; Table 3) present key figures for OL1 and OL2 during the current operation (VE0) and compare them to extending the service life at the current power level (VE1) and extending the service life at an uprated power level (VE2).

Table 1. Key figures in the various alternatives (per plant unit).

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Plant type	Boiling water reactor		
Electrical power output	890 MW		970 MW
Thermal power	2,500 MW		2,750 MW
Efficiency	35.6%		35.3%
Reactor operating pressure	70 bar		
Electricity production	approx. 7 TWh/a		approx. 7,6 TWh/a

Table 2. Key figures in the various alternatives (OL1 and OL2 plant units in total).

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Thermal power routed into the water system	98,000 TJ/a		109,000 TJ/a
Volume of cooling water	38 m³/s per plant unit		
Increase in cooling water temperature	10°C		11°C
Fuel procurement and accumulation of spent fuel	18 tU/a per plant unit		
Fuel procurement and accumulation of spent fuel (during the entire service life)	2,483 tU (in 2038)	2,861 tU (in 2048) 3,240 tU (in 2058)	
Very low, low and intermediate-level waste	50 m³/a		
Very low, low and intermediate-level waste (entire service life)	8,250 m³ (in 2038)	8,750 m³ (in 2048) 9,250 m³ (in 2058)	
Chemicals	Sulphuric acid 18 t/a Sodium hydroxide 14 t/a Ion exchange resins 14 t/a Sodium hypochlorite (100%) 8 t/a Glycol 5 t/a Nitrogen 140 t/a Bitumen 14 t/a Light fuel oil 255 t/a		

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Releases of radioactive substances into the air*	Noble gases (Kr-87equiv.): 0–9.7 TBq/a. Release limit: 9,420 TBq/a Iodine (I-131): 0.00000008–0.002 TBq/a. Release limit: 0.1 TBq/a Aerosols: 0.000007–0.2 TBq/a Carbon-14 (C-14): 0.6–1.2 TBq/a Tritium (H-3): 0.2–2.7 TBq/a		
Releases of radioactive substances into water	Fission and activation products: 0.00008–0.0006 TBq/a. Release limit: 0.3 TBq Tritium (H-3): 1.3–2.5 TBq/a. Release limit: 18.3 TBq		
Greenhouse gas emissions (emergency generators)	914 t CO_{2e}/a		927 t CO_{2e}/a
Other releases into the air	NO_x: 1.2 t/a SO_2: 0.0 t/a Particles: 0.1 t/a		
Process waste water	total 25,000 m^3/a Phosphorus: 5 kg/a, Nitrogen: 100 kg/a		

* Range of variation for OL1 and OL2 in 2007–2022. The highest values in the actual release ranges have been related to rare fuel leakages.

Table 3. Key figures in the various alternatives (OL1, OL2 and OL3 plant units in total).

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Service water	268,000 m^3/a		
Household waste water*	total 78,905 m^3/a Phosphorus: 15 kg/a, Nitrogen: 3,642 kg/a, BOD_{7ATU}: 629 kg/a		
Conventional waste	Recyclable waste: 2,650 t/a Hazardous waste: 210 t/a Landfill waste: 0 t/a		
Noise*	Nearest holiday housing (Leppäkarta) 39.4–42.1 dB, main gate 48.6–56.3 dB		
Traffic*	Approximately 1,050 vehicles/day. During annual outages, increases by approximately 1,000 vehicles/day.		

* Includes the operations of Teollisuuden Voima and Posiva.

Environmental impact assessment procedure

The aim of the environmental impact assessment procedure (EIA procedure) is to ensure that the significant environmental impacts of the planned project are analysed to a sufficient level of precision. Its aim is to produce information to support the planning and decision-making of the project but also to provide the various parties with increased access to information and opportunities for participation in the project's planning stage.

In Finland, the need for an EIA procedure is based on the Act on Environmental Impact Assessment Procedure (252/2017). The service life extension and thermal power uprating of the OL1 and OL2 plant units necessitate an environmental impact assessment procedure in accordance with the EIA Act. Under Section 3 of the EIA Act, the environmental impact assessment procedure is applied to projects and changes thereto that are likely to have significant environmental impacts. Appendix 1 to the EIA Act lists projects to which the EIA procedure applies. Under section 7 b of the list of projects, an assessment process pursuant to the EIA Act applies to nuclear power plants and other nuclear reactors.

The EIA procedure has two stages. In the first stage, an EIA programme was drawn up; it is a plan created by the project owner regarding the required analyses and the arrangement of an assessment procedure. The Ministry of Economic Affairs and Employment (MEAE), which acts as the coordinating authority in the project, provided its statement on the EIA programme on 25 April 2024. In the second stage of the EIA procedure, the environmental impact assessment report was prepared on the basis of the EIA programme and the coordinating authority's statement regarding it. In the assessment report, the project owner presents the data on the project and its alternatives as well as a harmonised assessment of their significant environmental impacts. The coordinating authority sets the assessment report on display for public inspection and requests statements from various parties. The EIA report and the reasoned conclusion provided by the coordinating authority must be enclosed with the new operating licence applications for the plant units.

Alongside the Finnish EIA procedure, this project will implement an assessment of crossborder environmental impacts (international hearing) pursuant to the Espoo Convention that is coordinated by the Finnish Environment Institute.

Assessment of impacts

The purpose of an environmental impact assessment is to examine, in the manner and accuracy required by the EIA Act and Decree, the environmental impacts caused by the project, which may affect the following:

- The population as well as the health, living conditions and comfort of people;
- Soil, ground, water, air, climate, vegetation as well as organisms and biodiversity, especially as regards protected species and habitats;
- Community structure, tangible property, landscape, townscape and cultural heritage;
- Use of natural resources;
- The mutual interactions between the aforementioned factors.

The purpose of the environmental impact assessment is to systematically identify and assess the environmental impacts caused and their significance. An impact refers to a change in relation to the current state of the environment brought about by the project, its alternative or a function related to them. The change may be either negative or positive, or a change might not occur at all when compared to the current situation. In this EIA report, the current state of the environment refers to the present state of the nearby areas of the Olkiluoto nuclear power plant area, where the OL1, OL2 and OL3 plant units are in operation. When assessing the significance of an impact, the magnitude of the change caused by the impact and the capability of the environment to receive changes, that is, the sensitivity of the affected aspect are considered.

Pursuant to Section 4 of the EIA Decree, the assessment report presents an estimate and description of the likely significant environmental impacts of the project and its reasonable alternatives as well as a comparison of the alternatives' environmental impacts.

Summary of the project's environmental impacts

The OL1 and OL2 plant units have been in operation since 1978 and 1980, respectively. The environment in the Olkiluoto area has been monitored for decades, and comprehensive research data is available on the area. The impacts of the plant units are known well. The largest environmental impact has been the discharge of warm cooling water into the sea area, which will increase the surface temperature of the seawater by a few degrees in Iso Kaalonperä bay when compared to the rest of the sea area. The cooling water discharge area remains unfrozen throughout the winter. Currently, cooling water is warmed by approximately 10°C in the process. When the operation is continued at the present power level (VE1), the temperature of the water being discharged will remain the same; when the operation is continued at an uprated power level (VE2), the temperature will increase by approximately 1°C.

If the operation of the OL1 and OL2 plant units is continued at the present power level or an uprated power level, the environmental impacts of both alternatives will be similar, and the impacts are not substantially different from the impacts of the current operation of the plant units. The largest change will be the extension of the operating time, that is, the current operation will continue for a longer time, until either 2048 or 2058, instead of electricity production at the plant units ceasing when the current operating licences expire in late 2038. In this case, both the positive and negative impacts of the current operation will continue with the additional years of operation. Extending the service life at the current power level (VE1) will take place following the existing operating licences, during 2038–2048 or 2038–2058. Extending the service life at an uprated power level (VE2) could be implemented at the earliest in 2028, in which case the operation would continue until 2048 or 2058.

The impacts of continued operation and power uprating

In terms of both continued operation and power uprating, the most significant positive impacts target the climate, the energy market and the regional economy.

Both alternatives support Finland's goal of being carbon neutral by 2035. The production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects. The electricity production of the nuclear power plant does not produce significant greenhouse gas emissions, and the emission-free electricity produced by the OL1 and OL2 plant units can replace other forms of electricity production that use fossil fuels. According to the estimate, at the level of Finland the cumulative emission reduction potential in alternative VE1 would be approximately 1,100,000 t CO_{2e}, and in the case of VE2 approximately 1,600,000 t CO_{2e}, if the plant units were to operate until 2058. For the power uprating alone, the emission reduction potential in Finland is approximately 500,000 t CO_{2e}. The total significance of the impacts on climate have been estimated to be a moderate positive in the case of VE1 and a large positive in the case of VE2. Greenhouse gas emissions during the life cycle of electricity produced by nuclear power are at the same level as with electricity produced by wind power.

If the operation of the plant units is continued at the current power level or an uprated power level, both alternatives will have a large positive impact on Finland's electricity market. In the future, as electricity consumption grows, extending the operation of the plant units will support the security of supply of Finland's energy system and reduce the need to import electricity. The emissions-free electricity generated by the plant units will also enable electricity exports.

In both alternatives, the significance of regional economic impacts at the local level in the Rauma region has been estimated to be a large positive, since the additional years of the plant units' operation will accumulate substantial financial gains through the multiplicative impacts of the value chain and consumption. The total impacts in the region will amount to more than €3,380 million in turnover, €1,520 million in added value and more than 7,080 person years in labour demand. In both alternatives, the significance of the regional economic impacts at the regional level in Satakunta and at the Finnish national level has been estimated to be a minor positive, when considering the size of the area being examined.

Most of the other impacts have been estimated to be at most a minor negative. Even though the impacts will remain similar to the current operation, the assessment takes into account the continuation of current impacts for a longer time when compared to a situation where electricity production at the plant units were to cease in 2038.

The most significant surface water impact from continued operation and power uprating results from the thermal load of the cooling water which targets the sea area. The impacts from the thermal load are local and mainly limited to Iso Kaalonperä bay. The magnitude of the impacts or the size of the affected area do not significantly differ from current operation, and they do not differ from each other in the continued operation and power uprating case. In the long term, the thermal load may contribute to the local eutrophication of the sea area due to the joint impacts of nutrient loads carried over by the river water and climate change. In both cases, the significance of the impacts targeting surface waters was estimated to be a minor negative, when considering the extended operation of the plant units and the additional impact brought about by climate change. Climate change will strengthen the impacts of the thermal load in the long term, which means that operating the plant units at the current or an uprated power level until 2048 will cause less load on the sea environment than a situation where operation is continued until 2058. In the nearby sea area, water quality and the state of the marine environment are mostly impacted by the long-term development of the nutrient loads in the river water and the general development of the state of the Bothnian Sea.

In the continued operation and power uprating case, the impacts of cooling water from the plant units on the Olkiluoto sea area and, thereby, on fish stocks and fishery will remain as they are. The continuation of the warming effect of the cooling water will maintain a situation that favours species of fish that are adapted to warm water, such as cyprinids. Water that is warmer than the rest of the sea area may also cause the invasive alien species round goby to become more abundant in the area. Fishing opportunities in the winter will remain at the present level; however, due to climate change, the thickness of the ice cover may be reduced and the time of ice cover may be reduced. The significance of the impact of continued operation and power uprating is a minor negative in terms of fish stocks and fishery.

In the continued operation and power uprating case, cooling waters will continue to make the Olkiluoto sea area a favourable wintering ground for aquatic birds. In the long term, the combined eutrophication impact of the cooling waters' thermal load, climate change and nutrients carried by rivers may degrade the status of the underwater habitats located in the affected area. Overall, continued operation and power uprating were assessed to have a minor negative impact on the nature of the sea area. Impacts on terrestrial habitats will remain as they are.

The extended service life will continue to define land use and the landscape in both the power plant area and its surrounding areas in the coming decades as well. In both alternatives, the impacts on land use and zoning are similar to those of current operations. The continuation of operations and the power uprating are in line with the zoning in the area and do not require any zoning changes. On the other hand, the restrictions caused by the operation of the nuclear power plant are taken into account in the zoning of the affected area. The magnitude of the impact was estimated to be a minor negative, because the extension of the service life of the plant units will limit land use in both the site area and its surrounding areas in the coming decades as well. The impacts on the landscape, its valuable areas and locations and the archaeological cultural heritage are similar to those of the current activities. When considering the continuation of the current landscape impact within the area due to additional years of operation, the impacts were, overall, estimated to be, at most, a minor negative, since the plant units will continue to impact the otherwise minute and wooded landscape visible from the sea, even over the coming decades.

In both alternatives, the impacts on traffic will remain as they are but continue with additional years of operation. Traffic safety on the roads leading into the site area will remain at the present level. However, especially during the annual outages, when traffic volumes are at their highest, the traffic flow may be temporarily degraded, which is also similar to current activities. The significance of the impacts has been estimated to be a minor negative.

The continued operation of the plant units at their current power level or an uprated power level will not have an additional impact on the soil and bedrock or on the quality, quantity or surface level of the groundwater, but the current effects will continue during the additional years of operation. The capacity of the facilities excavated earlier is also estimated to be sufficient for the final disposal of low and intermediate-level waste generated during the service life extension of the power plant and the power uprating. Taking into account the extended operating time of the plant units and possible additional construction, the effects on the soil, bedrock and groundwater are estimated to be a minor negative at most.

The impacts on people's living conditions and comfort and the detrimental impacts experienced by people will mainly remain as they are. In both alternatives, potential concerns among people regarding safety risks will continue to exist. In the power uprating case, the discharge of warm cooling water combined with the changes brought about by climate change may affect the recreational value of the water systems in the nearby sea area in the long term. Taking into account the extended operating time of the plant units, the significance of the impacts is assessed to be a minor negative.

The continued operation of the plant units and the power uprating do not change the power plant area's current limitations on the utilisation of natural resources. In both alternatives, the use of natural uranium in nuclear fuel will continue. Natural uranium is classified as a non-renewable natural resource that is practically only used by the nuclear power and defence industries. When compared to the current global uranium reserves, the amount of uranium procured during the operation of the plant units is very low, on the basis of which the significance of the impacts has been estimated to be, at most, a minor negative with the additional years of operation.

In both alternatives, with the additional years of operation, the volume of spent nuclear fuel as well as very low, low and intermediate-level waste being processed will increase and the radiation exposure caused to the processing personnel by the waste management activities will continue. However, the increase in total waste volumes will not significantly increase the radiation doses of the personnel when compared to current operations. The limit value set by the Government for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the various stages of waste management for the spent nuclear fuel and the very low, low and intermediate-level waste, is 0.1 mSv. During normal operation, the impacts caused by waste management activities are very minor and the statutory limits will not be exceeded. The significance of the impacts has been estimated to be a minor negativ.

The radiation dose caused by the Olkiluoto nuclear power plant to the residents of the surrounding areas has been clearly below one per cent of the dose limit of 0.1 mSv per year set by the Government. In both the service life extension and power uprating case, the releases of radioactive substances into the environment caused by normal operation are estimated to remain low and to continue to fall below the release limits set for them in the future. The impact of the releases on the radiation exposure of the residents in the surrounding areas and the radiation-induced load on the surrounding nature will remain at the present level, and the significance of the impacts is estimated to be, at most, a minor negative when considering the additional years of operation.

The activities taking place in the power plant area are not estimated to cause detrimental health effects on the residents of nearby areas. The exhaust gas emissions and dust resulting from road traffic are restricted to areas near the road network, where exposure to conventional health hazards is low. The alternatives do not cause air quality limit values or guideline values to be exceeded, and the alternatives are not estimated to have an impact on current air quality in the area. In both alternatives, the noise from the plant units and traffic as well as the vibration caused by traffic will remain at the present level, which is considered to be very low. Noise and vibration are not estimated to cause significant impacts during the additional years of operation.

Impacts during construction

The modification work required by the service life extension of the plant units will be implemented mainly inside the plant units. In the power uprating case, a new diesel-powered make-up water system and a new battery energy storage system would be built outside the plant units to improve the safety of the plant units. It is also possible that the capacity of the KPA storage will be expanded in both alternatives. The construction work taking place outside of the plant units is estimated to take approximately 2–3 years. During construction, short-term noise and vibration may occur due to earthmoving, the erection of buildings and equipment installation that mainly affects the nearby areas of the construction site. Furthermore, excavation of bedrock in relation to the KPA storage expansion may cause temporary increased noise. Traffic volumes will not increase significantly and will not, therefore, increase the resulting impacts on nearby roads. In terms of landscape, the additional construction will only affect the landscape image within the area, where the change will not be significant. The new structures will be located in areas already shaped by human activity, and they will not affect the natural environment in the area. If the KPA storage is expanded, the bedrock in its area will be excavated, and the surface layers and structures will be partly removed. The possible need for increasing storage capacity has been considered in the plans for the area.

Impacts of the ending of current activities

With the end of the commercial operation of the plant units, the major positive impacts of extending the power plant's operation on climate, the energy market and the regional economy will end. During the decommissioning of the plant units, some compensatory regional economic impacts will be generated for other actors and in other sectors, but they will be smaller than the impacts of commercial operation. With the end of operation, the impacts of cooling water discharge from the OL1 and OL2 plant units will also end.

Feasibility of the project

On the basis of the performed assessments, the project alternatives are feasible in terms of environmental impacts. The prevention and mitigation methods for adverse impacts presented in the assessment report may be used to mitigate the potential environmental impacts when they are considered, wherever possible, in the further planning and implementation of the project.

The operation of the Olkiluoto nuclear power plant has become very stable and its environmental impacts are known well. The techniques, processes and means for mitigating impacts are well known. When operation is continued, attention will be paid to the ageing management of the plant units. These measures are used to determine the safe continued operation of the plant units. During operation, the development of best available techniques (BAT), the requirements of legislation in the field and experience from other nuclear power plants will be monitored. The project plan will be updated and specified as the project progresses.

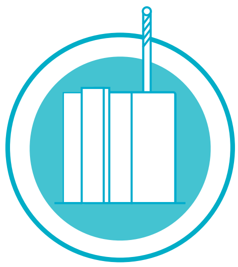
Incidents and accidents

The Nuclear Energy Decree (161/1988) and the Government Decree on Ionizing Radiation (1034/2018) set the limit values for radiation doses for the normal operation, operational occurrences and accident conditions in nuclear facilities as well as for decommissioning. A severe reactor accident at a nuclear power plant is a very unlikely, extreme event, for which preparations have also been made in the design and operation of the plant. The limit value for releases from a severe reactor accident has been defined in the Nuclear Energy Decree (Section 22 d) in a manner where the release must not result in the need for extensive civil protection measures or long-term usage limitations on large land or water areas. In order to limit long-term impacts, the constraint value for a cesium-137 release to the outdoor air is 100 terabecquerels (TBq). The assessment on the impacts of a severe reactor accident is based on this constraint value. The examined imaginary severe reactor accident corresponds to an INES level 6 accident.

Based on the results from modelling a severe reactor accident, the highest radiation dose at a distance of one kilometre, considering all age groups, will be approximately 19 mSv during the first week. The doses are reduced as distance increases. Radiation-induced health impacts on people are very unlikely as a result of the examined severe reactor accident. The average annual radiation dose of a Finn is approximately 5.9 mSv. In the early stages, the impacts of the release can be mitigated by means of civil protection measures, such as the digestion of iodine tablets, sheltering indoors and evacuations performed at different times. In the long term, the consequences of the fallout would include, among other things, the cleaning of the built-up environment, limitations on the recreational use of areas in their natural state and the organising of contamination measurements for people within a radius of less than 20 km from the OL1 and OL2 plant units. Furthermore, the use of constructed recreational facilities would need to be limited up to a distance of 100 km. Authorities would also set limitations on the use of products used for nutrition.

In other incidents and accidents, the impacts are clearly milder than those of a reactor accident.

Future permit processes for the project



Once the environmental impact assessment procedure has concluded, the project progresses to the various licence and permit stages. The coordinating authority's reasoned conclusion on the EIA report will be appended to the various licence and permit applications when the applications are submitted.

New operating licences pursuant to the Nuclear Energy Act (990/1987) must be applied for in all implementation alternatives of the project. If operation is continued at the current power level (VE1), the new operating licences will be applied for before 2038 at the latest, as this will be the year of expiration for the existing operating licences. If operation is continued at an uprated power level (VE2), the documents drawn up by the end of 2028 could be utilised when applying for new operating licences. The operating licences are issued by the Government.

If the operation of the OL1 and OL2 plant units is not continued (VE0), the decommissioning of the plant units will take place following the expiration of the current operating licences, from 2038 onwards. If the operation of the plant units is continued, decommissioning will take place after the expiration of the new operating licences, from either 2048 or 2058 onwards. According to the current decommissioning plan, however, the actual dismantling and related waste management would mainly take place in the 2080s. The decommissioning of nuclear power plants is subject to licence and regulated according to the Nuclear Energy Act and Decree and STUK's regulations and guides. According to the current EIA Act (252/2017), the dismantling or decommissioning of a nuclear power plant requires an EIA procedure. A separate environmental impact assessment will be drawn up for the decommissioning of the OL1 and OL2 plant units, according to the legislation in force, once decommissioning becomes relevant.

In addition to the operating licence and decommissioning licence, the project alternatives may require other permits and plans. For example, radiation practices take place at Olkiluoto nuclear power plant in addition to the use of nuclear energy, and this requires a safety permit pursuant to the Radiation Act. The transport of fresh nuclear fuel requires a transport permit pursuant to the Nuclear Energy Act, and the transfers of spent nuclear fuel within the Olkiluoto power plant area require approval from STUK.

The operation of a nuclear power plant requires an environmental permit in accordance with the Finnish Environmental Protection Act and a water permit pursuant to the Finnish Water Act for the water extraction and discharge structures. The Olkiluoto nuclear power plant has a valid environmental permit and water permit. Continuing operation at the current power level does not require an update of the environmental permit. If operation is continued at an uprated power level, the environmental permit will be updated. Olkiluoto power plant has a valid permit for the extensive industrial handling and storage of chemicals, and the power plant is an institution subject to a safety assessment regulated by the Finnish Safety and Chemicals Agency (Tukes). Any possible construction work and modifications in the power plant area may require a construction permit from the municipality. In addition to the above, the project alternatives may require other permits and plans.

1. Project owner and project background

1.1. Project owner

The project owner for the EIA procedure is Teollisuuden Voima Oyj (TVO). TVO produces zero-carbon energy domestically, all year round and regardless of the weather at Olkiluoto in Eurajoki by using three nuclear power plant units: Olkiluoto 1 (OL1), Olkiluoto 2 (OL2) and Olkiluoto 3 (OL3). In 2023, the combined electricity output of the plant units OL1, OL2 and OL3 was 24.67 terawatt hours (TWh). This corresponded to approximately 31% of the electricity produced in Finland.

TVO has been generating electricity for its owners safely and reliably for more than 45 years. TVO's shareholders are Finnish industrial and energy companies which, in turn, are partly owned by 131 Finnish municipalities. TVO operates under the cost price principle (Mankala principle) in the manner described in its Articles of Association.

Together with Fortum Power and Heat Oy, TVO owns Posiva Oy which is tasked with the final disposal research related to the spent nuclear fuel of its owners, the construction and operation of the disposal facility and its closure. TVO's ownership share of Posiva Oy (Posiva) is 60%.

1.2. Project background and schedule

As part of service life management for the Olkiluoto nuclear power plant, TVO is analysing the possibility of extending the service life of the OL1 and OL2 plant units and uprating their thermal power.

The OL1 and OL2 plant units are identical boiling water reactors that were commissioned in 1978 (OL1) and 1980 (OL2). They have been generating electricity for the good of Finnish society for more than 40 years already. The current net electrical output of the OL1 and OL2 plant units is 890 megawatts (MW) per plant unit and their annual electricity production in 2023 was 14.29 terawatt hours (TWh) in total, corresponding to approximately 18% of the electricity consumption in Finland. Since the early 1990s, the capacity factors for OL1 and OL2 have been around 90%. High capacity factors indicate that the plant units operate reliably.

The original planned service life of the OL1 and OL2 plant units was 40 years, until 2018. During their years of operation, the plant units have been modernised in many ways through annual servicing, while also improving their safety. Due to significant investments, the power plant units remain in excellent operating condition. Approximately EUR 50 million has been invested in OL1 and OL2 each year. As a result, it has been possible to extend the service life of the plant units to 60 years, and their current operating licences are in force until the end of 2038. The currently examined project involves analysing the possible extension of the service life of the plant units until 2048 or, alternatively, until 2058. The analyses related to extending the operation have considered the impacts of service life extensions on plant technology, nuclear safety, nuclear waste management and licensing, among other things. If the decision is made to continue operations, new operating licences pursuant to the Nuclear Energy Act (990/1987) must be applied for in good time before the expiration of the existing operating licences.

At the time of commissioning, the thermal power of the plant units' reactors was 2,000 MW, from where it has been uprated to the current 2,500 MW in two stages: in 1984 (to 2,160 MW) and between 1994 and 1998 (to 2,500 MW). Correspondingly, the nominal (net) electrical power of the plant units has gone up from the original 660 MW to 710 MW in 1984 and to 840 MW in 1998. As a result of the turbine plant modernisations carried out in 2005–2006 and 2010–2012 and the improvement in efficiency, the current nominal value for electrical power is 890 MW. The development of the electrical power of the OL1 and OL2 plant units is presented in the enclosed figure (Figure 1).

In the presently examined power uprating, the starting point is an increase of the reactor's thermal power by 10% to 2,750 MW, which corresponds to increasing the plant units' nominal electrical power output from the current 890 MW to 970 MW. The total additional electricity generated by the OL1 and OL2 plant units each year would be approximately 1,200,000 MWh, roughly equivalent to the annual consumption in a city the size of Jyväskylä or Kuopio.

A preliminary analysis for the uprating of the thermal power for the plant units' reactors was drawn up during 2022. In addition to the technical analyses regarding plant engineering and nuclear fuel, the preliminary analysis included assessments related to nuclear safety, preliminary licensing and permit plans for the project and the analyses related to the management and implementation of the power uprating project. Following the preliminary analysis, the project planning stage of the power uprating project has been launched. During the project planning stage, safety analyses were drawn up, the required plant modifications were defined and, on their basis, a plant-level plan for principles for the power uprating was drawn up that was completed in spring 2024.

If the decision is made to advance as regards the power uprating process, new operating licences must be sought for the plant units. The plant modifications required for the power uprating may be implemented and taken into use within the scope of the existing operating licence. At the earliest, the new operating licences would be sought in a manner in which the permits pursuant to the uprated thermal power would be in force in 2028. Test operation for the power uprating may be carried out under the supervision of the Radiation and Nuclear Safety Authority (STUK) pursuant to a binding advance information decision from the Ministry of Economic Affairs and Employment (MEAE). According to the terms of the valid operating licences, TVO must draw up a periodic safety assessment for the OL1 and OL2 plant units and submit it to STUK for approval by the end of 2028. The documents drawn up in connection with the periodic safety assessment may be utilised when applying for new operating licences as a result of the power uprating. If the power uprating were to be implemented, the operation of the plant units would be extended until 2048 or 2058.

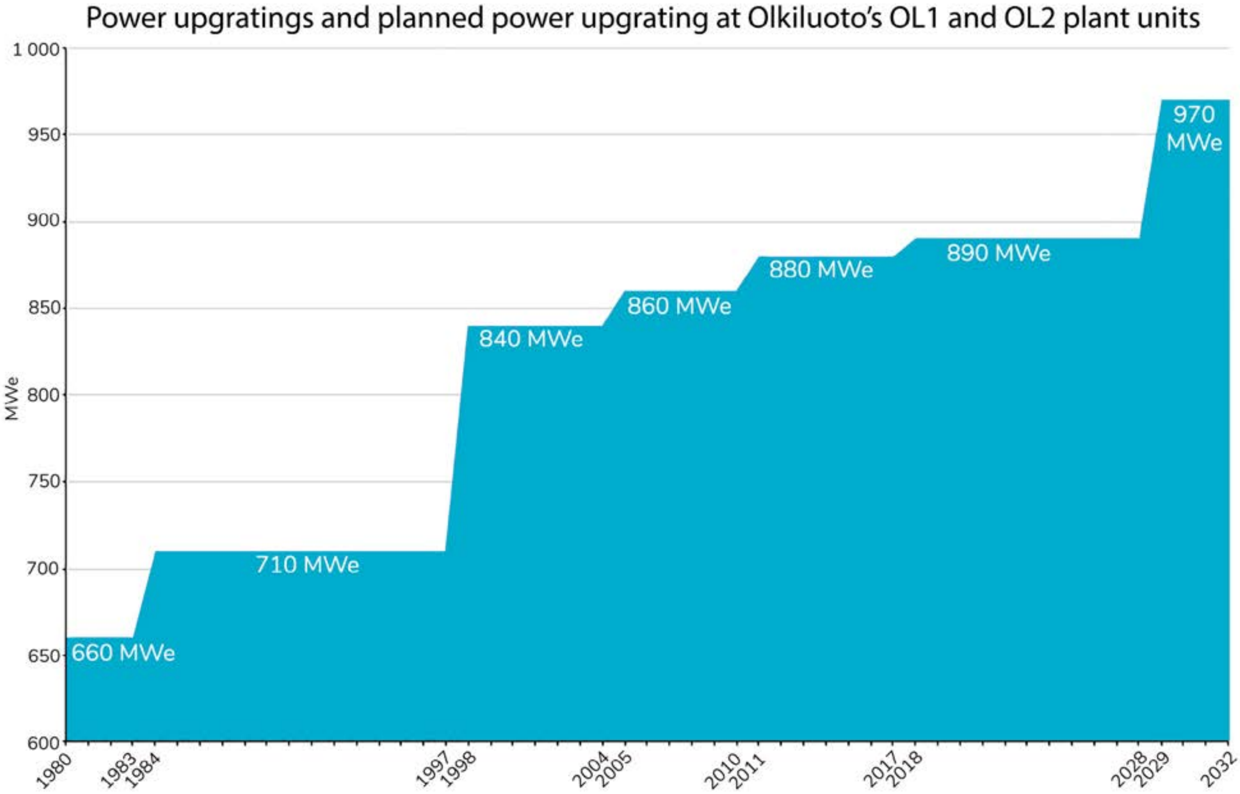


Figure 1. Power upratings and planned power uprating at Olkiluoto's OL1 and OL2 plant units.

1.3. Alternatives being examined

The service life extension and thermal power uprating of the OL1 and OL2 plant units necessitate an environmental impact assessment in accordance with the EIA Act (252/2017). Under Section 3 of the EIA Act, the environmental impact assessment procedure is applied to projects and changes thereto that are likely to have significant environmental impacts. Appendix 1 to the EIA Act lists projects to which the EIA procedure applies. Under section 7b of the list of projects, an assessment process pursuant to the EIA Act applies to nuclear power plants and other nuclear reactors. The EIA report and its reasoned conclusion must be enclosed with the new operating licence applications for the plant units.

In this EIA procedure, the implementation alternatives being examined for the project are continuing the operation of the OL1 and OL2 plant units at the current power level until 2048 or 2058 (VE1) and continuing the operation at an uprated power level until 2048 or 2058 (VE2). In the zero alternative, the operation of the plant units will continue until the expiration of the valid operating licences in 2038 (VE0). The alternatives being considered are presented in the enclosed figur (Figure 2).

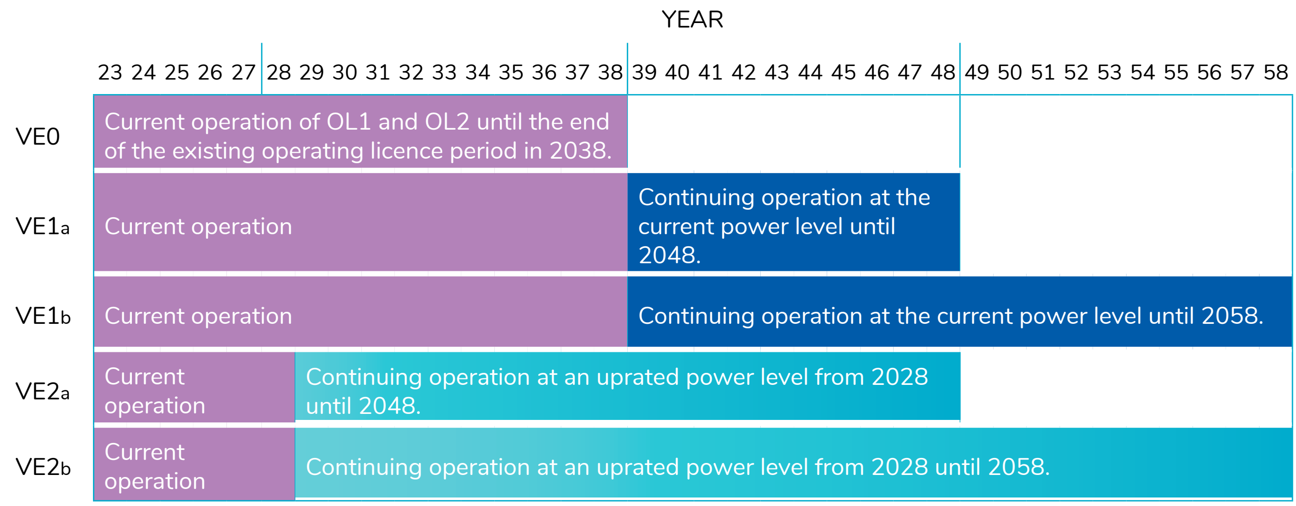


Figure 2. The alternatives examined in the EIA procedure and their preliminary, planned schedules.

New operating licences pursuant to the Nuclear Energy Act (990/1987) must be applied for in all implementation alternatives. In alternative VE1, the new operating licences will be applied for before 2038 at the latest, as this will be the year of expiration for the existing operating licences. For alternative VE2, this will be carried out during 2028.

If the operation of the OL1 and OL2 plant units is not continued (VE0), the decommissioning of the plant units will take place following the expiration of the current operating licences, from 2038 onwards. If the operation of the plant units is continued, decommissioning will take place after the expiration of the new operating licences, from either 2048 or 2058 onwards. According to the current decommissioning plan, however, the actual dismantling and related waste management would mainly take place in the 2080s. The decommissioning of nuclear power plants is subject to licence and regulated according to the Nuclear Energy Act and Decree and STUK's regulations and guides. According to the current EIA Act (252/2017), the dismantling or decommissioning of a nuclear power plant requires an EIA procedure. A separate environmental impact assessment will be drawn up for the decommissioning of the OL1 and OL2 plant units, according to the legislation in force, once decommissioning becomes relevant.

1.4. Principle of operation

The Olkiluoto nuclear power plant is an electricity generating power plant where uranium dioxide (UO_2) manufactured from enriched uranium is used as fuel instead of fossil fuels (such as coal, natural gas or peat). The use of uranium as fuel is mainly based on the fission of uranium-235 atomic nuclei, where a heavy atomic nucleus will split into two or more lighter nuclei as a free neutron collides with it. The reaction also releases a few neutrons that continue the chain reaction. A large amount of energy is released as the result of each splitting. In a nuclear power plant, the thermal energy created through fission is used to generate electricity by means of a steam turbine and an electrical generator. Very small amounts of uranium fuel can generate large amounts of thermal energy. For example, one gram of fissile material corresponds to 24,000 kilowatt hours (kWh) of energy.

The nuclear power plant units OL1 and OL2 are of a boiling water reactor type (BWR) (Figure 3). In the reactor of a boiling water reactor plant, water is circulated through the fuel assemblies in the reactor core, causing the water to heat up and vaporise. The steam generated in the reactor is routed, via the steam separator and steam dryer located in the pressure vessel, along the steam lines into the high pressure turbine, and from there to the reheaters and finally to the low pressure turbines. The turbines are connected by means of an axle to a generator that generates electricity for the national grid. The steam coming from the low pressure turbines is condensed into water inside the condenser, using a sea water cooling circuit. The generated condensate is pumped using condensate pumps, through the clean-up system and the condensate preheaters, to the feedwater pumps, which pump it as feedwater back into the reactor via the preheaters. The warmed sea water is routed back into the sea.

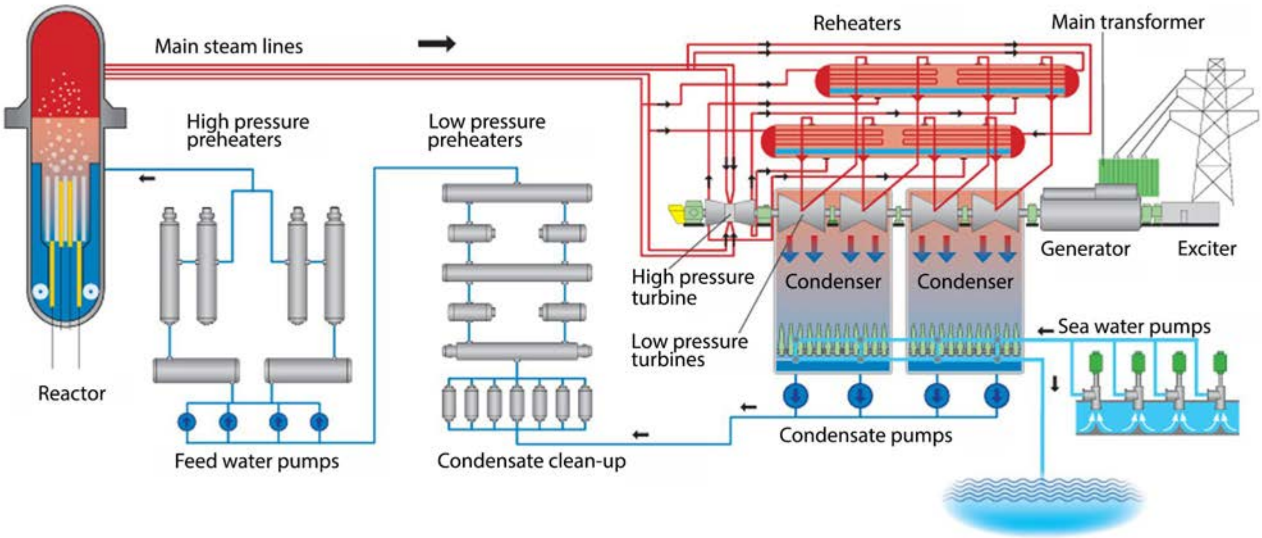
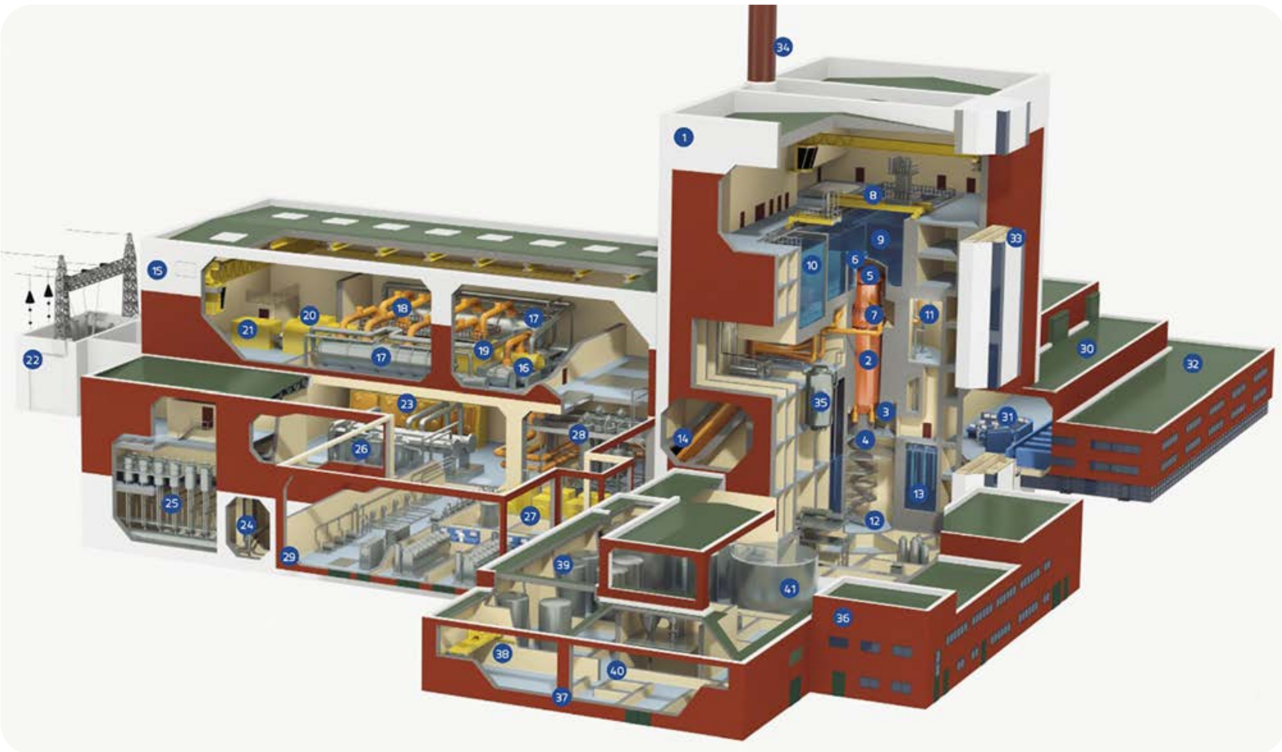


Figure 3. Flow diagram for the OL1 and OL2 plant units.

The OL1 and OL2 plant units may be divided into three separate building complexes: the reactor building, turbine building and the support and auxiliary buildings. The tallest building in each plant unit is the reactor building, which houses the reactor containment. The reactor is inside the containment. The top part of the reactor building contains the reactor hall, which houses the reactor pool, fuel pools, storage pools for the reactor internals, the fuel handling machine required for refuelling and a crane. The turbine building contains the high and low pressure turbines, generator, exciter and condensers. There is one high pressure turbine and four low pressure turbines. The support and auxiliary buildings include the emergency diesel generators, waste handling building and hot workshop, for example. The enclosed figure (Figure 4) shows a visualisation of the cross-section of the OL1 and OL2 plant units.



1. Reactor building
2. Reactor pressure vessel
3. Recirculation pumps
4. Control rod drives
5. Reactor pressure vessel lid
6. Containment dome
7. Main steam pipes
8. Fuel handling machine
9. Reactor pool
10. Fuel pool
11. Upper containment drywell
12. Lower containment drywell
13. Containment condensation pool
14. Main steam pipes
15. Turbine building
16. High pressure turbine
17. Reheater
18. Steam pipes to the low pressure turbines
19. Low pressure turbines
20. Generator
21. Exciter
22. Main transformer
23. Condenser
24. Condenser
25. Condensate clean-up
26. Low pressure preheaters
27. Feedwater pumps
28. High pressure preheaters
29. Auxiliary building
30. Control room building
31. Main control room
32. Entrance/office building
33. Lift
34. Ventilation stack
35. SAM filter (containment filtered venting system)
36. Hot workshop/laboratory building (OL1 only)
37. Waste building
38. Storage for low and intermediate-level waste
39. Liquid waste tanks
40. Intermediate-level waste handling
41. Make-up water tank

Figure 4. Cross-section of the OL1 and OL2 plant units.

1.5. Location and functions in the plant area

The Olkiluoto nuclear power plant area owned by TVO is located in the municipality of Eurajoki, on Olkiluoto Island (Figure 5). Generally speaking, the Olkiluoto power plant area refers to the area which houses TVO's plant units OL1, OL2 and OL3, the KPA storage, the operating waste repository (VLJ repository) and Posiva's encapsulation plant and disposal facility for spent nuclear fuel.

Within the power plant area, the OL1 and OL2 plant units are located in the site area that is delimited in the western part of Olkiluoto Island (Figure 5). The plant site contains the OL1, OL2 and OL3 plant units as well as facilities, equipment and functions related to the plant units; these include the interim storage for spent fuel (KPA storage) and the interim storage facilities for very low, low and intermediate-level operating waste (HMAJ, MAJ and KAJ storages). The proposed project alternatives do not require new space reservations in the power plant area; any modifications will be implemented within the existing, constructed power plant area. Key functions of the Olkiluoto power plant area are presented in the enclosed figure (Figure 6).

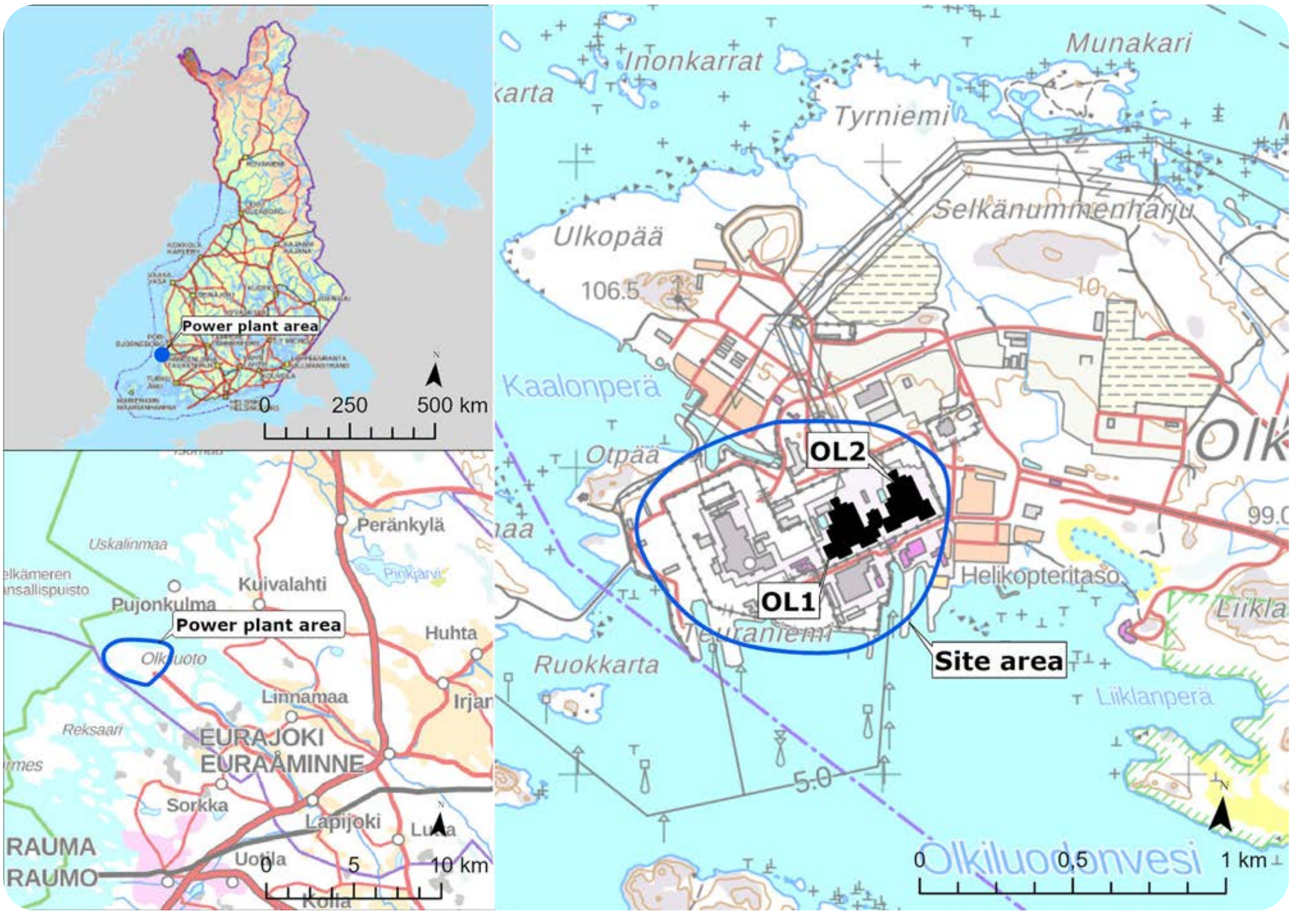


Figure 5. The location of the Olkiluoto power plant area and the location of the OL1 and OL2 plant units within the site area.

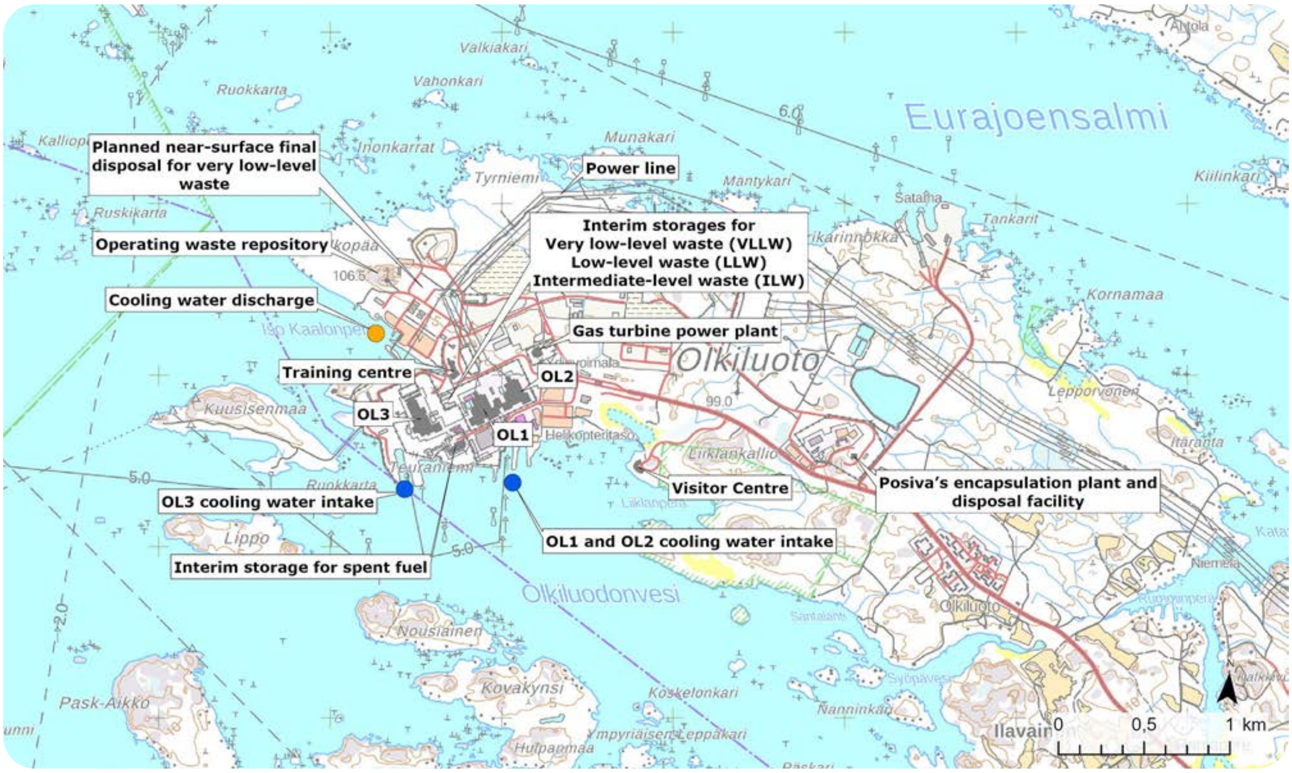


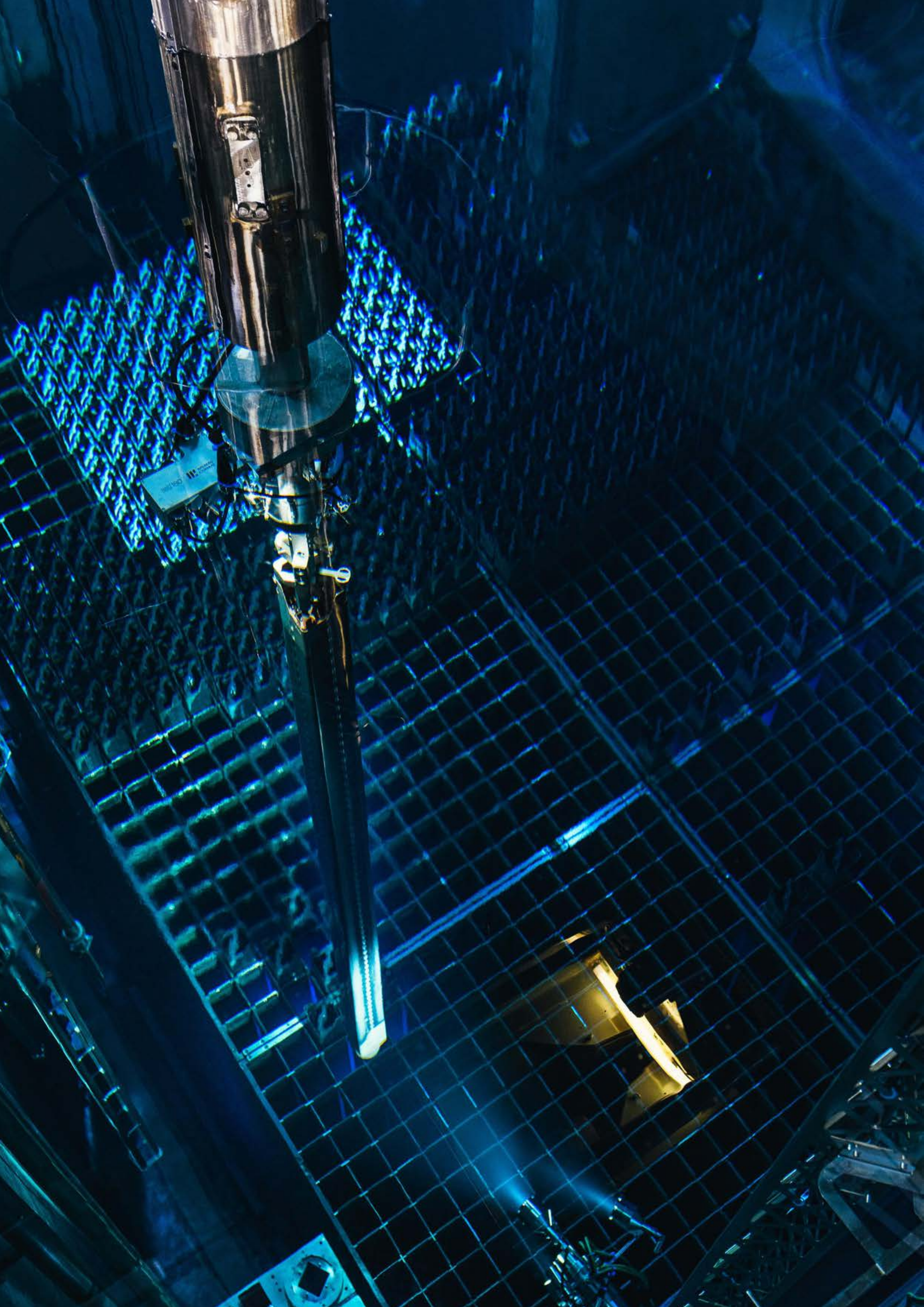
Figure 6. Functions in the Olkiluoto power plant area.

1.6. Connections to other projects

In addition to the OL1 and OL2 plant units, the Olkiluoto site area houses the OL3 plant unit, for which an operating licence was granted in 2019. The commercial operation of the plant unit started in May 2023. OL3 has a planned service life of 60 years. Its current operating licence pursuant to the Nuclear Energy Act is in force until the end of 2038.

The power plant area also houses the interim storage facility for spent nuclear fuel (KPA) and the storage facilities for very low-level waste (HMAJ), low-level waste (MAJ) and intermediate-level waste (KAJ) as well as the operating waste repository (VLJ repository), which has been in operation for more than 30 years. The VLJ repository's operating licence pursuant to the Nuclear Energy Act is in force until the end of 2051. TVO has also been planning the establishment of a separate near-surface final disposal facility for very low-level waste (HMAJ) in its power plant area *(Teollisuuden Voima Oyj 2021)*. The environmental permit for the near-surface final disposal facility was obtained in October 2023. A permit to operate has been sought from the Radiation and Nuclear Safety Authority for the HMAJ disposal repository in the spring of 2024. It will also require a construction licence from the municipality.

Posiva's encapsulation plant and disposal facility for spent nuclear fuel, currently under construction, is located in the Olkiluoto power plant area and constitutes a separate site area. Posiva is responsible for researching the final disposal of spent nuclear fuel generated in Finland by its owners, TVO and Fortum Power and Heat Oy, and its final disposal deep in the Olkiluoto bedrock. In November 2015, the Government granted Posiva a construction licence pursuant to the Nuclear Energy Act for building an encapsulation plant and disposal facility at Olkiluoto. In December 2021, Posiva submitted to the Government an operating licence application for a spent nuclear fuel encapsulation plant and disposal facility.



2. Nuclear safety and radiation safety

2.1. Legislation and regulatory monitoring concerning nuclear energy

In Finland, the starting point of the Nuclear Energy Act (990/1987) is that the use of nuclear energy shall be in line with the overall good of society, and it must not cause harm to people, the environment or property. The Nuclear Energy Act forms the basis for the Nuclear Energy Decree (161/1988) and the supplementary regulations from STUK concerning the use of nuclear energy. STUK's regulations concern the safety of nuclear power plants *(STUK Y/1/2018)*, emergency preparedness arrangements *(STUK Y/2/2024)*, security arrangements in the use of nuclear energy (STUK Y/3/2020) and the safety of the final disposal of nuclear waste *(STUK Y/4/2018)*. Radiation safety is set forth in the Radiation Act (859/2018) and the Government Decree on Ionizing Radiation (1034/2018). According to the Nuclear Liability Act (484/1972), the holder of a nuclear power plant shall have nuclear liability insurance that compensates for any damage caused by a possible nuclear accident to outside parties, up to an upper limit defined in the Act.

The MEAE has started the preparation of legislation aiming at the complete renewal of the Nuclear Energy Act *(Ministry of Economic Affairs and Employment 2023)*. The Nuclear Energy Act and its executive regulations will be renewed during this Government's term in a manner that supports the fluent progress of projects and Finland's competitiveness as an investment target *(Government 2023)*. The work to renew STUK's nuclear safety provisions, i.e. the regulations and guides, is also under way. The preparation of STUK's regulations is done in parallel with the preparatory work for the Nuclear Energy Act and Decrees *(STUK 2024f)*.

The limit values defined for the operation of a nuclear power plant are included the Nuclear Energy Decree, STUK's regulation concerning the safety of nuclear power plants, the YVL Guides and the operating limits and conditions and regulations approved for the plant by the Radiation and Nuclear Safety Authority. Limit values are also included in the Government Decree on Ionizing Radiation. The limit values concerning radiation exposure are related to the radiation doses of the personnel and the environment, the releases of radioactive substances and various different technical operating values related to the plant's operation. An essential part of the operating limits and conditions for the plant are the operability requirements for safety-related components and systems that are a prerequisite for continuing the operation of the plant.

2.2. Nuclear Safety

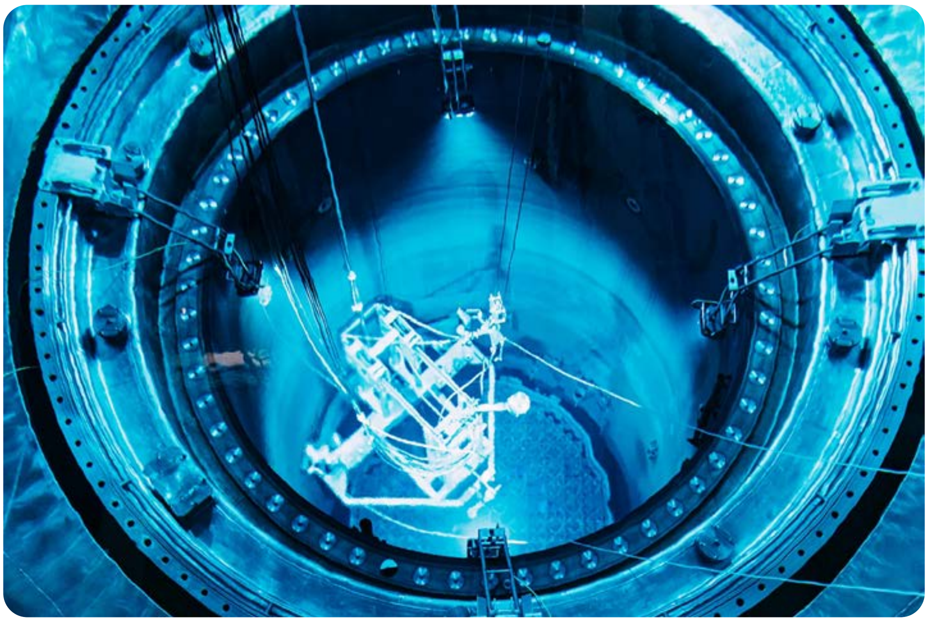
The safe operation of the Olkiluoto nuclear power plant is based on a high level of plant technology, the principle of continuous improvement, nuclear professionalism i.e. competent and responsible personnel, and independent internal and external oversight. The safety and safety requirements of the Olkiluoto nuclear power plant have been developed, and are being continuously developed, based on results from safety studies and operating experience, for example.

In order to ensure safe operation, the level of safety is being systematically assessed at TVO. TVO regularly assesses the status of overall safety from the perspectives of production, nuclear safety and radiation safety, corporate safety and security, plant unit service life management and leadership, the organisation and personnel. TVO regularly assesses and develops the operation of the plant units using internationally applied safety indicators. These include, for example, the unavailability of safety systems, the collective radiation dose, unplanned energy unavailability and unplanned automatic scrams/trips.

The basic principle for nuclear and radiation safety is to prevent the release of radioactive material into the environment. In order to prevent any releases, the safety of the plant units is ensured many times over by using diverse structural barriers and safety systems. Nuclear safety and radiation safety are developed by analysing risks and preparing for them.

The nuclear safety of the OL1 and OL2 plant units is ensured by means of safety functions that are intended to prevent the occurrence of incidents and accidents, to stop them from progressing or to mitigate the consequences of accidents. Safety functions have been defined in order to ensure the integrity of the release barriers for radioactive substances. The functions are supported by means of support actions that start automatically or are started by an operator.

The key safety functions of a nuclear power plant are as follows:
- Reactivity management, which aims at stopping the chain reaction inside the reactor if necessary.
- Residual heat removal, which aims at cooling the fuel and, thereby, ensuring the integrity of the fuel and primary circuit.
- Preventing the spread of radioactivity, which aims at isolating the containment and ensuring its integrity, thereby managing radioactive releases during an accident.



A nuclear power plant has systems for regular operation as well as safety systems that are used to implement the above-mentioned safety functions during normal operation and in case of incidents and accidents. The safety systems are used to ensure the cooling of the nuclear fuel inside the reactor even when normal systems for operation are not available. The most important safety systems are the systems related to shutting down the reactor and residual heat removal.

A nuclear power plant must be prepared for a severe reactor accident. A severe reactor accident refers to an accident where the fuel inside the reactor becomes significantly damaged. Even though such an accident is very unlikely, the OL1 and OL2 plant units are equipped with systems for managing a severe reactor accident. These systems are used to ensure that the power plant will not release radioactive substances in amounts that would cause major hazards to people, the environment or property.

During the operating history of the OL1 and OL2 plant units, numerous projects have been implemented to improve nuclear safety; as a result, the plant units are significantly safer now than when they first started. These safety improvements have been based on continuously seeking the highest possible level of safety in accordance with a high level of safety culture as well as STUK's evolved requirements. Following the Fukushima accident, for example, several changes that improve safety have been made, as a result of which the calculated probability of a severe reactor accident has been significantly reduced.

2.3. Radiation and its monitoring

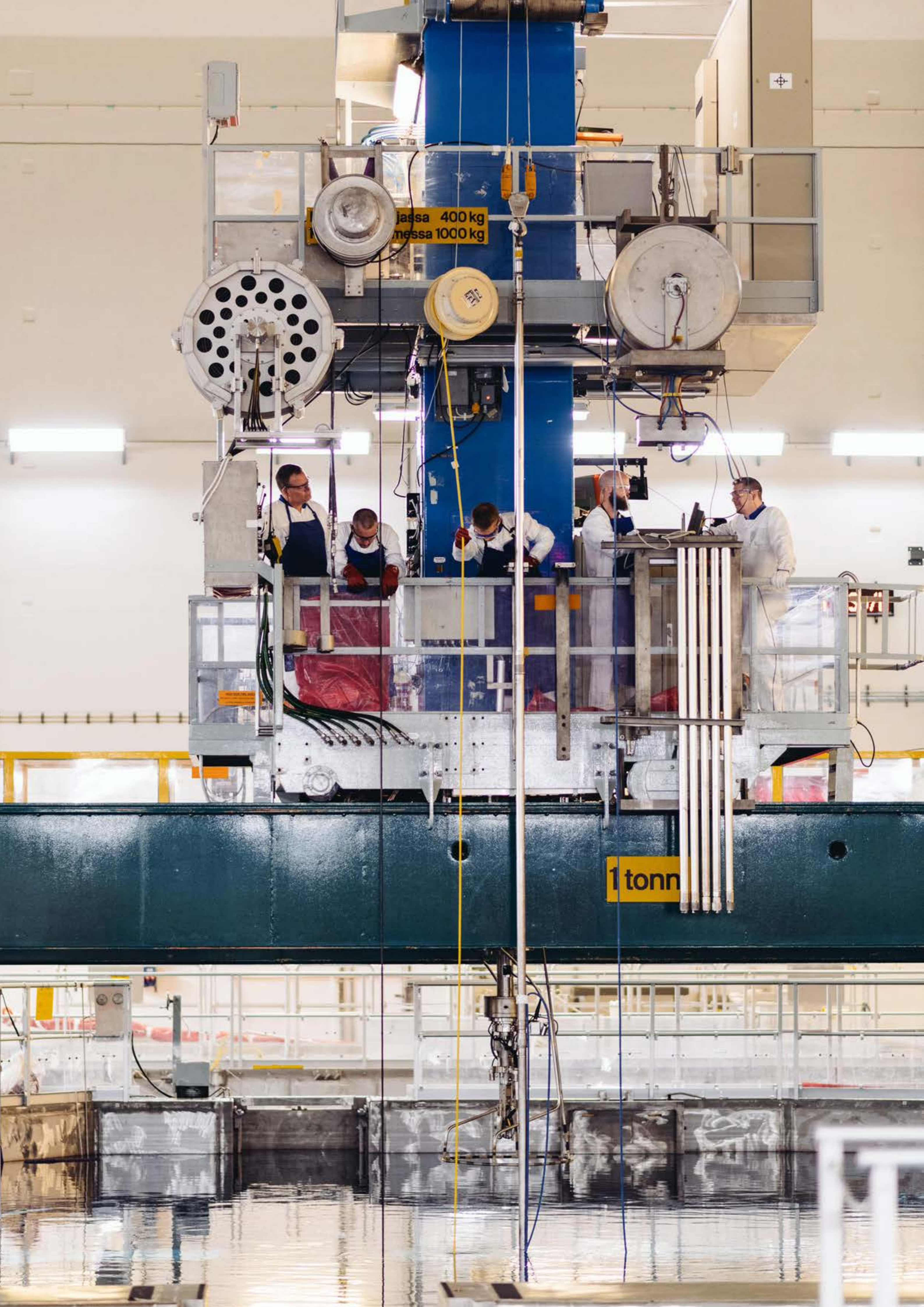
In all their radiation protection activities, TVO and its personnel are committed to following the principle of ALARA (As Low As Reasonably Achievable). According to the principle, individual and collective radiation doses are kept as low as possible by practical measures. Limiting the doses and keeping the level of radioactive releases as low as possible are already taken into account when designing the plant structures and functions. Each employee must take radiation protection matters into account in their own work. In addition to authority guidelines, the development of radiation protection operations also takes international recommendations into account.

At a nuclear power plant, radioactive substances are mainly formed as fission products as the atom nuclei in the fuel split, inside the reactor and in its vicinity by means of neutron activation, and as the products of radioactive decay chains of the substances mentioned above. Systems containing radioactive substances are located inside what is known as the radiation controlled area. In the radiation controlled area, specific safety instructions are followed in order to protect against radiation. Continuous radiation monitoring has been arranged for personnel working in the radiation controlled area, and radiation measurements are performed on people and items when leaving the radiation controlled area.

Radioactive releases from the OL1 and OL2 plant units are monitored by means of release measurements, and the dispersion of the releases into the environment are tracked in accordance with an environmental radiation monitoring programme approved by STUK. Environmental radiation monitoring is based on continuous dose rate measurements, air and fallout samples, sea water samples and samples taken from the food chain. The releases from the OL1 and OL2 plant units are reported to STUK for each quarter. Independent monitoring performed by STUK supplements the monitoring performed by TVO. Structural radiation protection, radiation monitoring for the personnel, release monitoring and environmental radiation monitoring are implemented under STUK's supervision.

According to section 13 of the Government Decree on Ionizing Radiation, the effective dose of a radiation worker must not exceed 20 mSv (millisieverts) per year. TVO's own targets regarding individual annual doses are keeping the dose obtained by all Olkiluoto employees from their work below 10 mSv per year and keeping doses caused by internal contamination below 0.5 mSv. During the normal operation of the OL1 and OL2 plant units, radiation doses incurred by the personnel are clearly below these dose limits.

The Nuclear Energy Decree (161/1988) and the Government Decree on Ionizing Radiation (1034/2018) set the limit values for radiation doses for the normal operation of nuclear facilities as well as for accident conditions. The limit value for the annual dose incurred by an individual from the normal operation of a nuclear power plant is 0.1 mSv, which is less than 2% of the average annual dose of 5.9 mSv incurred by Finns due to radiation. In recent years, the actual radiation dose incurred by individuals in the vicinity of the OL1 and OL2 plant units has been approximately 0.2% (approx. 0.0002 mSv) of the dose limit set in the Nuclear Energy Decree, and less than one ten-thousandth of the normal annual radiation dose received by Finns from other sources on average.


jassa 400 kg
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1 tonn

3. Project description

3.1. Summary of the alternatives

The enclosed tables (Table 4, Table 5, Table 6) present key figures for OL1 and OL2 during the current operation (VE0) and compare them to extending the service life at the current power level (VE1) and extending the service life at an uprated power level (VE2).

Table 4. Key figures in the various alternatives (per plant unit).

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Plant type	Boiling water reactor		
Electrical power output	890 MW		970 MW
Thermal power	2,500 MW		2,750 MW
Efficiency	35.6%		35.3%
Efficiency	70 bar		
Electricity production	approx. 7 TWh/a		approx. 7.6 TWh/a

Table 5. Key figures in the various alternatives (OL1 and OL2 plant units in total).

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Thermal power routed into the water system	98,000 TJ/a		109,000 TJ/a
Volume of cooling water	38 m^3/s per plant unit		
Increase in cooling water temperature	10°C		11°C
Fuel procurement and accumulation of spent fuel	18 tU/v per plant unit		
Fuel procurement and accumulation of spent fuel (during the entire service life)	2,483 tU (in 2038)	2,861 tU (in 2048) 3,240 tU (in 2058)	
Very low, low and intermediate-level waste	50 m^3/a		
Very low, low and intermediate-level waste (entire service life)	8,250 m^3 (in 2038)	8,750 m^3 (in 2048) 9,250 m^3 (in 2058)	
Chemicals	Sulphuric acid 18 t/a Sodium hydroxide 14 t/a Ion exchange resins 14 t/a Sodium hypochlorite (100%) 8 t/a Glycol 5 t/a Nitrogen 140 t/a Bitumen 14 t/a Light fuel oil 255 t/a		

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Releases of radioactive substances into the air*	Noble gases (Kr-87equiv.): 0–9.7 TBq/a. Release limita: 9,420 TBq/a Iodine (I-131): 0.00000008–0.002 TBq/a. Release limit: 0.1 TBq/a Aerosols: 0.000007–0.2 TBq/a Carbon-14 (C-14): 0.6–1.2 TBq/a Tritium (H-3): 0.2–2.7 TBq/a		
Releases of radioactive substances into water*	Fission and activation products: 0.00008–0.0006 TBq/a. Release limit: 0.3 TBq Tritium (H-3): 1.3–2.5 TBq/a. Release limit: 18.3 TBq		
Greenhouse gas emissions (emergency generators)	914 t CO_{2e}/a		927 t CO_{2e}/a
Other releases into the air	NO_x: 1.2 t/a SO_2: 0.0 t/a Particles: 0.1 t/a		
Process waste water	total 25,000 m^3/a Phosphorus: 5 kg/a, Nitrogen: 100 kg/a		

* Range of variation for OL1 and OL2 in 2007–2022. The highest values in the actual release ranges have been related to rare fuel leakages.

Table 6. Key figures in the various alternatives (OL1, OL2 and OL3 plant units in total).

	VE0 current operation	VE1 Continuing operation at current power level	VE2 Continuing operation at uprated power level
Service water	268,000 m^3/a		
Household waste water*	total 78,905 m^3/a Phosphorus: 15 kg/a, Nitrogen: 3,642 kg/a, BOD_{7ATU}: 629 kg/a		
Conventional waste	Recyclable waste: 2,650 t/a Hazardous waste: 210 t/a Landfill waste: 0 t/a		
Noise*	Nearest holiday housing (Leppäkarta) 39,4–42,1 dB, main gate 48,6–56,3 dB		
Traffic*	Approximately 1,050 avehicles/day. During annual outages, increases by approximately 1,000 vehicles/day.		

* Includes the operations of Teollisuuden Voima and Posiva.

3.2. Service life extension

This chapter describes actions related to continuing the operation of the OL1 and OL2 plant units that are similar to the current operation of the plant units. Changes to the current situation brought about by the thermal power uprating of the plant units are described in chapter 3.3.

3.2.1. Service life management and maintenance

The OL1 and OL2 plant units are among the best nuclear power plants in the world in terms of operability and safety. The annual capacity factors for the OL1 and OL2 plant units have been consistently around 90%, on average, and the indicators measuring safety are at a good level. This has been due, in part, to the approach chosen by TVO, which has been one of continuously improving safety and ensuring operability. The result has been achieved through proactive equipment replacements, comprehensive preventive maintenance and the development of the plant units' processes, which allow for good operability and the gradual improvement of the plant units' efficiency.

As regards the service life extension, the same basic principles for nuclear safety and radiological safety will be observed as are used during the current operation of the power plant, taking into account the requirements of evolving legislation. During the possible service life extension, safety improvements will also be made in line with a good level of safety culture.

Annual outages and modernisation projects

The OL1 and OL2 plant units have been systematically developed over the decades. TVO systematically modernises the plant units during annual outages and through modernisation projects. State-of-the-art solutions that improve operability, productivity and safety are being commissioned throughout the service life.

The nuclear power plant units at Olkiluoto are constantly kept in good condition by alternating between refuelling outages and service outages at the plant units. The annual outages for the OL1 and OL2 plant units, which take place each spring, usually start with a refuelling outage where the uranium fuel is replaced and the necessary defect repairs and maintenance are performed, along with any possible preparatory work for the plant unit's service outage for the next year. A refuelling outage usually lasts for approximately one week.

Annual outages at the OL1 and OL2 plant units continue with a service outage on the other plant unit, where major maintenance tasks and modifications are performed in addition to the refuelling. A service outage usually lasts for 2–3 weeks. Large-scale modernisation and overhaul projects have been completed during service outages approximately once every 5 years. At the OL1 and OL2 plant units, annual outages usually take place in April–June.

Ageing management

The ageing management for the plant units is integrated into TVO's daily operations. The goal for ageing management is to keep the plants up to date and in good condition in terms of their safety and availability. TVO's ageing management covers the safety-relevant systems, structures and components of the OL1 and OL2 plant units, the VLJ repository and the KPA storage. Substantial investments have been made in the plant units during their entire service life, thereby guaranteeing their disturbance-free and safe operation. A high level of investment has also enabled efficient and proactive ageing management. Efficient anticipation and management of ageing allows for extending the service life in line with current processes. The key analyses for the ageing of structures and components at the OL1 and OL2 plant units have been drawn up for a service life of 60 years; if the service life is extended, they will be updated for 80 years of operation. At the moment, no ageing mechanisms are known that would limit the technical service life of the plant units, taking into account the planned schedules of the project alternatives examined in the EIA.

TVO's more detailed plant-specific ageing management programmes are targeted towards plant sections that are important for safety. The determination of plant components important for safety utilises the plant units' Technical Specifications, safety classification and probability-based risk analysis. The inspection locations for the piping and piping supports for systems important for safety are determined on the basis of a risk-aware approach. The inspection locations are regularly updated on the basis of inspections, observations and operating experience received from other plants.

Ageing management for components important to safety has been improved by means of the equipment location-specific identification of ageing phenomena and an assessment of the adequacy of current actions.

The collection and update of the condition status and investment needs for the plant units' systems are performed annually in connection with the equipment and system ownership analyses. In other respects, the ageing of the plant units will be managed according to the normal programmes for maintenance, preventive maintenance, operation, chemistry and inspections. Ageing management also includes the management of technological obsolescence and maintaining a sufficient spare parts inventory.

During continued operation of the plant units, ageing management and its related processes as well as maintenance will continue under STUK's supervision, similarly to the current operation.

The systems, structures and components of power plant units are subject to various types of stress during their operation. This results in normal wear as a result of equipment operation or the fatigue of their structural materials, which may result in degraded integrity and operability. The authority requirements and other requirements targeting the systems, structures and components may change over the course of the power plant's operation, and the technology being used may develop in ways where the systems, structures and components no longer meet the current level of requirements. These factors, which are also referred to as the ageing of systems, structures and components, are prepared for during the design stage through justified design solutions and, during operation, by monitoring and maintaining the operability of systems, structures and components until their decommissioning. This includes, for example, periodic tests and inspections of the equipment as well as preventive and corrective maintenance. This allows for ensuring that the systems, structures and components operate as planned. Furthermore, the approvals of electrical I&C components approved for use for a set period of time under accident conditions are kept in force by means of new analyses or component replacements.

The suitability of the OL1 and OL2 plant units for a service life of 60 years has been demonstrated by means of analyses. In practice, this means that the load analyses, strength, fatigue and radiation tolerance and operational capabilities of the systems important for the safety of the plant unit and their components have been demonstrated to be sufficient. When the service life of the plant units is extended until 2048 or 2058, the suitability of the systems must be demonstrated for a service life of 70 or 80 years. The plan is to complete this with the help of a separate management programme by 2038, when the service life of 60 years is reached. This may cause a need to replace system components at the plant units. Ageing management is the responsibility of appointed system owners who monitor the condition of systems and take the necessary actions if shortcomings are observed in the operation of systems. Preventive maintenance performed at the plant units and periodic tests of systems are used to ensure that systems, structures and components meet the operability requirements under normal operating conditions as well as during incidents and accidents.

The load and strength calculations for the piping and supports for the reactor containment of the OL1 and OL2 plant units. The analysis takes into account the mechanical and thermal loads targeting the structures during their service life as well as erosion, corrosion and other key damage mechanisms. In the load monitoring of the operational events during the plant units' operation, the momentary load cycles occurring in the primary and secondary circuits are documented and an annual summary report is prepared regarding them.

The design basis used for the periodic inspection programmes for piping and components is the nuclear power plant standard from ASME (American Society of Mechanical Engineering). The programmes cover equipment and structures in Safety Class 1 and 2 as well as other equipment and structured assessed to be important in terms of nuclear safety. The standard defines the inspection targets and intervals.

The OL1 and OL2 plant units utilise a materials tracking programme. The programme is used to collect and store material samples of at least those plant components that are not designed to be replaceable during the service life of the nuclear facility and from which reference data concerning the structural material may be required later in order to evaluate the operability of the plant component or the repair method.

The operation and maintenance operations have prepared for the ageing of mechanical components. A maintenance class is defined for each equipment location. The maintenance class affects, among other things, the spare parts arrangements for the equipment location and the selection of preventive and corrective maintenance tasks. As regards mechanical plant components and construction components, the actions for plant components targeting less demanding conditions have been defined on a material technology basis. Spot checks are also used for ageing management. The aim is to focus them on locations where the modernisation or replacement of the equipment is not expected in the near future. The service life of other mechanical equipment is monitored according to the principles of ageing management, which allows the necessary repairs and replacements to take place as required. The operating organisation for the plants performs periodic tests on systems participating in safety functions in a temporally distributed manner, one subsystem at a time.

The ageing management programme for electrical and I&C plant components consists of periodic tests and preventive maintenance programmes compiled on a systematic basis. A service life and service life monitoring have been defined for electrical and I&C components and their subcomponents that operate under demanding conditions inside the containment. Additionally, they are classified as separately monitored equipment in the maintenance system, and replacement days have been defined for them in the preventive maintenance programme. The service life of other electrical and I&C equipment is monitored according to the principles of ageing management, which allows the necessary repairs and replacements to take place as required.

The inspection, testing and measurement actions as well as the investigations to be performed have been defined for the cables, conductors, connections and casings inside the containment of the OL1 and OL2 plant units. Similar actions are also taken on the containment-external electrical and I&C cables. The actual actions are defined in the preventive maintenance system, to be performed as part of the maintenance of the plant units.

The ageing of the buildings for the OL1 and OL2 plant units is monitored regularly by using periodic inspections and separate analyses. The lengths of the inspection cycles have been defined for the different buildings on the basis of their importance. Critical building parts that require more detailed condition monitoring (e.g. containment and sea water structures) have been separately defined and dedicated monitoring programmes have been developed for them.

The condition monitoring for equipment at the OL1 and OL2 plant units is performed as either periodic or continuous condition monitoring. Periodic condition monitoring is implemented by operation and maintenance during inspection rounds where data from the selected locations is collected into a database. TVO's preventive maintenance programme is used to control the condition monitoring inspections. Continuous condition monitoring covers equipment and structures that are highly significant in terms of the plant's safety and availability. For example, the reactor's recirculation pumps as well as turbines and main generators are covered by continuous condition monitoring.

Best Available Technique (BAT)

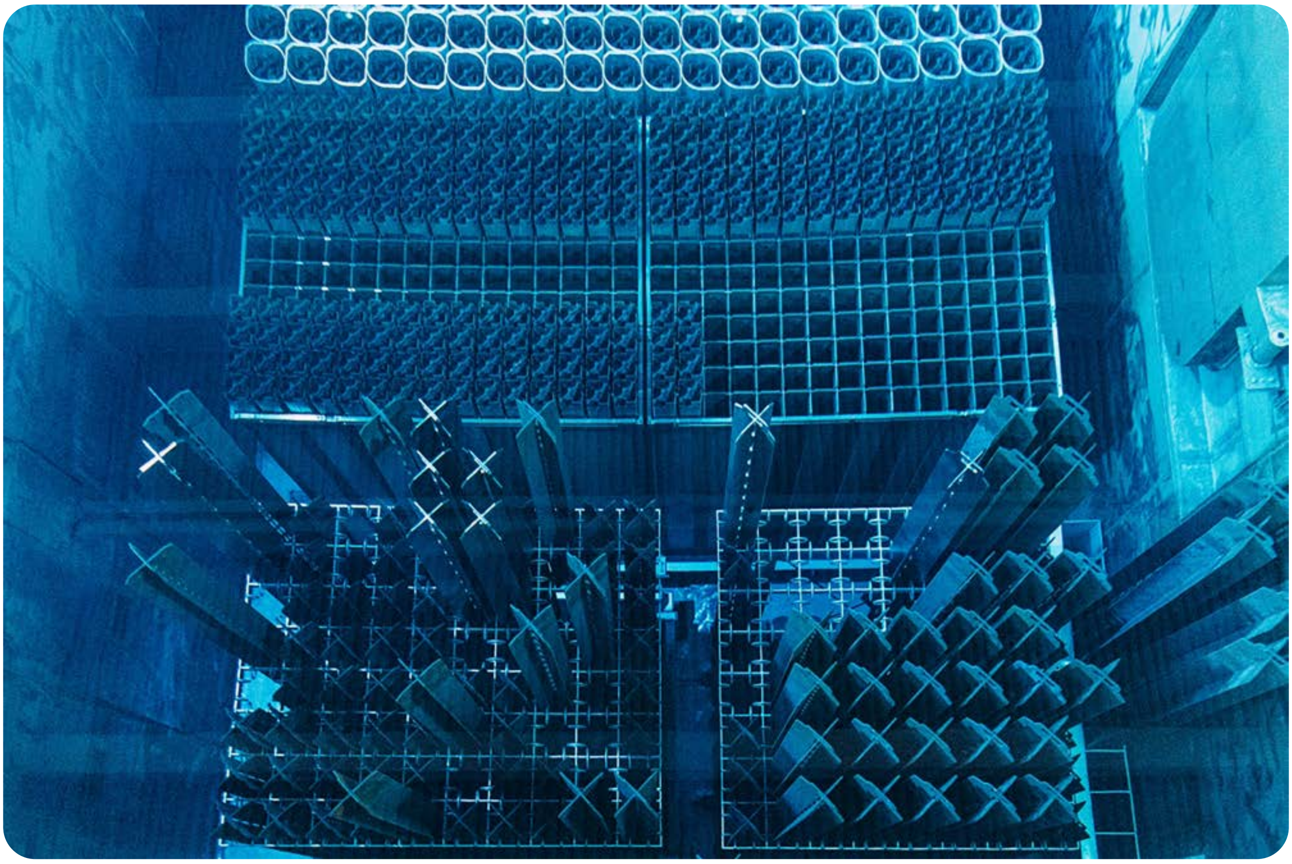
TVO aims to minimise releases from the OL1 and OL2 plant units by means of high-quality operations. The prevention of fuel failures and minimising the volume of generated waste aims to preserve the low release levels into the water and air, which have been seen during the past years during the continuation of operation. Technological developments are tracked at the Olkiluoto power plant also in order to ensure that the BAT (Best Available Technique) principle is implemented. In connection with limiting releases, the starting point for the BAT principle is to use the best available techniques that are technically and financially feasible and can be implemented at a reasonable cost to limit releases. When pursuing the BAT principle, however, the broader perspective of the radiation protection optimisation principle ALARA (As Low As Reasonably Achievable) must also be considered. According to the ALARA principle, the radiation exposure of the power plant employees must be considered in addition to the exposure of the inhabitants in nearby areas. The feasibility of a technique depends on the overall picture formed from these perspectives.

In limiting radioactive releases, the key factor is preserving fuel integrity. This is significantly affected by the cleanliness of the process, that is, the prevention of foreign material in the primary circuit. The aim is to prevent fuel failures and, in case of failure, to take commensurate action. In order to achieve this goal, a carefully considered fuel policy and appropriate approaches are applied to fuel procurements, planning of the reactor's mode of operation and while monitoring the progress of a fuel failure and planning any possible further actions once possible fuel damage has been observed. The approaches include, among other things, the prevention of foreign material ingress into the reactor, the utilisation of operating experience concerning fuel, observing earlier experience of fuel failures, monitoring and analysing failures, reporting on observations and replanning the operation of the reactor and control rods in order to limit the growth of the leak. Furthermore, inspections are performed on fuel assemblies and, in case of a fuel failure, the leak is located, the cause of the damage is analysed, the leaking fuel rod is removed and hermetically isolated and any experiences and actions taken are documented. The development of the fuel's mechanical structure, such as the foreign material exclusion (FME) screen, has also been considered when selecting the fuel types to be used in order to minimise the risk of fuel damage caused by foreign material. TVO uses state-of-the-art FME screens in its fuel, and they offer significantly better protection against foreign material than earlier designs.

One of the significant practical actions taken at TVO in order to reduce fuel failures has been to construct a new feed water recirculation line at the turbine plant. It allows for circulating feed water at the turbine plant more efficiently before it is routed into the reactor. The purpose of this is to remove any foreign material that has been left over in the turbine plant piping during the annual outages before water is taken into the reactor.

In terms of plant, radiation and personnel safety, it is important that any debris, impurities and foreign materials are prevented from entering the process. Cleanliness and the risk of foreign material are observed whenever materials or tools are taken to the plant and during the work, up to the point where any material and tools remaining after the work have been returned to their appropriate locations.

High-quality water chemistry is important for the power plant's radioactivity levels and corrosion. At NWC (Normal Water Chemistry) plants, which the OL1 and OL2 plant units represent, the optimal conductivity for reactor water is less than 0.1 S/cm (siemens per centimetre). The level of both radioactive and non-radioactive impurities must be kept at an optimal level, which most commonly means keeping the concentrations as low as possible.



Hermetically sealing leaking fuel rods in their own storage canisters has reduced the concentration of a possible Cs-137 water effluent, naturally depending on the extent of the fuel damage. Due to the adoption of this method and the commissioning of upgrades to the liquid waste handling systems, such as pre-filtration, Cs-137 concentrations have been below the limit of identification since 2007. Improvements in water treatment over the last 20 years have reduced the Co-60 concentration and other activated corrosion products. TVO has been engaged in long-term work towards minimising radioactive water effluents since 1994. TVO has utilised pre-filtration, separators and evaporators in water treatment. These actions have allowed TVO to reduce Cs-137 effluents, among others.

TVO is closely monitoring technological progress and always aims to utilise the best available techniques in order to keep the releases of radioactive substances caused by the operation of the nuclear power plant and, thereby, environmental radiation exposure as low as reasonably achievable. The reduction in the concentrations of radioactive water effluents and air releases in the long term provides an example of this.

The flow-through sea water cooling used at all three plant units at Olkiluoto is the best available cooling method under Finnish conditions. It achieves a higher electricity production efficiency than other cooling methods. Furthermore, the investment and operating costs are lower than in a cooling tower solution. Depending on environmental conditions, the relative benefits of flow-through cooling may be up to several percentage points higher than a cooling tower solution. At the cooling water inlet, the flow rate of the water outside of the structure is as low as possible. A low flow rate reduces the number of hazardous situations for marine traffic and the amount of fish and aquatic vegetation arriving at the plant unit, which also allows the travelling basket filters belonging to the cooling water clean-up system to operate more reliably under all conditions.

The power plant employs a certified environmental management system, the key practices of which are compiled in the environmental manual. The target for the environmental management system is the continuous improvement of operations and raising the level of environmental protection. Targets are set for minimising the detrimental environmental impacts of operations; they aim at preventing or reducing releases and the generation of waste as well as improving energy efficiency. The achievement of environmental targets is monitored by maintaining a log of the volume of waste as well as their handling and utilisation. The collection and handling of conventional waste is based on the presented approaches and guidelines, and on keeping the volume of generated waste as low as possible and the relative proportion of waste sent for reutilisation high.

Practices related to the best available techniques will also be adhered to in any equipment replacements related to the service life extension of the plant units.

3.2.2. Construction and modifications

The maintenance and improvement work required by the service life extension of the OL1 and OL2 plant units will be implemented in accordance with a long-term plan. The plans are specified on the basis of findings arising from TVO’s system ownership, maintenance and inspection plans.

Already at present, the emergency diesel generator and I&C system replacements are under way as regards service life management. Major updates related to service life extension involve, among other things, investments related to other I&C systems and the main generator as well as the replacement of mechanical components (valves, pumps, heat exchangers) that have been considered in the long-term plan drawn up for the plant units. The current plan includes approximately 100 identified modernisation projects, most of which are equipment and system replacements related to ageing management. The largest modernisation and overhaul projects are completed during service outages approximately once every 5 years.

The I&C modernisation that is currently under way at TVO’s OL1 and OL2 plant units renovates the I&C systems that control the operation of the reactor. The modernisation will replace the reactor’s power measurement and control systems as well as the pressure and water level control systems. Some of these represent original technology, some were already replaced once in the 1990s. In addition to these, the replacements of reactor I&C safety functions are under way at TVO; as part of this work, relay cabinets related to the operation of I&C systems are being replaced with new ones that are similar to those currently installed at the plant. No system functions are modified at this time; instead, the replacements ensure the reliable operation of the systems and their high availability going forward. Replacing the equipment also secures access to spare parts and product support well into the future.

Additionally, normal structural replacements based on the condition monitoring of buildings and the replacement of roofs, coatings, tunnels, after-fixings, sewage pipes, subsurface drains and water pool coatings are carried out at the plant units.

As regards the service life extension, construction work outside of the plant units will only be carried out in case of a capacity extension at the KPA storage (described in section 3.2.6).

3.2.3. Cooling water

The power plant units use cooling water for cooling the turbine condensers. Cooling water for the Olkiluoto power plant is taken from the southern side of Olkiluoto Island, on the shore of Olkiluodonvesi to the south of the OL1 and OL2 plant units (Figure 6). The volume of cooling water used by the OL1 and OL2 plant units is approximately 38 cubic metres per second (m^3/s) per plant unit. At present, the process heats the cooling water by approximately 10°C, and the water is routed back into the sea along the discharge tunnels and outlet channel. The cooling water ends up on the Iso-Kaalonperä bay located at the western end of the island (Figure 6). Aside from the temperature increase, the quality of the cooling water will not change as it flows through the nuclear power plant. The average thermal load into the sea from the OL1 and OL2 plant units is approximately 98,000 terajoules (TJ) per year. The thermal load has remained fairly stable in recent years.

A service life extension will not change how the cooling water is acquired. The thermal power routed into the water system and the volume and temperature of cooling water will remain the same. The cooling water intake and discharge locations will remain as they are.

3.2.4. Service water and wastewater

Service water

In addition to cooling water, a nuclear power plant requires raw water. The raw freshwater required in the power plant area is extracted from the lower reaches of Eurajoki, upstream of Tiironkoski rapids, and from Lapinjoki. In 2023, 272,713 cubic metres (m^3) were extracted from Eurajoki and 6,920 m^3 from Lapinjoki. The amounts vary each year. Raw water extracted from Eurajoki is pumped along a pipe of approximately 9 kilometres (km) in length to the Korvensuo pool at Olkiluoto; the pipe from Lapinjoki is approximately 15 km in length.

At Korvensuo, the water is treated in a sand filter and then routed into a storage reservoir constructed from soil that has a capacity of approx. 140,000 m^3. On average, 268,000 m^3 of raw water is extracted per year. Of this water, approximately one half is used as household water and half as process water, fire-fighting water and for other uses. The required demineralised process water is manufactured at the demineralisation plant by using ion exchange technology.

The service life extension does not change the power plant's current annual water requirement and supply.

Wastewater

Since December 2023, wastewater from the power plant has been routed via a transit sewer duct to the treatment plant jointly operated by the City of Rauma and the forestry industry. The processing of wastewater in a larger unit allows for its more efficient purification and reduces the load caused on the water systems. The total annual volume of household wastewater has been approximately 78,905 m^3 when considering the average for the OL1, OL2 and OL3 plant units from 2019–2023. The amount of phosphorus routed into the sea has been 15 kilograms per year (kg/a), while for nitrogen the value has been 3,642 kg/a and, for BOD_{7ATU}, 629 kg/a. These amounts will remain unchanged in the wastewater routed via the transit sewer in case the service life is extended.

At the power plant, process wastewater is mainly generated from the leak, drain, rinse and purge water coming from the radiation controlled areas of the power plant buildings and storages. The average volume of process water from the OL1 and OL2 plant unit has been approximately 25,000 cubic metres per year (m^3/a). Following activity concentration control, process wastewater from the plant units is routed into the cooling water discharge channel. The concentrations and releases of radioactive substances in the process wastewater is defined by means of samples taken before the pump-out tank before routing into the discharge channel, and from compiled samples taken during the pump-out. Nutrient releases into the sea from the process water have been approximately 5 kg/a for phosphorus and 100 kg/a for nitrogen. Extending the service life will not change the amount or composition of the process wastewater or its treatment.

Wastewater generated in the power plant area includes, for example, water from the raw water treatment plant and demineralisation plant, water from the liquid waste processing plant and rinse water from the travelling basket filters of the sea water pumphouses. Following appropriate processing, this water is routed into the sea via the discharge tunnel, along with the cooling water.

Rainwater is routed into the sea by way of the rainwater sewer network. The discharge of rainwater from the north part of the site area occurs in the cooling water discharge channel and, from the south part, in Olkiluodonvesi to the west of the cooling water inlet channel. Any possible oily rainwater is processed in oil separators before being routed into the sewer network. The subsurface drains of the power plant buildings' foundations are routed, via subsurface water wells, into the rain water sewers or the discharge channel. The surfaces in the site area have been levelled in a manner where, in case of exceptional flooding or heavy rainfall, rainwater will not flow inside the buildings or into their foundations; instead, they are allowed to flow directly into the sea without causing any damage or detriment.

3.2.5. Nuclear fuel procurement

The reactor core for OL1 and OL2 consists of 500 fuel assemblies, control rods and various detectors. The fuel assemblies are located inside fuel channels that route the reactor's recirculation flow around the fuel rods. Neutron flux detectors located on different sides of the reactor core are used to monitor the operation of the reactor and the power distribution.

Depending on the fuel type, each fuel assembly has approximately 90 to 110 metal clad fuel rods. The fuel rods contain uranium fuel. The uranium fuel consists of small sintered tablets made of uranium dioxide (UO_2) that contain uranium enriched for the fissile isotope U-235. The fuel has an enrichment of approximately 3–5%.

Over the course of one year, the OL1 and OL2 plant units require approximately 36 tonnes (t) of low-enrichment uranium for their fuel. In the service life extension scenario, the amount of nuclear fuel used each year will remain at the present level. However, the total amount of spent nuclear fuel will increase according to the number of additional years of operation. If operation is continued from 2038 until 2048, the total amount of nuclear fuel to be acquired will increase by a total of approximately 378 tonnes of uranium (tU). If operation continues until 2058, the corresponding addition will be approximately 757 tU.

TVO procures its fuel via a diversified procurement chain, and there are several suppliers for each stage of the chain. TVO has long-term contracts with leading uranium and fuel suppliers that TVO is constantly tracking and assessing. Uranium is only acquired from suppliers who meet the strict requirements set by TVO. Leading uranium suppliers have mining operations in several countries. At present, the countries with the highest uranium production are Kazakhstan, Canada, Namibia and Australia.

Fuel is transported to Olkiluoto as completed fuel assemblies. Due to the low radiation levels in fresh fuel, the packaging requires no radiation protection features; as a result, it is transported into the site area by boat and lorry.

3.2.6. Spent nuclear fue

During operation, nuclear fuel becomes highly radioactive inside the reactor, which means that its handling and storage require special procedures.

The reactor cores of the OL1 and OL2 plant units have approximately 500 fuel assemblies, 90–110 of which are changed each year depending on the annual outage interval variation. Approximately 18 tU of spent nuclear fuel is generated from the operation each year per plant unit. In the case of a service life extension, the annual accumulation of spent nuclear fuel will remain at the present level, but its total volume will increase according to the number of additional years of operation. For current operation, the total volume of spent nuclear fuel generated during the entire operating period is 2,483 tU (by 2038). If the service life is extended until 2048, the total amount of spent nuclear fuel accumulated will be approximately 2,861 tU; by 2058, it will be approximately 3,240 tU.

Once spent fuel has been removed from the reactor, it is stored underwater in the pool of the reactor building for a few years, after which its radioactivity and heat generation will be substantially reduced. Water acts as a radiation shield and cools the spent fuel. Following this, the spent fuel is transferred to the power plant's interim storage for spent nuclear fuel (KPA storage) where it is stored inside water pools (KPA-storage, Figure 7). Fuel transfers between the reactor building and fuel storage are carried out by using a special transfer cask that protects against radiation.

Presently, the KPA storage building has 7 storage pools. Four pools are reserved for fuel from the OL1 and OL2 plant units, two pools for fuel from the OL3 plant unit and one pool acts as the reserve pool (known as the evacuation pool). Currently, the total storage capacity is 12,400 assemblies for fuel from the OL1 and OL2 plant units and 1,600 assemblies for the OL3 plant unit. In total, 14,000 assemblies contain 3,040 tU of uranium. By 2023, a total of 10,118 assemblies of spent nuclear fuel have been generated from the operation of the OL1 and OL2 plant units. At the moment, 8,770 spent fuel assemblies are stored at the KPA storage and 1,348 assemblies are stored in the water pools of the OL1 and OL2 plant units.

At the KPA storage, fuel is cooled inside water pools. The cooling of the pools is secured by means of two parallel cooling systems, only one of which is normally used. The heat transferred from the fuel into the water is transferred into a secondary cooling circuit by means of a heat exchanger and, from there, further into the sea water cooling circuit via a heat exchanger. All cooling circuits are discrete and the water inside them will not come into contact with water from the other circuits. Cooling water for the KPA storage is extracted from and discharged into Olkiluodonvesi by using dedicated extraction and discharge pipes (Figure 8). Approximately 50 litres per second (l/s) of cooling water is extracted and discharged. The cooling system in the KPA storage is dimensioned for residual heat of at most 2,100 kilowatts (kW). At present, the residual heat generated by the spent fuel at the KPA storage is approximately 1,600 kW, in which case the thermal load of the cooling water returned into the sea is approximately 7.6 degrees higher than that of the extracted water.

In the KPA storage, the fuel assemblies are stored inside water pools for several decades, until their activity and heat generation are low enough to allow them to be transferred to Posiva's encapsulation plant and disposal facility for spent fuel. There, the spent fuel is packed and sealed into final disposal canisters and then transferred to the disposal facility for spent nuclear fuel that is located underground at a depth of more than 400 metres (m).

If Posiva starts the final disposal activities during the 2020s as per the current plan, capacity in the KPA storage will be sufficient even in the service life extension case. If the start of final disposal activities at Posiva were to be substantially delayed for some reason, the storage capacity at the KPA storage will need to be increased.

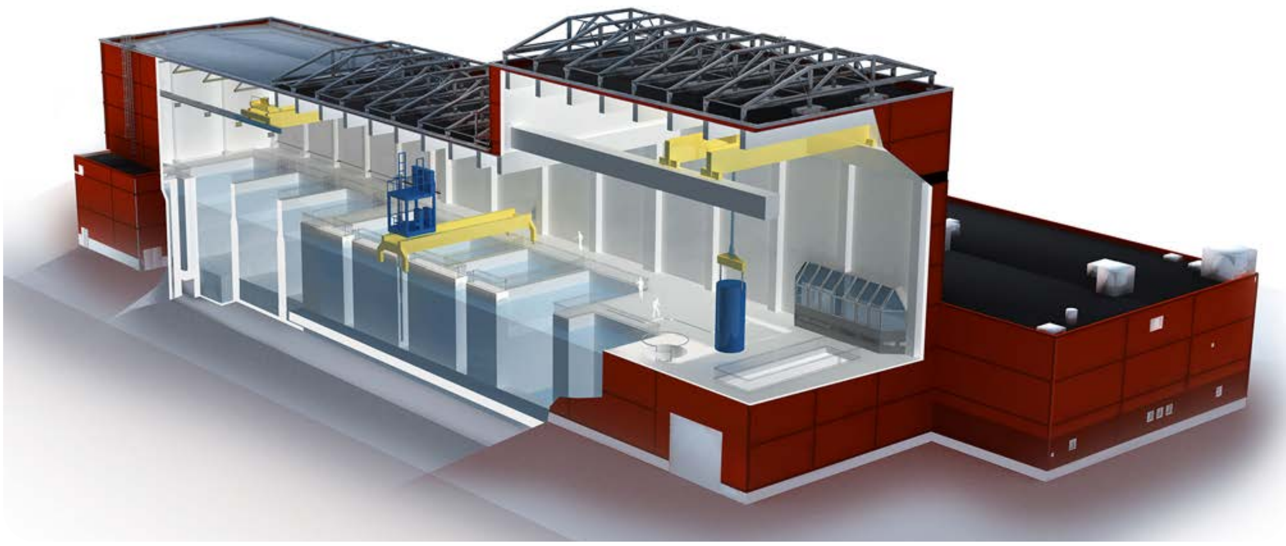


Figure 7. Current storage for spent fuel (KPA storage).

For example, the increase in storage capacity may be implemented by expanding the current KPA storage and constructing new pools as an extension of the current pools. In practice, this corresponds to the KPA storage extension completed in the 2010s where three new pools were added to the KPA storage. During the expansion, the necessary number of new pools and the piping required for their cooling will be constructed. The extraction and discharge locations will remain as they are. If three more pools were to be constructed at the KPA storage, this would increase the current thermal load by approximately 50%. In this case, the flow rate of the cooling water extracted from the sea and returned there would be increased correspondingly, and the temperature of the water returned into the sea will not rise from the current level.

Construction work on a potential expansion of the KPA storage is estimated to last for approximately two years. During construction, traffic volumes would increase by an estimated 5 lorries per day, while passenger traffic would increase by an estimated few dozen vehicles per day. Some transports will be special transports.

3.2.7. Very low, low and intermediate-level waste

In addition to spent nuclear fuel, very low, low and intermediate-level operating waste is generated during the operation of a nuclear power plant.

Intermediate-level waste has an activity concentration of more than 1 megabecquerels per kilogram (MBq/kg) but no more than 10 gigabecquerels per kilogram (GBq/kg), and its processing requires efficient radiation protection arrangements. Intermediate-level waste generated at the power plant is mostly liquid radioactive waste generated from the radioactive process and sewer systems during the operation of the power plant. Liquid waste comprises the ion exchange resins used for cleaning process systems, the evaporation concentrate from sewage water and various sludges and deposits generated during tank cleaning, for example.

During the current operation of the power plant, most of the radioactive waste generated in the radiation controlled area is low-level waste. This waste mainly consists of service waste (such as insulation material, parts of machinery and equipment, used tools and packaging material). Low-level waste has an activity concentration of less than 1 MBq/kg, and it can be handled without specific radiation protection arrangements.

Very low-level waste with an activity level of less than 100 kilobecquerels per kilogram (kBq/kg) is also generated at the power plant. Some of the waste also qualifies for clearance from regulatory control; due to its low level of radioactivity, it may be cleared from control under Section 27 c of the Nuclear Energy Act and processed further in a manner similar to that for conventional industrial waste.

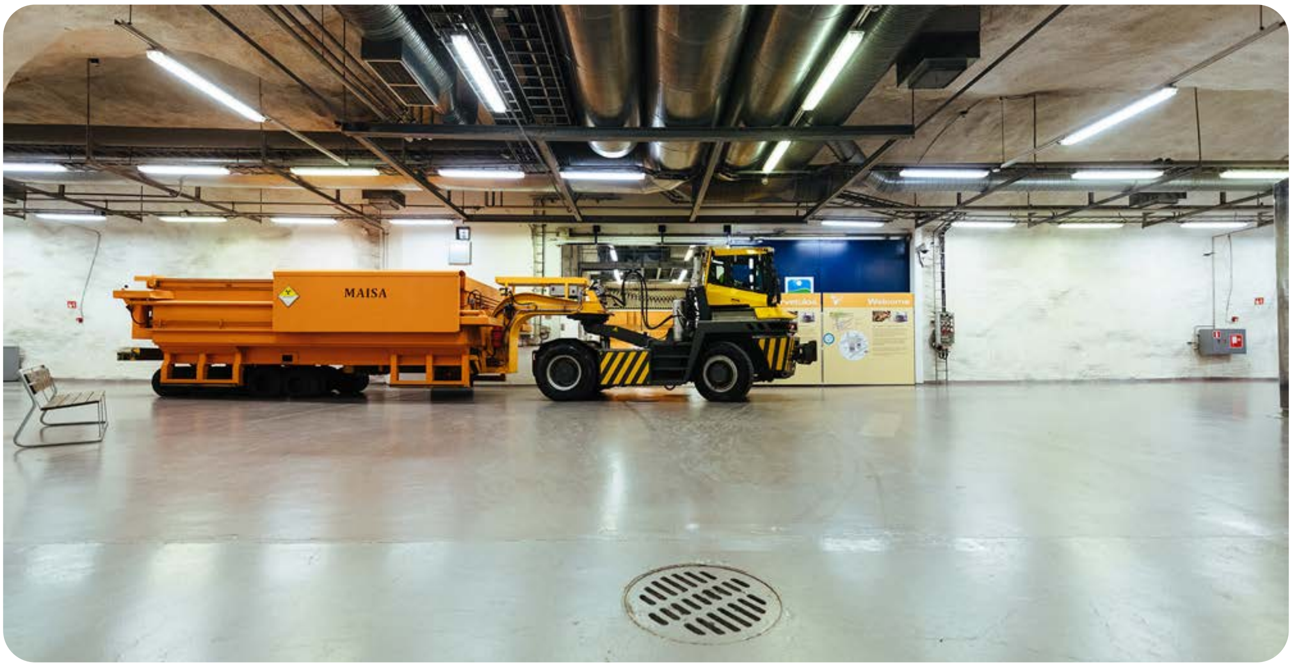
Most of this waste is immediately packed for handling, storage and final disposal. Very low-level waste is embaled or packed directly inside containers and placed in the HMAJ interim storage area at the end of the KAJ storage to await final disposal. Waste generated in the radiation controlled area of the power plant is temporarily stored in the storage facilities of the power plant units' waste buildings and in the reactor building fuel pools, the KAJ and MAJ storage facilities and, to a lesser extent, also inside the KPA storage. At the MAJ storage, the compressible part of dry low-level maintenance waste is packed as is or broken down and packed into 200-litre (l) steel drums which are then compressed to half of their original volume. Any contaminated scrap metal is decontaminated, broken down and compressed, if necessary, and packed inside drums or concrete boxes. Intermediate-level ion exchange resin generated during water clean-up is bituminised and other liquid waste is solidified with concrete inside steel drums. Waste is transported from the power plant to the KAJ and MAJ storage facilities by using bespoke vehicles and, from there, further for final disposal. According to its radioactivity concentration, operating waste is placed in final disposal either in the VLJ repository or in the HMAJ repository that is currently being planned.

The VLJ repository consists of two bedrock silos, a hall that connects them and auxiliary facilities that have been constructed inside bedrock at a depth of 60–100 metres. Low-level waste is placed in one of the silos inside concrete cases; intermediate-level waste is placed inside concrete cases in the other bedrock silo, where a reinforced concrete silo has also been constructed. The concrete silo for intermediate-level waste can fit 31 layers of concrete cases on top of each other. The total interior volume of the cases is 6,400 m^3. The low-level waste silo can fit an equal number of concrete case layers, but their total interior volume is 9,100 m^3.

Thus far, low and intermediate-level waste has been placed in final disposal inside the VLJ repository. A substantial part of the waste placed in the VLJ repository is very low-level waste (<100 kBq/kg). The placement of such waste inside bedrock is not purposeful, since the level of protection inside the VLJ repository is excessive when considering the level of radioactivity in the waste. The plan is for very low-level waste to be placed in final disposal in a separate HMAJ repository that is designed for a waste volume of 10,000 m^3. This will significantly reduce the volume of waste placed in final disposal in the VLJ repository. According to the current schedules, near-surface final disposal in the HMAJ repository will begin in the mid-2020s.

In the service life extension case, the operation of the OL1 and OL2 plant units will generate approximately 50 m^3 of very low, low and intermediate-level waste per year, as in the current situation. The estimated total accumulation of waste by the end of the plant units' existing operating licences will be approximately 8,250 m^3 (by 2038). In the service life extension case, 8,750 m^3 of waste will be generated by 2048 and 9,250 m^3 by 2058.

When the operation of the power plant is continued, waste management methods will mainly remain as they are. The capacity in the VLJ repository is estimated to be sufficient for the final disposal of low and intermediate-level waste generated during the service life extension of the OL1 and OL2 plant units.



The design of the VLJ repository contains provisions for expanding the facilities to accommodate low and intermediate-level decommissioning waste when the decommissioning of the Olkiluoto power plant is due. The expansion plans for the VLJ repository are specified periodically when new information and operating experience become available. When the expansion of the VLJ repository is due, permits will be acquired according to authority regulations.

3.2.8. Conventional waste

A nuclear power plant, as any other industrial facility, generates conventional waste (such as paper waste, plastic waste and biodegradable waste as well as wood waste and scrap metal) as well as hazardous waste (such as waste electrical and electronic equipment, waste oil, chemicals and batteries) that is not radioactive.

All waste generated at Olkiluoto is sorted and processed. The sorted waste is recycled as materials whenever possible, or reused as energy. Waste is managed according to the requirements of the legislation and the environmental permit for the Olkiluoto nuclear power plant.

The annual waste quantities vary depending on the scope of work carried out in the annual outage. The table below presents the volumes of conventional waste generated in 2023. In the service life extension case, no changes will occur in the current waste types or their volumes or processing.

In 2023, the Olkiluoto power plant generated a total of 2,578 t of waste sent for reuse as materials or energy and 242 t of hazardous waste, of which hazardous waste reusable as materials amounted to 74 t. The optimal use of chemicals is one of the ways aiming at reducing the amount of hazardous waste. The power plant generates no landfill waste. Since 2024, waste volumes will be materially reduced, since the termination of the wastewater treatment plant's operation will mean that no waste sludge is generated. It amounted to 1,339 t in 2023. (Table 7)

Solid matter, i.e. fish, algae and other screenings carried with the cooling water to the power plant are removed from the water by means of coarse and fine screens and travelling basket filters. From the debris handling building, biodegradable waste is delivered to an external waste management company for processing. In 2023, the debris handling building for the OL1 and OL2 plant units collected a total of 42 t of screenings.

Table 7. Annual waste volumes from plant units OL1, OL2 and OL3 in 2023.

Conventional waste, OL1, OL2 and OL3	2023 (t)
Mixed combustible waste	108
Landfill waste to TVO's landfill	0
Paper and cardboard	78
Combustible waste	130
Biowaste	95
Wood	212
Metal	158
Glass	0,4
Plastic	3
Cable scrap	13
Crushed brick and concrete	53
Screenings	73
Hazardous waste [1)]	242
Waste sludge [2)]	1,581

[1)] Includes 72 t of hazardous waste utilised as material.
[2)] Waste sludge from the wastewater treatment plant, sand/water mixture and shellfish/water mixture (solid matter concentration 8–10%).

3.2.9. Chemicals

The OL1 and OL2 plant units use various chemicals for, among other things, fuelling the emergency diesel generators and boiler plant, processing water and preventing polyp infestations. Chemicals are also used for cleaning equipment and pipelines, among other things. The most commonly used chemicals include oils, nitrogen, sodium hypochlorite, sodium hydroxide and sulphuric acid. In the service life extension case, the use of the currently employed chemicals will continue and there will be no changes to their usage or storage volumes. The current usage volumes and purposes of key chemicals at the OL1 and OL2 plant units are presented in the enclosed table (Table 8).

The industrial handling and storage of chemicals at the Olkiluoto nuclear power plant is extensive. Olkiluoto nuclear power plant is a facility subject to a safety analysis under the Decree (855/2012) on the industrial handling and storage of hazardous chemicals. Such a facility is required to draw up a safety analysis and submit it to the Finnish Safety and Chemicals Agency (Tukes). The obligation is based on the volumes and characteristics of chemicals. At Olkiluoto nuclear power plant, the basis for the analysis requirement is hydrazine used at the OL3 plant unit, which is classified as toxic and hazardous to the environment.

Table 8. The current usage volumes and purposes of key chemicals at the OL1 and OL2 plant units.

Chemical	Average usage per year (t)	Intended purpose
Sulphuric acid	18	Chemical for reviving ion exchangers at the demineralisation plant
Sodium hydroxide	14	Chemical for reviving ion exchangers at the demineralisation plant
Ion exchange resins	14	Process water clean-up
Sodium hypochlorite (100%)	8	Hydroid control
Glykoli	5	Anti-freeze
Nitrogen	140	Containment nitrogen fill
Bitumen	14	Solidification/binding of process waste
Light fuel oil	255	Fuel for the emergency diesel generator and the reserve power boiler plant

3.2.10. Releases of radioactive substances and their limitation

During the processing of radioactive gases generated at a nuclear power plant, the gases are collected, filtered and delayed in order to reduce radioactivity. Gases containing small amounts of radioactive substances are conveyed into the atmosphere in a controlled manner through the ventilation stack. Radioactive releases into the air during the operation of the power plant mainly consist of noble gases, iodine, aerosols, tritium and the carbon-14 isotope. Radioactive releases into the air from the Olkiluoto plant units fall clearly below the release limits approved by the authority. The enclosed table (Table 9) presents the variation of air releases of radioactive substances from the OL1 and OL2 plant units in 2007–2023. The highest values in the actual release ranges have been related to rare fuel failures, for example. In the service life extension case, releases of radioactive substances into the air will remain at the current level.

Table 9. Releases of radioactive substances into the air from the OL1 and OL2 plant units. Range of variation for 2007–2023.

Type of release	Minimum (TBq/a)	Maximum (TBq/a)	Emissions limit (TBq/a)
Noble gases	0	9.7	9,420
Iodine	0.00000008	0.002	0.1
Aerosols	0.000007	0.2	No emissions limit
Carbon-14	0.6	1.2	No emissions limit
Tritium	0.2	2.7	No emissions limit

Most of the radionuclides released into the environment are short-lived, and they are only observed in the immediate vicinity of the power plant during environmental radiation monitoring. The allowed release of radioactive substances into the immediate vicinity has been defined in a manner where an individual living near the plant can receive an annual radiation dose no greater than 0.1 mSv. The calculated dose resulting from the releases has been only a fraction of the allowed radiation dose.

Radioactive water effluents into the sea during the operation of a nuclear power plant mainly consist of treated process water, sewage water from the radiation controlled area and wastewater from the laundry for protective clothing inside the radiation controlled area. Radioactive water effluents into the sea from the Olkiluoto plant units fall clearly below the release limits approved by the authority (Table 10). Before the water is routed into the sea in a controlled manner, it is processed and delayed in order to reduce the radioactivity. The radioactivity is measured, and routing water into the sea is only possible when the radioactivity limits approved by the authority are not exceeded. In the cooling water discharge channel, the water released in a controlled manner from the power plant into the sea, which contains small amounts of radioactivity, is mixed with the cooling water flow and significantly diluted. In the service life extension case, releases of radioactive effluents into the sea will remain at the current level.

Table 10. Releases of radioactive substances into water systems from the OL1 and OL2 plant units. Range of variation for 2007–2023.

Type of release	Minimum (TBq/a)	Maximum (TBq/a)	Emissions limit (TBq/a)
Fission and activation products	0.00008	0.0006	0.3
Tritium	1.3	2.5	18.3

3.2.11. Other releases into the air

Conventional releases into the air from the power plant consist of releases from emergency diesel generators and back-up reserve power boiler plants. The greenhouse gas emissions (CO_{2e}) from the OL1 and OL2 plant units, calculated as an average of the past three years, have been 914 tonnes per year (t/a), nitrogen oxide emissions (NO_x) have been 1.2 t/a, sulphur dioxide emissions (SO_2) 0.0 t/a and particulate emissions have been 0.1 t/a. The replacement of emergency diesel generators (8 pcs) is currently under way at the OL1 and OL2 plant units, which has temporarily increased their releases into the air due to test runs performed during commissioning. In the service life extension case, releases into the air will remain at the current level.

The task of the emergency diesel generators is to automatically ensure the power supply to the nuclear power plant in a possible yet unlikely loss of power scenario. In order to ensure safety, the emergency diesel generators are regularly tested in compliance with the Technical Specifications, which means that their emissions cannot be lowered.

Releases into the air are also generated from the passenger and service traffic to and from the power plant and from various forms of transport.

3.2.12. Traffic

Commuting forms the main part of traffic towards Olkiluoto power plant. A total of slightly more than 1,000 people work in the Olkiluoto power plant area (OL1, OL2 and OL3 and Posiva), and they mainly arrive to work by car. Remote working practices have reduced commuting traffic. Some employees also use buses for their commute. Bus transport to Olkiluoto has been arranged from Rauma, Eurajoki and Pori. Commuting traffic mainly takes place between 7 and 9 am and 4 and 5 pm. During annual outages, the number of workers visiting the plant increases by approximately 1,000 people.

Inside the power plant area, goods transport occurs, in addition to transports of operating waste into the VLJ repository and near-surface final disposal and transports of nuclear fuel into the KPA storage. Transport mainly takes place between 9 am and 4 pm on weekdays. Transfers of spent nuclear fuel from the KPA storage to Posiva's encapsulation plant and disposal facility are estimated to begin during the 2020s.

In the service life extension case, traffic volumes will remain at the current level.

3.2.13. Noise

The main sources of noise at TVO's three power plant units are turbines and fans that generate a constant hum. In addition, the emergency diesel generators generate a low-frequency noise from time to time, during testing or in case they are needed. Noise measurements have been performed in order to survey noise in the vicinity of the power plant; environmental noise has, for the most part, been between 39.4 and 42.1 decibels (dB) in 2020–2023. This has been below the guideline values for noise set by the Government. High noise levels have been measured at TVO's main gate over the years due to passing traffic (in 2020–2023, the range of variation has been between 48.6 and 56.3 dB). In the service life extension case, no changes will occur in terms of the noise situation.

3.3. Uprating the thermal power

Chapter 3.2 describes activities related to the service life extension that is similar to the current operation of the OL1 and OL2 plant units until 2048 and 2058. This chapter describes the additional changes brought about by the thermal power uprating when compared to the current situation.

3.3.1. Service life management and maintenance

The power uprating has no effect on service life management; if TVO decides to implement the power uprating, the actions described in chapter 3.2.1 apply to the service life management of the plant units.

3.3.2. Construction and modifications

In the power uprating project, the thermal power of the reactor of the OL1 and OL2 plant units would be uprated from the current 2,500 MW to 2,750 MW. The power uprating would be implemented by means of extending the operating range of the reactor, increasing the reactor's main circulation flow from the current 8,360 kg/s to a new value of 10,000 kg/s. The increased thermal power of the reactor will increase steam production and, thereby, increase flow in the main process. Increasing the thermal power of the reactor may be implemented by means of modifications and the reparameterisation of existing systems without essentially changing their functionality. In all plant modification projects implemented as part of the power uprating, the equipment to be replaced will be designed while bearing in mind the extended service life.

Increasing the reactor's main circulation flow has been made possible by means of the reactor's recirculation pumps replaced in the late 2010s and the reactor's steam separators that will be replaced in 2027–2028. The increase of the main circulation flow will be achieved by means of the reparameterisation of the frequency converters controlling the operation of the pumps. The parameterisations will be performed during normal annual outages, and they do not require any special actions. The steam separator is one of the reactor internals that is normally removed for refuelling during each year's annual outage; its replacement consists of installing a new component in place of the old one that will be left in storage and scrapped in the future.

The possibility of a power uprating has already been considered earlier when replacing equipment at the plant units. As a result, the power uprating will not require large additional equipment or system replacements. The increased generation of residual heat resulting from the power uprating will require increasing the capacity of the residual heat removal pumps. This is a system modification performed by means of component replacement, and similar in nature to the equipment replacements performed due to reasons attributable to service life management. These have been carried out in several plant systems in order to ensure the reliability and high availability of the plant. As a safety improvement related to the power uprating, the opportunity to improve the management of operational occurrence with a new feed water source has been investigated; based on the performed analyses, the plan is to implement this as part of the potential power uprating. Performed analyses suggest that the generator and the electrical systems that are used to convey the increased electrical output into the national grid will require further improvements and equipment replacements. These will be implemented in connection with normal annual outage replacements prior to the power uprating. At the turbine plant, increased process flows will require the replacement of some components; this will also be implemented during annual outages that precede the power uprating.

To summarise the changes being implemented at the plant, the main process itself will remain unchanged during the power uprating and only the flows in the main process will increase. This will also cause a need for a reparameterisation of the plant's protection and control systems to match the new operating conditions. These changes will be implemented before the power uprating.

The increase in the main circulation flow will cause the temporary fluctuation in the electrical output of the OL1 and OL2 plant units that results from specific disturbances on the national electrical grid to increase. The construction of a new battery energy storage system has been planned to compensate for the temporary fluctuation. This would ensure that the national grid remains functional during disturbances.

Modifications required by the power uprating would mainly be implemented inside the plant units. The only modifications requiring construction that would be implemented outside of the plant units are the implementation of a new diesel-powered make-up water system that improves the safety of the plant units and the construction of a new battery energy storage.

In connection with the power uprating, a separate diesel-powered make-up water system must be constructed at the site area which would be used in a possible, but very unlikely, loss of alternating current supply to the plant. The make-up water system is used to manage reactor cooling. The make-up water system comprises the following structures:

- A demineralised make-up water tank that is shared between both plant units (approximately 1,300 m^3, height is approx. 11.5 m)
- 2 pump units (one has a volume of 91.5 m^3 and a height of approx. 3 m)

- 2 fuel tank containers (one has a volume of 69 m^3 and a height of approx. 3 m).

The plan is to place the pump units in dedicated containers near the water tank. Compared to the other buildings at the site area, the structures related to the make-up water system are small in size. The placement of the make-up water system structures in the site area is presented in the enclosed figure (Figure 8).

The plan is for the new battery energy storage system that would be used for supporting the national grid to be similar to the one already located in the power plant area (Figure 9). It would consist of a building containing batteries and a power transformer used for joining the national grid. A ground cable route will be constructed from the plant unit to the battery energy storage system. The size of the future battery energy storage system would be similar to the current one. The plan is for the battery energy storage system to be located in the area adjacent to the OL3 plant unit's parking lot, and it is presented in the enclosed figure (Figure 8).

It is also possible that, in the power uprating case, the capacity of the KPA storage will be expanded in the manner described for the service life extension in chapter 3.2.6.

The construction of the new battery energy storage system and make-up water system, which will be located outside of the plant units, is estimated to take approximately 2–3 years. During construction, traffic volumes would increase by an estimated 5 lorries per day, while passenger traffic would increase by an estimated few dozen vehicles per day. Some transports will be special transports.

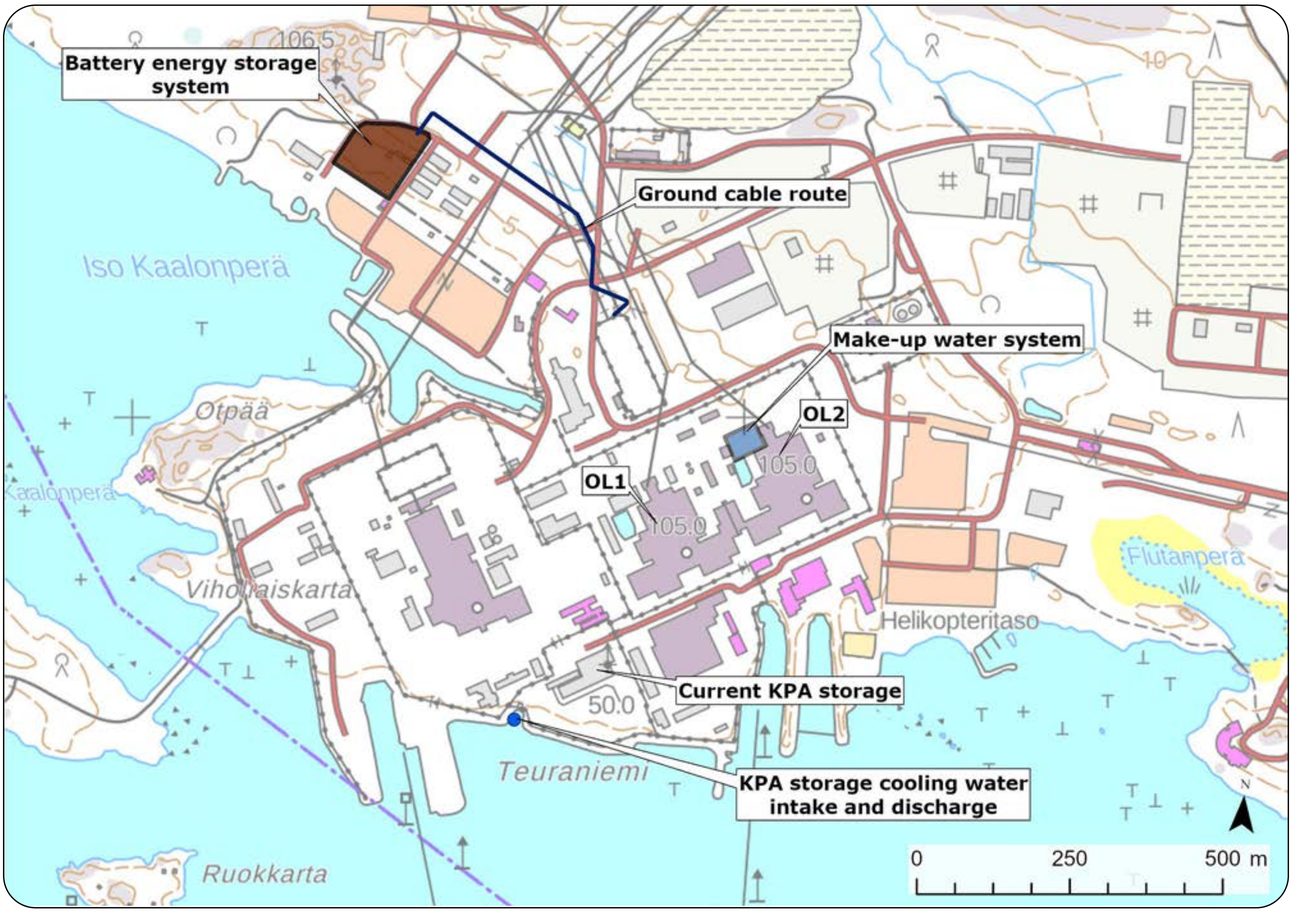


Figure 8. The preliminary placement of the new make-up water system and the battery energy storage system in the area, as well as the locations for the current KPA storage and its cooling water intake and discharge locations.

Figure 9. Current battery energy storage system in the area.

3.3.3. Cooling water

With the power uprating, the volume of cooling water being routed into the water system will remain similar to the current operation (38 m^3/s per plant unit), but the thermal load being routed into the water system will increase from an estimated 98,000 terajoules to approximately 109,000 terajoules at the annual level. In the power uprating scenario, the increase in cooling water temperature will be approx. 11°C, whereas during current operation the increase is approx. 10°C. The cooling water intake and discharge locations will remain unchanged.

The temperature of the cooling water routed into the sea has also varied previously as a result of plant modifications. For example, during the earlier power uprating in the 1990s (Figure 1), the thermal power discharged into the sea increased by approx. 420 MW and the temperature of the water used for cooling increased by 1.7°C. As a result of efficiency improvements implemented in the 2000s and the replacement of the sea water pumps, cooling water flow (30 m^3/s) increased to 38 m^3/s. The temperature of the cooling water discharged into the sea fell from 13 degrees centigrade to approx. 10 degrees.

3.3.4. Service water and wastewater

The thermal power uprating does not change the power plant's current annual water requirement and supply or the annual wastewater volumes or their treatment.

3.3.5. Nuclear fuel procurement

In the thermal power uprating case, the amount of nuclear fuel procured annually will not change. The total amount will increase similarly to the service life extension case (chapter 3.2.5). The nuclear fuel being used in the reactor must be approved for the new reactor power level, and this will be performed prior to the power uprating in collaboration with TVO's fuel suppliers.

3.3.6. Spent nuclear fuel

In the power uprating case, the annual consumption of nuclear fuel will not increase; instead, the amount of fuel being removed from the reactor each year will remain at the current level (18 t/a). The accumulated total amount will increase in accordance with the additional years of operation, as described above for the service life extension.

Changes to fuel technology will be implemented in connection with the power uprating that are related to, among other things, increasing the enrichment and burn-up of the fuel removed from the reactor. During the increase of enrichment, which is performed by the fuel manufacturer, the amount of fissile uranium contained in the fuel is increased. This will allow for increasing the thermal power extracted from the fuel used at the plant by 10%. As a result of the changes, the number of fuel assemblies removed from the reactor each year will remain at the current level.

Increasing the fuel burn-up will increase the residual heat generation of the fuel assemblies by approximately 10%. Following their removal from the reactor, fuel assemblies will be stored in the fuel storage pools of the reactor building until they can be moved to the KPA storage. The increased residual heat will increase the demand for residual heat removal at the KPA storage by a corresponding amount. The flow rate of the cooling water extracted from the sea and returned there will be increased, if necessary, in which case the temperature of the water returned into the sea will not rise from the current level. Once the decay heat power of the fuel assemblies has been reduced to an adequate level, they can be moved to Posiva's encapsulation plant and disposal facility. The increased decay heat power has no impact on Posiva's fuel handling, since the thermal calculations for Posiva's final disposal take into account heat generation that is even higher than the value following the power uprating, and the final disposal can be performed according to current plans.

If Posiva starts the final disposal activities during the 2020s as per the current plan, the capacity in the KPA storage will be sufficient even in the service life extension and power uprating case. If the start of final disposal activities at Posiva were to be substantially delayed for some reason, the storage capacity at the KPA storage will need to be increased as described in chapter 3.2.6.

3.3.7. Very low, low and intermediate-level waste

In the power uprating case, the annual amounts of very low, low and intermediate-level waste as well as waste cleared from regulatory control will remain at the present level. The accumulated total amount of waste will increase in accordance with the additional years of operation, as described for the service life extension in chapter 3.2.7.

3.3.8. Conventional waste

No changes when compared to the current operation and service life extension.

3.3.9. Chemicals

No changes when compared to the current operation and service life extension.

3.3.10. Releases of radioactive substances and their limitation

In the power uprating case, the releases of radioactive substances will remain within the same range of variation, and below the same release limits, as during current operation and in the service life extension case (Table 5).

3.3.11. Other releases into the air

In the power uprating case, other releases into the air (NO_X, SO_2 and particles) will remain at the present level, but greenhouse gas emissions (CO_{2e}) will increase by approximately 13 t/a due to the new diesel-powered make-up water system. During normal operation, the emissions from the make-up water system result from test operation, which is estimated to amount to approximately 50 hours (h) during the year.

3.3.12. Traffic

During operation, no changes when compared to the current operation and service life extension.

3.3.13. Noise

No changes when compared to the current operation and service life extension.

3.4. End of activities

Decommissioning following the end of a power plant's service life is subject to licence and regulated according to the Nuclear Energy Act and Decree and the Radiation and Nuclear Safety Authority's regulations as well as any guideline documents drawn up on their basis. Among other things, decommissioning requires applying for a decommissioning licence under the Nuclear Energy Act and an EIA procedure pursuant to the EIA Act. A separate environmental impact assessment will be drawn up for the decommissioning of the OL1 and OL2 plant units, according to the legislation in force, once decommissioning becomes relevant.

The decommissioning plan presents all the stages related to decommissioning and the present plans for them at the time of writing. In TVO's plans, decommissioning refers to the disassembly of radioactive systems, structures and components and the final disposal of disassembly waste. Preparations are made for the extension of the VLJ repository for accepting decommissioning waste and the licensing of the decommissioning well in advance before the actual decommissioning work begins.

A plan for the decommissioning is already drawn up during operation, and it is submitted to the authorities every six years, at a minimum, in accordance with the Nuclear Energy Act. The decommissioning plan for the Olkiluoto power plant was last updated in 2020. The plans are updated and specified in stages according to experience received from the operation of the power plant, comments and requirements from the authorities, and results from the follow-up of international projects. The final decommissioning plan will be submitted to the authorities for approval when applying for a decommissioning licence.

As regards the OL1 and OL2 plant units, the decommissioning plan is based on delayed dismantling. In this case, the actual dismantling activities for the plant units will only begin after several decades, following monitored storage. This ensures that the collective radiation dose for the workers will be low and the amount of waste placed in final disposal will be reduced. At the same time, the dismantling work for the three plant units may be scheduled to take place during consecutive years. This will allow for utilising the experience, equipment and personnel from the dismantling of the first units while dismantling the third unit.

For monitored storage, the OL1 and OL2 plant units are brought to a safe state where the spreading of radioactivity has been prevented. Following monitored storage, the radioactivity of these plant units will be significantly lower than immediately following the end of operation. For the OL1 and OL2 plant units, work related to the decommissioning will begin with a preparation stage for monitored storage. During this stage, spent fuel will be transferred to the KPA storage and the other actions required for the preparation stage will be taken. Following this, the plant units will be in monitored storage until the dismantling phase begins.

For all plant units, the dismantling strategy for decommissioning is based on the activated reactor pressure vessels and their internals beginning cut up and placed in final disposal in bespoke packages inside the final disposal facilities being excavated inside the VLJ repository expansion. The partially radioactive biological shields and thermal insulation plates from all three units will be cut up and packed inside concrete or plywood crates and drums, according to their activity. Contaminated process systems will be dismantled, cut up and packed inside concrete crates, with the exception of large contaminated components that will be placed in final disposal either unaltered or, if necessary, only cut up to the extent required by the dimensional limitations concerning transport.

The decommissioning plan has been prepared on the basis of current technology, and the limit values provided by STUK have been used as the limits for dismantled material during the analysis. All activated and contaminated systems whose activity exceeds the limit values will be dismantled and placed in final disposal inside the VLJ repository or the near-surface final disposal facility in the Olkiluoto site area. The plan is to leave systems, components and structures that are classified as clean in place and not to dismantle them. Their dismantling following the decommissioning will be considered to be ordinary dismantling of industrial facilities.

The starting point for the current decommissioning plan is a service life of 60 years for all power plant units. The actual dismantling activities for the plant units will be started following approximately 35 years of monitored storage. According to the current decommissioning plan, the dismantling and related waste management will mainly take place in the 2080s. If the decision is taken to implement the service life extension or power uprating for the plant units, they will be included in the plan during subsequent updates.

4. Environmental impact assessment procedure

4.1. Starting points

The aim of the environmental impact assessment procedure (EIA procedure) is to ensure that the significant environmental impacts of the planned project are analysed to a sufficient level of precision. Its aim is to produce information to support the planning and decision-making of the project but also to provide the various parties with increased access to information and opportunities for participation in the project's planning stage.

The EIA procedure is stipulated by law. The directive *(2011/92/EU)* of the European Parliament and of the Council on the assessment of the effects of certain public and private projects on the environment has been enacted in Finland via the Act on the Environmental Impact Assessment Procedure *(EIA Act, 252/2017)* and the Government Decree on the Environmental Impact Assessment Procedure *(EIA Decree, 277/2017)*. The first EIA directive is from 1985 *(85/337/EEC)*, and it entered into force in Finland in 1995. The directive, similarly to the EIA Act and Decree, has been amended on several occasions.

The service life extension and thermal power uprating of the OL1 and OL2 plant units necessitate an environmental impact assessment procedure in accordance with the EIA Act *(252/2017)*. Under Section 3 of the EIA Act, the environmental impact assessment procedure is applied to projects and changes thereto that are likely to have significant environmental impacts. Appendix 1 to the EIA Act lists projects to which the EIA procedure applies. Under section 7b of the list of projects, an assessment process pursuant to the EIA Act applies to nuclear power plants and other nuclear reactors. The EIA report and its reasoned conclusion must be enclosed with the new operating licence applications for the plant units.

The EIA procedure is carried out prior to the permit procedures for the project. The authority may not grant permission to implement the project before it has been given access to the assessment report and the authority's reasoned conclusion as well as the documents related to the international hearing concerning transboundary impacts.

4.2. Parties

The parties to the EIA procedure in this project are presented in the table below (Table 11).

Table 11. Parties to the EIA procedure.

Parties	
Project owner	Teollisuuden Voima Oyj (the operator responsible for the preparation and implementation of the project)
Coordinating authority	Ministry of Economic Affairs and Employment (ensures that the project's environmental impact assessment procedure is arranged in accordance with the EIA legislation)
EIA consultant	Ramboll Finland Oy (responsible for drawing up the EIA programme and report in accordance with the EIA legislation). The authors of the assessment report and their qualifications are presented in Appendix 2.
Other parties	» Finnish Environment Institute (FEI) (organising the international hearing) » Countries participating in the international hearing » Radiation and Nuclear Safety Authority (STUK) » Centre for Economic Development, Transport and the Environment in South-west Finland (ELY) » Southern Finland Regional State Administrative Agency (AVI) » Other authorities and experts from which the coordinating authority requests statements » The municipality of Eurajoki and, possibly, other nearby municipalities » Local stakeholders » Other parties whose conditions or interests the project may affect, including the general public » Media

4.3. Stages and contents

The EIA procedure has two stages. Dedicated reports will be drawn up during both stages; they are known as the environmental impact assessment programme (EIA programme) and the environmental impact assessment report (EIA report). For this project, an international hearing (chapter 4.3.3) will also be performed alongside the EIA procedure. The figure below (Figure 10) presents a summary of the stages of the EIA procedure in Finland and how the international hearing links to it.

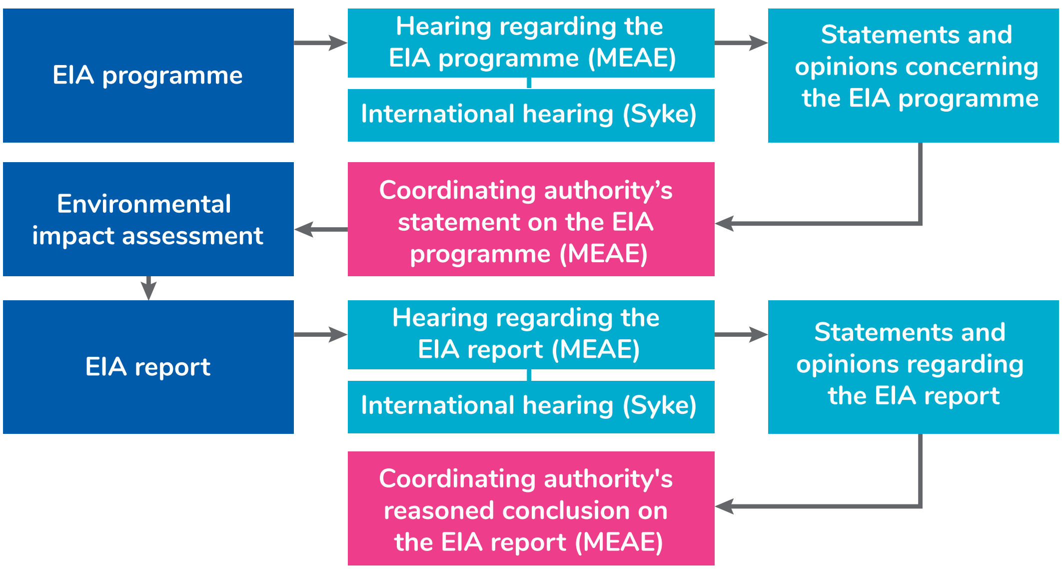


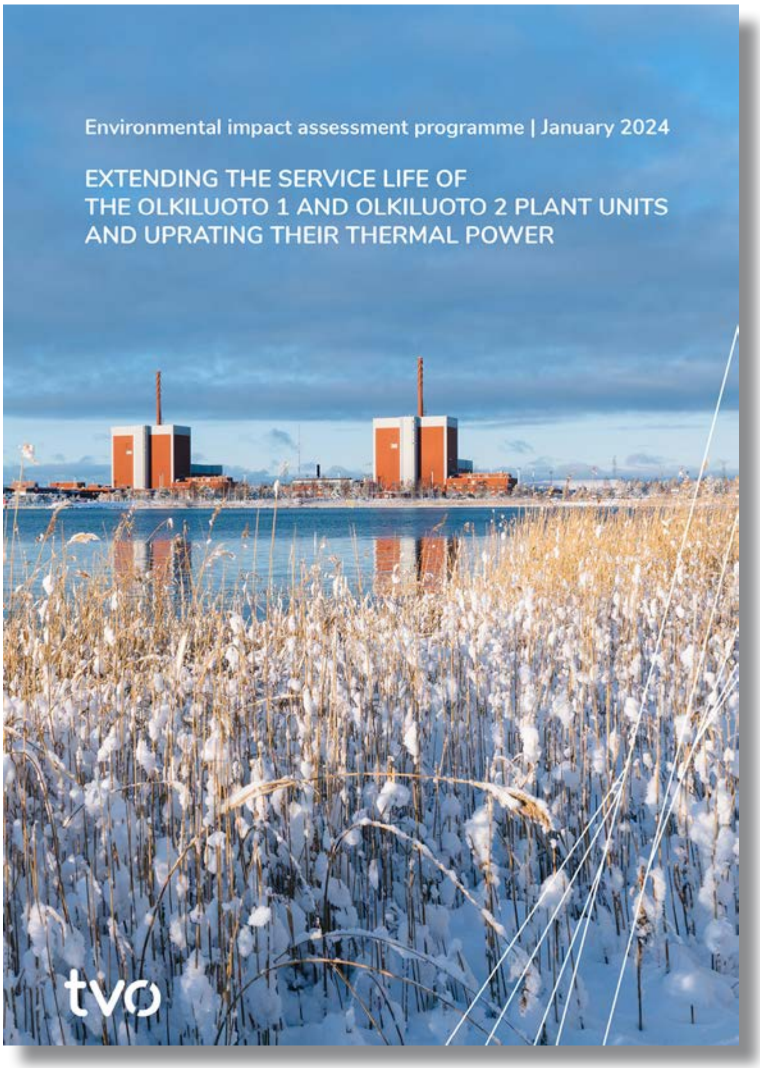
Figure 10. Stages of the EIA procedure. MEAE = Ministry of Economic Affairs and Employment. Syke = Finnish Environment Institute.

4.3.1. EIA programme

During the first stage of the EIA procedure, an environmental impact assessment programme is drawn up that presents a plan for the organising of the environmental impact assessment procedure and the analyses required for it. According to the EIA Decree, the assessment programme shall include, among other things, the following to a necessary extent:

- A description of the project, its purpose, design stage and location;
- Any reasonable alternatives in the project, one of which shall be that the project is not implemented;
- Information on the plans, permits and decisions required for implementing the project;
- A description of the current state of the environment in the likely affected area, any analyses planned or already completed and the methods and assumptions to be used;
- A plan on the arrangement of the EIA procedure and participation;
- Schedule.

The EIA procedure started when the project owner submitted the assessment programme (EIA programme) to the coordinating authority on 5 January 2024. The coordinating authority notified on the EIA procedure for the project on 23 January 2024, and the EIA programme was available for public viewing, for the purpose of issuing statements and opinions, between 23 Jan and 25 Mar 2024. Following this, the coordinating authority compiled the provided opinions and statements and provided its own statement on the EIA programme on 25 Apr 2024 (Appendix 3). An international hearing (chapter 4.3.3) was implemented simultaneously.



4.3.2. EIA report

In the second stage of the EIA procedure, the actual environmental impact assessment will be performed on the basis of the EIA programme and the coordinating authority's statement regarding it. The results of the assessment are compiled into an EIA report that is submitted to the coordinating authority when complete. According to the EIA Decree, the EIA report shall present the following information to a necessary extent:

- A description of the project and its aim, location, scope, land use needs and key characteristics, taking into account the various stages of the projects and exceptional circumstances;
- Information on the project owner, the schedule for the project's design and implementation, the plans, permits and similar decisions required for the implementation and the project's interfaces with other projects;
- An account of the interfaces of the project and its alternatives with land use plans as well as plans and programmes pertaining to the use of natural resources and environmental protection that are relevant in terms of the project;
- A description of the current state of the environment within the area of impact and its likely development if the project is not implemented;
- An estimate and description of the likely significant environmental impacts of the project and its reasonable alternatives as well as a description of the transboundary environmental impacts. The estimate and description of likely significant environmental impacts shall cover the immediate and indirect, cumulative, short-term, medium-term and long-term permanent and temporary, positive and negative impacts as well as joint impacts with other existing and approved projects;
- An estimate of potential accidents and their consequences as well as actions for preparing for these situations, including the actions taken for prevention and mitigation;
- A comparison of the environmental impacts of the alternatives;
- Information on the main reasons leading to the selection of the chosen alternative(s), including any environmental impacts;
- A proposal for actions to avoid, prevent, limit or eliminate any identified significant and detrimental environmental impacts;
- A proposal regarding any potential monitoring arrangements related to significant detrimental environmental impacts;
- An account of the phases of the assessment procedure with their participation processes and their interfaces with the project planning;
- A list of sources used when drawing up the descriptions and assessments included in the report;
- A description of the methods that have been used in the identification, prediction and assessment of significant environmental impacts as well as information on the short-comings observed and key uncertainty factors identified when compiling the necessary information;
- Information on the qualifications of the authors of the assessment report;
- An account of how the coordinating authority's statement regarding the assessment programme has been considered.

The coordinating authority sets the assessment report on display for public inspection, similarly to the EIA programme; for this project, the duration of the public inspection has been set at 60 days by agreement with the coordinating authority. An international hearing will also be held during the EIA report stage (chapter 4.3.3). Based on the EIA report and the statements provided concerning it, the coordinating authority draws up a reasoned conclusion on the key environmental impacts of the project that must be considered in the later permit processes. The assessment report and the coordinating authority's reasoned conclusion are enclosed with the permit application documents.

4.3.3. International hearing

A procedure pursuant to chapter 5 of the Act on the environmental impact assessment *(252/2017)* that concerns any possible transboundary environmental impacts is applied to this project.

The principles of international cooperation in environmental impact assessment are defined in the United Nations Economic Commission for Europe's Convention on Environmental Impact Assessment in a Transboundary Context *(SopS 67/1997, Espoo Convention)*. The Espoo Convention defines the general obligations for arranging a hearing of the member states' authorities and citizens in all projects that are likely to have major transboundary environmental impacts. The EIA Directive also contains provisions concerning communication on the project, and the EIA Directive further requires that a member state must be able to participate in the assessment procedure of another member state if so required. In addition to the EIA Directive, the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (*SopS 121–122/2004, Aarhus Convention)* contains provisions regarding the participation and appeal rights of the international public. One of the goals of the Aarhus Convention is to allow the public to participate in decision-making on environmental matters. The Aarhus Convention has been enacted within the EU by means of several directives, such as the EIA Directive and national EIA acts and decrees. Finland and Estonia have a mutual EIA agreement that further specifies the Espoo Convention. Furthermore, Finland and Sweden have a transboundary reactor agreement *(SopS 19/1977)*.

On 15 January 2024, the Ministry of Economic Affairs and Employment submitted to the Finnish Environment Institute a request to initiate an international hearing at the EIA programme stage. The Finnish Environment Institute notified the environmental authorities in the target countries that an EIA procedure has been started for the project and enquired whether they are willing to participate in the EIA procedure. A summary document for the EIA programme that had been translated into the target country's language and the EIA programme translated into Swedish or English was enclosed with the notification. The documents were submitted to Sweden, Estonia, Latvia, Lithuania, Norway, Denmark, Poland and Germany. The Finnish Environment Institute also notified the parties to the Convention on Environmental Impact Assessment in a Transboundary Context *(Espoo Convention)*. Bulgaria, Hungary and Austria requested a notification concerning the project, which the Finnish Environment Institute has submitted to the nations in question.

The Finnish Environment Institute received responses from various nations. Bulgaria, Austria, Latvia, Sweden, Germany, Denmark and Estonia have notified that they will participate in the process. Lithuania, Norway, Poland, Greece, Ireland, Switzerland, Hungary and Canada notified that they will not be participating in the environmental impact assessment procedure concerning the project. The Finnish Environment Institute relayed any feedback that it had received to the MEAE for consideration in its statement regarding the EIA programme.

A corresponding international hearing will also be arranged at the EIA report stage to the affected parties who have expressed that they will participate in the EIA procedure.

4.4. Schedule for the EIA procedure

The key stages and preliminary schedule for the EIA procedure are presented in the figure below (Figure 11). The EIA procedure ends when the coordinating authority has issued its reasoned conclusion regarding the EIA report.

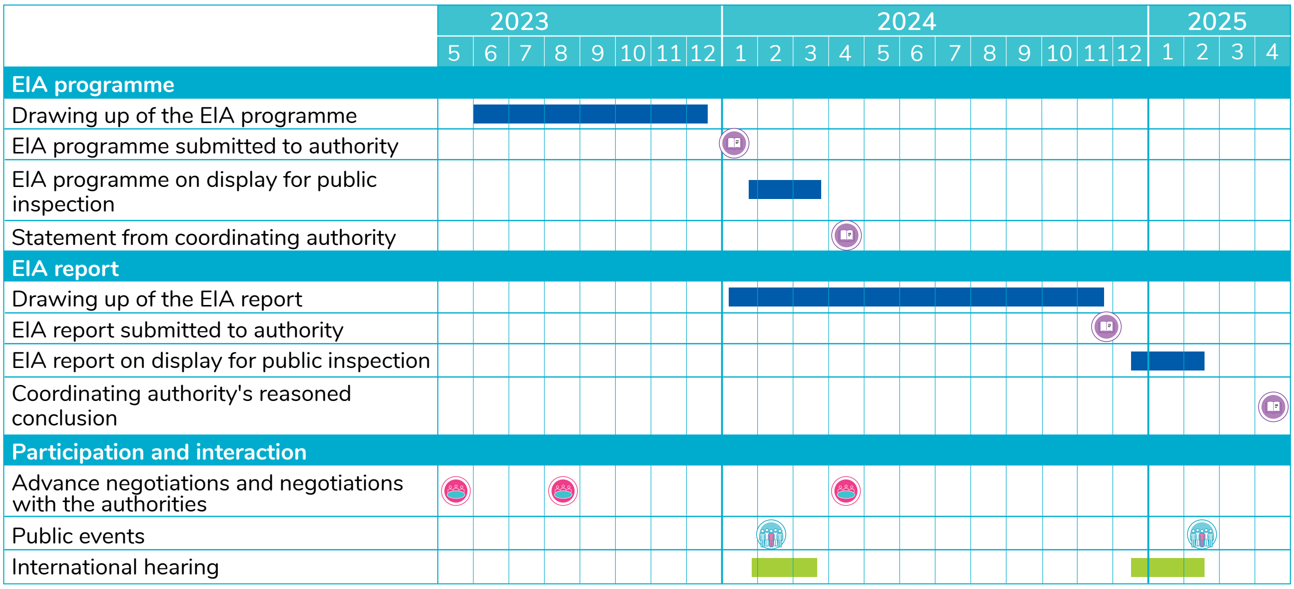


Figure 11. Preliminary schedule for the EIA procedure.

4.5. Participation and interaction

The EIA procedure is implemented interactively in order to provide the various parties with the opportunity to discuss and to express their opinion on the project and its impacts. One of the key goals of the EIA procedure is to promote communication regarding the project and to improve possibilities for participating in the planning of the project. Participation allows for bringing out the opinions of the various stakeholders.

Everyone whose living conditions and interests, such as housing, employment, mobility, leisure time and other conditions of living, may be impacted by the project may take part in the environmental impact assessment procedure. According to the EIA legislation, citizens may state their opinion on the EIA programme and EIA report to the coordinating authority while the documents are on display for public inspection.

The interaction plan in the EIA procedure covers all communication in the project, the acquisition of information from various parties, events that are open to everyone and cooperation between the stakeholders.

Advance negotiations and negotiations with the authorities

Before the EIA procedure was started and while the procedure was under way, advance negotiations were arranged between the project owner, the coordinating authority for the EIA and other key authorities. The aim for the advance negotiations was to advance the management of the evaluation, planning and permit procedures required by the project, support the information exchange between the project owner and the authorities, and to improve the quality and usability of the reports and documents as well as to make the practices more fluent.

Monitoring group

A monitoring group was set up during the EIA report stage that was intended to promote the transfer and exchange of information between the project owner, the authorities and the key stakeholders in the area while drawing up the EIA report. The following parties were invited to join the monitoring group:

- Ministry of Economic Affairs and Employment
- Radiation and Nuclear Safety Authority
- Finnish Environment Institute
- Centre for Economic Development, Transport and the Environment in South-West Finland
- Southern Finland Regional State Administrative Agency
- Satakunta Rescue Services
- Safety and Chemicals Agency Tukes
- Municipality of Eurajoki
- City of Rauma
- City of Pori
- Municipality of Eura
- Municipality of Nakkila
- Satakuntaliitto
- Rauma Chamber of Commerce
- Fingrid Oyj
- Posiva Oy
- Fortum Oyj
- Satakunta district for the Finnish Association for Nature Conservation
- Joint property association for the Munakari common lands
- Joint property association for the Olkiluoto and Orjasaari common lands
- Joint property association for Sorkka
- Eurajoki–Lapijoki fishery area
- Eurajoki water protection association
- Lapijoki water system care and protection association
- Pyhäjärvi-instituutti

Representatives from the project owner and the EIA consultant also took part in the work of the monitoring group. The monitoring group convened on 23 April 2024.

Public events during the EIA procedure

The events during an EIA procedure are public events showcasing the project and the information generated during the EIA procedure. During the events, citizens may present their opinions on the project and the impacts being assessed and receive additional information.

Following the completion of the EIA programme, an open public event concerning the project and the EIA procedure was arranged on 6 February 2024 at the Olkiluoto Visitor Centre in Eurajoki. The event was also streamed for remote attendance. Once the EIA report is complete and it has been publicly notified, a similar public event will be arranged; more detailed information on the event will be presented in the notification for the EIA report.

Communications

The EIA programme and report were published on the website of the Ministry of Economic Affairs and Employment. The documents were available for public viewing according to the information in the coordinating authority's public notice. The EIA programme and EIA report are also available on TVO's website, which also contains up-to-date information on the project, the environmental impact assessment procedure and licensing, among other things. TVO will also communicate on the progress of the project and, for example, the press conferences and public information events being arranged.

4.6. Statements and opinions

4.6.1. The coordinating authority's statement on the EIA programme and the consideration given to it

The coordinating authority requested statements regarding the EIA programme from the following parties:

- Akava–Confederation of Unions for Professional and Managerial Staff in Finland
- Confederation of Finnish Industries (EK)
- Finnish Energy (ET)
- Municipality of Eurajoki
- Municipality of Eura
- Southern Finland Regional State Administrative Agency
- Fingrid Oyj
- Geological Survey of Finland
- Greenpeace
- Ministry of Transport and Communications
- Southwest Finland Regional State Administrative Agency
- Southwestern Finland Police Department
- Ministry of Agriculture and Forestry
- Central Union of Agricultural Producers and Forest Owners (MTK)
- Finnish Heritage Agency
- Municipality of Nakkila
- Natur och Miljö rf
- City of Pori
- Posiva Oy
- Ministry of Defence
- City of Rauma
- Centre for Economic Development, Transport and the Environment in Satakunta
- Satakunta Rescue Services
- Satakuntaliitto
- Ministry of the Interior
- Ministry of Social Affairs and Health
- Central Organisation of Finnish Trade Unions (SAK)
- Finnish Association for Nature Conservation
- Finnish Environment Institute
- Suomen Yrittäjät ry
- Radiation and Nuclear Safety Authority
- VTT Technical Research Centre of Finland
- Finnish Confederation of Professionals (STTK)
- Safety and Chemicals Agency Tukes
- Ministry for Foreign Affairs
- Helsinki–Uusimaa Regional Council
- Ministry of Finance
- Centre for Economic Development, Transport and the Environment in South-West Finland
- WWF
- Advisory Committee on Nuclear Safety
- Ministry of the Environment.

The coordinating authority received a total of 20 statements concerning the EIA programme. No opinions regarding the EIA programme were submitted to the coordinating authority. In addition, the Finnish Environment Institute relayed to the coordinating authority the statements and opinions from various nations related to the international hearing. The received statements and opinions can be found in their entirety on the website of the Ministry of Economic Affairs and Employment.

The Ministry of Economic Affairs and Employment provided its statement on the EIA programme on 25 April 2024 (Appendix 3). In its statement, the Ministry of Economic Affairs and Employment states that the environmental impact assessment programme covers the content requirements pursuant to Section 3 of the EIA Decree.

The table in Appendix 4 compiles together the main points which, according to the coordinating authority's statement, required attention during the impact assessment or supplementation while drawing up the assessment report. The table also presents how the statement has been considered when drawing up this EIA report.

4.6.2. Statements and opinions regarding the EIA programme

In its own statement concerning the EIA programme, the coordinating authority has considered the received statements and opinions (including statements requested by the coordinating authority, statements from the international hearing and other statements and opinions). The key comments and questions from the statements and opinions and responses thereto have been compiled in Appendix 4.

4.7. Considering the EIA procedure during planning and decision-making

The planning of the project is being carried out simultaneously with the environmental impact assessment, but the planning will continue and be specified further following the assessment procedure, as part of the permit process and other processes. Efforts are made to take the mitigation and prevention of environmental impacts into account as efficiently as possible during the various stages of planning, licensing and implementation.

The EIA report and the coordinating authority's reasoned conclusion regarding it are enclosed with the permit applications concerning the project which the licensing authorities utilise in their own decision-making. The matters brought up in the reasoned conclusion are considered in any upcoming licensing stages. The permits, plans and decisions required for the project are described in chapter 9.

5. Starting points for the environmental impact assessment

5.1. Impacts to be assessed

The purpose of an environmental impact assessment is to examine, in the manner and accuracy required by the EIA Act and Decree, the environmental impacts caused by the project, which may affect the following:

- The population as well as the health, living conditions and comfort of people;
- Soil, ground, water, air, climate, vegetation as well as organisms and biodiversity, especially as regards protected species and habitats;
- Community structure, tangible property, landscape, townscape and cultural heritage;
- Use of natural resources;
- The mutual interactions between the aforementioned factors.

Pursuant to Section 4 of the EIA Decree, the assessment report presents an estimate and description of the likely significant environmental impacts of the project and its reasonable alternatives as well as a comparison of the alternatives' environmental impacts. The environmental impact assessment takes into account the impacts of the potential project alternatives during any possible modifications and operation. Furthermore, the project's possible joint impacts with other functions or other planned projects are assessed.

The results of the environmental impact work are presented, per impact, in chapter 6. The following matters have been discussed in connection with the impact assessment sections:

- Initial data and assessment methods
- Current state of the environment
- The environmental impacts of continued operation
- The environmental impacts of power uprating
- Comparison of the alternatives and an assessment of the significance of the impacts
- Actions to prevent and mitigate detrimental impacts
- Uncertainty factors related to the assessment.

The chapters concerning incidents and accidents, transboundary impacts and joint impacts have a slightly different structure than the one presented hereinabove.

5.2. Schedule and review of impacts

One of the implementation alternatives being examined for the project is continuing the operation of the OL1 and OL2 plant units at the current power level following the expiration of the existing operating licences, from 2038 until 2048 or 2058 (VE1). The operating impacts of this alternative take place across 10 or 20 additional years of operation. The second implementation alternative being examined for the project is continuing the operation of the OL1 and OL2 plant units at an uprated power level, from around 2028 until 2048 or 2058 (VE2). The operating impacts of this alternative take place across 20 or 30 years. For both alternatives, the assessment takes into account the impacts of potential modification or construction work in addition to the impacts during operation.

In the zero alternative, the operation of the plant units will continue until the expiration of the valid operating licences in 2038 (VE0). As regards the zero alternative, the potential impacts resulting from the end of the current operation have been described on a general level. A separate environmental impact assessment will be drawn up for the decommissioning of the OL1 and OL2 plant units, according to the legislation in force, once decommissioning becomes relevant; therefore, the impact assessment for the decommissioning is not included in this EIA report.

5.3. Area of impact being examined

In this environmental impact assessment, the site area refers to the area where the current functions of the OL1 and OL2 plant units and the planned changes are located. The environmental impacts targeting the site area or reaching outside of the site area describe the actual area of impact for the project's environmental impacts. It varies according to the impact.

The results of the environmental impact assessment are described in chapter 6. In connection with the impact assessment, the areas under review in terms of environmental impacts have been defined to be so large that no significant environmental impacts can be assumed to occur outside of the area under review.

5.4. Impact assessment approach and methods

The purpose of the environmental impact assessment is to systematically identify and assess the environmental impacts caused and their significance. An impact refers to a change in relation to the current state of the environment brought about by the project, its alternative or a function related to them. The change may be either negative or positive, or a change might not occur at all when compared to the current situation. In this EIA report, the current state of the environment refers to the present state of the nearby areas of the Olkiluoto nuclear power plant area, where the OL1, OL2 and OL3 plant units are in operation. When assessing the significance of an impact, the magnitude of the change caused by the impact and the capability of the environment to receive changes, that is, the sensitivity of the affected aspect are considered.

The assessment of each impact has been implemented as follows:
1. Identifying the origin of the impact and describing the initial data and methods used in the assessment.
2. Describing the current status of the affected aspect and, based on that, assessing its sensitivity or capability to receive the change being examined.
3. Describing the environmental impacts and the magnitude of the change that they cause.
4. Assessing the significance of the impact on the basis of the sensitivity of the affected aspect and the magnitude of the change and drawing conclusions on the significant impacts.
5. Comparing the different alternatives and identifying their differences in terms of feasibility.
6. Presenting any potentially required mitigation actions for detrimental impacts.
7. Analysing the uncertainty factors affecting the impact assessment.

5.4.1. Sensitivity of the affected aspect

The sensitivity of the affected aspect refers to the environment's capability to receive changes. The sensitivity is determined on the basis of the characteristic features and current status of the aspect or area. Characteristic features may include, for example, current traffic conditions, the current status for noise and air quality or natural values, scenic values or recreational values.

The affected aspect's sensitivity to change describes the capability of the asset to receive, withstand or tolerate changes caused by the project. For example, a recreational area is generally more sensitive to changes than an industrial area. Sensitivity is also affected by whether the aspect is protected by law or if there are any defined guideline values, norms or recommendations for the impact (e.g. guideline noise values or environmental standards for surface water quality). For impacts affecting humans, the number of people using or experiencing the aspect and their experience are also taken into account.

The sensitivity of the affected aspect is assessed using a scale of four steps: minor, moderate, large and very large, and it is based on the current state of the environment.

5.4.2. Magnitude of change

The magnitude of the change may be affected by, among other things, its scope, duration or intensity. Therefore, a change may be a direct impact on the environment caused by a change in operations or a long-term activity that maintains a change targeting the environment.

The magnitude of the change caused by the project is defined and assessed on the basis of several variables:

- The magnitude of the change: its scope, duration and strength
- The direction of the change: positive, negative or no change
- Geographical scope: regional, local or transboundary
- Duration: temporary, short-term, long-term or permanent
- Other factors: for example, the recurrence and timing of the change and its accumulation and restorability.

In some cases, the magnitude of measurable changes can be modelled from the initial data (for example, the spreading of cooling water). In order to determine the magnitude of qualitative changes, an expert assessment is prepared; in order to reduce its subjectivity, the initial data which the assessment is based on will be presented as transparently as possible.

Several methods are employed in the acquisition of initial data:

- Monitoring data from existing activities
- Field visits and studies carried out
- Various modelling techniques (e.g. cooling water modelling)
- Location of affected aspects and areas using the location data system
- Utilisation of literature, databases and research results
- Employment of participatory data acquisition methods (e.g. public events, monitoring group)
- Previous experience and expertise from the assessment workgroup
- Analysis of matters expressed in the statements and opinions.

The magnitude of the change is assessed on a four-step scale: low, medium, high and very high. It is also possible that the project will not cause a change when compared to the current status.

5.4.3. Significance of the impact

The significance of an impact is determined by the sensitivity of the affected aspect and the magnitude of the change (Figure 12). The significance of the impact is determined by cross-tabulating the sensitivity of the affected aspect and the magnitude of the change for the various alternatives in connection with the assessment of each impact (Figure 13). The significance of the impact is determined on a scale of four steps: minor, moderate, large and very large. The significance of the impact may be negative or positive or there may be no impacts at all. The significance of each impact is presented in a separate summary table at the end of the assessment section in question (for an example, see Table 12).

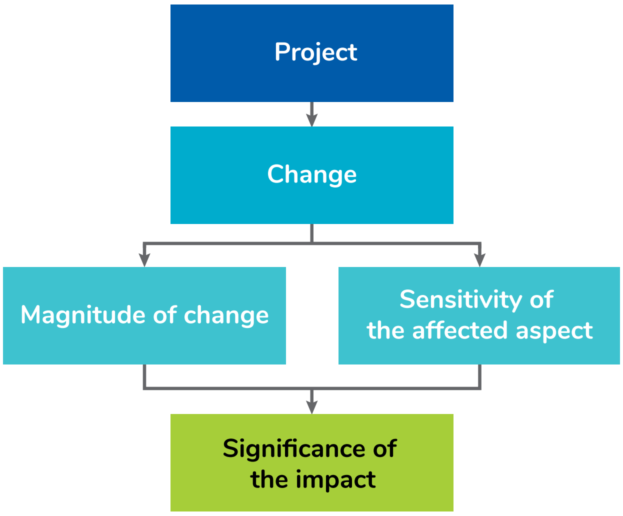


Figure 12. Factors affecting the significance of the impact.

the sensitivity of the affected aspect \ the magnitude of the change	negative: very large	negative: large	negative: moderate	negative: minor	no change	positive: minor	positive: moderate	positive: large	positive: very large
minor	large	moderate	minor	minor	no effect	minor	minor	moderate	large
moderate	large	large	moderate	minor	no effect	minor	moderate	large	large
large	very large	large	large	moderate	no effect	moderate	large	large	very large
very large	very large	very large	large	large	no effect	large	large	very large	very large

If the sensitivity or change is at the lower limit of a class, the significance may be assessed to be lower.

Figure 13. Assessing the significance of the impact on the basis of the sensitivity of the affected aspect and the magnitude of the change.

Table 12. Example of the assessment of the significance of an impact.

Alternative	Sensitivity	Magnitude of change	Significance
E.g. VE1	Minor	Minor positive	Minor positive

5.5. Analyses and other documentation used for the assessment

Environmental analyses and surveillance have been performed near the Olkiluoto power plant area for decades. Therefore, comprehensive information is available regarding the power plant area and, in particular, the sea environment in the nearby areas which could be used in the environmental impact assessment. Furthermore, the environmental impact assessment used available information on the current activities, emissions and impacts in the area and the technical information that becomes more detailed as the project is being planned.

The initial data and documentation used in the assessment are described in the following chapters 6.1–6.18, broken down by impact.

6. Environmental impact assessment

6.1. Community structure, land use and zoning

6.1.1. Initial data and assessment methods

The assessment of the impacts on the community structure and land use is based on an examination of the existing community structure and zoning situation. The initial data being used consists of an analysis of the current community structure and the provincial plans, master plans and local detailed plans that are in force in the power plant area and its vicinity. The review considers the national and regional goals and pending zoning projects.

In the assessment, it has been determined whether the modifications related to extending the service life of the power plant or increasing the power will affect the current and future land use of the site area or its immediate surroundings. When examining the impacts of the project and their significances, the perspective has been to assess how much the project would change the current use of the areas. Possible changes have been examined especially with regard to the site area and its immediate surroundings, but the assessment of the impacts on land use has also taken into account the effects on the nearest settlement. The focus of the assessment is on impacts affecting the nearby areas (radius of 5 km from the site area). As a result of the plan review, the impact of the project on the implementation of the goals of the plans, as well as the possible need for drawing up new plans or changing the existing ones, was evaluated. The assessment of impacts was performed as an expert assessment.

6.1.2. Current status

6.1.2.1. Societal structure and land use

Olkiluoto is an island located in the municipality of Eurajoki, in the southern part of the province of Satakunta, along the coast of the Bothnian Sea; approximately 12 km to the north-northwest of the centre of Rauma and approximately 16 km west-northwest of the centre of Eurajoki. Olkiluoto Island is 6 km long and 2.5 km wide. Teollisuuden Voima Oyj owns approximately 90% of the land areas on Olkiluoto Island. In addition, TVO partly owns the water areas north and south of the island.

Olkiluoto Island has a surface area of approximately 900 hectares (ha); the area constructed for nuclear power and final disposal is located on the western part of the island and spans approximately 170 ha. The OL1 and OL2 plant units are at the western tip of Olkiluoto, and the OL3 plant unit is located west of these (Figure 5). The Olkiluoto power plant area contains several functions related to the operation of the nuclear power plants and functions supporting them (Figure 6). These include, among other things, the interim storage for spent fuel (KPA storage), the interim storage facilities for very low, low and intermediate level operating waste (HMAJ, MAJ and KAJ storage), the operating waste repository (VLJ repository), the cooling water intake and outlet structures, the raw water treatment plant, the raw water treatment plant, a landfill area, a back-up heating plant, storage facilities and workshop facilities. The area also contains a training centre, a visitor centre and administrative buildings, among others.

Olkiluoto Island mainly comprises forests east of the power plant area. In the middle of the north shore of the island is Olkiluoto Harbour, where the Olkiluoto waterway leads from the open sea. A wide high-voltage wire area runs along the northern side of the island. The power plant area also houses a substation for Fingrid Oyj and a gas turbine power plant for back-up power needs. Connecting road 2176, Olkiluodontie, leads to Olkiluoto. Posiva Oy's disposal facility for spent nuclear fuel, currently under construction, is located on the eastern edge of the power plant area and constitutes a separate site area.

The island's eastern and south-eastern ends contain agricultural areas and scattered holiday housing and permanent housing. Using the general classification of the community structure, the power plant area is located in sparsely populated rural areas and partly in rural areas close to a town (Figure 14). In its easternmost part, the power plant area also has a village-like structure, according to the community structure monitoring documentation (YKR). The nearest permanent, year-round residential building to the facility area is located approximately 2.5 km southeast of the site area, on the other side of Olkiluodonvesi on the island of Ympyriäisenmaa. There are also permanent residential buildings northwest of the village of Ilavainen, some 3 km southeast of the site area, and on the island of Kornamaa, some 3.2 km northeast of the site area. The nearest holiday houses are at a distance of approximately 0.5 km from the power plant, on the island of Ruokarta (Leppäkarta) on the Rauma side, southwest of the site area. There is also holiday accommodation on the island of Lippo southwest of Ruokkarta, some 0.8 km southwest of the site area, and on the island of Nousiainen, some 0.8 km south of the site area.

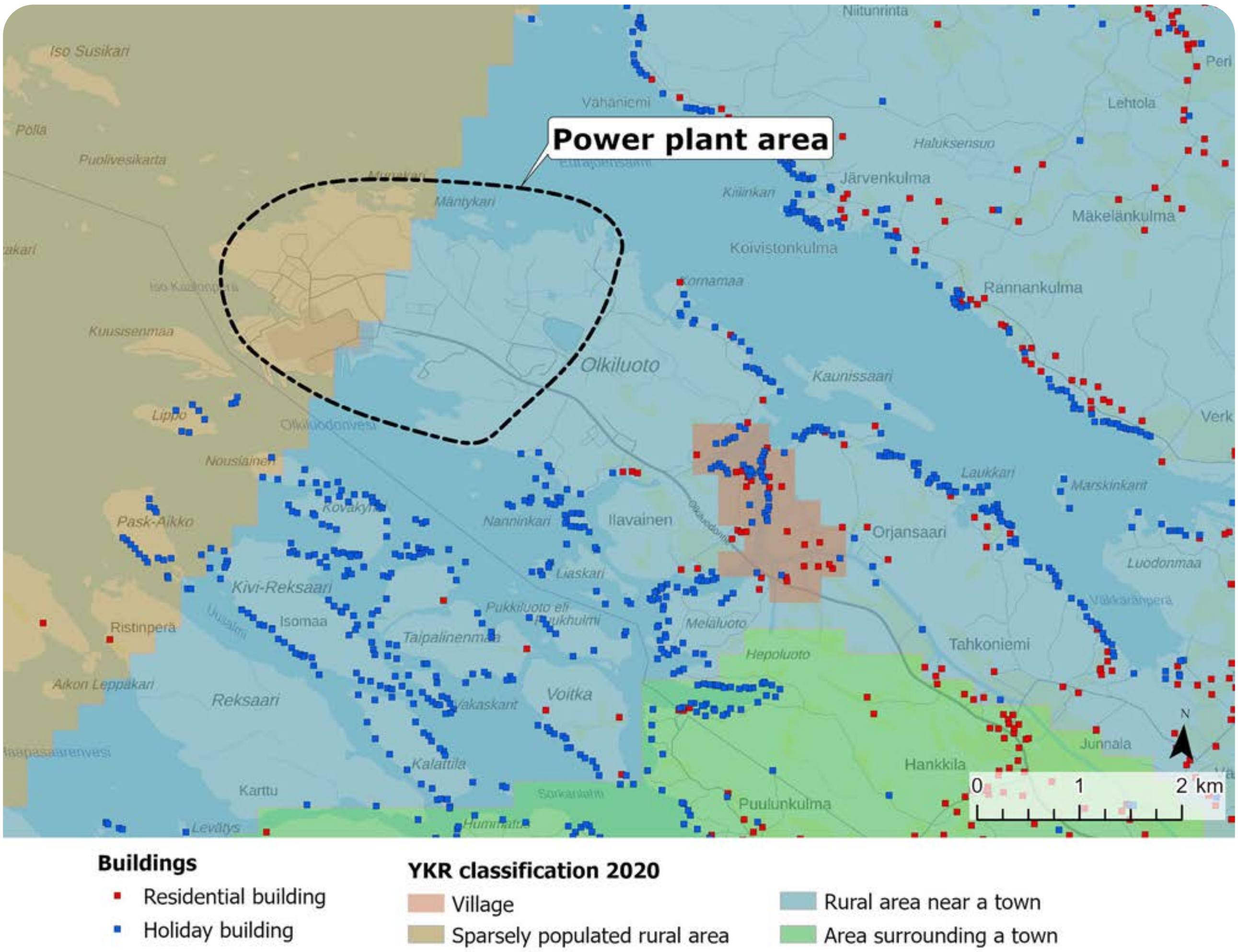


Figure 14. Location of the Olkiluoto power plant area in the community and habitation structure.

Some 0.8 km at the closest from the site area in the southeast direction, in the vicinity of the Olkiluoto visitor centre, is the Liiklankari conservation area, which is both a conservation area for old forests and part of the Natura area of the Rauma archipelago. The Selkämeri national park is located some 1.5 km west and northwest from the site area. The Kaunissaari cultural path, Katavankari lay-to and Pohjoisranta lay-to are located some 5 km east of the site area. The Raumanmeri nature and hiking area and the Rohela–Uusalmi hiking trail are located on Reksaari, some 2.6 km southwest of the site area.

There is a precautionary action zone spanning to a distance of 5 km around the site area, where limitations on land use are in effect. When planning and implementing functions in the precautionary action zone, the Radiation and Nuclear Safety Authority Regulation on emergency arrangements at a nuclear power plant *(STUK Y/2/2024)* shall be observed. The precautionary action zone must not contain, for example, facilities inhabited or visited by a considerable number of people, such as schools, hospitals, care facilities, shops, or significant places of employment and accommodation that are not related to the nuclear power plant *(YVL A.2)*.

6.1.2.2. Zoning

National land use goals

National land use goals are part of the land use planning system pursuant to the Land Use and Building Act. The Government decided on the new national land use goals on 14 Dec 2017, and they entered into force on 1 Apr 2018. Among other things, the task of land use goals is to help achieve the goals of the Land Use and Building Act and of land use planning, the most important of which are a good living environment and sustainable development. According to the Land Use and Building Act, the goals must be taken into account and their implementation must be advanced in provincial planning, municipal zoning and the operation of government authorities.

The new national land use targets cover the following entities *(Valtioneuvosto 2017)*:

1. Functional communities and sustainable mobility

- Promoting a multi-centred, networked and well-connected regional structure throughout the land; supporting the vitality of different regions and the utilisation of their strengths. Creating the conditions for the development of economic and business activities and for a sufficient and versatile housing production required by population development.
- Creating the conditions for a low-carbon and resource-efficient community development that primarily relies on the existing structure. Strengthening the integrity of the community structure in large urban areas.
- Promoting good accessibility of services, workplaces and leisure areas for different population groups. Promoting walking, cycling and public transport, as well as the development of services for communications, mobility and transportation.
- Locating any significant new residential, workplace and service areas in such a way that they are easily accessible by public transport, walking and cycling

2. Efficient traffic system

- Promoting the functionality and economy of the national transport system by primarily developing extant transport connections and networks; ensuring the conditions for travel and transport chains based on the joint use of different transport modes and services, as well as the functionality of freight and passenger transport hubs.
- Securing the continuity and development opportunities of internationally and nationally significant transport and communication links, as well as the development opportunities for internationally and nationally significant ports, airports and border crossings.

3. Healthy and safe living environment

- Preparing for extreme weather phenomena and floods as well as the impact of climate change. New construction is located outside flood risk areas or flood risk management is ensured otherwise.
- Environmental and health hazards caused by noise, vibration and poor air quality are prevented.
- A sufficiently large distance is left between activities that cause harmful health impacts and accident risks and activities that are sensitive to these impacts, or the risks are managed in some other way.
- Facilities that pose a risk of major accidents, chemical railyards and railyards for the transport of dangerous goods are placed at a sufficient distance from residential areas, areas of general activities and sensitive nature areas.
- The needs of society's overall security, especially the needs of national defense and border control, are taken into account. Sufficient regional development conditions and operational opportunities for these are secured.

4. Vital natural and cultural environment and natural resources

- Nationally valuable cultural environments and natural heritage values are safeguarded.
- The preservation of areas and ecological connections valuable in terms of biodiversity is promoted.
- The sufficiency of areas suitable for recreational use and the continuity of the green area network are ensured.
- Conditions for a bioeconomy and circular economy and the sustainable utilisation of natural resources are promoted. Steps will be taken to preserve unified farming and forest areas that are significant for agriculture and forestry, as well as areas that are significant for Sámi culture and means of livelihood.

5. Renewable energy supply

- Preparations are being made for the needs of renewable energy production and the logistic solutions this requires. Wind turbines are primarily located in a centralised way in multi-plant units.
- The alignment of power lines and gas pipelines necessary for long-distance transportation, important for the national energy supply, and the possibilities of their implementation will be secured. Power line alignments will primarily used the existing power corridors.

All of the aforementioned goal entities bear on the Olkiluoto region, but especially the goals of functional communities, healthy and safe living environment and renewable energy supply. Harmful factors related to the health and safety of the living environment include, in particular, emissions from traffic and production activities into the soil, water and air; exposure to noise; and accidents affecting the environment. One of the tasks of sustainable land use is to prevent significant harm to health and the environment. In order to improve Finland's competitiveness and safeguard the well-being of its residents, it is important that regions and communities retain their vitality when they develop, and that their strengths and resources can be utilised efficiently and sustainably. With respect to connection networks and energy supply, it is essential to secure national needs in such a way as to promote a functional regional structure and international competitiveness. A reliable energy supply is an important part of the national security of supply. *(Government decision on national land use aims, 14 Dec 2017)*

Provincial plan

The Satakunta provincial plan (legally valid 13 March 2013), Satakunta phased provincial plan 1 (legally valid 6 May 2016) and Satakunta phased provincial plan 2 (legally valid 1 July 2019) are in force in the power plant area. In the Satakunta phased provincial plan 1, regionally significant wind power production areas are indicated. In provincial plan 2, the themes include energy production, versatile use of marshlands, trade, landscape areas and built cultural environments. With the entry into force of Satakunta phased provincial plan 2, the corresponding entries and regulations in the Satakunta provincial plan were repealed.

The Satakunta provincial plan (Figure 15) indicates that the area of the OL1 and OL2 plant units is an energy supply zone (EN1). This is used to establish a nuclear power plant site area, which is reserved for facilities, buildings and structures serving energy generation as well as facilities and buildings implementing the final disposal of spent nuclear fuel. A construction restriction is in force in the area in accordance with Section 33 of the Land Use and Building Act *(132/1999)*. Movement and residence in the area are limited with a Ministry of the Interior Decree issued by virtue of the Police Act, due to reasons related to security or other reasons.

In the Satakunta provincial plan, the Olkiluoto power plant area and its surroundings are indicated to be a target area for the development of energy supply (en). This designation indicates the immediate surroundings of the site area reserved for energy supply which, due to functions related to energy supply, are subject to development needs related to the usage of the area. During planning, the prerequisites for long-term land use development and area reservations shall be secured in the target area for the development of energy supply. Special attention shall be paid to securing the prerequisites for the development of energy supply and final disposal activities and research in the planning related to the area. Furthermore, special attention should be paid to the general safety of existing housing, the other means of livelihood exercised in the area, any natural values, landscape values and Natura values and the conservation of bedrock integrity. When planning the area, the opportunity for providing a statement should be reserved for the parties responsible for the functions and supervision of the energy supply site area and, in water area planning, for the museum authority.

A nuclear power plant precautionary action zone (sv2), spanning to a distance of 5 km, has been established around the power plant area. This designation indicates areas where usage should be limited due to the activities in a nearby area or other activities of a nature that imposes a limitation on use in their surroundings. The Radiation and Nuclear Safety Authority's YVL Guides should be taken into account in the planning of the area, and the Radiation and Nuclear Safety Authority should be provided with the opportunity to provide a statement.

The power plant area is also part of the target area (kk) for urban development under the Satakunta provincial plan. The designation indicates the principles for land use in the development policy concerning urban regions, parts thereof or other communities. The designation indicates the zones that are targets for land use development needs of national, regional or local importance. In addition, the power plant area is also part of the target area (mv3) for the development of nature tourism under the Satakunta provincial plan.

In the Satakunta provincial plan, the Tankokari harbour at Olkiluoto is indicated as a harbour area (ls). A shipping lane is designated in the harbour area. A boat passage is designated in the direction of the Eurajoki strait. Liiklankari is indicated as a nature conservation area (SL) and a Natura 2000 network area (nat). Puolivesikarta and Ruokkarta with their nearby islands are indicated as a nature reserve (sl) northwest from Olkiluoto Island. South of Olkiluoto, Pask-Aikko – Kivi-Reksaari – Nousiainen has been identified as an area with dominant agriculture and forestry that has special environmental values (MY).

A power line (z) and a guideline for power line (z) from Olkiluoto have been designated. The road connection to Olkiluoto is indicated as an important connecting road (yt), and, in addition, the provincial plan has an indication of the need for a road traffic connection.

The plan designations and regulations in the Satakunta provincial plan for the site area and its surroundings are shown in the table (Table 13). In addition, the general planning provisions of the provincial plans are in force, of which the provision regarding the condition of water is particularly noteworthy in this project. According to the order, in the entire provincial plan area, detailed land use planning must be conducive to the implementation of water management plans and action programmes for the area.

In Satakunta phased provincial plans 1 and 2, no designations have been made in the power plant area or its immediate vicinity. In phased provincial plan 2, the Olkiluoto area has only been designated as an industrial and service area.

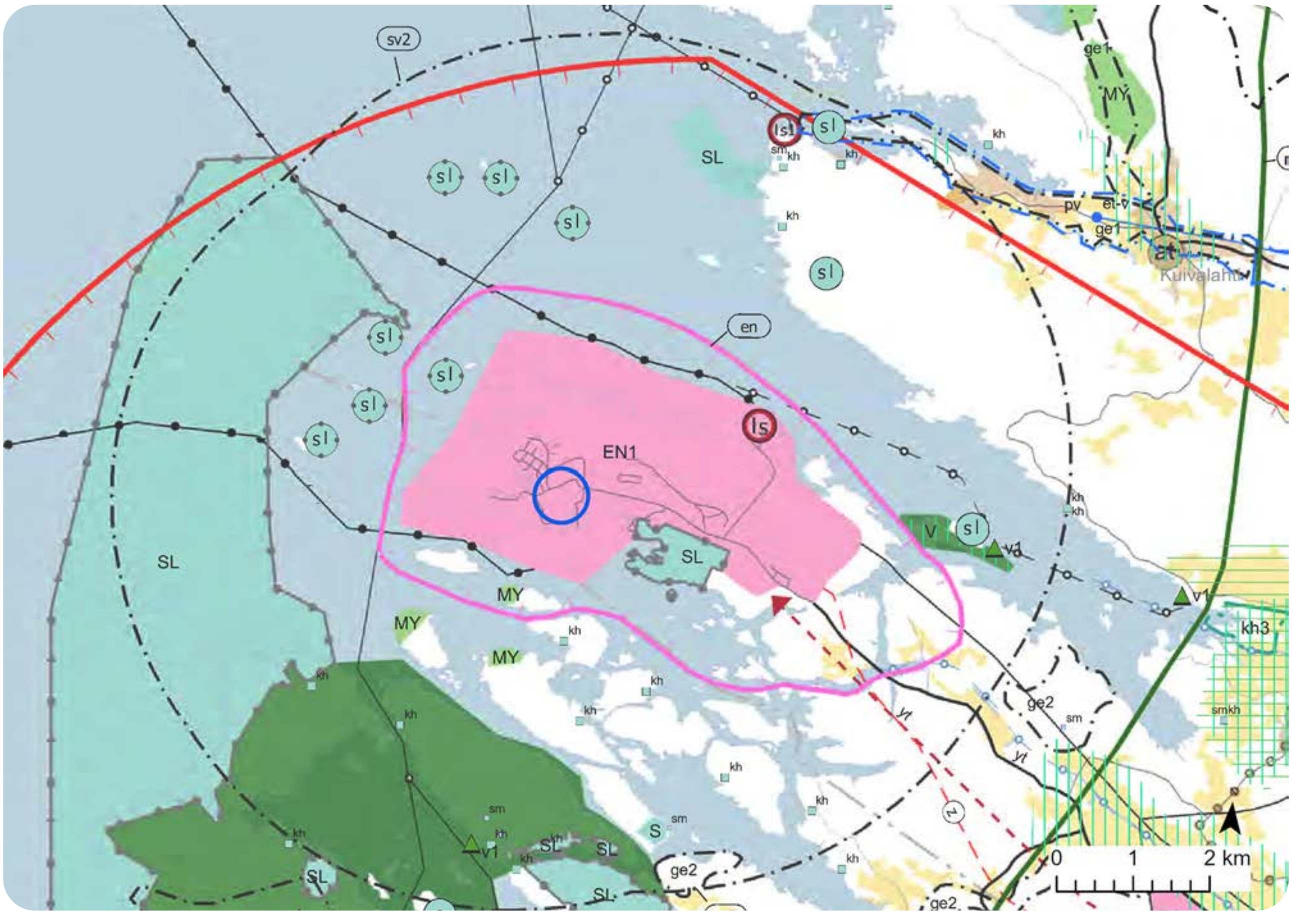


Figure 15. Excerpt from the Satakunta provincial plan. The zone designations and regulations located near the power plant area are listed in the table below (Table 13). The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

Table 13. Zone designations and regulations located near the power plant area in the combined Satakunta provincial plan.

Power plant area:	
EN	**ENERGY SUPPLY AREA** (Olkiluoto) This designation indicates areas that serve energy supply. Construction limitations in accordance with Section 33 of the Land Use and Building Act is in force in the area. The designation -1 is used to establish a nuclear power plant site area, which is reserved for facilities, buildings and structures serving energy generation and facilities and buildings implementing the final disposal of spent nuclear fuel. Movement and residence in the area are limited with a Ministry of the Interior Decree issued by virtue of Section 52 of the Police Act, due to reasons related to security or other reasons. Planning order: In the planning of the area, special attention must be paid to the valuable natural and landscape sites included in the area. When planning the area, the Radiation and Nuclear Safety Authority *(STUK)* must be given the opportunity to provide a statement. In the case of facilities complying with EU directive 96/82/EC on the manufacture and storage of hazardous substances *(SEVESO II directive with amendments)*, the opportunity must also be extended to the Finnish Safety and Chemicals Agency *(TUKES)*.

Power plant area:	
	**TARGET AREA FOR DEVELOPING ENERGY SUPPLY** (Olkiluoto in Eurajoki, TVO nuclear power plant) This designation indicates the immediate surroundings of the site area reserved for energy supply, which, due to functions related to energy supply, are subject to development needs related to the usage of the area. Planning order: During planning, the prerequisites for long-term land use development and area reservations shall be secured in the target area for the development of energy supply. Special attention shall be paid to securing the prerequisites for the development of energy supply and final disposal activities and research in the planning related to the area. Special attention should be paid to the general safety of existing housing, the other means of livelihood exercised in the area, any natural values, landscape values and Natura values and the conservation of bedrock integrity. When planning the area, the opportunity for providing a statement should be reserved for the parties responsible for the functions and supervision of the energy supply site area and, in water area planning, for the museum authority.
	**PRECAUTIONARY ACTION ZONE** (Olkiluoto) This designation indicates areas where usage should be limited due to the activities in a nearby area or other activities of a nature that imposes a limitation on use in their surroundings. The designation -2 indicates a precautionary action zone for nuclear power plants. Planning order: The planning of the area must take into account what is stated in the nuclear power plant guidelines *(YVL 1.10)* of the Radiation and Nuclear Safety Authority *(STUK)* concerning the nuclear power plant's precautionary action zone. When planning the area, the Radiation and Nuclear Safety Authority *(STUK)* must be given the opportunity to provide a statement.
	**TARGET AREA FOR URBAN DEVELOPMENT** (Rauma) The designation indicates the principles for land use in the development policy concerning urban regions, parts thereof or other communities. The designation indicates the zones that are targets for land use development needs of national, regional or local importance. Planning order: Zones with multiple centres in terms of regional structure are developed by improving the community structure of the existing centres and agglomerations, and by securing the continuity of the green area and recreation network and the availability of services. In more detailed planning, the functionality and economy of living environments should be promoted by utilising built networks, reducing the need for traffic, and promoting the conditions for public transport and light transport. The area's archaeological sites, nationally valuable landscape areas and significant cultural environments should be the starting points for land use planning. Recommendation for development: The needs for further development of land use in the area should be examined and resolved with a more detailed regional land use plan.
	**TOURISM DEVELOPMENT ZONE** (Satakunta coastal region) The designation indicates zones that are subject to significant tourism development needs. The designation of -3 indicates significant target zones for the development of nature tourism, which are subject to the development and coordination needs related to nature tourism; recreational use of nature; outdoor recreation trails and other trails; and nature conservation. Planning order: In the land use planning carried out within the zones, special attention must be paid to the development of tourism business and recreation services. The planning must take into account the coordination of the implemented measures with cultural, landscape and nature values as well as any existing businesses and settlements. When planning activities related to tourism and developing the attractiveness of the zone, the special characteristics of the zone and the preservation of these must be taken into account.

Surroundings external to the power plant area:	
ls	**HARBOUR AREA** (Tankokari, Olkiluoto) The designation indicates storage and terminal areas immediately related to harbours and harbour functions. A construction restriction is in force in the area in accordance with Section 33 of the Land Use and Building Act. Planning order: When planning the area, the Finnish Transport Infrastructure Agency, the body responsible for port operations and the relevant museum authority must be given the opportunity to provide a statement.
	SHIPPING LANE The designation indicates shipping lanes that have a draught above 2.5 metres. A construction restriction is in force in the area in accordance with Section 33 of the Land Use and Building Act.
	BOAT PASSAGE The designation indicates the most important boat passages that are marked with signs. A construction restriction is in force in the area in accordance with Section 33 of the Land Use and Building Act.
z	**POWER LINE** The designation indicates power lines of at least 110 kV. A construction restriction is in force in the area in accordance with Section 33 of the Land Use and Building Act.
z	**GUIDELINE FOR POWER LINE** The designation indicates guidelines for power lines of at least 110 kV. Planning order: Land use planning must secure the possibility of implementing the power line.
yt	**IMPORTANT CONNECTING ROAD** The designation indicates connecting roads and similar local distributor roads. A construction restriction is in force in the area in accordance with Section 33 of the Land Use and Building Act.
	CONNECTION REQUIREMENT FOR ROAD TRAFFIC The designation indicates the connection needs that are important for the development of the road network. Planning order: Land use planning must secure the possibility of meeting the need for road traffic connections. In order to meet the need for connections, the alternatives most appropriate for land use and least harmful for the environment must be identified in the more detailed planning of the road network.
MY	**AREA WITH DOMINANT AGRICULTURE AND FORESTRY THAT HAS SPECIAL ENVIRONMENTAL VALUES** (Pask-Aikko – Kivi-Reksaari – Nousiainen) The designation indicates areas dominated by agriculture and forestry that have specific values related to culture, landscapes, nature and the environment. Planning order: In the planning of the area, the cultural, landscape, nature and environmental values of the area must be taken into account.
	AREA BELONGING TO NATURA 2000 NETWORK (Rauma archipelago) The designation indicates areas belonging to the Natura 2000 network pursuant to decisions by the Government.

Surroundings external to the power plant area:	
SL sl	**NATURE RESERVE** (Liiklankari) The designation indicates nature reserves that are or will be protected by virtue of the Nature Conservation Act. Planning order: The regional environmental authority responsible for nature conservation must be given the opportunity to provide a statement on significant plans and projects that may affect land use in the area or before taking measures that significantly alter the prevailing conditions. Protection order: No measures or projects may be carried out in the area that could substantially imperil or weaken the conservation values of the area. However, with the permission of the state nature conservation authority, measures intended to preserve and restore the area's conservation values can be carried out. The protection order is in force until the area is established as a nature reserve in accordance with the Nature Conservation Act.

Master plans

The Olkiluoto partial master plan (approved in 2008, entered into force in 2010), which includes impacts on rights, is in force in the Olkiluoto area. In the plan, the power plant area in its entirety is indicated as an energy supply area with the EN reservation designation (Figure 16). The OL1 and OL2 plant units are located in the subarea intended for the actual nuclear power plants (v) and the subarea where nuclear waste facilities may be placed (yj).

According to the zoning regulations, the following may be constructed in the area:

- Nuclear power plants intended for electricity generation, other power plants, nuclear facilities and facilities intended for the transfer of electricity, other facilities and equipment serving these as well as buildings, constructions, structures and roads related to them.
- Nuclear waste facilities related to the final disposal activities of very low, low and intermediate-level waste in accordance with the construction licence granted by virtue of the Nuclear Energy Act. These comprise entrance buildings and structures leading into underground disposal repositories, encapsulation plants and related auxiliary facilities.
- Research facilities, storage and office buildings, assembly facilities and plants, equipment and devices serving final disposal as well as buildings, constructions and structures related to them, such as access and ventilation shafts and safety structures.

Furthermore, the area allows for storing and handling soil required for construction and final disposal activities, and for establishing a pre-processing area for landfill waste and a landfill.

During the construction of the areas limited by the area's shoreline, the shore terrain and landscape shall be preserved as close to their natural state as possible. During the further planning and implementation of the area, natural values related to the Natura area of the Rauma archipelago (FI0200073) shall be considered in accordance with Sections 65 and 66 of the Nature Conservation Act.

The partial master plan for Olkiluoto also provides the following general regulations in relation to nuclear power plants:

- The entire plan area is part of a precautionary action zone that extends to about 5 km from the nuclear power plants in the area.
- According to YVL Guide A.2, published by the Radiation and Nuclear Safety Authority, dense housing, hospitals or facilities where substantial numbers of people visit or reside must not be placed inside the precautionary action zone. The precautionary action zone shall also not contain significant production functions that could be affected by an accident at the nuclear power plant. The number of permanent residents should be kept at less than 200. This area may contain more holiday housing or leisure time activities, if an appropriate rescue plan can be drawn up for the area.
- Access restrictions may be defined for the nuclear facility area determined by the Ministry of the Interior or a part thereof in the safety and security plan for nuclear facilities.
- In the entire plan area, the lowest construction height is +2.0 m above the mean water level.

The Eurajoki master plan for shore areas covers all the shore areas and islands in Eurajoki (Figure 17). The master plan for shore areas confirmed in 2000 was overturned with an amendment of the master plan for shore areas in 2015. The Olkiluoto power plant area was not included in the amendment of the master plan for shore areas, as the Olkiluoto partial master plan had been approved for the area in 2008.

In the partial master plan for Rauma's northern shores (valid from 2000) and its amendment (valid from 2008), Kuusisenmaa Island located to the west of Olkiluoto is mainly designated as an energy supply area (EN-1); its northern parts are designated as a protective green zone (EV) (Figure 18). The Kuusisenmaa energy supply area allows for constructing warehouses and surveillance and office buildings as well as assembly facilities supporting electricity production, as well as buildings, constructions, structures, equipment and roads related to them. No nuclear power plants or nuclear waste facilities may be constructed in the area. Wind power plants may be constructed in the area, but the prerequisites for constructing them are determined by the local detailed plan. During the construction of the areas limited by the area's shoreline, the shore terrain and landscape shall be preserved as close to their natural state as possible. The protective green zone (EV) is significant in terms of landscape, and any actions that detrimentally affect the area should be avoided.

Most of the other islands in the vicinity of the power plant area are designated as areas for agriculture and forestry, some of which have environmental value (MY) or individual designations for holiday housing (ra designation). Some nature conservation areas are located in the vicinity of the power plant area.

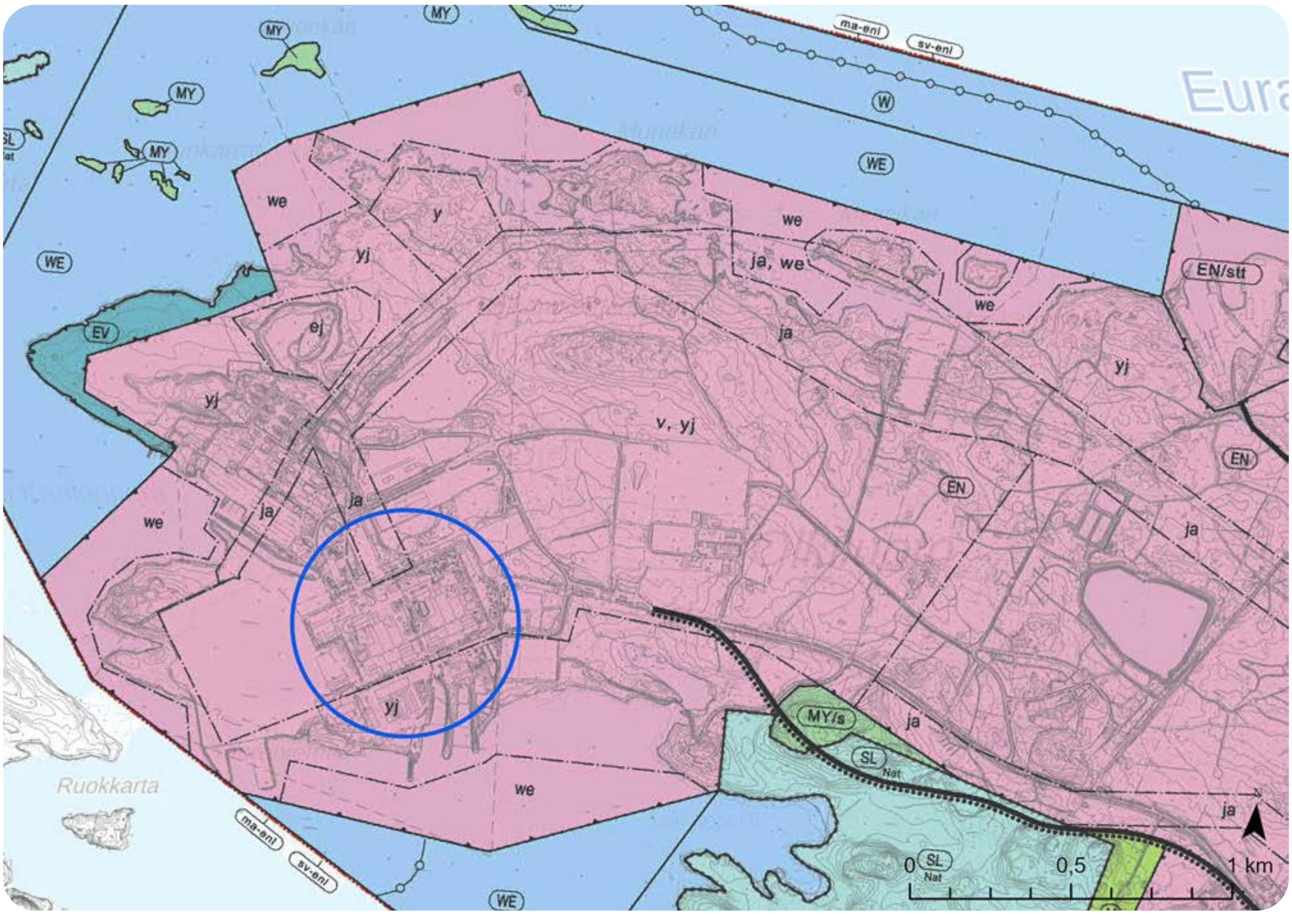


Figure 16. Excerpt from the Olkiluoto partial master plan. The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

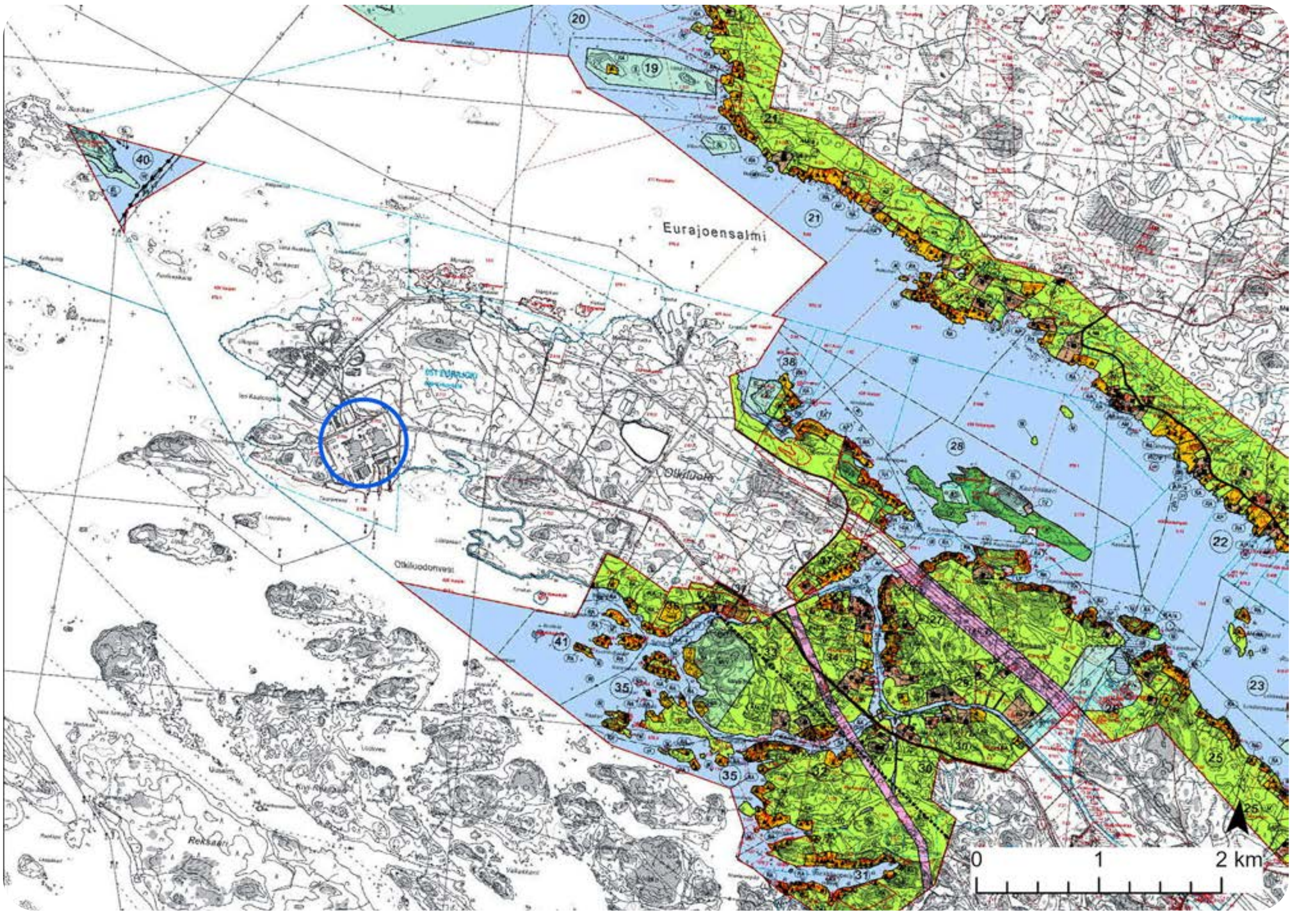


Figure 17. Excerpt from the master plan for shore areas in Eurajoki and its amendment (2000 and 2015). The location of the OL1 and OL2 plant units is marked with a blue circle in the picture. They are not located in the area covered by the master plan for shore areas.

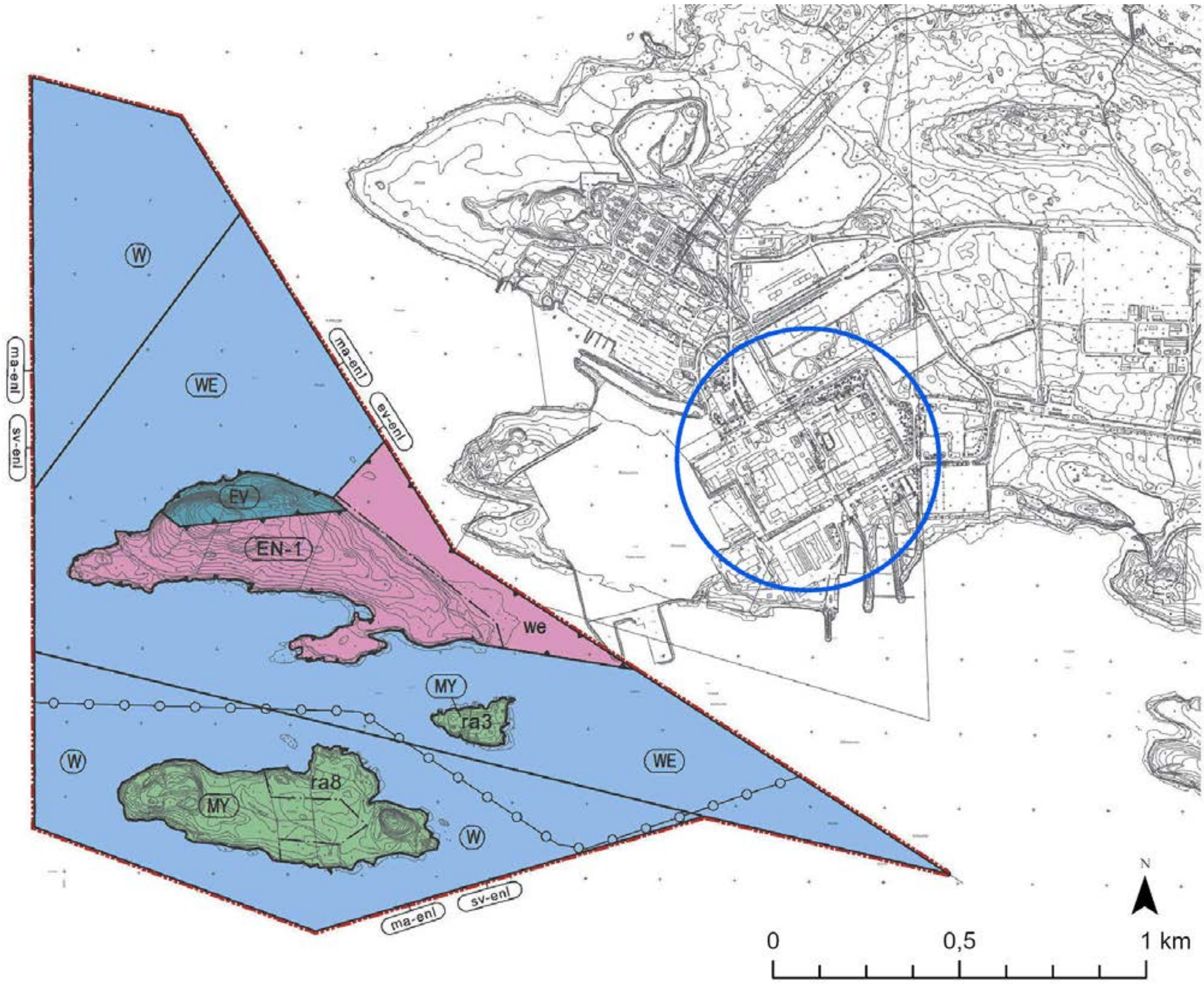


Figure 18. Excerpt from the partial master plan for northern shore areas in Rauma and its amendment (2000 and 2008). The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

Local detailed plans

The amendment of the building plan for Eurajoki parish village is in force in the area of the OL1 and OL2 plant units (confirmed as of 7 March 1997, Figure 19). The site area is designated as a block area (T), block 1, for industrial buildings and storage buildings, in which the construction of nuclear power plants and other facilities and equipment intended for the generation, distribution and transfer of energy and their related buildings, constructions and structures is allowed, unless this has otherwise been limited. The figure of 20% indicates how much of the area or construction area can be used for construction. The figure of 3,550,000 m^3 shows how many cubic metres of building rights the block has. The maximum elevation of the highest point of the building's outer roof is 100 m. The area where the actual nuclear power plants must be located is indicated by designation a.

The amendment of the building plan for Eurajoki parish village (1997) also contains a general provision according to which, in the blocks for buildings and in water areas, buildings, structures and other equipment may be located below ground level.

To the east of the site area, the Eurajoki building plan (confirmed on 14 Feb 1974) is in force. In the building plan, the areas to the east are designated as block area 3 for industrial and storage buildings, the provisions for which are identical to those for area T in the building plan from 1997.

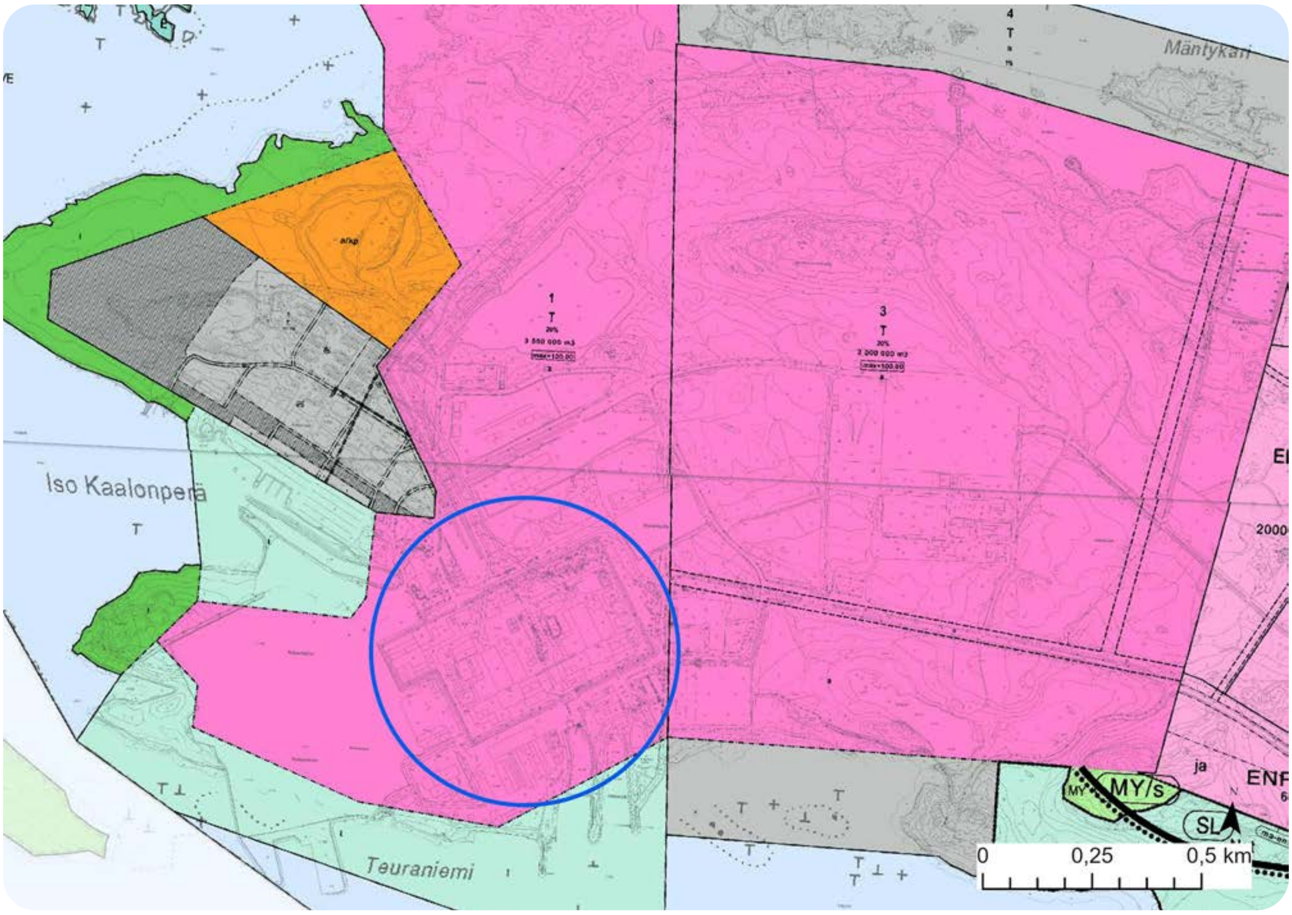


Figure 19. Excerpt from the current local detailed plan. The amendment of the building plan for Eurajoki parish village (1997) is in force in the site area. The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

In order to implement TVO's battery energy storage and near-surface final disposal project for very low-level waste, an amendment of the local detailed plan (Amendment of the local detailed plan for the Olkiluoto area) has been drawn up that was approved by the municipal council of Eurajoki on 14 Nov 2022 and became legally valid on 2 Jan 2023 (Figure 20). The aim for the plan was to update the plan provisions for the part of the power plant area so that the amendment enables the planned activities (battery energy storage and the near-surface final disposal of very low-level waste). In the plan, the area is designated as a block area for industrial buildings and storage buildings, in which the construction of buildings, constructions, structures and equipment related to nuclear power generation and the distribution and transfer of energy is allowed, unless this has otherwise been limited. Sub-areas where the structures and equipment required by the power plant and the disposal repositories for very low-level waste may be constructed are indicated with their own designation (en-1). In addition, sub-areas (en-2) have been assigned to the area in which nuclear power plant support functions can be built; power lines and equipment and buildings related to them and to energy storage may be placed in the area. The plan area is located approximately 350–400 m northwest of plant units OL1 and OL2.

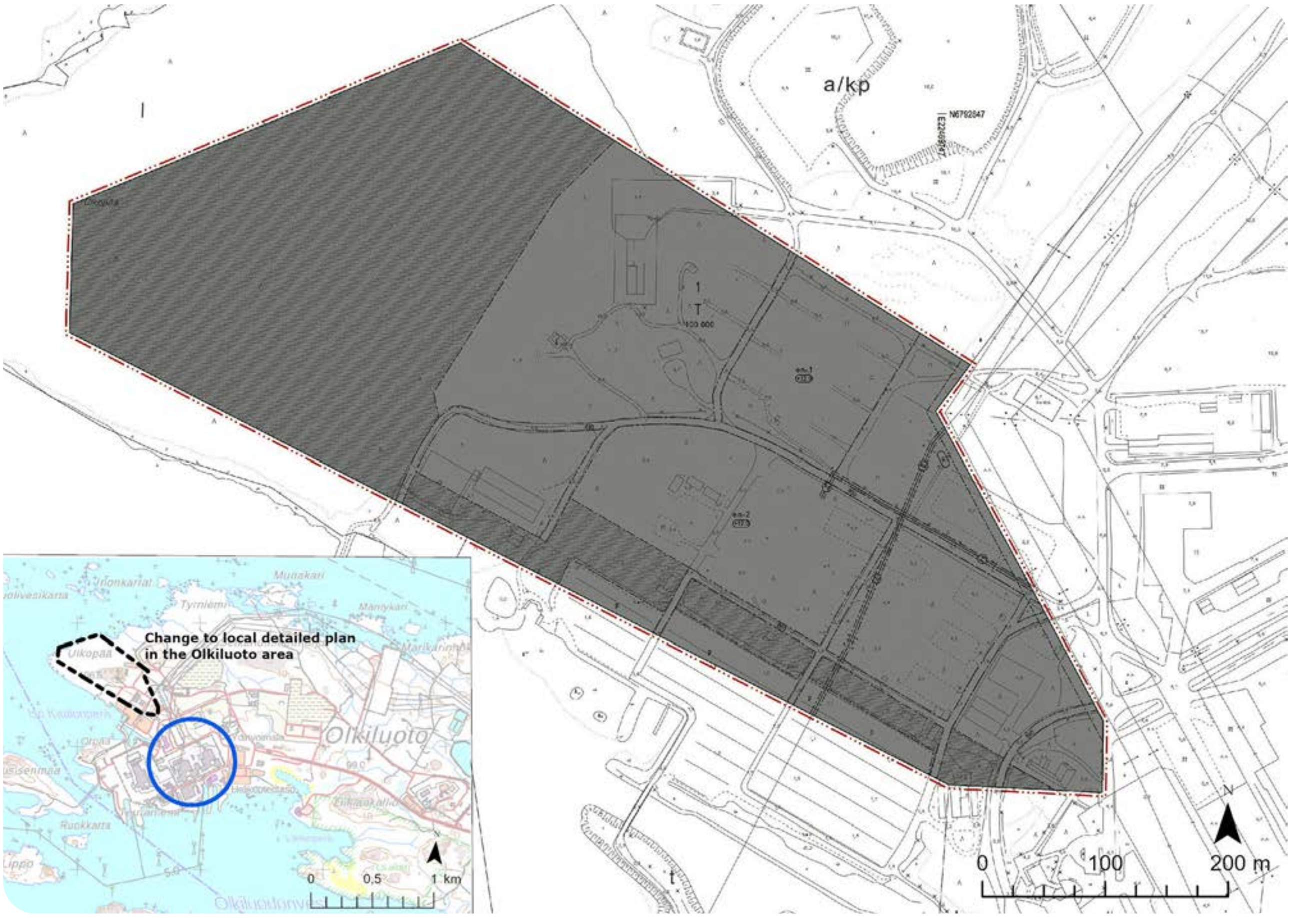


Figure 20. Amendment to the local detailed plan for the Olkiluoto area became legally valid on 2 Jan 2023. The location of the OL1 and OL2 plant units is marked with a blue circle in the location map on the bottom left picture.

The following local detailed plans are in force in the eastern part of Olkiluoto Island:

- Eurajoki: Local detailed plan and amendment for the final disposal area and the partial repeal of the local detailed plan and local detailed plan for the shore areas (year of approval 2010), including block areas for dormitories serving energy production – the plan was used to reserve an area for the final disposal activities of spent nuclear fuel according to the partial master plan.
- Olkiluoto local detailed plan 3 (year of approval 2005), including the block areas for dormitories serving energy production, the block area for office buildings, a caravan site serving energy production.

Furthermore, the eastern parts of Olkiluoto island have three confirmed local detailed plans for shore areas that guide holiday housing at a distance of approximately 2.6–4 km from the site area.

Pending plans

Preparation of the Satakunta provincial plan for 2050 started at the end of 2021. The Satakunta provincial plan for 2050 is drawn up as an overall provincial plan covering all forms of land use, where the principles of land use and community structure and the areas necessary for development in the entire province are discussed. New reports have been prepared for the plan, including a green structure survey and wind power and cultural environment surveys.

The central starting point for the preparation of the Satakunta provincial plan for 2050 are the current valid Satakunta provincial plan, phased provincial plan 1 and phased provincial plan 2. The plan designations and regulations in these are examined based on the updated national land use goals and the latest reports, plans and inventory data. The intention is that when the Satakunta provincial plan for 2050 comes into force, it will repeal Satakunta's previous comprehensive and phased provincial plans. *(Satakuntaliitto 2024)*

The participation and evaluation plan of the Satakunta provincial plan for 2050 has been available for viewing from 1 Apr 2022 to 13 May 2022. The Satakuntaliitto regional council approved the responses to the feedback given on the participation and evaluation plan of the Satakunta provincial plan for 2050 on 22 Nov 2022. The participation and evaluation plan has been updated and supplemented based on the responses and other detailed information received. The regional council approved the revised participation and evaluation plan on 19 Dec 2022. The aims of the Satakunta provincial plan for 2050 were approved on 17 Apr 2023. The goal of the Satakunta provincial plan for 2050 is to secure the land use conditions for the nuclear power production centre and the final disposal of nuclear waste at Olkiluoto in Eurajoki. The Satakunta provincial plan for 2050 is proceeding to the preparatory stage. According to the preliminary schedule estimate by Satakuntaliitto, the plan would advance to the proposal phase during 2024, and would possibly reach the approval phase in 2025–26. The provincial plan must be approved by the highest decision-making body of the provincial association, i.e. the Satakuntaliitto regional council. *(Satakuntaliitto 2024)*

No local detailed plan or master plan projects are currently pending in the power plant area or its immediate vicinity. The area of the beach site plan covering the pending Tuulikari camping centre is located some 4.5 km northeast of the site area. The closest change target and sub-area of the pending change to the Eurajoki waterside partial master plan is located some 4.4 km southeast of the site area on the shore of Karhunkarinrauma.

6.1.2.3. Sensitivity of the affected aspect

The sensitivity of the affected aspect is determined by the community structure, land use and zoning of the power plant area and its surrounding areas. Sensitive to changes are those areas in which, or in the vicinity of which, there are valuable natural sites, settlements or other land use that may be disturbed by the change.

In terms of zoning, the sensitivity is affected by whether the zoning of the power plant area accords with the planned project and for what kind of use the area affected by the project is zoned. The sensitivity of the site in terms of land use and zoning is estimated to be low. The site area is in the current nuclear power plant area, and the protective distances to sensitive sites have already been taken into account currently. There is no permanent settlement in the vicinity of the power plant area, but there is some leisure settlement. The zoning of the site area is in accordance with the operation of the nuclear power plant.

6.1.3. Environmental impacts

6.1.3.1. Service life extension

Relationship to national land use goals

The national land use goals are primarily put into practice through provincial planning. In provincial planning, the goals are matched with provincial and local conditions and goals. A new provincial plan is being drawn up for Satakunta, and the national land use goals are also taken into account in the provincial plan and programmes. In terms of energy supply, the goal of the Satakunta provincial plan for 2050 is to secure the land use conditions for the nuclear power production centre and the final disposal of nuclear waste at Olkiluoto in Eurajoki. The provincial plan will be discussed later in this chapter. Some of the national land use goals are such that they are taken into account directly in municipal planning. In the municipality, the master plan is a central planning level in the practical implementation of the national land use goals and the provincial plan. A master plan and town plan are in force in the area, and they will be discussed later in this chapter.

Continued operations will not cause changes to the regional or community structure. Continuation of operations in the existing power plant area is favourable in terms of low-carbon and resource-efficient urban development and directly supported by the existing structure. Continuation of operations also helps to ensure the low-carbon nature of electricity production in Finland.

Preparations for extreme weather phenomena, such as floods, have been made in the current operation of the plant units. Similar preparations must also be included in the plans regarding the extension of service life. Environmental and health hazards caused by noise, vibration and poor air quality (the goal of a healthy and safe living environment) are also prevented in the case of continued operations.

A sufficiently large distance is left between activities that cause harmful health impacts and accident risks and activities that are sensitive to these impacts. For example, there is a precautionary action zone spanning to a distance of 5 km around the nuclear power plant site area, where limitations on land use are in effect. The risks related to nuclear power are managed in many different ways, such as the nuclear power plant's emergency preparedness. The nuclear power plant and its operations are located at a sufficient distance from residential areas and particularly sensitive natural areas.

Extending the service life of the plant units directly or partly supports some of the national land use goals (e.g. energy production and economic activity) and does not, as a whole, cause a change in the realisation of any goal when compared to the current situation.

Impacts on community structure, land use and zoning

The town plan in force enables the expansion of the KPA storage, if required, as the area is designated (T) for industrial buildings and storage buildings, and the construction of nuclear power plants and other facilities and equipment intended for the generation, distribution and transfer of energy and their related buildings, constructions and structures is allowed, unless this has otherwise been limited. The building right of the block is indicated as cubic metres (3,550,000 m^3). According to the general provision of the town plan, buildings, structures and other equipment can be placed below ground level in blocks for buildings and in the water area. The possible expansion of the KPA storage is in accordance with the valid zoning of the area and does not cause significant impacts in terms of land use and zoning.

During the continued operation of the plant units, the operation of the power plant will be similar to the current situation. During operation, the site area is closed and the movement of outsiders in the area is prevented.

The extension of operations until either 2048 or 2058 will limit land use in the vicinity of the power plant in the coming decades as well. In the Satakunta provincial plan, most of the island of Olkiluoto and the site area are designated as an energy supply plant area (Olkiluoto) and a target area for energy supply development (Olkiluoto, Eurajoki, TVO nuclear power plant), and a nuclear power plant precautionary action zone is designated around the area. The planning solution has secured the operational possibilities of the current power plant units and the development of the area in the future as well. The 5 km precautionary action zone assigned in the provincial plan is based on the location of the existing nuclear power units on the island of Olkiluoto. The precautionary action zone prevents the location of functions in the vicinity of the power plant that could endanger the safe operation of nuclear power plants. For example, it is not possible to place in the 5 km precautionary action zone of the power plant any entities that are visited by or include considerable numbers of people *(YVL A.2)*. In addition, land use and construction decisions shall aim at maintaining the number of permanent and leisure-time inhabitants inside the precautionary action zone at a level where it will not substantially increase during the construction and operation of the nuclear power plant. The nuclear power plant does not restrict land use outside the precautionary action zone.

The area is covered by the Olkiluoto partial master plan, where the site area is designated an energy supply area and a sub-area intended for the actual nuclear power plants is designated. The current operations of the plant units and the extension of the operations conform to the law.

The amendment of the building plan for Eurajoki parish village is in force in the area of the OL1 and OL2 plant units. In it, the site area is designated as a block area for industrial buildings and storage buildings, in which the construction of nuclear power plants and other facilities and equipment intended for the generation, distribution and transfer of energy and their related buildings, constructions and structures is allowed, unless this has otherwise been limited. The town plan currently in force enables the continued operation of the plant units.

The impacts of continued use of the plant units on community structure, land use and zoning are similar to those of current operations. The extension of the service life of the plant units will limit land use in both the site area and its surrounding areas in the coming decades as well, until either 2048 or 2058. The operations of the plant units and the extension of the operations are in accordance with the zoning of the area, and no zoning changes are required. The restrictions caused by the Olkiluoto nuclear power plant are taken into account in the zoning of the affected area. Extending the service life of the plant units relies on the current community structure. The magnitude of the change to land use and zoning is estimated to be a minor negative on the whole, considering the continuation of restrictions on land use.

6.1.3.2. Uprating the thermal power

Relationship to national land use goals

Like extending the service life of plant units, the uprating of thermal power also directly or partly supports some of the national land use goals (e.g. energy production and economic activity) and does not, as a whole, cause a change in the realisation of any goal compared to the current situation (see Chapter 6.1.3.1).

Impacts on community structure, land use and zoning

In the case of uprating the thermal power, a new diesel-powered supplementary water system and a new battery energy storage will be built outside the plant units to improve the safety of the plant units (Figure 3). The supplementary water system is to be placed inside the fenced site area. In the town plan in force, the site area is designated as a block area for industrial buildings and storage buildings, in which the construction of nuclear power plants and other facilities and equipment intended for the generation, distribution and transfer of energy and their related buildings, constructions and structures is allowed, unless this has otherwise been limited.

The battery energy storage is planned to be located further north in the power plant area, where a town plan change for the Olkiluoto area is valid (from 2 Jan 2023). In the plan, the primary location area is designated as a block area for industrial buildings and storage buildings, in which the construction of buildings, constructions, structures and equipment related to nuclear power generation and the distribution and transfer of energy is allowed, unless this has otherwise been limited. The area has a subdivision designation (en-2) indicated in the plan, according to which nuclear power plant support functions can be built in the area; power lines and equipment and buildings related to them and to energy storage may be placed in the area.

In addition, in the case of uprating the thermal power, it may be necessary to expand the current KPA storage, as described in Chapter 6.1.3.1 regarding the continuation of operations. The possible expansion of the KPA storage is in accordance with the current town plan (amendment of the building plan of Eurajoki parish village from 1997) and will not cause significant impacts in terms of land use and zoning. The possible need to expand the KPA storage does not therefore cause the need for an amendment to the plan.

Additional construction required by the uprating of thermal power is not significant, and is in accordance with the existing plans and the current land use of the area. The magnitude of the change to land use and zoning is estimated to be a minory negative on the whole, considering the continuation of restrictions on land use during the years of extended service life.

6.1.3.3. Significance of the impacts

The sensitivity of the affected aspect in terms of community structure, land use and zoning was estimated to be low, as the site area is in the current nuclear power plant area and the protective distances to sensitive sites have already been taken into account currently. There is no permanent settlement in the vicinity of the power plant area, but there is some leisure settlement. The zoning of the site area is in accordance with the operation of the nuclear power plant.

In the case of continuing operation at the current power level (VE1) and continuing use with an uprated power level (VE2), the impacts on land use and zoning are similar to the current operation. Additional construction in the area is not significant, and is in accordance with the existing plans and the current land use of the area. The continuation of the operation of the plant units fulfils the purpose of use according to the zoning of the area and does not require amendments to the plan. On the other hand, the restrictions caused by the nuclear power plant are taken into account in the zoning of the affected area. However, the magnitude of the impact was estimated to be a minor negative, because the extension of the service life of the plant units will limit land use in both the site area and its surrounding areas in the coming decades as well.

In both alternatives, the significance of the impacts is therefore a minor negative, considering that the land use restrictions in the area will continue until either 2048 or 2058 (Table 14).

Table 14. Significance of the impacts: community structure, land use and zoning.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.1.4. Mitigation of harmful impacts

In additional construction activities, harmful impacts can be mitigated by taking into account the surrounding land use. In accordance with Section 83 of the Land Use and Building Decree, fencing off of the construction site; protective structures to prevent personal and property damage; measures to avoid traffic and other disturbances; and the organisation of construction work in such a way that the construction site does not cause unreasonable harm to neighbours or passers-by can be stipulated in the building permit or during construction work.

6.1.5. Uncertainty factors

The impacts caused by the project have been taken into account as widely as possible. The assessment does not include uncertainties related to current land use. The assessment of the impacts on zoning is based on valid provincial, master and town plans. The Satakunta provincial plan for 2050 is being drawn up, and the goal there is also to secure the land use conditions for the nuclear power production centre and the final disposal of nuclear waste at Olkiluoto in Eurajoki.

6.2. Landscape and cultural environment

6.2.1. Initial data and assessment methods

The assessment of landscape impacts examined whether the project causes changes to the landscape or impacts on objects of the cultural environment or archaeological objects. A description was drawn up for the landscape structure, views and cultural environment of the area. In the assessment of impacts affecting the landscape and the constructed cultural environment, the documentation used consisted of the project's design information, maps, aerial photographs, land use plans and other analyses drawn up for the area, as well as register information from the authorities (such as the open data location information from the Finnish Heritage Agency and the Ministry of the Environment's Administrative Branch).

The assessment of impacts affecting the landscape focused on examining the change in the landscape image: how are the possible changes brought about by the project visible to the outside of the site area, how forceful the change in the landscape is and which locations are most affected by the change. As regards the cultural environment, the assessment examined whether the impacts can reach the closest locations. The focus of the impact assessment is on impacts affecting the nearby areas (5 km).

6.2.2. Current status

6.2.2.1. General description of the landscape

In the provincial distribution of landscapes, Olkiluoto Island belongs to the Satakunta coastal region of the Southwestern landscape province. When moving north from the southwestern archipelago, the archipelago zone becomes narrower and nature becomes more barren. The landscape area has varying island regions, and the terrain is low with minute features. The coast has sheltered, long and reedy bays *(Ministry of the Environment 1992)*.

The landscape image in the site area and its surroundings is closed due to tree-filled strips and existing industrial construction. A wide corridor for powerlines heads towards the continent from the power plant area, splitting the closed landscape of the forest region. The plant units can be viewed from the south across Olkiluodonvesi. Direct views of the plant area from the sea (north/west) are limited by the trees along the shoreline; however, the power plant buildings and ventilation stacks are visible across a wide area above the tree tops.

In addition to the structures in the power plant area, the landscape image of Olkiluoto Island is dominated by the closed forest areas and shores, between which there are local open coastal cliffs. Buildings consist of holiday housing constructed along the shores and small, village-like complexes of residential buildings. Some small open fields are located on the island among the forests. The area is characterised by low elevations, and the highest point is 18 m above sea level. Overall, the landscape image of Olkiluoto Island is a mosaic of closed forest areas, coastal cliffs, the power plant area, small-scale construction and farming landscape. The shore landscape at Olkiluoto itself is varying, with minute features and a fragmented shoreline. The coastal areas are largely filled with thick forests; occasionally, there are bays with rocky terrain or reed fields.

The OL1 and OL2 plant units are located in the existing Olkiluoto power plant area, in a large-scale industrial environment where human activity has had a significant impact on the landscape (Figure 21). The power plant units are a dominating element in the nearby landscape of the area. In the distant landscape, the area has a wooded appearance, and the elements of power plant activity, with the ventilation stacks, can be seen in the silhouette.

Figure 21. Aerial photograph of the site area.

6.2.2.2. Valuable landscape and cultural environment areas and locations

No nationally or provincially valuable landscape areas or nationally or provincially significant constructed cultural environments are located in the power plant area or its immediate vicinity (Figure 22). The nearest provincially significant cultural environment is located approximately 5 km south-east of the site area (Kaunissaari). The nearest nationally significant constructed cultural environment (RKY), Sorkka village, is located about 8 km to the southeast of the site area. No objects protected by virtue of the Antiquities Act are located in the power plant area or its immediate vicinity. *(Finnish Heritage Agency 2009)*

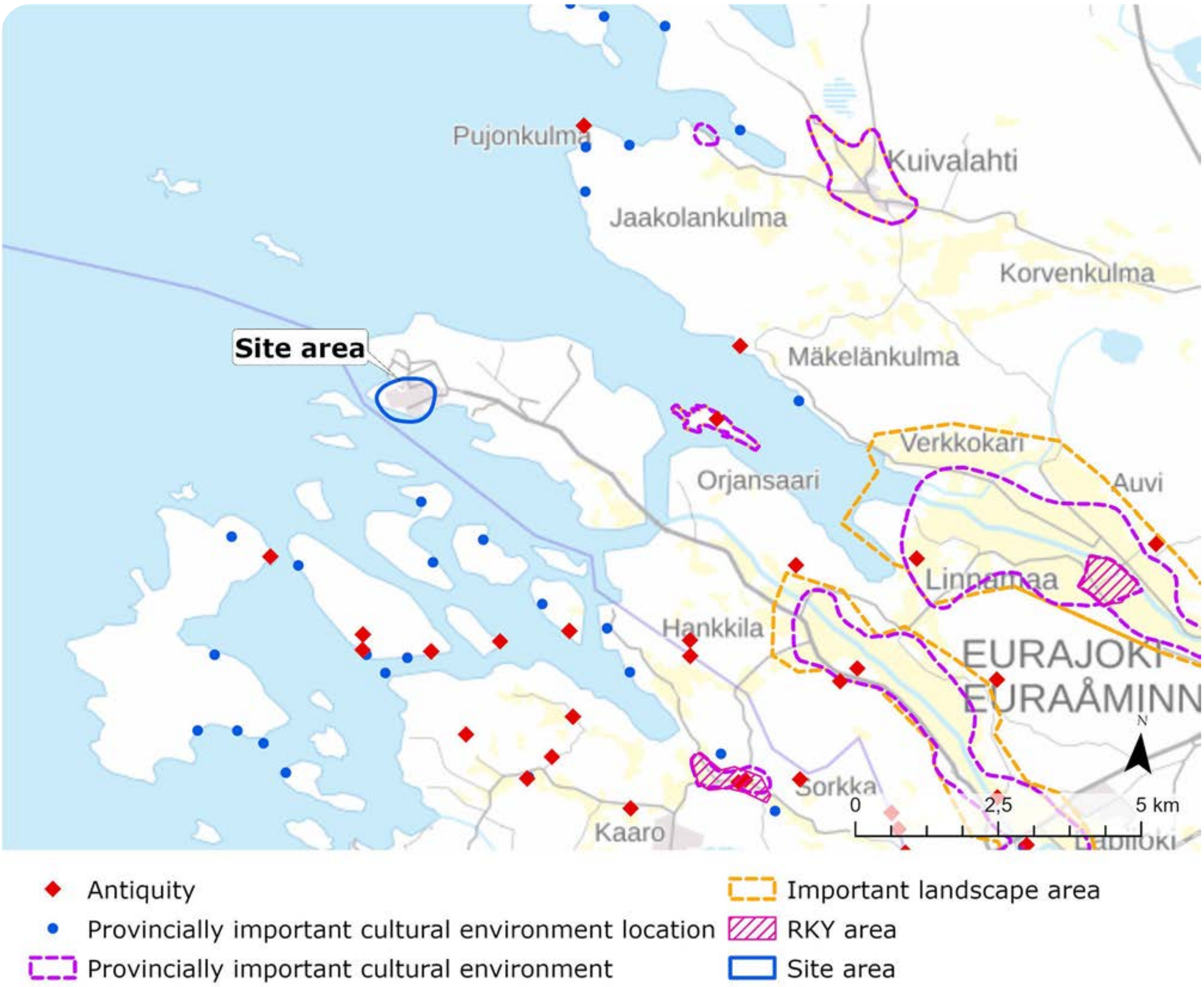


Figure 22. Landscape areas, cultural environments and fixed antiquities located in the vicinity of the power plant area.

6.2.2.3. Sensitivity of the affected aspect

The plant units are located in an existing power plant milieu that has already shaped and characterised the landscape on Olkiluoto Island and its surroundings. The power plant and its structures form a clear, separate complex in the coastal landscape that is otherwise wooded with minute features. When viewed from further away, however, its impact on the landscape is a local disturbance. The plant units are not located in a valuable area in terms of the landscape or cultural environments, and no archaeological cultural heritage is situated in the area. The coastal zones surrounding the power plant have a low number of holiday homes and year-round residences. The site area can mainly be seen from the surrounding sea areas, in terms of both the local and distant landscapes, as power plant structures that rise above the treetops. The sensitivity of the affected aspect is estimated to be low in terms of the landscape and the areas and locations categorised as part of the cultural landscape, when taking into account the functions already located in the area and their impact on the landscape across decades.

6.2.3. Environmental impacts

6.2.3.1. Service life extension

The maintenance and improvement work required by the service life extension of the OL1 and OL2 plant units will be implemented inside the plant units, and no additional construction will be required for them in the power plant area. If the KPA storage is expanded, the size of the storage building located in the area will be slightly extended at one end of the building. The appearance or height of the building will not change and, therefore, the expansion will not affect the landscape image in the area. In terms of landscape, the expansion of the building will only affect the landscape image within the area, where the change will not be significant. The expansion of the KPA storage will not result in impacts on the landscape, its categorised areas or locations or the archaeological cultural heritage during construction.

In the service life extension alternative, the operation of the OL1 and OL2 plant units will continue in the present manner. The OL1 and OL2 plant units are located in their entirety in a landscape defined by a large-scale industrial environment where the impacts of human activity are already significant. No nationally or regionally important landscape areas or constructed cultural environments are located in the immediate vicinity of the power plant, and no objects of archaeological cultural heritage are known to exist in the area. At the moment, the landscape impacts of the power plant area can mainly be observed from the sea and from inside the power plant area. When viewed from the continent, the power plant area is largely covered behind wooded zones. In terms of the distant landscape, the reactor buildings and stacks of the power plant area are visible from far away. The distant landscape image is characterised by nature or small-scale construction, which means that the power plant structures create the hierarchical key point in the landscape and dominate the location in terms of the distant landscape.

The impacts of the service life extension of the plant units on the landscape, its valuable areas and locations and the archaeological cultural heritage are similar to those of the current activities. The site area is in the current nuclear power plant area, and the protective distances to sensitive locations have already been taken into account currently. The possible additional construction relate to the service life extension will not cause a major change in terms of the landscape; however, when considering the continuation of the present landscape impact within the area until either 2048 or 2058, the total magnitude of the impact is estimated to be at most a minor negative.

6.2.3.2. Uprating the thermal power

The modifications required by the power uprating will mainly be implemented inside the OL1 and OL2 plant units. Furthermore, a new make-up water system and battery energy storage system will be constructed in the site area (Figure 3). Both additional buildings will be located in the power plant area where the visual appearance of the landscape is heavily industrial.

The make-up water system will be located inside the site area, next to the OL2 plant unit. The make-up water system consists of two diesel pump containers, a tank container and a water tank. The containers are 2.5 m in height, while the height of the water tank is 11.5 m. The height of the adjacent plant unit's ventilation stack is approximately 100 m, and the power plant building has a height of approximately 60 m. Compared to the existing buildings in the site area, the new structures of the make-up water system are small in scale. The structures of the make-up water system will not change the landscape as such, as they will be part of a site area that consists of significantly larger buildings.

The battery energy storage system will be located to the north-west of the site area, approximately 500 m away and next to the parking area for the OL3 plant unit, near the other hall buildings. At present, this location has a small (10,000 square metres (m^2) rocky forest area and hall buildings. The area reserved for the battery energy storage system is approximately 1.2 ha. The new battery energy storage system will consist of separate halls, a local control room building and a power transformer. The buildings will be similar in size to the adjacent, existing hall buildings (Figure 9). To the west, the area is delimited by a forest area and an existing hall building; to the south-west, there is a parking area located on the shore as well as a road, and there are several hall buildings to the east. The removal of trees required for the construction of the battery energy storage system will not have a substantial impact on the views towards the area. The young trees that would potentially be felled due to the construction of the battery energy storage system are only visible in the broader landscape when viewed from the sea in the southwest and, viewed from there, the landscape is delimited by the existing parking area on the shore. When viewed from the southwest, the dominant elements on the landscape are the parking area, the hall storage buildings locate to the east of the battery energy storage system and the power plant buildings in general. In the local landscape, the landscape image of the battery energy storage system is characterised by the industrial area. The cable connection to be constructed from the plant units to the battery energy storage system is underground and, thereby, will not affect the landscape.

In addition, in the case of uprating the power, it may be necessary to expand the current KPA storage, as described in Chapter 6.2.3.1 regarding the continuation of operations.

The landscape impacts of the construction of additional structures mainly focus on internal views inside the power plant area. The additional structures are located closely within the current power plant area, and their scale is small when compared to the other buildings in the area. The landscape impacts are assessed to be a minor negative at most when considering the extension of the plant units' operation until either 2048 or 2058. No impacts will target categorised areas or locations or the archaeological cultural landscape.

6.2.3.3. Significance of the impacts

The sensitivity of the affected aspect was assessed to be minor in terms of the landscape and cultural environment, since the plant units and their structures are located in an existing power plant milieu that has already shaped and characterised the landscape on Olkiluoto Island and its surroundings for decades.

The impacts of the service life extension (VE1) and power uprating (VE2) of the plant units on the landscape, its valuable areas and locations and the archaeological cultural heritage are similar to those of the current activities. The possible additional construction related to the service life extension or the possible construction of an extension of the KPA storage will not cause a significant change in the landscape, since the new structures will be located closely within the existing power plant area. When considering the continuation of the current landscape impact within the area until either 2048 or 2058, the total magnitude of the impact is estimated to be at most a minor negative, since the plant units will continue to impact the otherwise minute and wooded landscape visible from the sea even during the coming decades.

In both alternatives, the significance of the impacts was assessed to be a minor negative, with the current landscape impacts continuing until either 2048 or 2058. (Table 15)

Table 15. Significance of the impacts: landscape and cultural environment.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.2.4. Mitigation of harmful impacts

As regards the prevention and mitigation of the landscape impacts, the key is to preserve and maintain the trees in the area as well as the vegetation around the site area and, in particular, on the shore areas viewable from the sea. In part, the impacts may be mitigated by adhering to good construction practices in the design and implementation of new structures and, for example, ensuring that their colour schemes blend in with the landscape in the area, forming a harmonious whole with the existing buildings.

6.2.5. Uncertainty factors

Landscape impacts are not objectively measurable or unambiguous. The experience of visual impacts from any construction is highly subjective and, thereby, assessing the significance of the impacts and the manner of impact is challenging. How the impacts are experienced is affected by, among other things, the individual's relationship with the area and locations, knowledge of and interest in the topic, life experience as well as personal opinions and justifications for valuing the area. The landscape impacts will also vary according to the season, weather and other environmental conditions.

6.3. Traffic

6.3.1. Initial data and assessment methods

Traffic impacts were examined by estimating traffic volumes and changes thereto on the roads leading to the power plant area. The review accounts separately for the changes in overall traffic volumes, passenger traffic volumes and the volumes of heavy vehicle traffic. The impact assessment accounted for traffic arriving at and departing from the power plant area. The impacts on the load of the traffic network, the flow of traffic and road safety attributable to changes in traffic volumes were assessed as an expert assessment. Special attention was paid to any possible sensitive aspects located along the transport routes, such as housing, day nurseries and recreational areas. Data describing the present state was compared to the maximum volumes of traffic during the project, taking into account normal operation and annual outages.

The road connections leading into the power plant area and their current traffic volumes have been compiled from the documentation of the Finnish Transport Infrastructure Agency *(Finnish Transport Infrastructure Agency 2023)*. In terms of road safety, accident statistics of the roads leading to the power plant area and other available documentation were utilised. Various map reviews were also utilised in terms of the properties of the road and sensitive aspects, among other things. The area under review comprised the roads leading to the power plant area and their immediate surroundings (0–2 km), up to main road 8.

Emissions caused by traffic are assessed in chapters 6.5 and 6.6, while noise and vibration impacts are described in chapter 6.4. Transfers of spent nuclear fuel are examined in chapter 6.15.

6.3.2. Current status

The Olkiluoto area has functional transport connections for vehicles, with roads, parking areas and harbours (Figure 23).

Olkiluodontie (connecting road 2176, Lapijoki–Olkiluoto), with a length of approximately 13 km, branches out from main road 8 at Lapijoki towards the power plant area. The distance from the intersection to Rauma is approximately 7 km and to Pori approximately 40 km.

Traffic volumes on the road section of main road 8 leading towards Rauma at the Olkiluodontie intersection were approximately 10,605 vehicles per day in 2023. Of this, heavy traffic amounted to 961 vehicles per day. The total traffic volume towards Eurajoki was approximately 10,222 vehicles per day, of which 932 were heavy vehicles. *(Finnish Transport Infrastructure Agency 2023)*

On Olkiluodontie, the highest traffic volumes are seen immediately past the intersection with main road 8, over a distance of approximately 5 km until the intersection of Sohantie. In 2023, the average daily traffic volume along this road section was approximately 2,319 vehicles per day, of which approximately 119 were heavy vehicles. From Sohantie towards the power plant area, the total traffic volume was approximately 1,960 vehicles per day, of which approximately 148 were heavy vehicles. *(Finnish Transport Infrastructure Agency 2023)*. Most of the traffic on Olkiluodontie is commuting traffic, which mainly takes place between 7 and 9 am and 4 and 5 pm. Traffic volumes along Olkiluodontie vary greatly, in particular during construction projects in the area and the annual outages of the nuclear power plant units.

Olkiluodontie intersects several smaller roads. Olkiluoto is accessible by road from Rauma via Sorkka and from the centre of Eurajoki via Linnamaa. On Sohantie, which intersects Olkiluodontie towards Rauma, the traffic volume amounted to 764 vehicles per day and on Vähäkyläntie, which turns towards Eurajoki, there were 341 vehicles per day. On both roads, the share of heavy traffic amounted to less than 1% *(Finnish Transport Infrastructure Agency 2023)*.

Traffic volumes in the area were at a significantly higher level in 2018–2022. During these years, traffic volumes on Olkiluodontie exceeded 3,000 vehicles per day; in 2023, traffic volumes fell to 2017 levels, at slightly more then 2,000 vehicles per day. The change can be mainly attributed to the start of test operation at the OL3 plant unit in early 2018. The actual construction work and installations of heavy components at the OL3 plant unit were already completed in the early 2010s.

The road section on Olkiluodontie has a tarmac surface, is partially lit and has a speed limit of 30 to 80 km/h. A separate pedestrian and bicycle way runs up to Hankkila, approximately 5 km from the main road. During the past five years (2018–2022), 19 accidents that have been reported to the police took place on Olkiluodontie *(Ramboll 2024b)*. Of these, three were head-on collisions or single accidents that resulted in injury. No personnel injuries occurred in the other accidents. They were accidents involving elks, deer or other animals (8 pcs), single accidents (7 pcs) and head-on collisions (1 pc). In 2018–2022, a total of 4 accidents occurred in the intersection of Olkiluodontie and main road 8; they were either rearend collisions, overtaking accidents or single accidents. *(Ramboll 2024b)*. Lapijoki school (primary school) is located along Olkiluodontie. During the period under review, there have been four accidents leading to property damage at the intersection of Olkiluodontie and main road 8.

The Centre for Economic Development, Transport and the Environment of Southwest Finland has had an ongoing design project for main road 8 between Rauma and Eurajoki. In October 2023, on the basis of an EIA procedure and stakeholder dialogue regarding the road project, alternative VE2 was chosen which includes improving the current main road to have four lanes (2+2). A general plan according to the legislation will be drawn up for this alternative, and it is expected to be completed during 2024. The general plan specifies the details of the solutions. For Olkiluoto, the likely way forward is alternative VE3 in the EIA report, according to which road 2176 will be redirected between Pohjoiskehä and Olkiluodontie with the construction of a new interchange at the intersection of Olkiluodontie and main road 8. *(Finnish Transport Infrastructure Agency 2023)*

Olkiluoto harbour is located in the northern part of Olkiluoto Island, on the shore of Eurajoki strait, approximately 20 km north of Rauma (Figure 23). A shipping route with a length of 7.5 km and a depth of approximately 6 m leads to the harbour. During the open water season, the harbour is used for both import and export. The harbour is visited by approximately 60–70 ships each year. The harbour is mainly used for bulk goods transport, such as crushed stone and raw timber. The piers for the Olkiluoto nuclear power plant are located to the south of Olkiluoto island, with a shipping route of 5 m in depth leading to them. The piers are visited at most by 1–2 ships per year. Furthermore, a shipping route of 2 m in depth leads to the fishing harbour in Pujonkulma. Other marine traffic in the waters near Olkiluoto mainly comprises boating related to recreational use and fishing.

The sensitivity of the location is determined in accordance with the characteristics of the traffic network and the environment, as well as the surrounding land use. The road network in the area is designed for high traffic, taking into account the traffic volumes of the power plant area. As regards OL3, which was constructed in the area, the completion of the construction work has reduced traffic volumes on the road network when compared to earlier years. Heavy traffic amounts to a small share of the total traffic volumes. No major residential areas or sensitive locations are located near the road network. On this basis, the sensitivity of the location is estimated to be low. The sensitivity of the area is emphasised during annual outages, when the total traffic volumes are higher than normal.

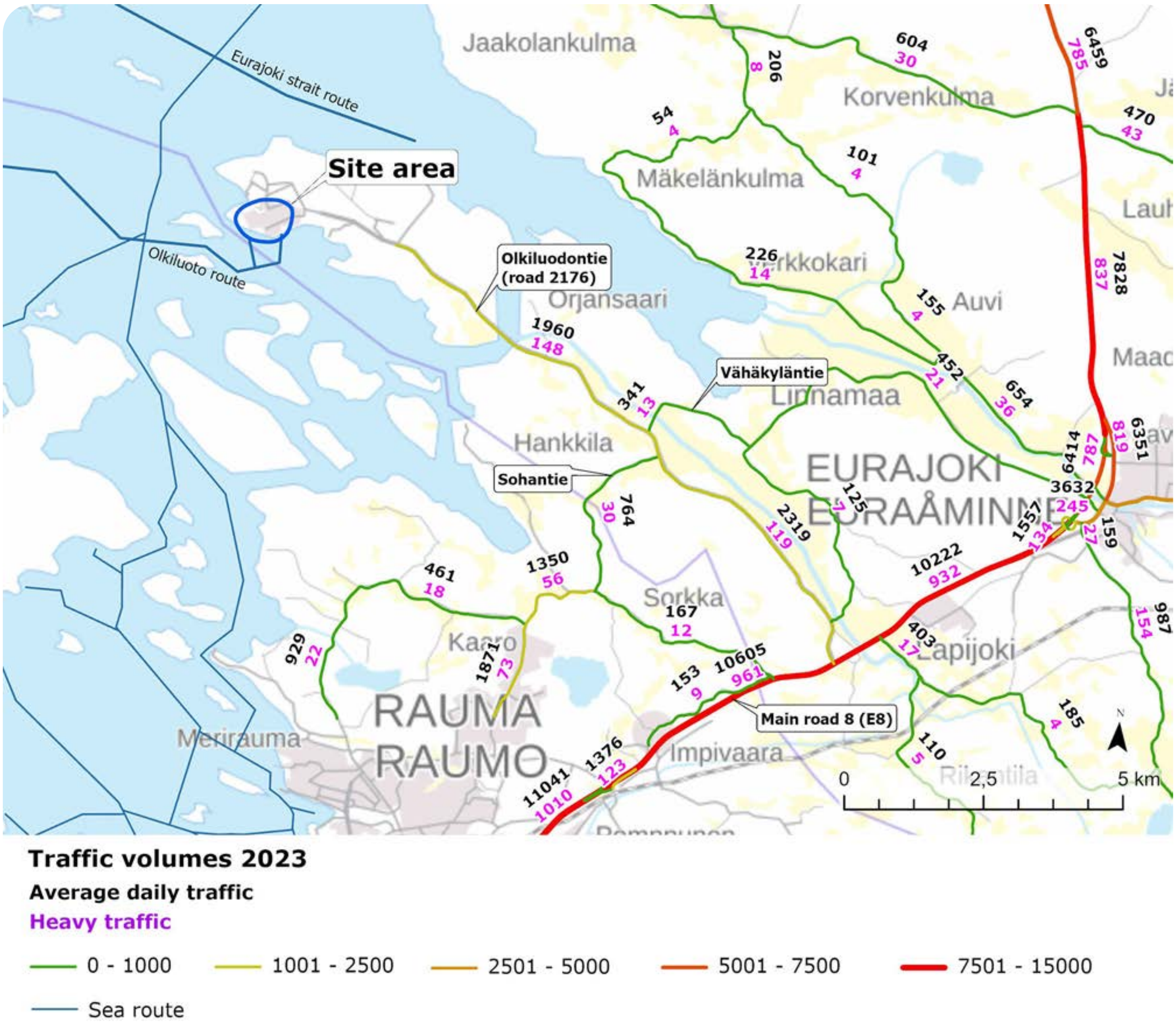


Figure 23. Roads and sea routes leading to the Olkiluoto power plant area.

6.3.3. Environmental impacts

6.3.3.1. Service life extension

The modification work required by the service life extension will be implemented inside the plant units. This will not affect traffic volumes, as they are estimated to remain at the same level when compared to the current situation. If the KPA storage is expanded, this may cause a temporary, minor addition to the traffic volumes on the roads leading to the site area. During the construction, which is estimated to last for approximately 2 years, traffic volumes would increase by an estimated 5 lorries per day, while passenger traffic would increase by an estimated few dozen vehicles per day for the duration of the construction project. Some transports will be special transports. The minor increase in traffic volumes is not estimated to have a significant impact on the traffic volumes of the roads in the area, or on traffic safety.

In the service life extension case, traffic volumes for the power plant will remain at a similar level to that of the current operation. The average daily volume of passenger traffic towards the power plant is approximately 1,000 vehicles per day. There are approximately 50 heavy vehicles per day. These are related to transports of fresh nuclear fuel, various pieces of equipment, chemicals, fuel oil and gases and waste management.

The enclosed table (Table 16) presents the share of traffic volumes related to the power plant's service life extension from the total traffic volumes on the roads and the heavy traffic volumes (vehicles/day). The figures presented in the table assume a situation where all heavy traffic for the power plant will exclusively run along Olkiluodontie and divert into main road 8 in a manner where 50% runs in the direction of Rauma and 50% towards Eurajoki. Most passenger traffic to the power plant is likely to run from main road 8 along Olkiluodontie. A small volume of passenger traffic may also run to the north of Rauma along Sohantie and from Eurajoki via Vähäkyläntie. For passenger traffic, it has been estimated that approximately 80% will use Olkiluodontie, 10% will use Sohantie and 10% will use Vähäkyläntie. Similarly to heavy traffic, the assumption is that 50% of the users of main road 8 will travel in the direction of Rauma and 50% towards Eurajoki. The calculation has not considered that some employees may use public transport (buses) or ride-sharing for their commute.

Table 16. Total traffic volumes and volumes of heavy traffic on the roads leading to the power plant area (Finnish Transport Infrastructure Agency 2023) and the share of traffic to the power plant.

Road	Total traffic volume (vehicles/day)	Power plant's share of total traffic volumes	Volume of heavy traffic (vehicles/day)	Power plant's share of heavy traffic volumes
Main road 8 (Rauma)	10,605	5%	961	3%
Main road 8 (Eurajoki)	10,222	5%	932	3%
Olkiluodontie (E8–Sohantie)	2,319	38%	119	42%
Olkiluodontie (Sohantie – site area)	1,960	54%	148	34%
Sohantie	764	14%	30	0%
Vähäkyläntie	341	31%	13	0%

In the service life extension case, the traffic impacts on the various road sections will remain as they are, but they will continue until either 2048 or 2058. Overall, the volumes of heavy traffic to the power plant are low when compared to the volumes of passenger traffic. The table (Table 16) presents an estimate of the power plant's shares of traffic volumes along different road sections. The total traffic volumes for the power plant are at their highest in the section of Olkiluodontie that runs from the site area to Sohantie, amounting to approximately 54% of the total traffic volumes for the road. The power plant accounts for approximately 34% of heavy traffic. On the section of Olkiluodontie between Sohantie and main road 8, traffic to the power plant accounts for approximately 38% of the total traffic volumes. On this road section, heavy traffic to the power plant accounted for approximately 42% of the total volume of heavy traffic. On Olkiluodontie, the share of traffic to the power plant is estimated to be moderate when compared to the volumes for total traffic and heavy ttaffic. On main road 8 in the direction of Rauma or Eurajoki, the share of traffic from the power plant is negligible, amounting to approximately 5% for the total traffic volume and 3% for heavy traffic volumes (Table 16). Only passenger traffic is likely to be routed into Sohantie from the power plant, and its share has been estimated to amount to approximately 14% of the total traffic volumes on the road. On Vähäkyläntie, the corresponding share of passenger traffic is approximately 31% and there is no heavy traffic.

Annual outages at the power plant will temporarily increase passenger traffic by an estimated 1,000 vehicles per day. At this time, the power plant's share of the total traffic volumes on the roads will temporarily increase. An annual outage for one unit usually lasts between 1 and 8 weeks.

During the annual outages, when traffic volumes are at their highest, traffic flow may be temporarily degraded especially at the intersection of main road 8 and Olkiluodontie. On average, slightly fewer than 4 accidents per year have occurred on Olkiluodontie during the past five years. There have been accidents involving animals as well as single accidents, but they have usually not resulted in personal injuries. During 5 years, there have been 3 accidents leading to personal injuries, which is a relatively low number. A separate bicycle path and pedestrian walkway as well as an underpass have been constructed for Lapijoki school, which is located along Olkiluodontie. There have been no accidents involving pedestrians, bicyclists or mopeds on Olkiluodontie.

Since the traffic volumes will not change from the current level as a result of the project, traffic safety is estimated to remain at the same level on Olkiluodontie as well as near the school (a sensitive location). As regards continuing the operation of the power plant, traffic volumes and their impact on traffic safety will remain at the present level. However, the impacts will continue past the end of the current activities, until either 2048 or 2058. Therefore, the magnitude of the change in traffic is estimated to be a minor negative, especially on Olkiluodontie.

If the planning project for main road 8 between Rauma and Eurajoki is implemented by building a new interchange to Olkiluoto between Pohjoiskehä and Olkiluodontie with a new alignment of road 2176, the road project, if implemented, may improve the safety of the Olkiluoto intersection as part of the traffic moves to the new road connection.

6.3.3.2. Uprating the thermal power

As regards the power uprating project, a new diesel-powered make-up water system and a new battery energy storage system will be constructed in the site area. Furthermore, the KPA storage may be expanded. The transport and passenger traffic related to the construction may cause a temporary, minor addition to the traffic volumes on the roads leading to the site area. The construction of the new make-up water system and battery energy storage system is estimated to last for approximately 2–3 years. Similarly, the construction of a possible expansion of the KPA storage will last for approximately 2 years. During construction, traffic volumes would increase by an estimated 5–10 lorries per day, while passenger traffic would increase by an estimated few dozen vehicles per day. Some transports will be special transports. The minor increase in traffic volumes is not estimated to have a significant impact on the traffic volumes of the roads in the area, or on traffic safety.

During the operating phase of the power uprating, the traffic volumes and traffic safety on the roads will remain at the current level, as described in chapter 6.3.3.1. However, the impacts will continue past the end of the current activities, until either 2048 or 2058. Therefore, the magnitude of the change in traffic is estimated to be a minor negative, especially on Olkiluodontie.

6.3.3.3. Significance of the impacts

The sensitivity of the affected aspect was estimated to be minor, since the road network in the area is designed for high traffic, taking into account the traffic volumes towards the power plant area. No major residential areas or sensitive locations are located near the road network. However, the sensitivity of the area is emphasised during annual outages, when the total traffic volumes are higher than normal.

The small-scale additional construction planned near the plant area may cause a minor temporary addition to the traffic volumes on the roads leading to the site area. Continuing the operation of the plant units at the current power level (VE1) or uprated power level (VE2) will not change the current traffic volumes in the power plant area. Therefore, traffic safety is estimated to remain at the present level. However, the impacts will continue until either 2048 or 2058. Therefore, the magnitude of the change in traffic is estimated to be a minor negative, especially on Olkiluodontie.

Taking into account the extended operating time, the significance of the impacts caused by traffic is assessed to be a minor negative (Table 17).

Table 17. Significance of the impacts: Traffic.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.3.4. Mitigation of harmful impacts

Harmful traffic impacts caused by heavy traffic may be mitigated by, for example, scheduling transport to take place during off-peak hours. Additionally, passenger traffic during annual outages could be staggered if necessary, which could reduce congestion at the intersection of main road 8 and Olkiluodontie in particular. However, building the interchange that is currently in the planning stage would have the largest impact on improving the flow of traffic.

As regards passenger traffic, volumes may be reduced by supporting opportunities for using public transport, remote work practices and bicycle benefits wherever possible.

6.3.5. Uncertainty factors

The long operating time creates a slight uncertainty in the assessment, as the traffic volumes on the road network may change. For example, forecasts indicate that the total volume of domestic passenger traffic will grow by 42% from the 2022 level by 2060 and the volume of domestic goods transport will grow by 5.9% from the 2022 level by 2030, following which the transport volume is estimated to decline (*Moilanen et al. 2024*). The assessment does not consider the impact of a potential new interchange that may be constructed later.

The distribution of passenger traffic from the power plant between different road sections creates uncertainty in the assessment. The current assumptions are indicative estimates. The assessment also assumes that most of the personnel will arrive to work by car, since the power plant is located far from residential areas and there is no cycleway. In reality, however, some employees may use public transport or share vehicles. Nevertheless, the applied values may be considered to be sufficiently reliable to describe the magnitude and significance of the impact.

6.4. Noise and vibration

6.4.1. Initial data and assessment methods

As regards noise and vibration, the effects resulting from the functions in the project and transport were examined. The area under review for noise impacts was the site area and its immediate surroundings at a radius of approximately 3 km and, for the assessment of vibration impacts, the nearby areas of the power plant area and along the transport routes (0–2 km).

The assessment of noise impacts was based on an expert assessment performed on the basis of the project's planning data and the results of earlier environmental noise measurements and noise dispersion modellings from the area. The noise levels caused by the project were compared to the results from existing studies in the area, the limit values in the power plant's environmental permit and the guideline values for noise.

Vibration impacts were assessed on the basis of the strength of the pressure wave generated by the vibration source and the spreading of the vibration. The buildings nearest to the power plant and the roads leading to the area and any possible vibration disturbances experienced by people were accounted for.

6.4.2. Current status

Noise

The noise levels in the Olkiluoto power plant area and its surroundings are affected by the industrial functions located on Olkiluoto Island, which are TVO's power plant area (the plant units OL1, OL2 and OL3 as well as their auxiliary functions), Posiva's encapsulation plant and disposal facility for spent nuclear fuel that is under construction, a stone crushing facility and Fingrid Oy's gas turbine plant which acts as a reserve power plant for TVO's functions and also for the national grid. Furthermore, Olkiluoto harbour located on the northern edge of the island and traffic along Olkiluodontie, which crosses the island, cause noise on Olkiluoto Island.

TVO has an environmental permit granted by the Regional State Administrative Agency of Southern Finland, according to the provisions in which TVO carries out noise measurements each year by using several measurement points near the power plant area. The locations of the measurement points are presented in the enclosed figure (Figure 24). Noise measurements are performed, among other places, at the nearest holiday home in Ruokkarta (known as Leppäkarta) and at the holiday home on the island Nousiainen, as well as at the nearest residential building.

The environmental permit for the power plant provides a daytime limit value of 45 dB and a night-time limit value of 40 dB for the average noise level during the power plant's normal operation at locations used for holiday housing. In the environmental noise measurements performed in 2016–2023, the noise level at Ruokkarta varied between 38 and 51 dB. During this time, the daytime limit value of 45 dB was exceeded once at Ruokkarta in 2017 (the measured value was 51 dB). At the measurement point on the island of Nousiainen, the noise level has been between 38 and 45 dB in 2016–2023 and the limit value has not been exceeded at all. The highest measured noise level on Nousiainen is from 2019, when the result was equal to the limit value.

Environmental noise has also been measured at the nearest residential building, at the Raunela which is more than 3 km away from the site area. At the measurement point closest to habitation, the noise level in 2016–2023 has been 37–52 dB. The environmental permit does not provide a limit value for the noise level in the area of residential buildings; however, according to the Government decision *(VNp 993/1992)* on guideline values for noise levels, the daytime guideline value for residential buildings is 55 dB. At the nearest residential building, the measurement results are below the guideline value, even though they have been affected by the traffic noise from Olkiluodontie during various years.

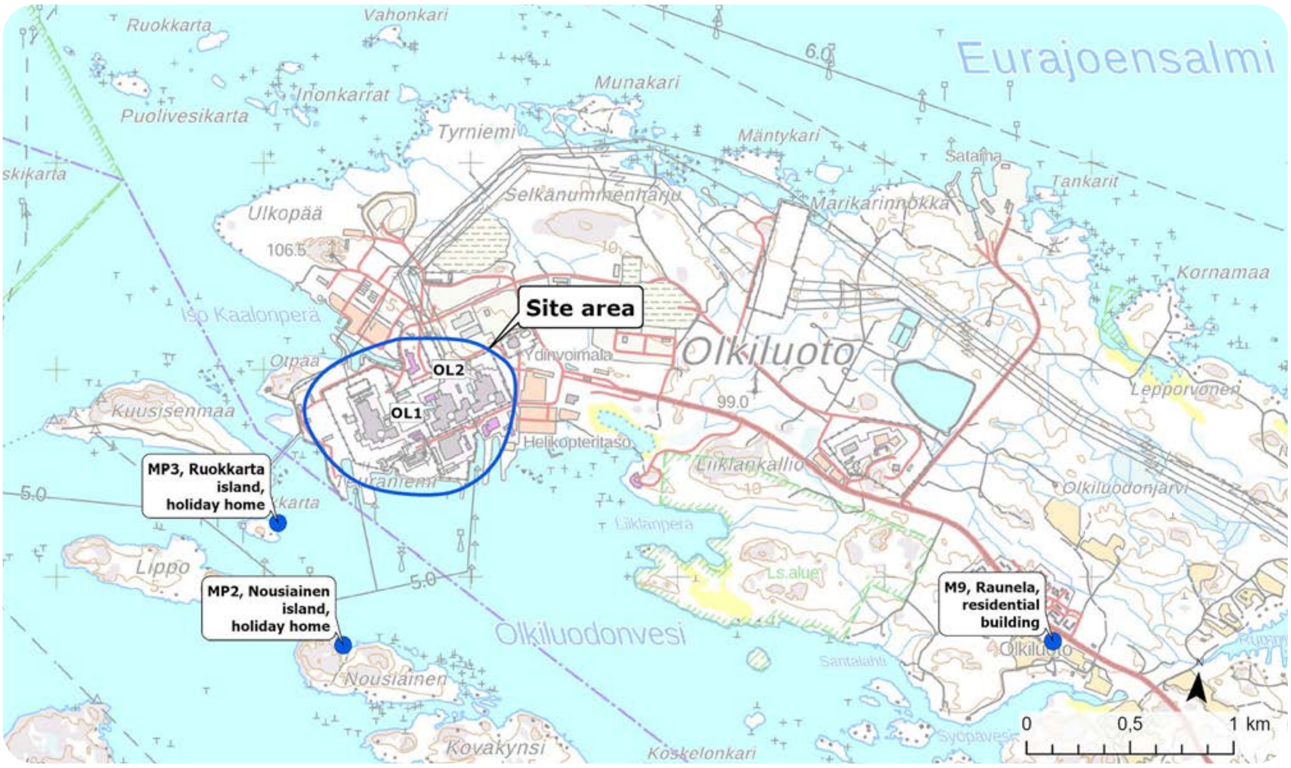


Figure 24. Measurement points for environmental noise for the residential buildings and holiday homes in the vicinity of the power plant area.

The environmental noise analysis drawn up in 2024 presents the results of the noise modelling for the OL1, OL2 and OL3 plant units *(Promethor Oy 2024)*. The enclosed figure presents the noise modelling map from the analysis (Figure 25). The plant units operate around the clock, which means that the same image represents average noise levels for the day and night. In the noise dispersion calculation, the combined noise from the plant units at the holiday residence on the island of Nousiainen is 39 dB during the day and night. The noise level clearly falls below the daytime limit value of 45 dB. The night-time limit value for holiday housing is 5 dB lower, i.e. 40 dB (LA_{eq}22–7). The night-time limit value for holiday housing is also not exceeded, but since the limit value for the night is 5 dB lower than for the day, night-time is the limiting factor for noise in the power plant area. The environmental permit for the power plant units does not provide limit values for noise regarding permanent residences. The general night-time limit value for noise at residential buildings is 50 dB, and no residential buildings are within the night-time limit value of 50 dB for nuclear power plant units. According to the noise measurements, high noise levels have been measured at TVO's main gate over the years due to passing traffic (in 2020–2023, the range of variation has been between 48.6 and 56.3 dB).

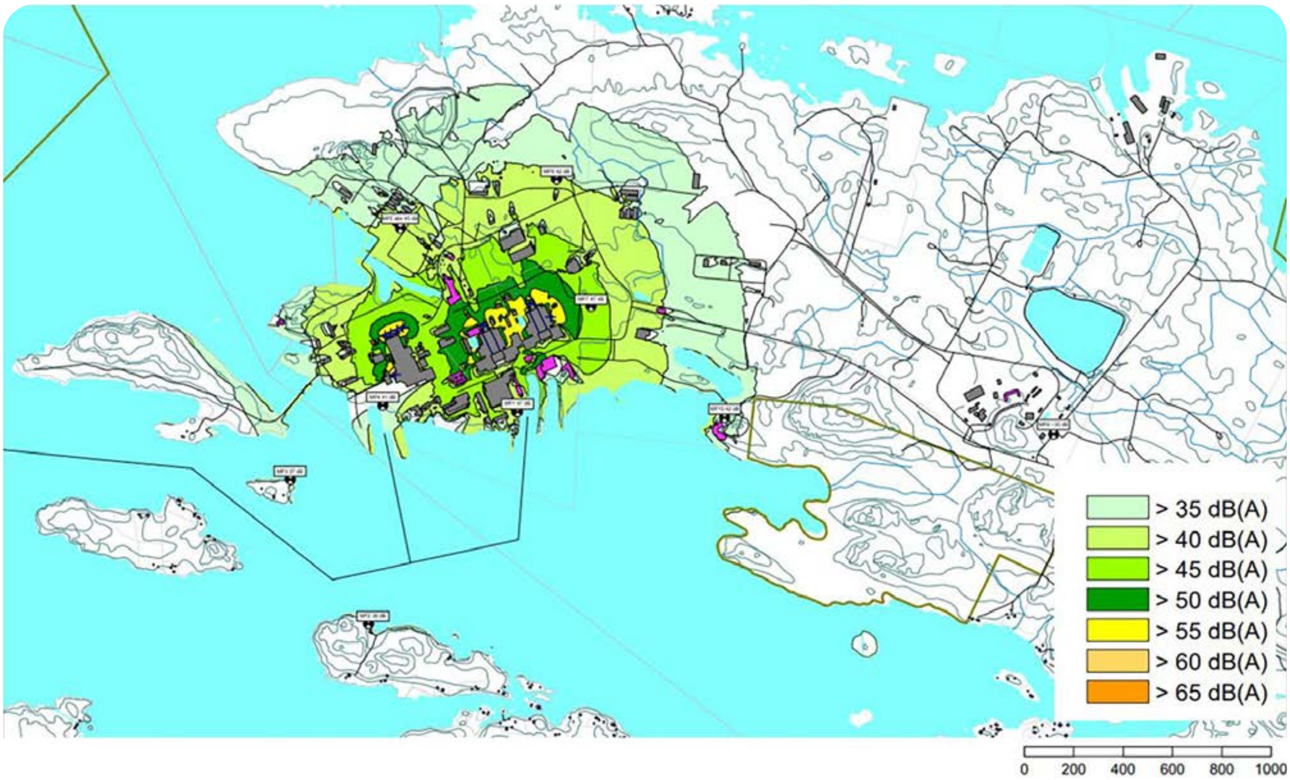


Figure 25. Noise modelling map for TVO's plant units OL1, OL2 and OL3. Picture contains the day and night time average sound levels, LA_{eq}7-22/22-7. (Promethor Oy 2024)

The sensitivity of the affected aspect is influenced by the land use status in the area and, in particular, the placement of especially sensitive locations, such as schools, day nurseries and significant recreational areas. The presence of natural conservation areas that are protected on the basis of noise level will increase the sensitivity. In addition to the potentially exposed locations, sensitivity is affected by the current noise situation in the area. As regards noise, the sensitivity of the Olkiluoto region is estimated to be low, since the nearest residential building is at a distance of more than 3 km, there are relatively few holiday homes near the nuclear power plant area and they are located sufficiently far away. The nearest conservation area is not located within the noise area for the power plant.

Vibration

There are no permanent sources of vibration in the power plant area. Vibration in the Olkiluoto area is caused by the functions at Posiva's worksite (excavation and crushing), but the construction work causing the most powerful vibration has already been completed. Heavy traffic may also cause mild vibration in the immediate vicinity of roads. The closest residential buildings along Olkiluodontie are located at a distance of approximately 25 m from the road.

The sensitivity of the location in terms of vibration will be determined by the current vibration-inducing functions in the area and the vibration tolerance of buildings or equipment located within the zone of impact. The nuclear power plant has been designed in a manner where its functions are not sensitive to vibration. The operation and design of a nuclear power plant also takes earthquakes into account, for example. As regards vibration, the sensitivity of the Olkiluoto region is estimated to be low.

6.4.3. Environmental impacts

6.4.3.1. Continuing operation

The additional construction related to the expansion of the KPA storage will necessitate excavating the bedrock, and the drilling and blasting during this work may cause temporary noise. Mild vibration may also occur in the nearby areas of the construction work. Earthmoving, additional construction and equipment installation will cause normal, short-term construction noise. Traffic volumes will not increase substantially during construction, which means that traffic noise will remain at the present level.

The main sources of noise at the OL1 and OL2 plant units are turbines and fans that generate a constant hum. In addition, the emergency diesel generators generate a low-frequency noise that is typical of large engines from time to time, during testing or in case they are needed. In the continuing operation scenario, the operation of the power plant will not change and the continuation has no effect on the environmental noise level in the Olkiluoto area. At present, the noise levels at the closest residential buildings and holiday homes have been within the provided guideline and limit values. During the environmental noise measurements of 2016–2023, the daytime limit value of 45 dB was exceeded once at the nearest holiday home in Ruokkarta in 2017 (the measured value was 51 dB). This was likely due to the conditions of the measurement. The service life extension will not increase the traffic volumes on the roads leading to the site area, and the traffic noise caused by them will remain at the present level.

The operation of the power plant units will not cause vibration, and traffic vibration in the area is limited to the immediate vicinity of the access road. There are no residential buildings or holiday homes within the current vibration areas.

As regards the service life extension of the power plant, the noise from the plant units and traffic as well as the vibration caused by traffic will remain at the present level, but the impacts will continue past the end of the current activities, until either 2048 or 2058. However, based on the low noise and vibration levels, the magnitude of the change in impact is estimated to be “no change”. Furthermore, any possible additional construction will not have a significant impact on noise or vibration in the area.

6.4.3.2. Power uprating

As regards the power uprating project, a new diesel-powered make-up water system and a new battery energy storage system as well as a potential KPA storage expansion will be constructed in the site area. During this construction work, minor noise may be generated mainly from earthmoving, the erection of the building and equipment installation. The work will cause normal, short-term construction noise. Furthermore, excavation of bedrock in relation to the KPA storage expansion may cause temporary increased noise. Mild vibration may also occur in the nearby areas of the construction work. Traffic volumes will not increase substantially during construction, which means that traffic noise will remain at the present level.

During operation, the make-up water system will be used to manage reactor cooling only during a potential and rare loss of AC power supply scenario. The system is not used under normal conditions. The battery energy storage system consists of a building containing batteries and a power transformer, which is similar to a unit that already exists in the power plant area. The operational noise level from both systems is estimated to be low, and the change in environmental noise levels caused by them is limited to the yard area of the power plant. Operating-time traffic volumes and the traffic noise caused by them will remain as they are.

In the power uprating scenario, the functions of the power plant units will not cause vibration and traffic vibration in the area is limited to the immediate vicinity of the access road. There are no residential buildings or holiday homes within the current vibration areas.

In the power uprating case, the noise from the plant units and traffic as well as the vibration caused by traffic will remain at the present level, but the impacts will continue past the end of the current activities, until either 2048 or 2058. However, based on the low noise and vibration levels, the magnitude of the change in impact is estimated to be “no change”. Furthermore, any possible additional construction will not have a significant impact on noise or vibration in the area.

6.4.3.3. Significance of the impacts

As regards noise and vibration, the sensitivity of the affected aspect is estimated to be low, since the nearest residential building is at a distance of more than 3 km, there are relatively few holiday homes near the nuclear power plant area and they are located sufficiently far away. The nearest conservation area is not located within the noise area for the power plant.

As regards the service life extension (VE1) and power uprating (VE2) of the power plant, the noise from the plant units and traffic as well as the vibration caused by traffic will remain at the present level, but the impacts will continue past the end of the current activities, until either 2048 or 2058. However, based on the low noise and vibration levels, the magnitude of the change in impact is estimated to be “no change”. Furthermore, any possible additional construction will not have a significant impact on noise or vibration in the area.

When considering the current, low noise and vibration levels, the alternative is not estimated to have significant noise and vibration impacts (Table 18).

Table 18. Significance of the impacts: Noise and vibration.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	No change	No change
VE2	Minor	No change	No change

6.4.4. Mitigation of harmful impacts

In the service life extension and power uprating cases, noise measurements pursuant to the provisions of the environmental permit will continue within the surroundings of the power plant which will be used to ensure that the noise caused by the power plant follows the regulatory guidelines. The operation of the noise sources is monitored and, if necessary, equipment is serviced or replaced if its noise level is determined to be too high. The electrification of traffic will lower noise caused by traffic on road sections where speeds are low.

6.4.5. Uncertainty factors

Uncertainties involving measurements and modelling are related to the results for noise measurements and noise dispersion that are presented in the noise assessment for the current status. According to the Ministry of the Environment’s measurement instructions for environmental noise (*procedure 1/1995*), uncertainty will mainly increase when the distance from the noise source increases; for example, the uncertainty for a measurement point at a distance of 500 m is approximately 7 dB according to the procedure. The uncertainty related to the Nordic calculation model for industrial noise applied in the noise modelling is said to be approximately 3 dB at distances of less than 500 m for wide-band noise.

6.5. Air quality

6.5.1. Initial data and assessment methods

The description of the current status of air quality in the area is based on the data of the air quality monitoring stations closest to Olkiluoto and on applicable studies related to air quality. There is no air quality monitoring station in Eurajoki. Emissions affecting air quality (nitrogen oxide, sulfur dioxide and particle emissions) caused by the use of backup boilers and emergency diesel generators at the Olkiluoto power plant are presented based on fuel consumption and quality data. The assessment also considers exhaust gas emissions from traffic and dust emissions caused by any possible modifications and construction work as well as traffic.

The air quality impacts of the project are estimated as an expert assessment based on data received concerning the current state of the air quality in the area, the releases into the air resulting from the operations and the traffic volumes. The impact of air emissions have been evaluated by comparing them with information on the air quality of the area. The significance of the change has been assessed by comparisons to the existing air quality limit and guideline values. The impacts are assessed locally, at a radius of approximately 1–2 km from the power plant area.

The impact on air quality of releases of radioactive substances is assessed in Chapter 6.16. The impact of greenhouse gas emissions is assessed in Chapter 6.6.

6.5.2. Current status

The usual emissions into the air caused by the operation of the Olkiluoto power plant are so minor on the island of Olkiluoto that there is no requirement for air quality monitoring in the area. Usual emissions in this context include sulphur and nitrogen oxides as well as particulate emissions, for example.

There is no continuous monitoring of air quality in the municipality of Eurajoki. The nearest air quality monitoring stations are located more than 10 km away in the centre of Rauma, in Tarvonsaari and Sinisaari. The monitoring stations are located south-southeast of Olkiluoto and are approximately as far from the power plant as the centre of Eurajoki. According to the air quality reports of the monitoring stations in the centre of Rauma and in Sinisaari, the air quality in Rauma in 2022 was good most of the time. In the vicinity of the centre of Rauma, negative impacts on air quality are mainly caused by traffic-related emissions and the forestry industry. In the Eurajoki area, air quality is mainly affected by emissions from industrial plants; small-scale wood burning and heating; and traffic-related emissions. The air quality of the area is also affected by small particles (diameter < 2.5 micrometres (μm)) carried over long distances.

A bioindicator study of air quality has been conducted in the region of Pori and Southern Satakunta in 2022–23 *(Ramboll 2024a)*. In the Eurajoki region, samples were collected from 15 different observation areas. In each area, a mapping of the trunk lichens of the pines was done; needle loss was assessed; and moss and needle samples were collected. Nothing abnormal was discovered in the samples collected in the Eurajoki region. Looking at each individual area, the pines suffered from defoliation (needle loss of at least 25%) in one observation area located in the eastern part of Eurajoki. No clear reason was found for the needle loss. In the sampling area of the Pori region and Southern Satakunta, the lichen species were on average between depleted and slightly depleted, based on the number of species. The monk's-hood lichen was on average slightly damaged, and the general damage to the species was clear on average. However, the damage to the monk's-hood lichen was slight even a little further away from the strain. The generalised zones in the most natural state were in Eurajoki, among other locations.

The sensitivity of the affected aspect is determined based on current local activities affecting air quality and the sensitive aspects located in the area. The area is slightly sensitive to changes regarding air quality. There is no significant activity affecting air quality in the area. There are no sensitive sites such as schools or day care centres in the area or in its immediate vicinity. There are no settlements or nature reserves in the immediate vicinity of the area. The sensitivity of the affected aspect is estimated to be minor.

6.5.3. Environmental impacts

6.5.3.1. Continuing operation

The modification work required by the service life extension of the OL1 and OL2 plant units will be implemented inside the plant units. These will not cause any change to the current traffic volumes. Possible additional construction related to the expansion of the KPA storage may cause local dusting to a small extent when the bedrock is quarried and the surface layers of the earth are processed in the construction area. The impacts of dust on air quality affect the immediate surroundings of the construction area. Any possible momentary change to the current situation is very local and will end when the earthworks and excavation work is finished. The construction works will not significantly change the traffic volumes in the area, and, thus, the impacts of exhaust gas and dust emissions on air quality will not change.

The maintenance and improvement work required by the service life extension of the OL1 and OL2 plant units will be implemented inside the plant units, and no additional construction will be required in the power plant area.

In the case of continued operation, the impacts on air quality are estimated to mainly remain unchanged. The usual emissions into the air consist mainly of emissions from the use of backup boilers and emergency diesel generators. The average annual nitrogen oxide emissions from operations (NO_x) have been approximately 1.2 t/year, sulphur oxide emissions (SO_2) 0.0 t/year and particulate emissions 0.1 t/year. The carbon dioxide emissions are discussed in connection with climate impacts in Chapter 6.6. Overall, the emissions resulting from the operation are very small and are not estimated to have a significant impact on the air quality of the area.

Releases into the air are also generated from the passenger and service traffic to the power plant and various forms of transport, the quantities of which will remain at the current level in the case of continued operation. It is estimated that the daily passenger traffic volume is approximately 1,000 vehicles per day and the heavy traffic volume approximately 50 vehicles per day. During the annual outage, the amount of commuter traffic at the plant increases by approximately 1,000 passenger cars daily for 1–8 weeks. In addition, air quality is affected by particulate concentrations raised by road traffic during the street dust season. The continuation of operation will not cause changes to the current traffic volumes, so traffic-related emissions are not estimated to change significantly from the current level. In the future, traffic-related emissions are expected to change with the increasing electrification of cars. The decrease in the amount of exhaust gas emissions especially impacts the decrease in the amount of small particles and nitrogen oxides, but the amount of respirable particles (diameter < 10 μm) is estimated to increase due to the wear to the road surface caused by heavier vehicles.

The area of influence of traffic emissions is their entire driving distance, and the emissions are, therefore, part of the emissions from other road traffic in the region. The impact of traffic-related emissions is estimated to be mainly limited to the immediate vicinity of the roads. The carbon dioxide emissions from traffic are discussed in Chapter 6.6.

Continued operation is not estimated to cause the limit or guideline values for air quality to be exceeded or to change the current air quality in the area.

6.5.3.2. Power uprating

The modifications required by the power uprating of the OL1 and OL2 plant units will mainly be implemented inside the plant units. Furthermore, a new make-up water system and battery energy storage system will be constructed in the site area, outside the plant units but in their immediate vicinity. It is also possible that the KPA storage will be expanded. Possible additional construction work outside the plant units may cause local dusting to a small extent when the surface layers of the earth are processed in the construction area. Possible additional work related to the expansion of the KPA storage may cause local dusting to a small extent when the bedrock is quarried and the surface layers of the earth are processed in the construction area.

The impacts of dust on air quality affect the immediate surroundings of the construction area. Any possible change from the current situation is very local and will end when the construction work is finished. The modification work will not significantly change the traffic volumes in the area, and, thus, the impacts of exhaust gas and dust emissions on air quality will not change.

The impacts on the air during operation come from the nitrogen oxide and particle emissions caused by the use of backup boilers and emergency diesel generators. They are estimated to remain as they are now, and the new diesel-powered make-up water system is not estimated to increase these emissions in the power uprating alternatives. The make-up water system is only used in unlikely situations where the backup electricity of the plant has been lost. The impacts of the power uprating on greenhouse gas emissions are assessed in Chapter 6.6.3.2.

During the operating phase of the power uprating, it is estimated that the amounts of passenger and service traffic and transports will remain as they are now. In the future, traffic-related emissions are expected to change with the increasing electrification of cars, as has been described with respect to the service life increase in Chapter 6.5.3.1.

The power uprating is not estimated to cause the limit or guideline values for air quality to be exceeded or to change the current air quality in the area.

6.5.3.3. Significance of the impacts

The sensitivity of the affected aspect in terms of air quality was assessed as minor, as there are no significant operations affecting air quality in the area, and no sensitive sites, settlements or nature conservation areas in the immediate vicinity of the area.

Continuation of operation (VE1) or power uprating (VE2) is not estimated to cause a significant change to the current state, as the minor emissions to the air caused by the power plant's operations and traffic will mostly remain as they are now, but will continue with the additional years of use. The alternatives do not cause air quality limit values or guideline values to be exceeded, and the alternatives are not estimated to have an impact on current air quality in the area (Table 19).

Table 19. Significance of the impacts: air quality.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	No change	No change
VE2	Minor	No change	No change

6.5.4. Mitigation of harmful impacts

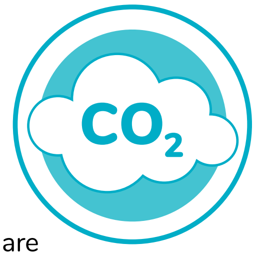
The task of the emergency diesel generators is to automatically ensure the power supply to the nuclear power plant in a possible yet unlikely loss of power scenario. In order to ensure safety, the emergency diesel generators are regularly tested in compliance with the Technical Specifications, which means that their emissions cannot be lowered. In addition, the diesel-powered make-up water system would be used for longer periods only in the very unlikely situation of a loss of the plant's alternating current.

Emissions from transportation can be reduced, for example, by optimising transport times and routes, and in the case of passenger transport, by increasing the use of public transport and opportunities for remote work. Electric vehicles will also reduce traffic-related exhaust emissions. Cleaning the streets during the street dust season and planning sand dressing during the winter can also affect the amount of dust.

6.5.5. Uncertainty factors

There is no continuous air quality monitoring in Eurajoki or in the vicinity of the power plant area, which causes uncertainty in the description of the current situation. Regarding the average emissions of cars, exhaust gas emissions from traffic will probably decrease with the development of technology and as the use of electric cars becomes more common. The electrification of cars has been faster than estimated, so previous estimates of the energy sources used in future traffic will probably change.

6.6. Climate



6.6.1. Initial data and assessment methods

The impact on climate change is examined on the basis of greenhouse gas emissions generated by the project and emissions avoided as a result of the project. Emissions are presented as carbon dioxide equivalent (CO_{2e}), which is used to harmonise the greenhouse gas emissions in order to describe the total climate-warming impact.

Regarding the implementation alternatives, the greenhouse gas emissions related to their functions have been examined. These are mainly generated from the use of the power plant's emergency diesel generators, the backup boiler plant and traffic fuels. The emission calculations done to support the impact assessment were done on the basis of the fuel being used, its consumption and the estimated kilometres driven by vehicle type. The following initial data and assumptions were used in the emission calculations:

- The greenhouse gas emissions caused by the backup emergency diesel generators and the backup boiler plant were calculated based on light fuel oil consumption data. 69.4 t/TJ was used as the emission factor for light fuel oil *(Statistics Finland 2024b)*.
- For heavy traffic, the vehicles used in transports were assumed to be large combination vehicles (total mass 3.5–33 t, half loaded), based on which the unit emission factor was chosen *(Defra 2023)*. For heavy traffic, the average transport distances in Finland were used as the background data for transports *(Statistics Finland 2024c)*.
- Regarding emissions from passenger traffic, an assumption was made that the average daily staff commute by passenger car is approximately 20 km in one direction. The unit emission coefficient of a medium-sized petrol-powered passenger car was used as the passenger transport emission coefficient *(Defra 2023)*. The calculation did not take into account the possible use of public transport by staff or the electrification of passenger cars.

Regarding indirect greenhouse gas emissions, the gas emissions caused during the life cycle of the different fuels used in energy production have been examined and compared based on published international reports *(IPCC 2014, World Nuclear Association 2016)* and a report produced for TVO on the emissions during the life cycle of electricity generated with nuclear power in Olkiluoto *(Etteplan Oyj 2024)*.

The assessment has also looked at the emission reduction potential brought by the extension of the service life of the OL1 and OL2 plant units and the power uprating at the levels of Finland and Europe. The calculation has assumed that electricity generated with nuclear power without greenhouse gas emissions will replace electricity produced with fossil fuels in the electricity production structure. The emission factor of the electricity production structure will decrease as forms of energy produced with fossil fuels are removed from the structure. The following scenarios have been taken into account in the calculation:

- In Finland, the change in electricity emission factors has been calculated according to the baseline scenario in the low-carbon road map of Finnish Energy (2020). In 2020, the emission factor was 87 t CO_{2e}/GWh, from which it is believed to decrease by 52% by 2030. After this, the emission factor will decrease steadily until 2050. After 2050, there will no longer be a greenhouse gas-replacing effect.
- The emission factor of EU electricity production was 338 t CO_{2e}/GWh in 2012 and 251 t CO_{2e}/GWh in 2022 *(European Environment Agency 2024)*. If the emission factor of EU electricity production decreases as it did in the years 2012–22, there will no longer be any replacement effect after 2050.

The risks caused by climate change (such as sea level rise or flooding) are identified and the preparation for them is described in Chapter 6.18.4.3. In the cooling water modelling (Appendix 5), the rise in temperature caused by climate change has been taken into account. In order to model the largest possible impacts, an effort was made to choose extreme climate conditions for the modelling.

6.6.2. Current status

Eurajoki is located in the Satakunta province, which mainly belongs in the southern boreal climate zone. The climate in Satakunta is characterised by the dichotomy between the maritime coast and continental inland. Yearly average temperatures typically vary from approximately +6 degrees centigrade on the coast between Rauma and Pori to approximately +4 degrees in the northeast. Annual precipitation on the coast of the Bothnian Sea is slightly below 600 millimetres (mm) on average and 600–650 mm elsewhere in the province. Maximum snow cover thickness is 20–30 cm in the southern and central parts of Satakunta. The growing season lasts between 170 and 190 days *(Ilmatieteen laitos 2022b)*. The prevailing wind direction is from the southwest *(Ilmatieteen laitos 2024a)*.

Olkiluoto is located on the coast of the Bothnian Sea in a maritime climate, characterised by stable temperature conditions. In the spring, temperatures near the coast are clearly lower than further inland. In autumn, the warm sea evens out the temperature differences during the day, and there are few night frosts. Winter is mild in the area, as the Bothnian Sea remains free from ice nearly throughout the winter.

According to the Intergovernmental Panel on Climate Change *(IPCC)*, the climate on Earth had, by the year 2017, warmed up by approximately 1°C when compared to the preindustrial era *(IPCC 2018)*. In the Paris Climate Agreement, various countries committed to the target of limiting the increase in average temperature to below 2 degrees and to aiming for actions that would limit the warming below 1.5 degrees. The Earth's climate is constantly warming as a result of human activities, but the magnitude and impacts of the change vary in different parts of the world.

In Finland, the average annual temperature has increased by 0.2–0.4°C per decade over the past 40 years. In Finland, the warming up of the climate will impact winters more than summers, on average. Precipitation will also increase and torrential rain will be stronger *(Ilmatieteen laitos 2024b)*. During the current century, the climate in Satakunta is estimated to warm up by approximately 1.9–5.1°C when compared to the reference period of 1981–2010. The temperature will increase at the monthly level during all months when compared to the reference period of 1981–2010, but mostly between November and March. Correspondingly, annual precipitation in the area is expected to increase by 6%–15% when compared to the period of 1981–2010. The average annual precipitation would be 680–740 mm. By the middle of the century, precipitation will increase during all months, but the change will be small in July–August. The highest precipitation would occur in November–February *(Ilmatieteen laitos 2022b)*. The climate change factor for the intensity of torrential rain by 2050 has been estimated to be 1.25–1.3 for daily rain and 1.25–1.5 for hourly rain *(Suomen ilmastopaneeli 2021)*.

Greenhouse gas emissions from the municipality of Eurajoki in 2022 amounted to 61,900 kilotonnes of carbon dioxide equivalent (kt CO_{2e}) in total. Compared to 2005, emissions have been reduced by 31%. In 2022, the main part of the total emissions was caused by traffic (32%), agriculture (21%) and machinery (11%) *(Finnish Environment Institute 2024a)*. The municipality of Eurajoki participates in the "Kohti hiilineutraaleja kuntia" (Towards carbon neutral municipalities) project (HINKU), where municipalities are committed to reducing their greenhouse gas emissions by 80%, compared to the 2007 levels, by 2030 *(Eurajoki 2024)*. The carbon neutrality target for Satakunta has been set for 2030 based on the Hinku targets *(Satakunnan ammattikorkeakoulu 2021)*.

Finland's total greenhouse gas emissions in 2023, exclusive of the LULUCF sector, amounted to an estimated 40.6 million tonnes CO_{2e}. Emissions were estimated to be down by approximately 5.1 million tonnes from 2022 *(Statistics Finland 2024d)*.

Finland's new Climate Act (423/2022) contains an emissions reduction target of -60% by 2030, -80% by 2040 and -90% (while aiming for -95%) by 2050, compared to the 1990 levels. The programme for Finland's former government stated that the production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects. One of the means mentioned as a way of achieving this is that extending the licences of existing nuclear power plants will be regarded positively, provided that STUK is in favour of them *(Valtioneuvosto 2019)*. Among other things, the programme for Finland's new government *(Valtioneuvosto 2023)* states that Finland's self-sufficiency in terms of energy will be reinforced in a sustainable manner by advancing the transition to green energy. Fossil fuels will be discontinued in the generation of electricity and heat in the 2030s at the latest. The government's programme also brings up that more nuclear power is required in Finland *(Valtioneuvosto 2023)*.

The sensitivity level of the affected aspect cannot be determined regarding the climate, because the impacts of climate change at the local level are indirect and affect the natural environment and its phenomena in different ways. Climate change is a global problem, the prevention of which is a joint task for the governments of the world's countries. As part of the EU, Finland is committed to the Paris climate agreement and has set a national goal for reducing emissions in order to be carbon neutral by 2035. This requires several different actions in different industries. The production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects.

6.6.3. Environmental impacts

6.6.3.1. Continuing operation

Greenhouse gas emissions from construction

The traffic during the minor construction work related to the possible expansion of the KPA storage will not significantly increase the current traffic volumes, and will not, therefore, cause increased greenhouse gas emissions from vehicle fuel consumption.

Greenhouse gas emissions from the operations

Electricity produced by nuclear power is carbon neutral for electricity users. However, in the operation of a nuclear power plant, greenhouse gas emissions are generated from the fuel consumption of emergency power generation and traffic. The greenhouse gas emissions caused by emergency power generation (backup boilers and emergency diesel generators) at the OL1 and OL2 plant units have been calculated according to the consumption of light fuel oil. The use of light fuel oil produces greenhouse gas emissions of 914 t CO_{2e} annually when the use remains at the average level. In case of continued operation, the annual emissions will not change. In the years 2038–2048, greenhouse gas emissions are estimated to be generated cumulatively at a total of approximately 9,140 t CO_{2e} and in the years 2038–2058 a total of 18,280 t CO_{2e} (Table 20).

Table 20. Greenhouse gas emissions from the use of light fuel oil in case of continued operation of the power plant.

	Emissions per year (t CO_{2e})	Cumulative emissions in 2038–2048 (t CO_{2e})	Cumulative emissions in 2038–2058 (t CO_{2e})
Light fuel oil	914	9,140	18,280

There is daily commuting and freight traffic to the plant, which causes greenhouse gas emissions. The average daily traffic to the power plant is approximately 1,050 vehicles, of which some 50 are heavy vehicles. The annual outage temporarily increases traffic volumes to an estimated maximum of approximately 2,000 vehicles per day. The duration of the annual outage is 1–8 weeks, with 35 days being the average.

A total of 5,117 t CO_{2e} greenhouse gas emissions per year are generated from the daily commuting and freight traffic to the power plant. Taking into account the increased traffic during the annual outage, the emissions caused by all traffic are a maximum of 5,366 t CO_{2e} per year. Daily traffic accounts for 95% of this, while traffic during the annual outage accounts for a maximum of 5%. The share of passenger car traffic in the total emissions of all traffic is 53% and the share of heavy traffic 47%. In the case of continued operation, the annual traffic volumes and the resulting greenhouse gas emissions remain the same as in the current operation. In the years 2038–2048, greenhouse gas emissions are estimated to be generated cumulatively at a total of approximately 53,658 t CO_{2e} and in the years 2038–2058 a total of 107,317 t CO_{2e} (Table 21). The emissions do not take into account the use of public transport or the electrification of cars.

Table 21. Greenhouse gas emissions from work transportation and business trips in case of continued operation.

	Number of vehicles (per day)	Emissions per year (t CO_{2e})	Emissions in 2038–2048 (t CO_{2e})	Emissions in 2038–2058 (t CO_{2e})
Daily traffic				
Passenger cars	1,000	2,599	25,988	51,976
Heavy vehicles	50	2,518	25,178	50,357
Total	**1,050**	**5,117**	**51,166**	**102,333**
Maximum increase during annual outage				
Passenger cars	1,000	249	2,492	4,984
Heavy vehicles	0	0	0	0
Total	**1,000**	**249**	**2,492**	**4,984**
All traffic (daily traffic and increase due to annual outage)				
Total	**2,050**	**5,366**	**53,658**	**107,317**

In the case of continued operation, the annual greenhouse gas emissions, taking into account both the use of backup power and the traffic from and to the power plant, are of the same order of magnitude as in the current operation: approximately 6,280 t CO_{2e} per year. This is approximately 10% of the total emissions of the municipality of Eurajoki (61,900 t CO_{2e}) and less than 0.01% of the total emissions of Finland (45,800,000 t CO_{2e}). The impact of the total amount of greenhouse gas emissions is minor on an annual level compared to the total emissions of Eurajoki municipality or Finland. With continued operation, the climate change impact will remain at the current annual level, but will continue for 10 or 20 more years.

Specific emissions for the life cycle of various fuels

In the generation of electricity by nuclear power, no direct greenhouse gas emissions are generated by the use of the reactor. In this respect, nuclear power can be compared to greenhouse gas-free water, wind and solar energy. However, when looking at the greenhouse gas emissions for different forms of energy production, the emissions during the entire life cycle of the forms of production must be evaluated; so in the case of nuclear power, the procurement of nuclear fuel is also included, for example. The total emissions from different forms of energy production are affected by how much energy and fossil fuels are consumed at different stages of the life cycle.

Several life cycle studies have compared the greenhouse gas emissions from different forms of energy production. One study published by the IPCC: *(IPCC 2014)* compares the specific emissions for the life cycle of various forms of electricity generation. These include direct emissions, emissions from infrastructure construction, biogenic CO_2 emissions and methane emissions. According to the IPCC estimate, life cycle greenhouse gas emissions for electricity generated by nuclear power are approximately 12 grams of carbon dioxide equivalent per kilowatt hour (g CO_{2e}/kWh) (*IPCC 2014, Figure 26*). Country-specific estimates range from 3 to 16 g CO_{2e}/kWh (*World Nuclear Association 2016*). TVO has commissioned a report on the emissions during the life cycle of the electricity produced with nuclear power in Olkiluoto (*Etteplan Oyj 2024*). The carbon footprint of electricity produced at the O1 and OL2 plant units at Olkiluoto is 8.5 g CO_{2e}/kWh. The entire life cycle of the nuclear power plant is taken into account in the calculation, including all stages from uranium mining to the final disposal of the nuclear waste. The construction and demolition of the nuclear power plant itself; the processing of nuclear waste; and the infrastructure of the electricity transmission network and nuclear fuel procurement are also all taken into account. Excluding the electricity transmission network, the carbon footprint of electricity produced by the plant units is 3.8 g CO_{2e}/kWh.

The emissions from electricity produced with coal and natural gas are tens of times higher: 820 g CO_{2e}/kWh for coal and 490 g CO_{2e}/kWh for natural gas. The CO_2 emissions during the life cycle of electricity generated with nuclear power are mostly caused by the fuel production chain and the construction of the power plant. In particular, the fossil fuels used as production inputs in the nuclear fuel supply chain (uranium mining, fuel refining, transportation, etc.) affect the generation of emissions. In the case of fossil fuels, CO_2 emissions during the life cycle of electricity production are mostly caused in the electricity production phase (*IPCC 2014, World Nuclear Association 2016*). Burning wood-based fuels or other biomass produces direct greenhouse gas emissions, but bioenergy is calculated as emission-free in Finland's greenhouse gas inventory, as the growing tree has sequestered an amount of carbon from the atmosphere similar to that which is released during burning.

Greenhouse gas emissions during the life cycle of electricity produced by nuclear power (12 g CO_{2e}/kWh) are at the same level as with electricity produced by wind power (11 g CO_{2e}/kWh) (Figure 26). In the case of the Olkiluoto plant units, the emissions are even lower than the global average emission factor of nuclear power (Figure 26). Therefore, the continued use of the OL1 and OL2 plant units and the use of nuclear power in electricity production supports Finland's goal of being carbon neutral by 2035. The production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects.

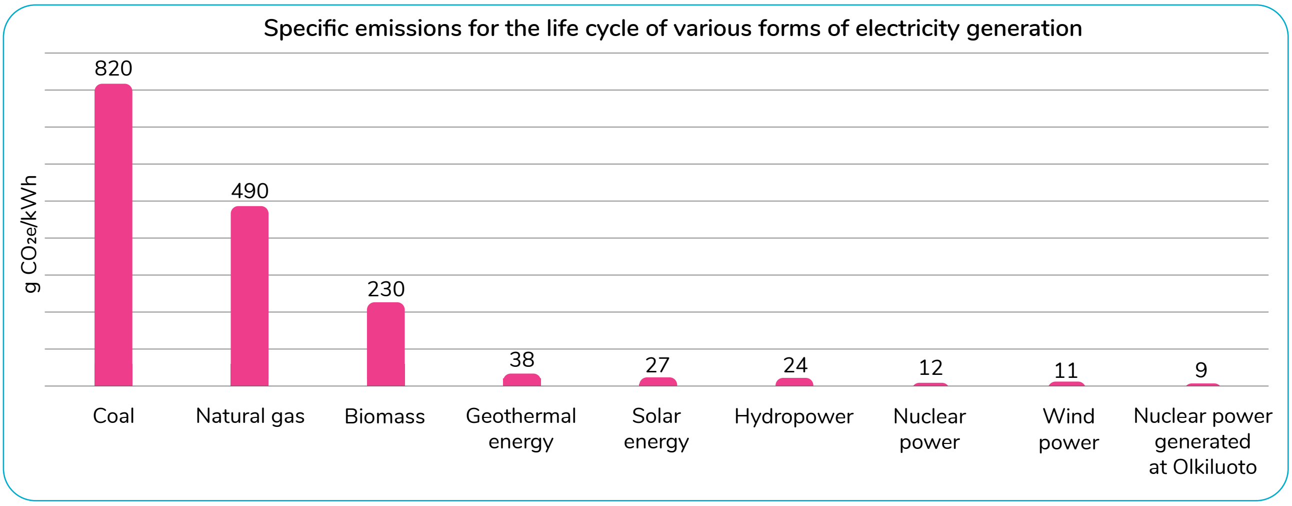


Figure 26. Comparison of specific emissions during the life cycle of various forms of electricity generation (IPCC 2014, Etteplan Oyj 2024).

Impact decreasing greenhouse gas emissions

In the case of extending the service life of the OL1 and OL2 plant units, the annual electricity production will remain the same as at present, but will continue after the currently valid operating licences for 10 or 20 years. During the additional years of operation, electricity produced with nuclear power without greenhouse gas emissions can replace electricity produced with fossil fuels still on the market to the extent of its produced amount. According to both Finnish and EU forecasts, the greenhouse gas emissions of electricity production will decrease so that the emission factor of electricity production will finally be zero after 2050. After this, the production of nuclear power will no longer have a greenhouse gas-replacing effect on the electricity market.

The greenhouse gas-replacing effect of the electricity produced by extending the service life of the OL1 and OL2 plant units at the levels of Finland and the EU is shown in the accompanying table (Table 22). According to the estimate, during 10 additional years of operaiton, the cumulative emission reduction potential in the Finnish electricity market would be approximately 1,075,000 t CO_{2e}, and during 20 years, approximately 1,115,000 t CO_{2e} (Table 22). At the EU level, the emission reduction potential would be clearly higher, totalling approximately 8,953,000 t CO_{2e} during 10 additional years and 9,282,000 t CO_{2e} during 20 years. If the emission reduction scenarios of the Finnish and EU electricity markets are realised, the annual greenhouse gas-replacing effect will decrease to zero from 2050 onwards (Table 22).

Table 22. Cumulative emission reduction potential of electricity produced by the OL1 and OL2 plant units at the levels of Finland and the EU in case of continued operation.

	Cumulative emission reduction potential, 2038–2048 (t CO_{2e})	Cumulative emission reduction potential, 2038–2058 (t CO_{2e})
Finland	1,075,000	1,115,000
European Union	8,953,000	9,282,000

6.6.3.2. Power uprating

Greenhouse gas emissions from construction

The traffic during the minor construction work related to the construction of a new make-up water system and battery energy storage system and to the possible expansion of the KPA storage will not significantly increase the current traffic volumes, and will not, therefore, cause increased greenhouse gas emissions from vehicle fuel consumption.

Greenhouse gas emissions from the operations

In the case of a power uprating, the testing of the new diesel-powered backup water system will produce approximately 13 t CO_{2e} more emissions than in the current operation. At the annual level, the emissions resulting from the fuel consumption of backup engines total approximately 927 t CO_{2e}. In the years 2028–2048, greenhouse gas emissions are estimated to be generated cumulatively at a total of approximately 18,540 t CO_{2e} and in the years 2028–2058 a total of 27,810 t CO_{2e} (Table 23).

Table 23. Greenhouse gas emissions from the use of light fuel oil in case of power uprating.

	Emissions per year (t CO_{2e})	Cumulative emissions in 2028–2048 (t CO_{2e})	Cumulative emissions in 2028–2058 (t CO_{2e})
Light fuel oil	927	18,540	27,810

In the power uprating options, the annual traffic volumes and the resulting greenhouse gas emissions remain the same as in the current operation. In the case of continued operation, in the years 2028–2048 greenhouse gas emissions are estimated to be generated cumulatively at a total of approximately 107,317 t CO_{2e} and in the years 2028–2058 a total of 160,975 t CO_{2e} (Table 24).

Table 24. Greenhouse gas emissions from work transportation and business trips in case of power uprating.

	Number of vehicles (per day)	Emissions per year (t CO_{2e})	Emissions in 2028–2048 (t CO_{2e})	Emissions in 2028–2058 (t CO_{2e})
Daily traffic				
Passenger cars	1,000	2,599	51,976	77,964
Heavy vehicles	50	2,518	50,357	75,535
Total	**1,050**	**5,117**	**102,333**	**153,499**
Maximum increase during annual outage				
Passenger cars	1,000	249	4,984	7,476
Heavy vehicles	0	0	0	0
Total	**1,000**	**249**	**4,984**	**7,476**
All traffic (daily traffic and increase due to annual outage)				
Total	**2,050**	**5,366**	**107,317**	**160,975**

In the case of a power uprating, the annual greenhouse gas emissions are approximately 6,293 t CO_{2e} when taking into account both the use of backup power and the traffic of the power plant. The annual emissions are approximately 10% of the total emissions of the municipality of Eurajoki (61,900 t CO_{2e}) and less than 0.01% of the total emissions of Finland (45,800,000 t CO_{2e}). The impact of the total amount of greenhouse gas emissions is minor on an annual level when compared to these. With continued operation, the climate change impact will remain at the current annual level, but will continue for 20 or 30 more years.

Specific emissions for the life cycle of various fuels

In the generation of electricity by nuclear power, no direct greenhouse gas emissions are generated by the use of the reactor. In the case of a power uprating, the emissions during the life cycle of electricity produced with nuclear power are the same as those described in the case of continued operation (see Chapter 6.6.3.1).

Impact decreasing greenhouse gas emissions

In the case of a power uprating, the annual electricity production of the OL1 and OL2 plant units will increase from the current total of approximately 14 terawatt hours to approximately 15.2 terawatt hours. During the additional years of operation, electricity produced with nuclear power without greenhouse gas emissions can replace electricity produced with fossil fuels still on the market to the extent of its produced amount. According to both Finnish and EU forecasts, the greenhouse gas emissions of electricity production will decrease so that the emission factor of electricity production will finally be zero after 2050. After this, the production of nuclear power will no longer have a greenhouse gas-replacing effect on the electricity market.

The greenhouse gas-replacing effect of the electricity produced by the power uprating of the OL1 and OL2 plant units at the levels of Finland and the EU is shown in the accompanying table (Table 25). According to the estimate, if the power uprating of the plant units were to be implemented from 2028 onwards, the cumulative emission reduction potential in the Finnish electricity market would be approximately 1,551,000 t CO_{2e} by 2048 and 1,594,000 t CO_{2e} by 2058. For the power uprating alone, the emission reduction potential in Finland is approximately 500,000 t CO_{2e}.

At the EU level, the emission reduction potential would be significantly higher than this. In the years 2028–2048, the potential is approximately 11,770,000 t CO_{2e}, and in the years 2028–2058 approximately 12,128,000 t CO_{2e}. If the emission reduction scenarios of the Finnish and EU electricity markets are realised, the annual greenhouse gas-replacing effect will decrease to zero from 2050 onwards.

Table 25. Cumulative emission reduction potential of electricity produced by the OL1 and OL2 plant units at the levels of Finland and the EU in the case of a power uprating.

	Cumulative emission reduction potential, 2028–2048 (t CO_{2e})	Cumulative emission reduction potential,. 2028–2058 (t CO_{2e})
Finland	1,551,000	1,594,000
European Union	11,770,000	12,128,000

6.6.3.3. Significance of the impacts

Regarding climate change, the sensitivity level of the affected aspect and the magnitude of the change cannot be precisely determined, as climate change is a global phenomenon that encompasses many direct and indirect impacts. However, the overall climate-warming effect of the total amount of greenhouse gas emissions has been taken into account in the impact assessment.

The rough overall significance of the impacts has been estimated to be a moderate positive in the case of a service life extension and a large positive in the case of a power uprating (Table 26). The electricity production of the nuclear power plant does not produce greenhouse gas emissions, and the emission-free electricity produced by the OL1 and OL2 plant units can replace other forms of electricity production that use fossil fuels. According to the estimate, at the level of Finland the cumulative emission reduction potential in alternative VE1 would be approximately 1,100,000 t CO_{2e}, and in the case of VE2 approximately 1,600,000 t CO_{2e}. For the power uprating alone, the emission reduction potential in Finland is approximately 500,000 t CO_{2e}. The extended operation of the plant units and the power uprating would support Finland's goal of being carbon neutral by 2035. The production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects. Greenhouse gas emissions during the life cycle of electricity produced by nuclear power are at the same level as with electricity produced by wind power. The greenhouse gas emissions generated by the operation of the power plant (e.g. backup power and traffic) are very small when compared to the total emissions of the region or Finland as a whole or to the emission reduction potential of the project.

Table 26. Significance of the impacts: climate.

Alternative	Sensitivity	Magnitude of change	Significance
VE1	Cannot be determined	Cannot be determined	Moderate positive
VE2	Cannot be determined	Cannot be determined	Large positive

6.6.4. Mitigation of harmful impacts

Alternatives for reducing greenhouse gas emissions include, for example, improving the energy efficiency of backup boilers and emergency diesel generators and replacing fossil fuels with bio-based ones where possible. Regarding passenger traffic, the impact of traffic emissions can be reduced by offering incentives for the use of public transport, for example. The reduction of greenhouse gas emissions during the life cycle of the fuel is especially related to the replacement with other fuels of the fossil fuels used as production inputs in the nuclear fuel supply chain.

6.6.5. Uncertainty factors

The uncertainty factors in the assessment are related to electrification of commuting traffic in the future. The assessment has been done on the assumption that all transport vehicles and passenger cars operate with diesel or gasoline-based fuels, although, in reality, of all persons who drive to work at Olkiluoto with a passenger car, some 11% drive a hybrid car and 12% an electric car (*Teollisuuden Voima Oyj 2024f*).

In addition, uncertainty factors are related to estimates of the amount of greenhouse gas emissions and the replacement of electricity produced by nuclear power by other forms of electricity production in the future. Estimates of the greenhouse gas emissions generated during the operation of the project have been calculated by using the average amount of greenhouse gas emissions generated in recent years. The amount of greenhouse gas emissions created in reality is lower than the values used in the calculation, as the average of the last years is higher than the average level due to the replacement of emergency diesel generators and also their increased test operation.

6.7. Soil, bedrock and groundwater

6.7.1. Initial data and assessment methods

The assessment of impacts affecting soil and bedrock examines the modification work in the project, among other things, on the basis of the land areas required by the related structures and buildings and the planned construction activities (such as any possible excavation and filling work). Existing research data and map documentation concerning the soil and bedrock in the area are used as initial data for the assessment. The groundwater impacts assessment examines whether the project causes impacts on the quality, volume or surface level of groundwater. Existing research data on the groundwater conditions in the area and groundwater quality will be used as initial data. The impacts of the project have been reviewed in the power plant area.

6.7.2. Current status

The soil, bedrock and groundwater conditions on Olkiluoto Island are very well known, as the area has been studied since the 1970s. Studies in bedrock and groundwater chemistry and the monitoring of environmental conditions in the area continue, especially as regards Posiva's disposal facility for spent nuclear fuel.

The VLJ repository intended for low- and medium-level waste from all the plant units is located approximately 830 m northwest of the site area on the Ulkopää cape of Olkiluoto. The VLJ repository was excavated to a depth of 60–100 m into the bedrock, and the disposal repository was commissioned in 1992. The capacity for low-level waste in the VLJ repository is approximately 5,000 m^3, and for medium-level waste approximately 3,500 m^3. In addition, the KPA storage is located in the site area, the foundations of which have been excavated approximately 20 m below ground level.

Posiva's final disposal facility for spent nuclear fuel, excavated into bedrock to more than 400 m below the ground surface, is located approximately 1.5 km east of TVO's site area. Research in different scientific fields relating to the final disposal site for spent nuclear fuel has been carried out by Posiva at the Olkiluoto area, both at the site scale and on a more detailed level. The geological studies are focused on the properties of the bedrock, such as the rock types, bedrock fissures and fracture zones. Geophysical research provides information on the physical properties of the bedrock, such as electrical conductivity and magnetic properties. Rock mechanics examines the mechanical properties of the bedrock, such as the state of strain and the thermal conductivity properties of the bedrock. In terms of hydrogeology, the focus is on the occurrence of groundwater on the ground surface and in the bedrock, groundwater flow, the water conductivity properties of fissures, pressure height and groundwater level. Hydrogeochemistry, on the other hand, examines groundwater chemistry at different scales, the chemical processes relating to groundwater and the occurrence of microbes in groundwater, among other things. *(Posiva 2021b)*

The site studies and the Olkiluoto Site Description produced based on them serve as initial data for the safety case analyses and safety case modellings in terms of the properties and processes of the site. The current information on the site is used as initial data when modelling past time (so-called paleo modelling) and future developments (evolution modelling) as part of the final disposal safety case *(Posiva 2021b)*.

In order to monitor the long-term development of the final disposal site and facility, Posiva is implementing a monitoring programme at Olkiluoto *(STUK Y/4/2018 and YVL Guide D.5)*. The monitoring programme is divided by discipline into the monitoring of rock mechanics; hydrology and hydrogeology; hydrogeochemistry; surface environment; and engineered release barriers. The majority of the monitoring programme's studies are carried out underground, either in the disposal repository or research holes drilled in the Olkiluoto area, but research is also being conducted overground and at a distance of several kilometres from the actual final disposal site. The most important aim of monitoring is tracking that the conditions in the disposal facility and the surrounding bedrock remain favourable for final disposal and meet the related requirements. *(Posiva 2021b)*

6.7.2.1. Bedrock

The Paleoproterozoic bedrock in the Olkiluoto area is approximately 1.8 to 1.9 billion years old. The main bedrock mineral in the area is migmatite, which is a compound of mica gneiss and granite. According to bedrock data from the Geological Survey of Finland, the Olkiluoto area features granodiorite, biotite paragneiss and granite (Figure 27). Generally, the surface part of the bedrock in the Olkiluoto area has more fissures up to a depth of 120–140 m than the bedrock below it.

Bedrock in the Olkiluoto area has been studied by examining the aboveground rock exposures, logging the cores of deep bore holes (length approximately 300–1,000 m) and by surveying the excavated spaces of the disposal facility. Geological investigations in Olkiluoto began in the mid-1970s in connection with the construction and design of the power plants. In the early 1980s, they were focused on the Ulkopäänniemi area for the planning of the VLJ repository. The first geological mapping, which covered most of the Olkiluoto area, was done in 1988 in connection with site selection studies. The mapping material has been supplemented later in several stages with different mappings, and the rock exposures were studied in more detail, e.g. in terms of geological structures. The geological and geophysical studies carried out are described in more detail in Posiva's reports *(e.g. Aaltonen et al. 2016)*.

The Olkiluoto geological site model was updated in 2016 *(Aaltonen et al. 2016)*. The geological model has been created by using hundreds of rock exposures, tens of kilometres of cores of bore holes, large-scale tunnel mapping and many kinds of geophysical studies. The geological modelling consists of four parts: ductile deformation model, rock type model, alteration model and brittle deformation model. The ductile deformation model describes the plastic deformations that have occurred in the bedrock, for example, in the orientation of the bedrock. The alteration model models the hydrothermal alteration observed in the bedrock. The brittle deformation model is used to describe in detail the brittle displacement and fracture zones in the bedrock, which have been modelled e.g. based on rock exposures and the displacement of bore hole cores. According to the site model, veined gneiss occurs as a rock type in the power plant area, and the fault structure OL-BFZ020a interpreted in the model (a so-called site-scale structure) is located in the nearby area *(Aaltonen et al. 2016)*.

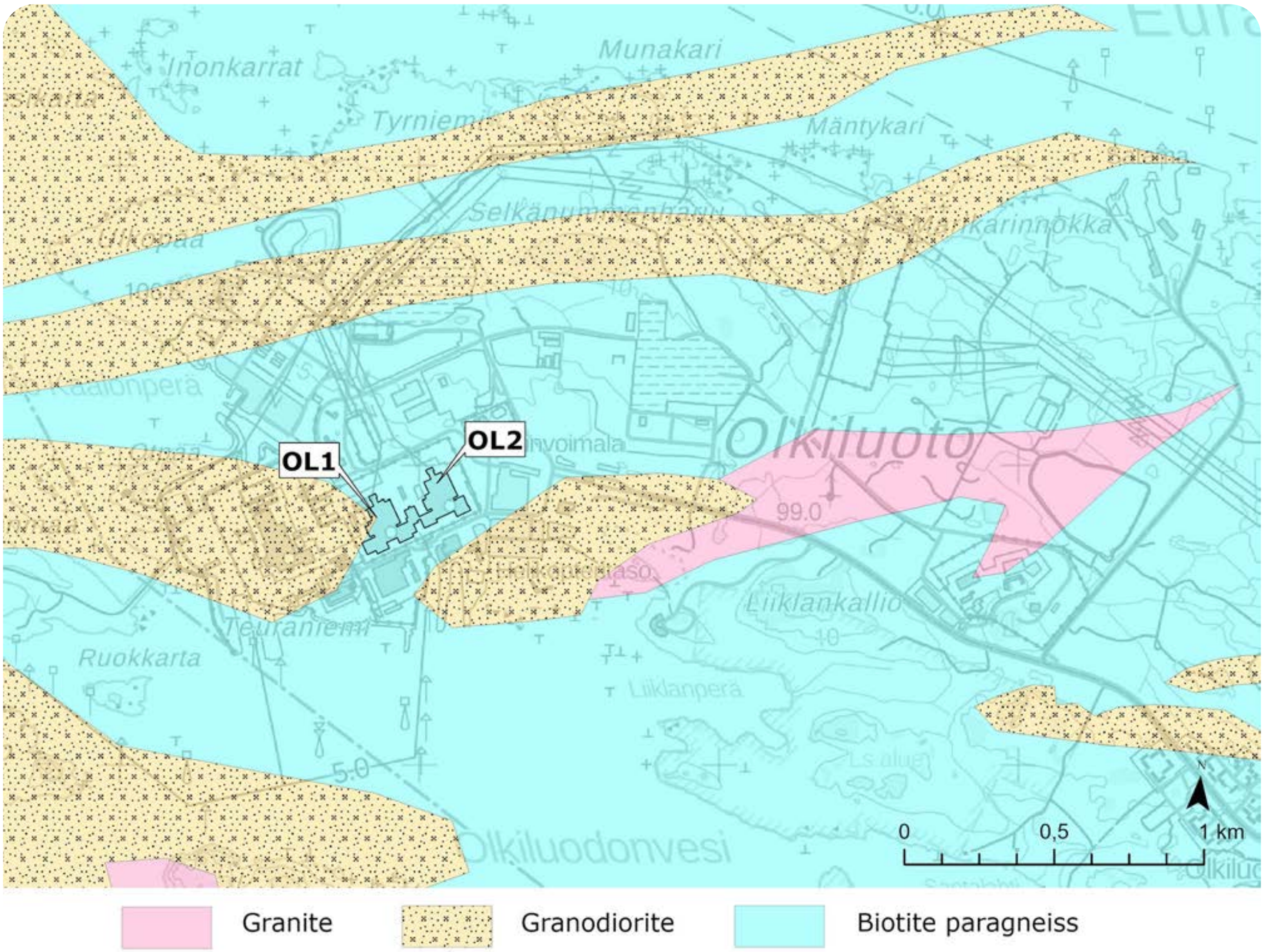
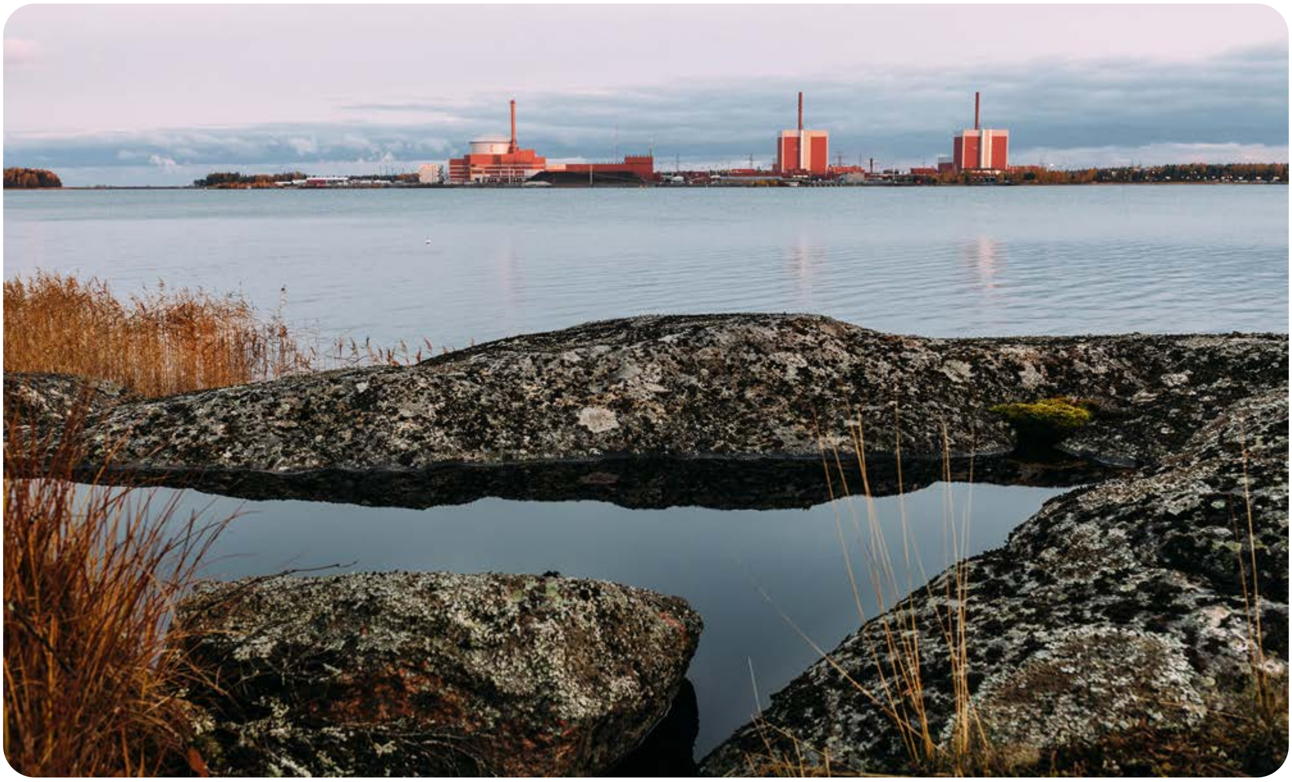


Figure 27. Bedrock in the power plant area and its surroundings.



6.7.2.2. Soil

Soil in the Olkiluoto area mostly consists of rocky fines moraine. Low sections also feature thin layers of clay and peat (Figure 28). The area also includes rock exposures. In the site area, virgin soil has been mostly replaced by artificial fill. The overburden in the area is 2.5 m thick on average. The thickest layers of overburden, some 16 m, are located to the west of the island. The overburden mostly consists of sandy moraine with layers of silt, clay, sand and gravel. The soil layers in the seabed are moraine, clay and sand. In the planned near-surface final disposal area for very low-level waste, the subsoil is a load-bearing moraine.

The probability of acid sulphate soil occurring in the Olkiluoto area is very low according to the data from the Geological Survey of Finland.

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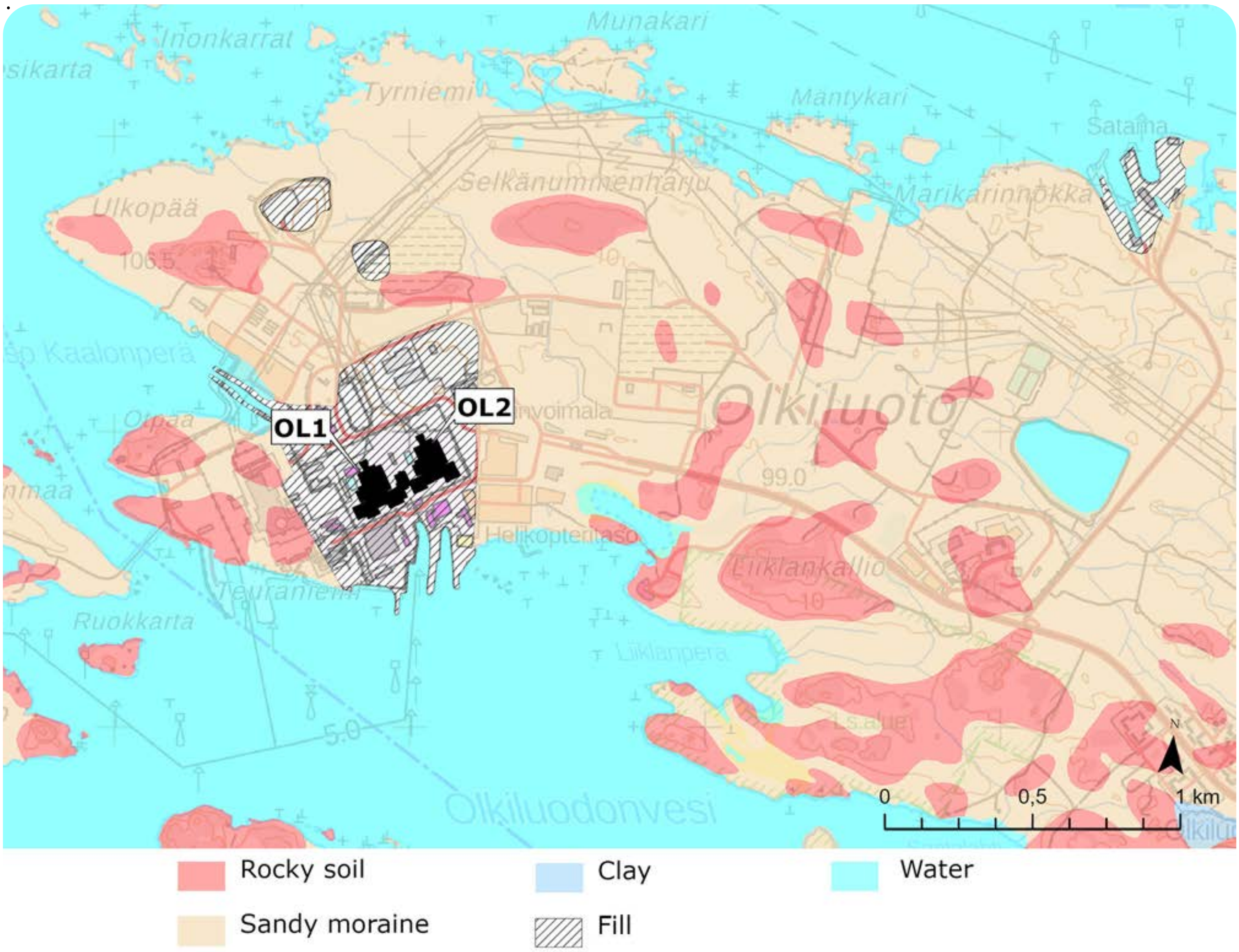


Figure 28. Soil map for the power plant area and its surroundings.

6.7.2.3. Groundwater

The surface of groundwater loosely follows the topography of the ground surface. In moraine-covered areas, groundwater is typically at a depth of 1–2 m and, on the shore, the groundwater level coincides with that of seawater. In the Olkiluoto area, the fluctuations of the groundwater level interact with the sea level fluctuations. In shallow holes drilled from the ground surface, a typical seasonal variation is observed, where the hydraulic pressure height decreases during the summer due to evaporation and low precipitation and then recovers with the autumn rains.

There are no classified groundwater areas at Olkiluoto, and the area is not significant in terms of supplying water to the communities. The nearest classified groundwater area, Korvenkulma (class 1, 0205106) is located in Kuivalahti, approximately 6 km northeast of the power plant (Figure 29). The formation is part of a ridge sequence that continues southeast up to Säkylänharju. The Kuivalahti water intake plant is located in the groundwater area. The Korvensuo raw water pool was built in the Olkiluoto area in the 1970s to produce household water and process water for power plant operations. There are a few privately owned bored wells on the island that are either in continuous or leisure-time use *(Posiva 2021b)*. The water quality of private wells is at a moderate or poor level for natural reasons, and the operations in the Olkiluoto area have not been found to have any effect on them *(Posiva 2021c)*. Posiva has been monitoring the water quality of the wells since 2003.

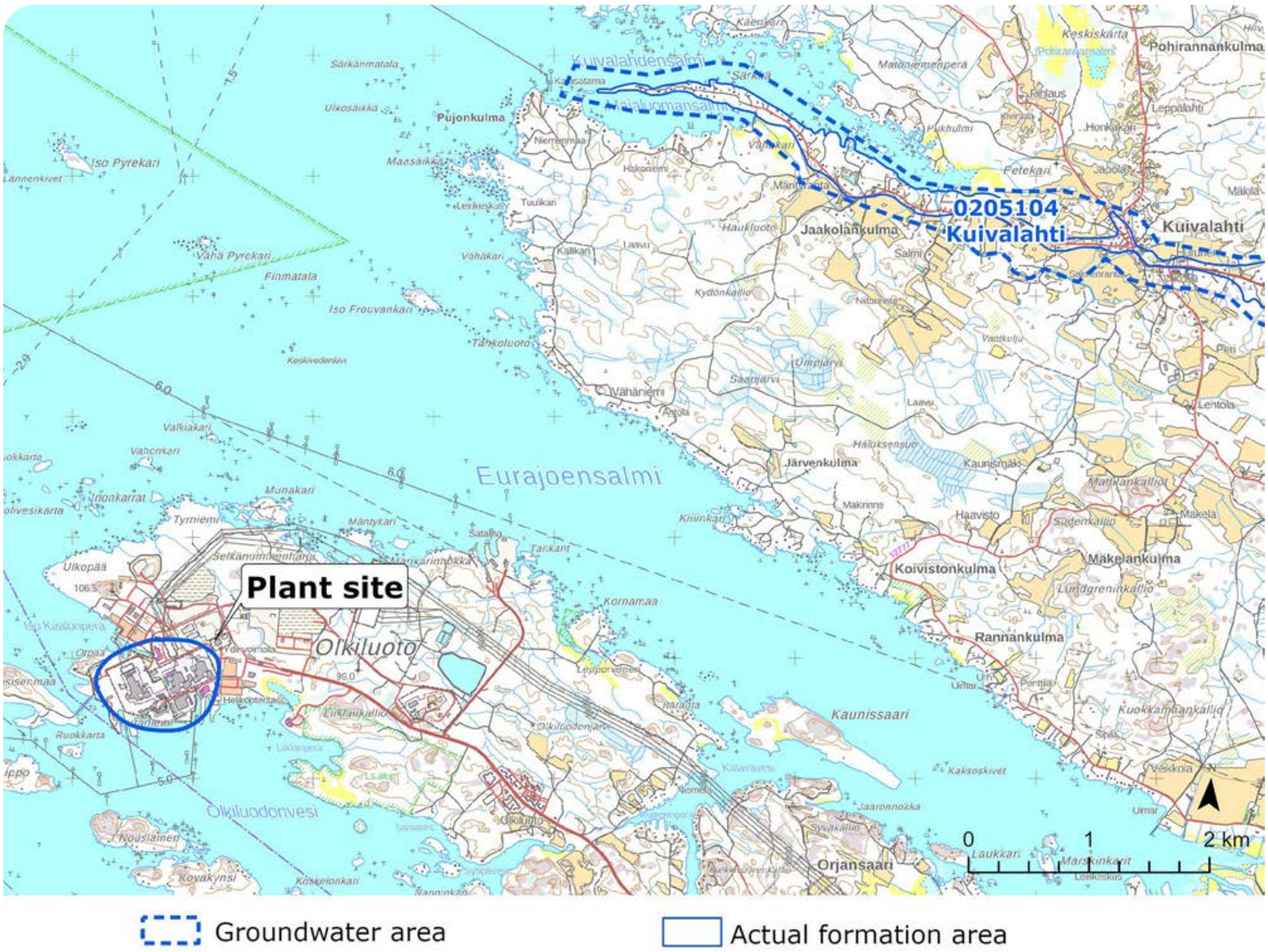


Figure 29. The classified groundwater area that is located the nearest to the power plant area.

The groundwater level has been monitored in the Olkiluoto area since the early 1980s *(Posiva 2021c)*. Groundwater level monitoring point OL-PP31 (shallow borehole) that belongs to Posiva's monitoring programme is located at a distance of approximately 70 m from TVO's site area. The groundwater level at the monitoring point has increased during the monitoring period from the year 2004 onwards, and it was at its highest during 2016–2019 which is likely related to the tillage and construction work in the area. In 2022, the groundwater level in shallow borehole OL-PP31 was, on average, 1.43 m above sea level *(Posiva 2023a)*. Monitoring points OL-PVP41A and OL-PVP41B (groundwater pipes) that are part of Posiva's monitoring programme are located approximately 330 m east of the site area; during the monitoring period, from the year 2012 onwards, a minor groundwater level decrease of approximately 0.1–0.2 m has been observed in them. In 2022, the groundwater level was, on average, 0.15 m above sea level in groundwater pipe OL-PVP41A and 0.1 m above sea level in groundwater pipe OL-PVP41B *(Posiva 2023)*.

Bedrock groundwater flows in bedrock fissures and fracture zones. Hydrogeology in the Olkiluoto area has been studied by means of aboveground studies by using various shallow (approximately 0–40 m) and deep (approximately 300–1,000 m) boreholes and in the underground spaces of the disposal facility for spent nuclear fuel. A hydrogeological structure model is maintained for the known water-conducting zones of the Olkiluoto bedrock (Figure 30) *(HZ model, Vaittinen et al. 2020a)*, according to which the bedrock in Olkiluoto is divided into extensive regional hydrogeological zones. The hydraulic conductivity of fractures occurring in the surface part of the bedrock (10-7 m/s) is generally higher than that of the fractures occurring deeper, at the final disposal depth (10-10 m/s) *(Posiva 2021a)*. The most significant hydrogeological zones in the Olkiluoto area are HZ19 and HZ20. Between these hydraulic zones, the bedrock is sparsely fractured. The hydrogeological zones dominate groundwater flow deeper in the bedrock and near the underground facilities. At Olkiluoto, the hydraulic connections in the bedrock join the southern, southeastern or eastern zones with a shallow inclination.

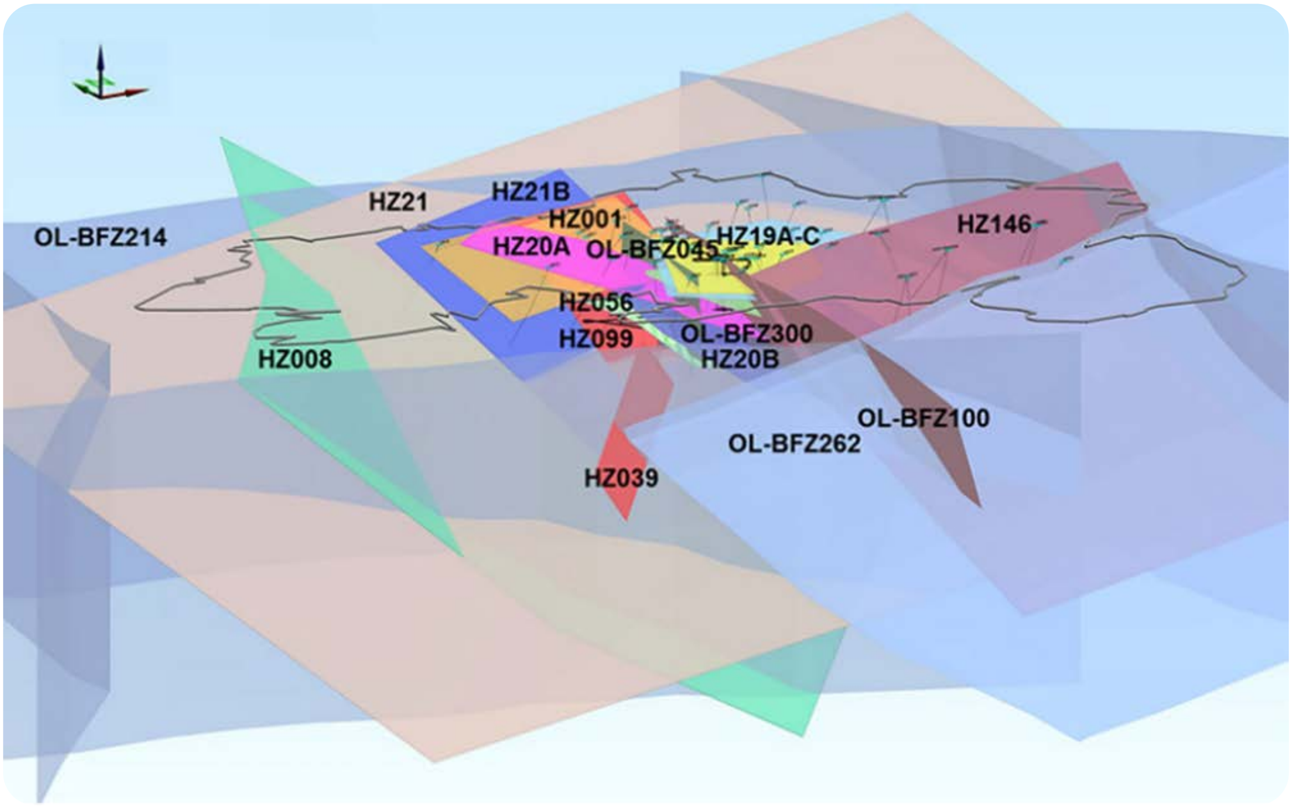


Figure 30. Hydrogeological model of Olkiluoto. (Vaittinen et al. 2020, Posiva 2021a).

The hydraulic pressure height of groundwater has been monitored in boreholes in the Olkiluoto area since the 1990s *(Posiva 2021c)*. The monitoring provides information on the state and development of the pressure conditions in the rock groundwater. The excavation of underground spaces for Posiva's disposal facility for spent nuclear fuel has affected the flow paths and velocities of water moving in the bedrock of Olkiluoto, and, thus, also the hydrogeochemical properties of the water when different groundwater types mix. Quarrying of underground facilities has caused the groundwater level above Posiva's disposal repository to drop by 0.5 m *(Posiva 2021c)*. Local lowering of the groundwater level can occur in places where zones with better water-conducting qualities are located close to the ground surface. Changes in Olkiluoto's groundwater chemistry, groundwater pressure heights and flow directions caused by the quarrying of underground facilities are described in Olkiluoto's monitoring programme.

The chemical conditions of Olkiluoto's rock groundwater are generally oxygen-free and slightly alkaline. Hydrothermal activity, periods of glaciation and land upheaval are processes that have had an impact on Olkiluoto's groundwater chemistry in its current state. The groundwater of the Olkiluoto bedrock is divided into layers that differ in things such as salt content and anion composition. Groundwater is fresh for the first scores of metres (salinity less than 1 g/l), after which there is brackish water up to a depth of around 400 metres (salinity 1–10 g/l). At the final disposal depth of nuclear fuel (−420 m), the water is either brackish water or saline groundwater (salt content ≤21 g/l). The salinity continues to increase as the depth increases *(Posiva 2021b)*.

Highly saline, low-sulphate groundwater leaking from the zones leading water to open underground spaces is replaced by water flowing from the upper layers, which is more dilute in salinity and contains more sulphate and bicarbonate. The salinity of the rock groundwater is diluted in some of the water-conducting zones (e.g. HZ19 and HZ20), where the structures intersect the open underground disposal repository or are indirectly connected hydraulically with other zones *(Posiva 2021c)*.

The groundwater studies in the Olkiluoto area and their results, as well as the research methods, are described in the annual reports of Posiva's hydrology, hydrogeology and hydrogeochemistry monitoring programme. The latest monitoring reports cover the results for 2022 *(Laakso et al. 2023, Yli-Kaila et al. 2023)*.

6.7.2.4. Seismology

The Finnish bedrock is part of the Precambrian Fennoscandian Shield that is one of the most seismically stable areas on Earth. However, it does contain tensions which, when released, may cause weak earthquakes. These are often focused on existing bedrock weakness zones. Finland registers approximately 10–20 earthquakes per year. These earthquakes are relatively week, magnitude 1–4 (Richter scale).

In recent decades, bedrock at Olkiluoto has been examined in particular detail. Current seismic activity at the Olkiluoto plant site has been monitored by the macroseismic monitoring network maintained by the Institute of Seismology of the University of Helsinki, and, since 2002, also by Posiva's microseismic monitoring network *(Posiva 2021b)*.

Geological analyses have shown that the bedrock is stable and no earthquakes affecting the operation of the power plant occur. Natural seismic activity in the Olkiluoto area is low according to historical data, monitoring data and continuous measurements. The risks of a seismic accident involving the Olkiluoto nuclear power plant have been assessed in a separate safety analysis *(Tunturivuori 2018)*.

6.7.2.5. Sensitivity of the affected aspect

In terms of soil and bedrock, the sensitivity assessment criteria are the geological values of the affected aspect, the current state of the area and the degree to which it is in a natural state. The sensitivity is estimated to be low, because the soil and bedrock in the power plant area have no special value due to their geological properties and the soil and bedrock have already been modified.

Groundwater areas, water catchments and private domestic wells located in the impacted area affect the sensitivity of the site in terms of groundwater. The sensitivity of the site was assessed as low, as there are no classified groundwater areas, water catchments or private domestic wells in the immediate vicinity of the site area. The groundwater in the site area is neither qualitatively nor quantitatively usable as domestic water.

6.7.3. Environmental impacts

6.7.3.1. Continuing operation

The OL1, OL2 and OL3 plant units and the KPA storage with its underground structures have already been built a Olkiluoto. If the KPA storage is expanded, the existing surface layers and some of the existing structures (e.g. protection against sea level rise) will be removed to make room for the reservoirs to be built. In addition, some rock material has to be excavated in connection with the expansion, as the foundations of the KPA storage extend to a depth of approximately 20 m from ground level. Depending on the level of the groundwater level and the density of the bedrock, the excavation of bedrock causes groundwater to flow into the empty space being quarried, which is controlled e.g. by compaction works performed in connection with the quarrying. The water used at the construction site of the KPA storage extension and the groundwater accumulated in the area during the excavation work are pumped into the sea after appropriate treatment. The quality and quantity of water discharged into the sea is monitored. After the completion of the KPA storage building, the water accumulated in the foundations will be discharged to the sea through the rainwater system, as is the case now. The expansion of the KPA storage has no negative effects on the quantity or quality of groundwater in the area. The soil in the vicinity of the KPA storage has already been modified, and the storage is located in a built-up area. The effects on the soil and bedrock are permanent, but are limited locally to the area required by the new structures.

The VLJ repository has already been built, and maintenance waste and solidified liquid waste from the operation of the power plant have been moved there for final disposal. The capacity of the facilities quarried earlier is also estimated to be sufficient for the final disposal of low and intermediate-level waste generated during the service life extension of the power plant, which will, therefore, not require an expansion of the facilities.

The final disposal of very low-level waste generated from the operation of the power plant will take place in a separate near-surface final disposal facility, which will be located near the VLJ repository. The planned disposal repository is located approximately 2–3 m from sea level. In connection with the construction of the near-surface final disposal operation, the surface level of the area will be raised to a sufficient extent. The design capacity of the near-surface final disposal facility is approximately 45,000 m^3. The structural material of the facility mainly consists of different loose materials, such as soil, crushed stone and sandstone powder, and, in addition for the sealing layer, geotextile or 1–10 mm thick LDPE film, for example *(Teollisuuden Voima Oyj 2021)*. The capacity of the facility is sufficient for the very low-level waste generated during continued operation, and there is no need to build new facilities. Continued operation will not cause any impacts on the soil in the area that would differ from the current state. The bottom and surface structures of the near-surface final disposal facility have hydraulic release barriers, drainage layers and sealing layers which prevent the transport of nuclides into the environment via groundwater or surface water.

The Olkiluoto VLJ repository was completed in 1992, and the construction of the research tunnel belonging to Posiva's disposal repository for spent nuclear fuel began in 2004. In the current situation, groundwater conditions in the Olkiluoto area are affected especially by the disposal repositories quarried underground, as the construction of underground premises creates a disturbance in the groundwater conditions of the surrounding bedrock. However, the disturbance caused by the construction of the disposal repositories has not had a significant permanent effect on the groundwater levels of the soil layers in the Olkiluoto area. The drop in the groundwater level of less than 0.5 m above Posiva's disposal repository is not estimated to further increase significantly, as the facilities close to the ground have already been excavated *(Posiva 2021c)*.

In a space excavated in bedrock, hydraulic cracks intersecting open tunnels and bedrock fracture zones typically leak groundwater into the space, causing the groundwater level to drop in the surroundings. Based on hydrological monitoring, the development of the amount of seepage water in the VLJ repository has been stable. Based on the measurement results from the last few years, the average seepage water flow of the VLJ repository has been around 38–39 l/min *(Posiva Oy 2023b)*. In recent years, no significant changes have been observed in the hydraulic pressure heights of the VLJ repository or the boreholes in its vicinity. The seepage water is pumped to the ground and conveyed to the sea. There are no classified groundwater areas, water catchments or private domestic wells in the immediate vicinity of the site area.

The continued operation of the plant units will not have an impact on the soil and bedrock or on the quality, quantity or surface level of the ground water, but the current effects will continue during the additional years of operation, and the magnitude of the impact is, thus, estimated to be a minor negative at most.

Contamination of the soil or groundwater can occur in accident situations related to chemicals or fuel oil. Incidents and accidents are discussed in Chapter 6.18. The annual storage and use volumes of chemicals and oils remain the same. With regard to the possible risks to the soil or to groundwater quality, there will be no significant change when compared to the current situation.

6.7.3.2. Power uprating

In the event of a power uprating, a new additional water system and battery energy storage system will be built in the power plant area, together with the associated underground cable route. The construction work is partly focused on the already built-up area, and the project does not require large-scale use of undeveloped land. The additional construction does not require bedrock excavation in the area. The effects of the construction are directed at the surface parts of the ground and are comparable to conventional earthworks. In addition, it is possible that the KPA storage located in the area will be expanded. The effects of expanding the KPA storage on the soil, bedrock and groundwater are similar to those described in Chapter 6.7.3.1.

The continued operation of the plant units on uprated power will not have an impact on the soil and bedrock or on the quality, quantity or surface level of the ground water, but the current effects (see Chapter 6.7.3.1) will continue during the additional years of operation, and the magnitude of the impact is, thus, estimated to be a minor negative at most.

Contamination of the soil or groundwater can occur in accident situations related to chemicals or fuel oil. Incidents and accidents are discussed in Chapter 6.18. In connection with the power uprating, the amount of diesel fuel stored in the site area will increase. With regard to the possible risks to the soil and to groundwater quality, there will, however, be no significant change when compared to the current situation. There are no classified groundwater areas, water catchments or private domestic wells in the immediate vicinity of the site area.

6.7.3.3. Significance of the impacts

The sensitivity of the affected aspect in terms of soil and bedrock was assessed as low, because the soil and bedrock in the power plant area do not have a special value due to their geological properties and the soil and bedrock have already been modified. In terms of groundwater too, the sensitivity of the site was assessed as low, as there are no classified groundwater areas, water catchments or private domestic wells in the immediate vicinity of the site area.

The continued operation of the plant units (VE1) or their power uprating (VE2) will not have an impact on the soil and bedrock or on the quality, quantity or surface level of the groundwater, but the current effects will continue during the additional years of operation. The capacity of the facilities quarried earlier is also estimated to be sufficient for the final disposal of low and intermediate-level waste generated during the service life extension of the power plant or the power uprating. If the KPA storage needs to be expanded, the bedrock of the area will be quarried, and the surface layers and structures will be partly removed. The impacts during additional construction are limited to the excavation and earthworks for possible new buildings.

Taking into account the extended operating time of the plant units and possible additional construction, the significance of the effects on the soil, bedrock and groundwater is estimated to be a minor negative at most (Table 27).

Table 27. Significance of the impacts: Soil, bedrock and groundwater.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.7.4. Mitigation of harmful impacts

During the additional construction works for the power uprating, attention is paid to the condition of the machinery and equipment, so that fuel or lubricants do not end up in the soil and groundwater as a result of equipment breakdowns, for example. If necessary, any possible locations with contaminated soil in the area are determined before starting construction activities.

The maintenance, ageing management and monitoring of the VLJ repository are defined in the power plant's procedures. These include several measurements of rock mechanics as well as regular measurements of groundwater chemistry and hydrology. Regarding the HMAJ disposal repository, the effects on the soil and groundwater are prevented by a carefully constructed release barrier. Soil pollution that may occur in the event of an accident or emergency can be prevented by structural and technical risk management measures.

6.7.5. Uncertainty factors

The research data on the soil, bedrock and groundwater of the area are not associated with any uncertainty factors relevant to the impact assessment.

6.8. Surface water

6.8.1. Initial data and assessment methods

The OL1 and OL2 plant units located in the Olkiluoto power plant area were commissioned in 1978 (OL1) and 1980 (OL2). The impacts of the nuclear power plant units on the quality of the seawater off Olkiluoto and the marine biological environment have been studied comprehensively over a long period of time, which means that the state of the sea area and any long-term changes occurring therein are well known. In the future, however, climate change will intensify the effects of the operation of the plant units in the sea area.

The description of the current state of the sea area made use of the cooling water and wastewater monitoring reports of the Olkiluoto power plant; the annual physical-chemical and biological monitoring reports of the sea area off Olkiluoto *(KVVY Tutkimus Oy 2019, 2020, 2021, 2022b, 2023a & 2024)*; separate reports made during the EIA procedure, such as the Natura needs assessment (Appendix 6) and the cooling water spread modelling report (Appendix 5); as well as materials from the Finnish environmental administration's Hertta open information database.

The effects on the quality of surface waters and possible indirect effects on aquatic life caused by the continued operation of the OL1 and OL2 plant units until 2048 and 2058 and by their power uprating were evaluated as expert work. The evaluation was based on descriptions of operations and changes to them; information on the current state of the water environment; and regarding the effects of the cooling water of Olkiluoto's OL1, OL2 and OL3 plant units, cooling water modelling based on flow calculation, the methods of which are briefly described in the following text section. The full report on the cooling water modelling is in Appendix 5.

The modelling takes into account the thermal load of the cooling waters of Olkiluoto's OL1, OL2 and OL3 plant units, as well as the effect of climate change.

The impact assessment has examined the effects of the intake and discharge of cooling water on the water quality, currents and depositional conditions of the sea area at a distance of approximately 10 km from the site area. In addition, the effects of other service water, process water, domestic wastewater and stormwater on water quality and aquatic life have been examined, based on their quantities and treatment methods. Emissions of radioactive substances into water bodies and the effects of these have been described in Chapter 6.16.

Based on the results of the impact assessment, the compliance of the project was evaluated in relation to the EU water policy framework directive *(2000/60/EC)* and the marine strategy directive *(2008/56/EC)*. The EU's water policy framework directive has set a goal for the member states that the ecological and chemical status of surface waters does not deteriorate. According to the directive, the aim is to achieve a good status in all surface water bodies by 2027 at the latest. Finland's water resources management plan and marine strategy plan are updated every six years. The third water resources management classification period, 2022–2027, is currently underway. The fourth water resources management classification period will begin in 2028. The classifications for this fourth period are currently being prepared, so it should be noted that the status classifications of the water bodies in the Olkiluoto sea area may change when the water management period changes.

In 2015, the obligation of status goals in the consideration of permits for projects was made more specific by the EU Court's judgement in the so-called Weser case (C-461/13). According to the water policy framework directive, a project being evaluated must not weaken the ecological or chemical status of the surface water body or endanger the achievement of a good state for surface waters. In water resources management, the ecological and chemical status of surface waters was assessed for each water body. In the environmental impact assessment, compliance with legislation was assessed separately for each water body regarding each classified quality factor of the ecological state and the chemical state. The effects on macrophytes, i.e. aquatic vegetation and macroalgae, are described in Chapter 6.10. The assessment also took into account the effects on marine strategy.

Cooling-water modelling

The warming of seawater caused by the thermal load of the cooling water and the dispersion and mixing of the warm cooling water into the sea area off Olkiluoto are modelled by using an YVA3d model that is based on solving hydrostatic 3D flow equations with the differential method. The calculation is based on solving Navier-Stokes equations of motion. These equations represent how a very small box of fluid behaves and how the examined quantity (in this modelling, the temperature) moves from one elementary cell to another. The same model has been used previously when modelling the Olkiluoto sea area, when the thermal impacts on Natura areas of the potential construction of the OL4 plant unit were being assessed (*Inkala & Lauri 2009*). The aim of the modelling is to describe the dispersion and mixing of warm cooling water in the sea area. Modelling winter conditions also provides information on how cooling water will affect the size of the ice-free area near the cooling water outlet.

For the modelling, a model grid consisting of horizontal and vertical squares (elementary cells) is constructed. In the horizontal direction, a gradually specified nested model grid is used, allowing for the impacts of a wider sea area on the target area to be calculated at the necessary precision (Figure 31). The area near Olkiluoto is modelled to a precision of 40 m (precision 40 m, size of grid level 11 x 10.4 km). The outermost level of the grid covers a section of the Baltic Sea from approximately the Hiidenmaa level to the Northern Quark (precision 5 km, size 300 x 475 km). Furthermore, there are two grid levels between the nearby areas and the outermost area, with precisions of 1 km and 200 m. Depthwise, the grid is divided into 21 levels whose size varies from half a metre, used near the surface, to dozens of metres used in the open sea abysses. The creation of the depth grid utilises Baltic GIS's documentation at a resolution of approximately 1 km, digital map data from the Finnish Transport and Communications Agency, depth contours for the areas off Olkiluoto and technical drawings of the surroundings of the cooling water inlet and outlet locations. The modelling has estimated temperature changes in the surface layer of the sea at a depth of 0–0.5 m and in the water layer near the bottom, the thickness of which varies, depending on the depth of the water, from 0.3 to 4 m above the bottom.

Water starts flowing when a factor forces the water to move. In the Olkiluoto area, the most important factors creating currents are the wind, water flow from the nearby rivers and cooling water intake and discharge from the power plant. Currents are also affected by the state of the water mass, such as temperature stratification and differences in salinity. The modelled area also usually has edges (in this case, from Hiidenmaa to the north side of the Bothnian Sea), in which case you need to know the water levels or flow rates at the edges of the area. With the edge values, the model also accounts better for level variations in the Baltic Sea. These values (daily averages of salinity and temperature on the Baltic Sea and water level) are calculated with the NEMO model in the EU's Copernicus programme. Since the edges of the modelled area are located far from Olkiluoto, their impact in the sea area near Olkiluoto, inside the densest grid is minor in relation to local changes in conditions. Currents are slowed down by friction forces, mainly friction at the bottom and on the shoreline and turbulence.

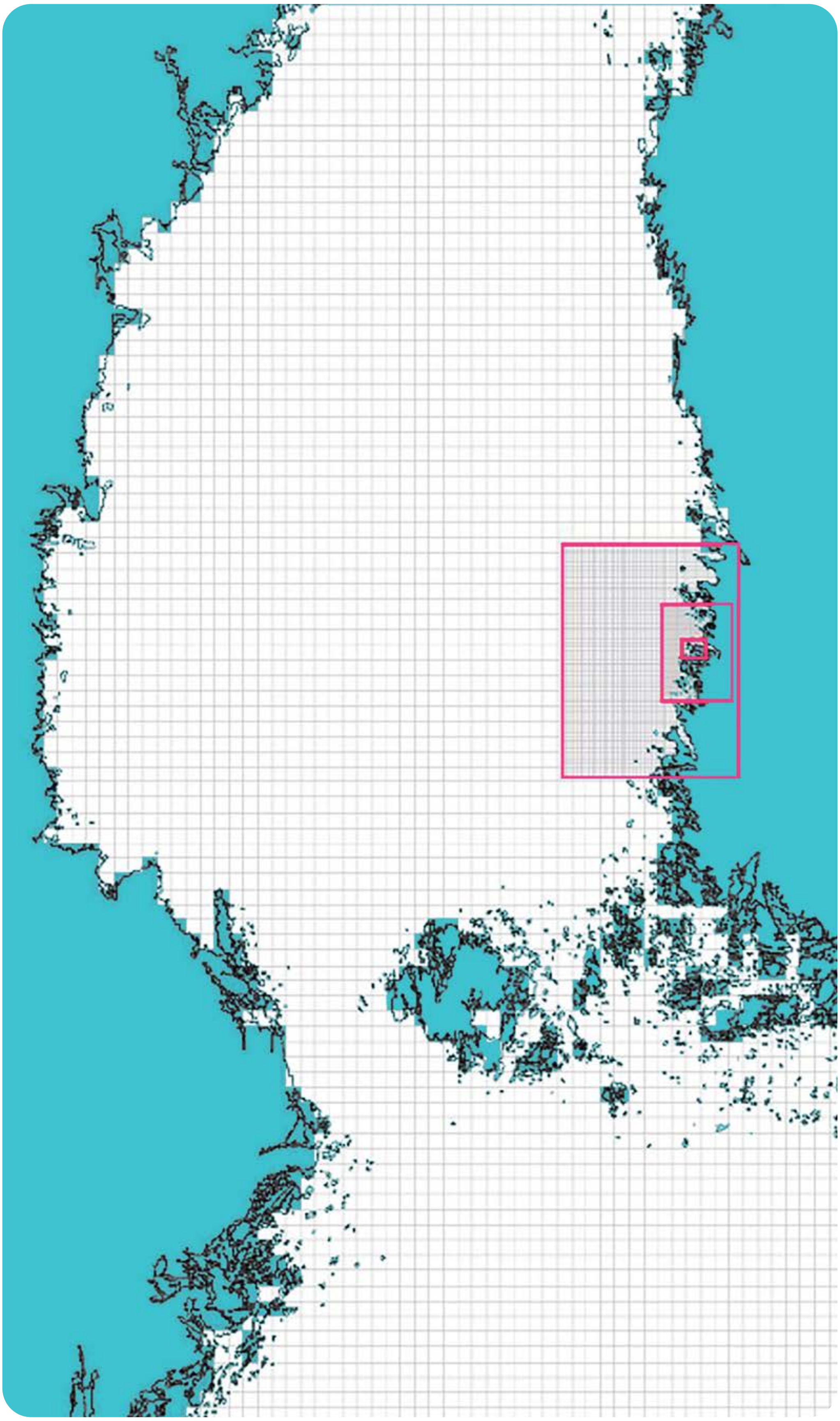


Figure 31. Entire model grid with nested sections delimited in red. The sizes of the elementary cells, from largest to smallest, are 5 km, 1 km, 200 m and 40 m.

As a meteorological driving force (wind impact) the model uses the ERA5 data. ERA5 is a data set combined from the reanalysis of the calculated results and measurements of atmospheric models, with a horizontal resolution of 0.25 degrees or approximately 28 km and a time step of one hour. Local wind is interpolated for each grid square in the model. The impact of islands and other obstacles is not considered. As hydrological driving forces (river flows), the model considers the largest rivers running to the Bothnian Sea (Ångermanälven, Indalsalven, Ljungan, Ljusnan, Dalälven, Kokemäenjoki, Aurajoki and Paimionjoki) as well as Eurajoki and Lapinjoki which are located in the densest areas of the grid. Winter simulation is started from a situation where ice has not yet formed in the sea area, which means that no initial value is set for the ice cover.

The model calculates the temperature and salinity of the water and, at the same time, the horizontal and depth-wise differences in density caused by the temperature and salinity which affect, among other things, the convection and depth-wise mixing of the discharged cooling water. The flows are calculated dynamically, that is, a representative period is selected from the weather history that is simulated by means of the model calculation by using the measured weather data and boundary values, such as river flow rates. The outcome of the calculation is the water flow, temperature and salinity for each of the elementary cells in the model grid at the selected time precision for the selected simulation period. The calculation of temperature changes (convection and mixing of cooling water) in the sea area is based on flow data received from the flow model.

The aim of the modelling is to achieve an understanding of the potential impacts of uprating the power of the OL1 and OL2 plant units and to assess extending the operation of the plant units from 2038 until 2048 and 2058. Since the time periods being examined are far in the future, the impacts of climate change will also be assessed in the model. The modelling scenarios (Table 28) ohave been chosen so that the impacts of the alternatives presented in the environmental impact assessment (see Figure 2) can be assessed.

Table 28. Scenarios modelled in the EIA.

Scenario	Description
Current status (alternatives VE0, VE1)	The OL1, OL2 and OL3 plant units operate at their current power level until 2038, 2048 or 2058
Power uprating (alternative VE2)	The OL1 and OL2 plant units operate at an uprated power level and OL3 at its current power level until 2048 or 2058

The model is used to simulate the open water season in the summer period from 1 May to 1 September and the winter period from 1 December to 30 April. In order to assess the current situation, periods will be chosen from the past ten years that are as warm or as cool as possible, which means that the impacts will most likely remain between these two extremes. Based on the weather statistics from Pori *(Finnish Meteorological Institute 2024c)*, the year 2017 has been selected as a cool summer, while 2021 represents a warm summer; 2018 and 2020 have been selected as corresponding years for the winter simulations.

Based on Finland's eighth national report on climate change *(Ministry of the Environment and Statistics Finland 2022)*, the climate in Finland is estimated to warm up and precipitation is expected to increase. Heat waves are becoming longer and more frequent, as a result of which the surface temperature of the northern Baltic Sea is estimated to rise by 2–4 °C by the year 2100. In addition, severe cold periods are gradually disappearing, as a result of which the duration and surface area of ice cover will decrease. Wind speeds are expected to remain approximately at the present level. According to the report from the Intergovernmental Panel on Climate Change *(IPCC)*, the sea level is estimated to rise by a total of 15–20 cm by 2050, which is of the same magnitude as the land upheaval in the Olkiluoto area *(Poutanen 2023)*. Because of this, rising water levels are not considered in the climate change scenario. The scenario selected to depict climate change was SSP5-8.5, which represents very high greenhouse gas emissions, i.e. a situation where greenhouse gas emissions are not limited at all. This scenario was chosen because of a need to assess the impacts by applying the precautionary principle and because, in early 2040, the differences between the temperature changes caused by the various climate change scenarios continue to be fairly minor. Changes compared to the year 2020 were estimated using information in the national report on climate change. Climate change scenarios are calculated for both cool and warm summer and winter periods by adding the estimated impact of climate change to the input data for these years (Table 29).

Table 29. Changes using the year 2058 SSP5-8.5 climate change scenario when compared to the situation in 2020.

	Summer		Winter	
Year	Air temperature increase (°C)	Addition to flow rates and precipitation (%)	Air temperature increase (°C)	Addition to flow rates and precipitation (%)
2058 SSP5-8.5	2.2	5.3	2.6	10.7

The simulation scenarios to be calculated are compiled in the enclosed table as a summary (Table 30). Comparison and validation simulations are performed under actual weather conditions under two different thermal loads and four simulation periods (2x summer and 2x winter). Climate change is estimated using one scenario (SSP5-8.5) for the same four summer and winter periods. In total, there will be 2x4 simulation periods under actual weather conditions and 2x4 under the climate change scenarios. The impacts for the intermediate years 2038 and 2048 are calculated by means of interpolation.

Table 30. Scenarios simulated in the modelling. Climate change scenario SSP5-8.5 is calculated for 2058 and the impacts for the intermediate years 2038 and 2048 are interpolated (i).

	Actual weather conditions	2038	2048	2058
Validation, OL1 and OL2 plant units	x			
Plant units OL1, OL2 and OL3, current power	x	i	i	x
Plant units OL1 and OL2, uprated power, and plant unit OL3, current power			i	x

The accuracy of the model was improved by using the observation results from the Olkiluoto sea area. The measurements used for the reference periods (summers 2017 and 2021 and winters 2018 and 2020) are TVO's own measurements as well as measurements performed in connection with obligatory monitoring. During calibration, the model was calculated by using several alternative parameter combinations and the alternative that best fits the measurements was selected. The calibration used all reference periods together. Therefore, all comparison simulations and scenarios use the same model parameters.

The results of the modelling are presented as map images visualising the spread of temperature and the ice situation. The cooling water modelling and its results are described in full in Appendix 5.

6.8.2. Current status

6.8.2.1. General description of the sea area

Olkiluoto Island is located on the coastal area of the Bothnian Sea. In the north, Olkiluoto is bordered by the Eurajoensalmi strait; in the south by the sea area called Olkiluodonvesi; and in the west by Iso Kaalonperä bay. In the east, a narrow strait separates the island from the mainland. The Rauma archipelago begins south of Olkiluoto, and the west side has rocky islands and islets. A causeway was built between Olkiluoto and Kuusisenmaa Island in 2015. Eurajoki, which runs into Eurajoensalmi, and Lapinjoki, which runs into the strait between Olkiluoto and Orjasaari, carry turbid, nutrientrich river water into the sea; this affects the water quality and nutrient load in the sea area.

The sea area near Olkiluoto is divided into four water bodies: to the west and north, the Rauma and Eurajoki archipelago (3_Ses_038, surface area 8,220 ha); further to the west and south-west, Luvia–Rauma open sea (3_Seu_110, 48,380 ha); to the south, Olkiluodonvesi–Haapasaarenvesi (3_Ses_040, 1,844 ha); and to the east, Eurajoensalmi strait (3_Ses_039, 803 ha). The Luvia–Rauma open sea water body is of the type “Outer coastal waters of the Bothnian Sea”, while the other three bodies are of the type “Inner coastal waters of the Bothnian Sea” (Figure 32).

The areas surrounding Olkiluoto are typically shallow coastal areas of less than 10 m in depth; however, abysses extending to 15 m are located to the southwest and northwest of the island. The Bothnian Sea deepens relatively evenly from the continent to the outer sea, and a depth of 50 m is only reached at a distance of approximately 30 km from the coast. The Bothnian Sea coast is fairly open and water changes relatively well at the coast. However, eutrophication and internal nutrient load caused by oxygen deficiency in the benthic water are, from time to time, a significant problem in the abysses of the inner archipelago and in the inner bays of the Bothnian Sea *(Bonde et al. 2012)*.

Environmental monitoring has been carried out in the sea area in front of Olkiluoto since 1979. The environmental monitoring programme of the Olkiluoto nuclear power plant approved by the relevant authority was updated in 2022 *(Teollisuuden Voima Oyj 2023)*. This monitoring, which is required by the environmental permit, analyses the impacts of cooling water for the Olkiluoto power plant on the physicochemical quality and fauna of the sea area. The area has seven water quality monitoring points where the monitoring of water quality, phytoplankton and benthic fauna is regularly performed (Figure 32). In addition, sediment surveys and aquatic vegetation surveys are carried out at regular intervals in the sea area near Olkiluoto. The fisheries surveys are described in Chapter 6.9. There are no small water systems in the Olkiluoto area, with the exception of a raw water pool constructed in the 1970s for the operation of the power plant. Temperatures in the cooling water discharge area are monitored by means of continuous instruments that are located at a distance of 500 m from the point of discharge.

Table 31. . Environmental monitoring points in the sea area off Olkiluoto and their locations (WGS84); Ses = Inner coastal waters of the Bothnian Sea, Seu = Outer coastal waters of the Bothnian Sea.

Observation point	P WGS84	I WGS84	depth (m)	water body	surface water type
Olki 480	21.50538	61.25149	8.4	Rauma and Eurajoki archipelago	Ses
Olki 500	21.44693	61.22819	5.9	Olkiluodonvesi–Haapasaarenvesi	Ses
Olki 505	21.39688	61.23006	13.4	Rauma and Eurajoki archipelago	Ses
Olki 510	21.41044	61.24158	8.7	Rauma and Eurajoki archipelago	Ses
Olki 515	21.38197	61.24508	7.9	Rauma and Eurajoki archipelago	Ses
Olki 525	21.42069	61.25646	11.3	Luvia–Rauma open sea	Seu
Olki 530	21.43426	61.28136	13.7	Luvia–Rauma open sea	Seu
Olki 531	61.29519	21.42615	16.5	Luvia–Rauma open sea	Seu

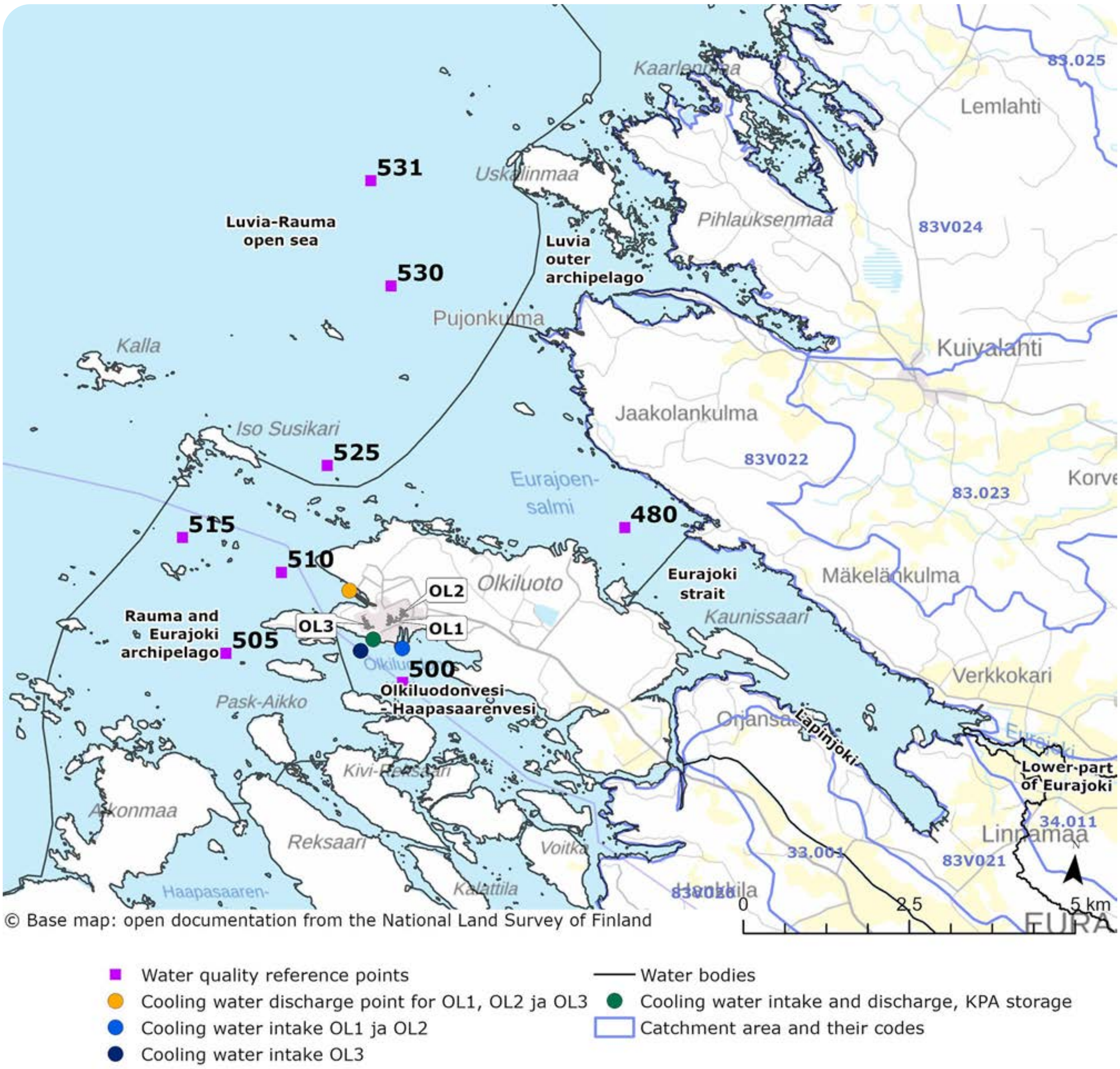


Figure 32. The monitoring points for environmental surveillance in the Olkiluoto sea area; of these, points 480–525 are monitoring points for both water quality and benthic fauna in the cooling water's area of impact, point 530 is a reference monitoring point for water quality and point 531 is a reference point for benthic fauna. The map also shows the cooling water intake and discharge locations for the OL1 and OL2 plant units and the KPA storage.

6.8.2.2. Nutrient load

Beginning in the 1980s, the Bothnian Sea has slowly eutrophicated. In the Bothnian Sea, the total phosphorus load is approximately 580 t/a and the nitrogen load 17,100 t/a, of which more than 75% is caused by human activity *(Laamanen et al. 2021)*. The Bothnian Sea receives a nutrient load as both point loads and scattered loads. Most of the nutrient load in the southern Bothnian Sea is received as scattered load from the land *(Westberg et al. 2022)*. Kokemäenjoki River is the largest individual load source there, amounting to 80% of the nutrient load carried by river water in the area. The background load carried by currents also affects the state of the sea area. For example, the eutrophic effect of the nutrient load originating from the Archipelago Sea can be seen on the southern Bothnian Sea *(Bonde et al. 2012)*. Point loads caused by industry, built-up areas and fish farming can be observed locally in the water quality.

The most significant nutrient load sources in the Olkiluoto sea area are the rivers Eurajoki, which runs into Eurajoensalmi, and Lapinjoki, which runs east of Olkiluoto. Fish farming also takes place near the project area; the nearest location is approximately 10 km away.

Since December 2023, wastewater from Olkiluoto has been routed via the Eurajoki–Rauma transit sewer duct to the treatment plant jointly operated by the City of Rauma and the forestry industry. Previously, the Olkiluoto power plant had its own wastewater treatment plant where the water from the power plant's sanitary facilities was treated. The Rauma wastewater treatment plant discharges its water into the sea off Rauma.

After appropriate treatment, the process wastewater generated at the power plant is directed to the discharge tunnel and the sea. The average nutrient discharges of the process wastewater, rainwater and basic water of the OL1 and OL2 plant units to the sea have been approximately 5 kg per year for phosphorus and 100 kg for nitrogen, so the current share of the plant units in the point nutrient load of the sea area is very small.

6.8.2.3. Thermal load and stratification conditions

The current operation of the OL1 and OL2 plant units uses a total of 76 m^3/s of cooling water, and the water warms by approximately 10 °C as it passes through the turbine condenser. In 2013–2023, the annual cooling water volume for plant unit OL1 has been 1.13 billion m^3 on average (1.06–1.17 bn m^3); for the OL2 unit, it has been 1.12 billion m^3 on average (0.98–1.17 bn m^3) (Table 32). The OL3 plant unit was commissioned in 2022, and in 2023 after a test operation, the total cooling water volume for OL3 was 1.47 bn m^3. The cooling water volume for the KPA storage is low (<0.01 mrd. m^3), and the thermal load caused by it has been included in the total thermal load of the sea area caused by the power plant. The total thermal load from the OL1 and OL2 plant units into the sea has been, on average, 93,800 TJ (88,900–98,500 TJ). In 2023, the total thermal load for all plant units was 159,500 TJ *(Levy 2023)*. According to the environmental permit, the thermal release routed from the power plant into the sea with the cooling water may be 205,000 TJ per year at most.

Table 32. The amount and thermal load of cooling water discharged into the sea by the Olkiluoto plant units in 2023.

Unit	Amount of water (mrd m^3/a)	Thermal load (TJ/a)
OL1 ja OL2	2.24	93,800
OL3	1.47	65,700*
KPA-varasto	<0.01	50
Yhteensä	3,71	159,500

* thermal load from 15 March to 31 Dec.

The effects of the cooling water intake of the OL1 and OL2 plant units concern the Rauma and Eurajoki archipelago water body, and the effects of the cooling water discharge additionally the Luvia–Rauma open sea water bodies. The cooling waters are led to the epilimnion of Iso Kaalonperä bay through discharge tunnels and an outlet channel.

The thermal impact from the power plant's cooling water mainly affects the surface layer of the seawater. The thermal impact is equalised fairly quickly, as the currents will mix the heat in the large water volume and some of the heat will also dissipate when the distance to the discharge tunnels increases. During open water season, the increase in seawater temperature is relatively local. In winter, the cooling water is mixed with the sea area's surface layer, and the local temperature increase caused by it is observed at a distance of 3–5 km from the Olkiluoto coast *(KYVY Tutkimus Oy 2023)*.

In the Bothnian Sea, water is stratified depth-wise in terms of temperature in the summer. In general, the stratification of the Bothnic Sea is much weaker than, for example, in the central parts of the Baltic Sea, and water in the benthic area rotates well, preventing major oxygen issues from arising. A weak thermocline for salinity occurs in the deepest areas of the Bothnian Sea, at depths of approximately 60–80 m *(Myrberg et al. 2006)*. In the sea areas near Olkiluoto, the heated cooling water routed from the power plant into the epilimnion may amplify the temperature stratification. Discharging cooling water affects the temperature conditions in the nearby sea area. During 2013–2023, the average temperature for the epilimnion at monitoring point Olki 510, which is closest to the discharge point for cooling water, was clearly higher than at other monitoring points (Figure 33). Point Olki 510 is located approximately 1.4 km away and point Olki 515 2.5 km away from the cooling water discharge point. At monitoring points Olki 510 and Olki 515 in front of the cooling water discharge point (Figure 32), In July–August, surface temperatures of up to 26 °C were measured in July/August. However, no significant temperature differences can be observed in benthic water (Figure 33). In winter, the impact of cooling water is the clearest at point Olki 510, wherethe average temperature for the epilimnion was 7.7 °C, while further out, at points Olki 525 and Olki 530, it was 3.0 °C *(KVVY Tutkimus Oy 2023a & 2024a)*.

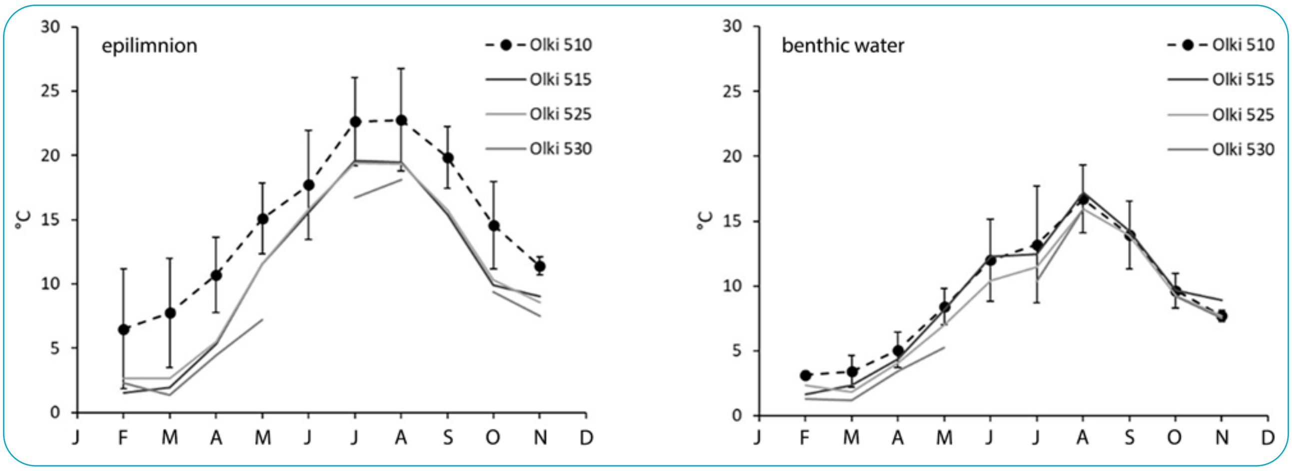


Figure 33. Variation in monthly average water temperatures in the epilimnion (1 m) and benthic water at monitoring points off Olkiluoto during 2013–2023. During the period under review, the average temperature for the epilimnion at monitoring point Olki 510, which is closest to the discharge point for cooling water, was clearly higher than at the other stations. The hypolimnion shows no significant temperature differences between monitoring points.

The KPA storage cooling water intake and discharge occur at the Olkiluodonvesi–Haapasaarenvesi water body. The effects of the thermal load of the cooling water of the KPA storage in the sea area correspond to the effects of the cooling water of the OL1 and OL2 plant units, but as the temperature and quantity of the water discharged from the KPA storage is clearly lower, the effects on the temperature of the seawater, the spread of the thermal load and the stratification of the seawater are also clearly smaller.

6.8.2.4. Flow conditions

The dominant water current direction on the coast of the Bothnian Sea runs from south to north. Usually, only the epilimnion will flow into the Bothnian Sea from the main basin of the Baltic Sea; due to the Åland Sills, hypolimnion can flow only rarely when salinity pulses occur. Locally, the water flow is affected by the topography of the sea area, the contours of the sea floor, the height of seawater, wind conditions and river flow rates.

In the areas off Olkiluoto, currents are also materially affected by the intake and discharge of cooling water at the nuclear power plant. Cooling water for the power plant units is taken from Olkiluodonvesi to the south of the power plant, which causes a local northbound current. Cooling water is routed back into the sea to the west of the power plant, creating a westbound current. Prevailing southern and western winds may, however, turn the flow from the mouth of the discharge channel towards the north *(KVVY Tutkimus Oy 2019)*. The sea area around Olkiluoto is an open area, which is why winds may have a strong effect on the currents and, for this reason, water will generally rotate well.

The water intake and discharge of the KPA storage takes place at Olkiluodonvesi south of the power plant area (Figure 32). Compared to the cooling water intake and discharge flows of the OL1 and OL2 plant units, the flows caused by the cooling water intake and discharge of the KPA storage are clearly weaker and very localised.

6.8.2.5. Ice conditions

Ice conditions on the coast of the Bothnian Sea vary a lot each year. Depending on ice coverage, winter ice conditions on the Baltic Sea are classified as mild, moderate or severe. Descriptions of past ice conditions are available from 1995 onwards *(Ilmatieteen laitoksen jäätilastot)*. Only one case of ice conditions in winter being classified as severe has been observed during this period; this was in 2010–2011, when ice cover reached 303,000 square kilometres (km^2). During the past ten years, ice conditions on the Baltic Sea have been mild, only winters 2012–2013, 2017–2018 and 2023–2024 were classified as moderate *(Ilmatieteen laitoksen jäätilastot)*. In the last ten years, the ice cover of the Baltic Sea was at its widest in the winter of 2017–2018, when the surface of the ice cover was 170,000 km^2. During the winter of 2019–2020, the ice cover on the Baltic Sea was the smallest in recorded history (37,000 km^2) *(Ilmatieteen laitoksen jäätilastot)*. During moderate winters, the Bothnian Sea will freeze almost completely, but it will stay fully open during mild winters *(Ilmatieteen laitos 2022a)*. On average, permanent ice cover is formed in the inner archipelago of the Bothnian Sea at the turn of December/January and cleared in early April. The open sea and outer archipelago stay free from ice for longer than the more sheltered inner archipelago *(Ilmatieteen laitoksen jäätilastot)*.

The size of the ice cover and the open water area in the area off Olkiluoto have been studied since the 1970s. As a result of the thermal load from the cooling waters, ice cover is formed later and, correspondingly, ice will melt earlier in the spring than on average *(KVVY tutkimus Oy 2023)*. In typical winters, the surroundings of the cooling water intake channels freeze, but the cooling water discharge side remains thawed. After the commissioning of the OL3 plant unit, the weak and partly open areas in the solid ice area have expanded. The solid ice area grows towards the sea if there are longer frost periods in the area.

The ice situation in the Olkiluoto sea area varies depending on the prevailing weather conditions, the currents in the sea area and the ice conditions on the Bothnian Sea. The river waters running into the area may also affect the currents and ice conditions. For example, in the winter of 2019–2020, which according to the Finnish Meteorological Institute was the second mildest ice winter in history, no ice formed in the Olkiluoto sea area at all. At the beginning of 2024, on the other hand, an exceptionally cold period occurred, and more ice formed in the sea area than is usual (Figure 34). *(Teollisuuden Voima Oyj 2024c)*.

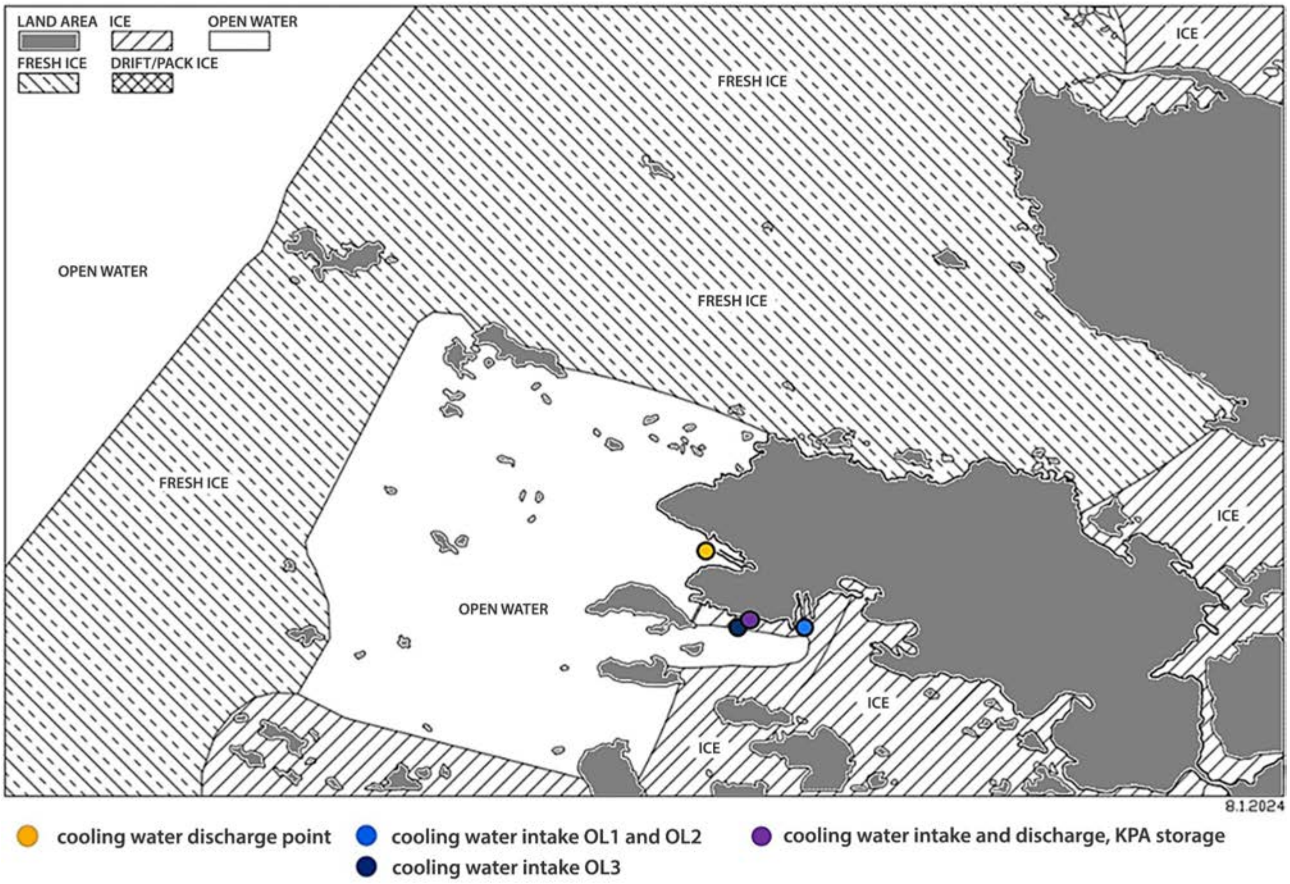


Figure 34. Ice situation in the sea area near Olkiluoto on 8 Jan 2024. At this time, there was ice in front of the cooling water in-take channels, and the area of open water on the cooling water discharge side was the smallest in recent history (Teollisuuden Voima Oyj 2024c).

Climate change will have a significant impact on the ice conditions of the Bothnian Sea. As a result of climate change, ice cover in the Baltic Sea has been forecast to decrease by 50–80% and the time during which the Bothnian Sea is covered by ice to be shortened by 1–2 months *(HELCOM 2013)*. Ice winters are predicted to shorten at both ends in the long term, but the date of the beginning will move more than the date of the end *(Ilmatieteen laitos 2022a)*.

6.8.2.6. Seawater quality

The quality of the water in the Olkiluoto sea area is affected by the point loads located in the area and scattered loads from a wider area (see Chapter 6.8.2.2). Eutrophication has been observed in the Olkiluoto sea area in recent decades *(Laari & Hakanen 2020, Leinikki 2017)*. In the years 2013–2023, the average total phosphorus concentration in sea area has varied between 17–28 micrograms per litre (µg/l) and the total nitrogen between 247–486 µg/l (Table 33). KThe Olkiluoto sea area is slightly eutrophic based on the average total phosphorus content, but barren based on the total nitrogen content *(Oravainen 1999, Laari & Hakanen 2020, KVVY Tutkimus Oy 2019 & 2024a)*.

During the past ten years, the highest total nitrogen concentrations in the epilimnion have been repeatedly measured at Eurajoensalmi strait, monitoring point Olki 480 (Figure 32), where the water quality is affected by the nutrient loads carried by the rivers Eurajoki and Lapinjoki. Nutrient concentrations in the hypolimnion are at their highest at monitoring points Olki 480 and Olki 510, which are located closest to the discharge channel for the power plant's cooling water and wastewater (Figure 32). In winter, no major differences can be observed between the different monitoring points, but in summer, nutrient concentrations at point Olki 510 are slightly above those of the other monitoring points. For example, the total nitrogen concentration in the hypolimnion in August during the review period of 2013–2021 at point Olki 510 was 311 µg/l on average, whereas at other points it varied between 253 and 260 µg/l (Table 33). At Olki 510, the average total phosphorus concentration of 36 µg/l was also higher in comparison with the concentration of 17–19 µg/l at the other points. In July/August 2022 and 2023, exceptionally high nutrient concentrations were measured in the hypolimnion at point Olki 510, which were caused by exceptionally warm summers and low-oxygen conditions in benthic water (oxygen 2.7 mg/l). During the other months, nutrient concentrations were, however, at an average level in these years.

The oxygen situation in the benthic layer of the Olkiluoto sea area is generally good: approximately 8 mg/l in summer and 13 mg/l in winter. However, at monitoring point Olki 510, which is located closest to the cooling water discharge point, lower than average oxygen concentrations of around 3 mg/l have been measured in July and August in 2022 and 2023 (Figure 35). In this case, however, oxygen oversaturation was not detectable in the surface layer, which would point towards lively algae production. The low-oxygen conditions are likely to have been caused by a warmer than usual summer and by the increased stratification of water. The commissioning of the OL3 plant unit in 2022 may also have affected the oxygen conditions of the hypolimnion.

The pH of the water is, on average, 7.9 in both the surface layer and the hypolimnion layer. The average seawater salinity has remained fairly stable and at typical levels for brackish water. Differences between the surface layer and the hypolimnion layer are small (Table 33). At point Olki 480, the salinity of the epilimnion is slightly lower when compared to other points, reflecting the effect of river waters.

Table 33. Average of water quality measurement results in the Olkiluoto sea area monitoring points (480–530) in the epilimnion and hypolimnion during the review period of 2013–2023. The results for chlorophyll A were measured as a composite sample from the trophogenic layer.

epilimnion	480	500	505	510	515	525	530
temperature (°C)	12.4	13.1	13.0	16.7	12.7	13.2	10.6
salinity (‰)	4.7	5.7	5.7	5.6	5.7	5.6	5.7
pH	7.9	8.0	8.0	8.0	8.0	8.0	8.0
oxygen (mg/l)	12.6	10.7	10.9	10.6	10.9	10.8	10.6
total nitrogen (µg/l)	486.2	265.8	270.5	290.2	273.3	288.5	257.6
ammonia nitrogen (µg/l)	22.1	5.1	6.1	7.5	5.7	6.8	6.4
nitrite-nitrate-nitrogen (µg/l)	172.0	16.3	20.4	32.6	27.1	36.8	20.3
total phosphorus (µg/l)	20.1	17.3	17.0	18.2	17.1	17.5	15.6
phosphate phosphorus (µg/l)	3.3	4.5	4.9	5.0	5.1	4.4	4.7
visibility depth (m)	2.0	2.8	3.3	3.0	3.4	3.3	3.9
chlorophyll A (µg/l)	3.7	4.1	3.9	4.2	3.4	3.6	3.7

hypolimnion	480	500	505	510	515	525	530
temperature (°C)	10.6	11.8	9.0	10.4	10.3	9.7	8.9
salinity (‰)	5.6	5.7	5.7	5.7	5.7	5.7	5.8
pH	8.0	8.0	7.9	7.9	8.0	7.9	7.9
oxygen (mg/l)	10.4	10.7	10.2	10.2	10.5	10.5	10.5
total nitrogen (µg/l)	282.2	263.0	266.1	288.3	258.3	248.9	243.6
ammonia nitrogen (µg/l)	5.6	5.8	18.1	34.4	9.5	7.2	7.9
nitrite-nitrate-nitrogen (µg/l)	30.3	16.6	19.1	20.7	20.9	21.1	19.5
total phosphorus (µg/l)	17.8	17.0	21.6	28.4	17.5	16.2	16.5
phosphate phosphorus (µg/l)	4.6	4.7	8.8	13.6	6.6	5.8	6.4

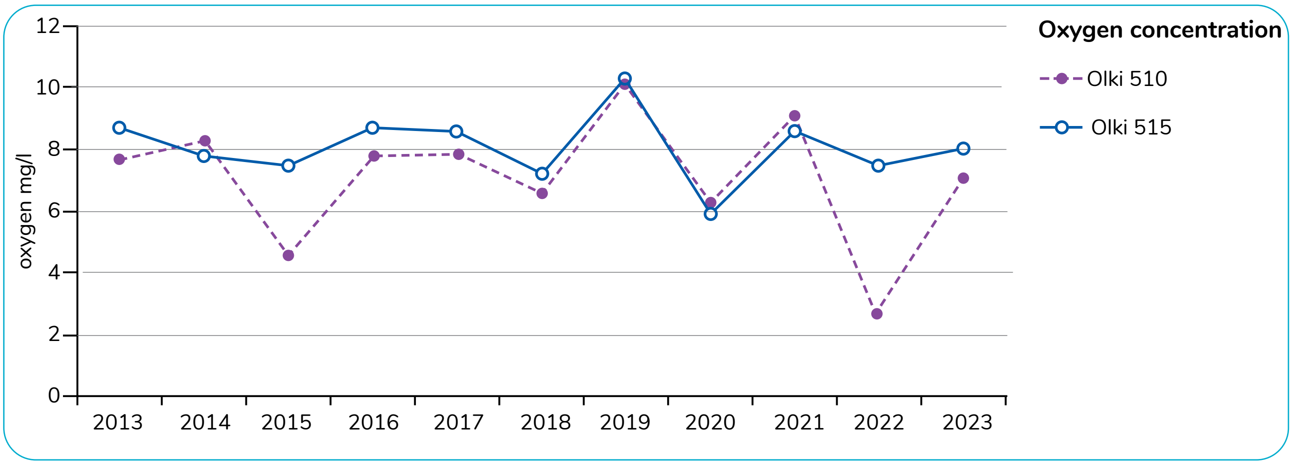


Figure 35. Oxygen concentration in the benthic water layer at the water quality monitoring points located closest to the cooling water discharge point in August 2013–2023.

At the power plant, process wastewater is mainly generated from the leak, drain, rinse and purge water coming from the radiation controlled areas of the power plant buildings and storages. The average volume of process water from the OL1 and OL2 plant unit has been approximately 25,000 m^3 per year. Following activity concentration control, process wastewater from the plant units is routed into the cooling water discharge channel. Wastewater generated in the power plant area includes, for example, water from the raw water treatment plant and demineralisation plant and rinse water from the travelling basket filters of the seawater pumphouses. Following appropriate processing, this water is routed into the sea via the discharge tunnel, along with the cooling water.

Rainwater and storm water is conveyed from the site area into the sea through the rainwater sewer network. The discharge of rainwater from the north part of the site area occurs in the cooling water discharge channel and, from the south part, in Olkiluodonvesi to the west of the cooling water inlet channel. Any possible oily rainwater is processed in oil separators before being routed into the sewer network. The subsurface drains of the power plant buildings' foundations are routed, via subsurface water wells, into the rain water sewers or the discharge channel. The surfaces in the site area have been levelled in a manner where, in case of exceptional flooding or heavy rainfall, rainwater will not flow inside the buildings or into their foundations; instead, they are allowed to flow directly into the sea without causing any damage or detriment.

The concentration of harmful substances in the water discharged into the sea through the cooling water channel was last investigated in November 2023. The water sample was taken as a one-time sample from the cooling water channel. The substances investigated included pesticides, hydrazine, polyaromatic hydrocarbons (PAH), PCB compounds, phenolic compounds, dioxins and furans, VOC compounds, brominated flame retardants (HBCDD, TBBPA), thiazoles (MBT, TCMBT), alkylphenols and their ethoxylates, phthalates, perfluoroalkyls (PFCs), chloroalkanes, organic tin compounds, ethylenethiourea and metallic compounds: arsenic, cadmium, chromium, lead, nickel, zinc and mercury. Only the arsenic content of 0.86 µg/l and the nickel content of 1.6 µg/l in the cooling water exceeded the detection limits of the environmental laboratory. For nickel, an environmental quality standard has been defined, i.e. a concentration that must not be exceeded in order to protect the environment and human health. The environmental quality standard for nickel as an annual average value is 9.6 µg/l in coastal waters, taking into account the background concentration *(Government Decree 1308/2015)*. The natural nickel concentration in coastal waters is approximately 1 µg/l, so the nickel content of the cooling water is at a natural level and clearly lower than the environmental quality standard. No environmental quality standard has been determined for the arsenic content of surface water, but the environmental quality standard for groundwater is 5 µg/l, so the arsenic content of the cooling water is very low. Overall, the concentrations of harmful substances in the power plant's cooling water are very low and correspond to natural background concentrations. The radioactivity of cooling and process wastewater is discussed in Chapter 6.16.

In 2006, freshwater hydroid growth was observed for the first time in the cooling water pipes of the OL1 and OL2 plant units. This involved the Caspian polyp *(Cordylophora caspia)*, which is an alien species. Polyp growth slows down the flow of water and, thus, has a weakening effect on the heat transfer ability of heat exchangers, causing a so-called fouling problem. Polyp control is done with sodium hypochlorite (NaClO), which contains 15% active chlorine. Sodium hypochlorite is fed to the seawater systems of the OL1 and OL2 plant units and to the seawater cooling systems of the generator during the hydroid growth season, from July to October. In 2023, a total of approximately 43,000 litres of sodium hypochlorite solution were fed into the systems in the OL1 and OL2 plant units. During polyp control, the chlorine content of the cooling water discharged into the sea is monitored. Water samples are taken from the seawater system in the wave pool, before the water is lowered into the cooling water channel. The average values of the total chlorine concentrations of the samples measured from the wave pool were below the detection limit of 0.07 mg/l at both plant units, which is a harmless chlorine concentration for aquatic organisms. Sodium hypochlorite has not been found to pass into the food chain or accumulate in organisms. In practice, hypochlorite is no longer detectable in the cooling water discharged into the sea. *(Teollisuuden Voima Oyj 2024b)*

6.8.2.7. Phytoplankton

The species of phytoplankton in the Olkiluoto sea area and their biomass vary in ways that are typical of the Baltic Sea and Bothnian Sea *(Hällfors & Lehtinen 2012)*. The last phytoplankton studies were performed in 2023 *(KVVY Tutkimus Oy 2024a)*. The amounts of algae and the structure of phytoplankton communities varied similarly at all the monitoring points. In 2023, the biomass for phytoplankton was at its highest in April, during the spring bloom, and consisted mostly of diatoms. The total biomass of phytoplankton dropped to its lowest at the end of May, as the diatoms decreased after the spring bloom. The phytoplankton communities were at their most diverse in June, when the most significant groups of algae were filamentous green algae, sea fire and golden algae. In July there was an increase in cyanobacteria, which caused another biomass peak. Filamentous cyanobacteria of the genus Aphanizomenon accounted more than half of the total biomass of the phytoplankton community. In addition, the cyanobacteria Nodularia spumigena and Dolichospermum lemmermannii were observed at all monitoring points. According to the national cyanobacteria monitoring, in 2023 a large cyanobacteric bloom occurred in the entire Bothnian Sea from the beginning of July to the beginning of August. In late August and September, the total biomass of the phytoplankton community in the Olkiluoto sea area still remained reasonably high due to the increase in diatoms. The prevalence of diatoms increased especially at monitoring points Olki 505, 510 and 515, which are located closest to the cooling water discharge channel. At sample point Olki 525, diatoms occurred less and the total biomass was more evenly distributed among different groups of algae.

The level of eutrophy in the marine area is assessed by measuring the concentration in phytoplankton of the so-called chlorophyll A, which indicates the amount of phytoplankton biomass. On average, the chlorophyll A concentrations of the southern Bothnian Sea in the inner coastal waters have varied from 3 to 6 µg/l between 2018 and 2023, and from 2 to 3 µg/l in the outer coastal waters *(Varsinais-Suomi Centre for Economic Development, Transport and the Environment 2023)*. On average, chlorophyll concentrations have varied between 2.5 and 6.6 µg/l during the past five years in the Olkiluoto sea area. Generally speaking, the biomass for phytoplankton in the Olkiluoto sea area has been at a slightly eutrophic level *(KVVY Tutkimus Oy 2019 & 2024, Laari & Hakanen 2020)*. The chlorophyll A concentration in the Olkiluoto sea area has increased over the past ten years (Figure 36). The increase in chlorophyll concentration has been clearest at monitoring point Olki 510, which is closest to the discharge point. At other monitoring points, the yearly variation in the chlorophyll concentration has been large. The commissioning of the OL3 plant unit in 2022 has increased the thermal load of the cooling water in the sea area, and together with the warm summers, this has probably contributed to the higher-than-average chlorophyll A concentrations in the summers of 2022 and 2023 (Figure 36).

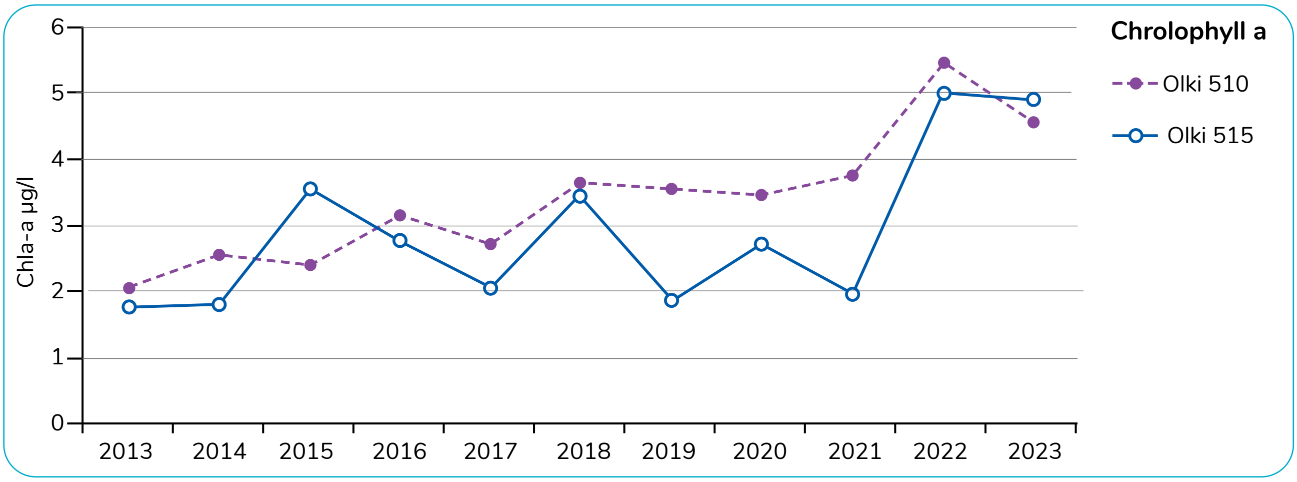


Figure 36. Chlorophyll a concentration at the water quality monitoring points Olki 510 and Olki 515, which are the closest to the cooling water discharge point, during 2013–2023.

The state of the coastal waters of the Bothnian Sea is especially affected by the load coming through rivers. The worst situation is in the coastal area adjoining Kokemäenjoki, which is burdened by the agriculture in the catchment area *(Korpinen et al. 2018)*. Chlorophyll concentration in the Olkiluoto sea area varies by season and is at its lowest in winter, where only little basic production occurs, and is often at its highest during spring bloom or in summer when cyanobacteria are most plentiful. On average, chlorophyll concentrations have varied between 2.5 and 6.6 µg/l during the past five years (Table 33). The level of eutrophy has been at its highest at point Olki 480, which is located off Eurajoensalmi and receives nutrient loads from Eurajoki and Lapinjoki that run into the strait. Chlorophyll concentrations have also been occasionally high near the cooling water discharge channel at point Olki 510.

During the years 2017–2022, the concentration of chlorophyll A in the open sea areas of the Bothnian Sea has remained at the same level as in the previous assessment period *(Varsinais-Suomi Centre for Economic Development, Transport and the Environment 2023)*. In addition to chlorophyll, the July/August averages of the total biomass of phytoplankton are used in the classification of the ecological state of the outer coastal waters. At the Olkiluoto sample points, the July–August 2023 averages were very high due to the large amount of cyanobacteria. The average values were now higher than earlier, but almost similar values have been observed in 2014 and 2022.

Visibility depth, which indicates the opacity of water, has varied between 2.4 and 4.0 m at the monitoring points (Table 36). Visibility depth has annually been at its lowest at point Olki 480 due to the clouding effect of river water. Visibility depth has typically increased from the inner archipelago towards the open sea, and it has been at its highest at the outermost monitoring point Olki 530. Visibility depths are typically greatest in June, when phytoplankton biomass is low. In the summer of 2023, the visibility depth was lower than average at all monitoring points, due to a strong algal bloom *(KVVY Tutkimus Oy 2024a)*.

The macrophytes, i.e. aquatic vegetation and macroalgae, of the Olkiluoto sea area have been discussed in Chapter 6.10.2.1.

6.8.2.8. Benthic fauna

The sea bed in the area most commonly consists of rock, moraine or muddy clay *(KVVY Tutkimus Oy 2019)*. The benthic fauna of the soft soil sea bed in the Olkiluoto area is examined every three years as part of the environmental monitoring of the power plant, and the latest benthic sampling was carried out in 2022 *(KVVY Tutkimus Oy 2023a)*.

The benthic fauna communities in the sea area near the power plant consist of species typical to the soft soil sea beds in the Baltic Sea. The most common species in terms of density and biomass per year have been *Macoma balthica*, *Marenzelleria spp.*, *Oligochaeta* and *Chironomidae (Ympäristöhallinto 2024a)*. Other common species at the observation stations include *Potamopyrgus antipodarum*, *Hydrobia sp.* and *Hediste diversicolor*. At the observation points Olki 505, Olki 515 and Olki 525, there also occur species more common to sand beds, such as *Mya arenaria*, *Corophium volutator* and *Manayunkia aestuarina*.

During the past 10 years, benthic fauna counts have been generally on the decline in the Olkiluoto sea area (Figure 37). This has most likely been caused by the eutrophication of the sea area. In 2022, the highest count was measured in the outer archipelago at station Olki 525 (2,669 specimens/m^2) and the lowest at station Olki 515 (778 specimens/m^2). The number of species was the highest at the monitoring points Olki 480 and Olki 525 (13 and 12 species, respectively), but it was the lowest at point Olki 515 (5 species). For benthic fauna, the Brackish Water Benthic Index (BBI index) is used to assess the ecological state of the water body. This describes the diversity of the benthic communities of the soft soil sea bed in coastal areas *(Perus et al. 2009, Aroviita et al. 2019)*. At the monitoring points of Olkiluoto, the BBI index has been good for the most part. No major differences can be observed between the monitoring points on the basis of benthic fauna *(KVVY Tutkimus Oy 2019)*.

The benthic fauna of the sea area near the Olkiluoto power plant contains several alien species, i.e. species that have spread outside their natural range due to human activity. Cordylophora caspia and Mytilopsis leucophaeata have been found in the cooling water channels of the nuclear power plant *(Holopainen et al. 2016, Teollisuuden Voima Oyj 2021)*. These species may cause substantial harm by clogging the power plant's heat exchangers, which is why special attention is paid to their condition and any possible growth is removed. *Cordylophora caspia* is prevented at the OL1 and OL2 plant units by feeding sodium hypochlorite into the seawater systems in July–October. In 2022, Mytilopsis leucophaeata was also encountered at the furthest monitoring points, in the outer archipelago at point Olki 525 and Eurajoensalmi at point Olki 480. *Mytilopsis leucophaeata*, also known as the dark false mussel, originates from the Gulf of Mexico and it occurs in Finland under conditions that are warmer than usual, such as in the areas affected by the condensate water of power plants *(Laine et al. 2006)*. However, the rise in seawater temperature as a result of climate change may contribute to an increase in the prevalence of the species and cause it to spread even wider than at present.

Furthermore, *Laonome xeprovala* was observed in the Olkiluoto sea area for the first time in 2022 at the monitoring point Olki 480. So far, *Laonome xeprovala* has no observed impacts on the native species or human activity *(Vieraslajiportaali 2023)*. The bryozoan Conopeum chesapeakensis, originally from the Chesapeake Bay in North America, was found in 2023 as the newest alien species among the screenings , i.e. the solid material recovered from the cooling water of the nuclear power plant *(Teollisuuden Voima Oyj 2024a)*.

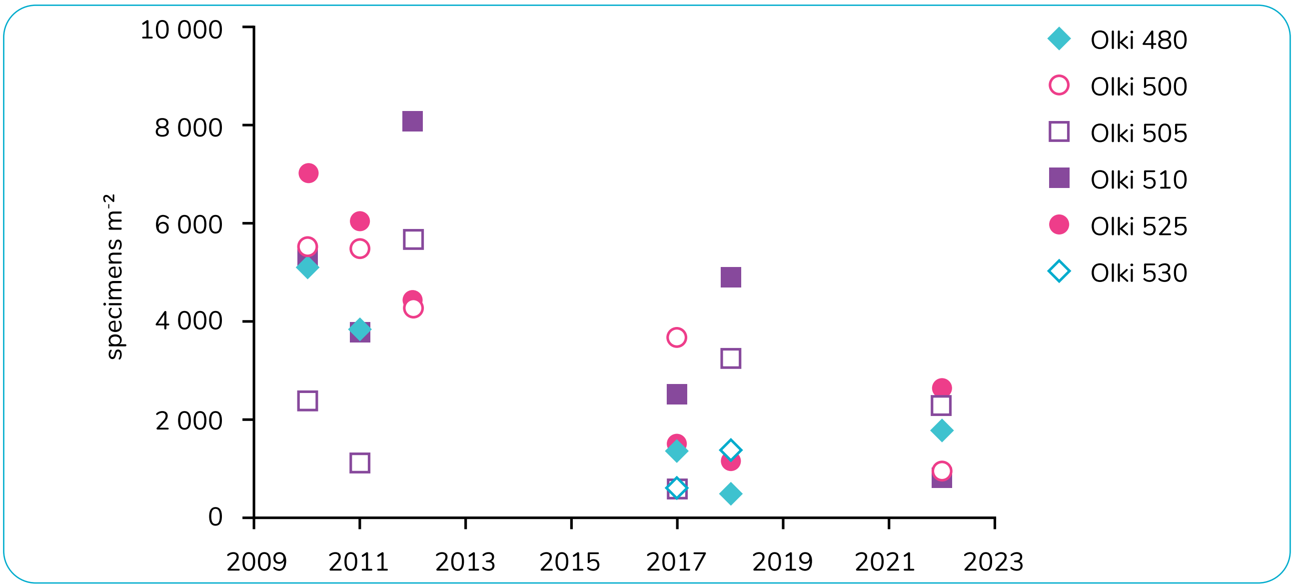


Figure 37. The densities of benthic fauna have declined in the sea area near the power plant during the past 10 years.

6.8.2.9. Eurajoki and Lapinjoki

The raw freshwater required in the power plant area is extracted from the lower reaches of Eurajoki some 9 km away, upstream of Tiironkoski rapids, and from Lapinjoki, some 15 km away. In 2023, some 272,700 m^3 of raw water were taken from Eurajoki and some 6,900 m^3 from Lapinjoki. Raw water is pumped from the river through a pipe to the Korvensuo basin in Olkiluoto, where the water is treated in a sand filter and led to a storage basin built in the soil. Of this water, approximately one half is used as household water and half as process water, fire-fighting water and for other uses.

Eurajoki is a river 53 km long that flows into the Eurajoensalmi strait on the eastern side of the island of Olkiluoto. In terms of surface water type, the lower part of Eurajoki is a large loam river (Ssa). The catchment area of the lower part of Eurajoki is 1,336 km^2, of which more than 50% is forests, some 30% fields and 10% marshes. Agriculture and forestry, wastewater and peat production all cause loading in Eurajoki. Eurajoki serves as a source of raw water for the production of drinking water and for industrial use. Eurajoki is a constructed river with three power plant dams and a regulation dam. A fishway has been built in two of the dams *(Kipinä-Salokannel & Mäkinen 2022)*.

Lapinjoki flows into the strait between Olkiluoto and Orjasaari southeast of the power plant area. Lapinjoki is 39 km long and its catchment area is 462 km^2. In terms of surface water type, Lapinjoki is a medium-sized heathland river (Kk). Farming causes a significant nutrient load into the Lapinjoki water body. There are also acidic sulphate and peat soils in the catchment area, due to which the river water can be acidic at times *(Kipinä-Salokannel & Mäkinen 2022)*.

Eurajoki and Lapinjoki carry turbid and nutrientrich river waters which have a significant impact on the water quality and nutrient load of the sea area near Olkiluoto.

6.8.2.10. Water resources management, marine strategy and other strategies and policies in the sea area

Water resources management in Finland

The target for water resources management in Finland is to secure and achieve, at a minimum, a good ecological and chemical status of surface water and groundwater by 2027. However, for all water bodies, a good state is not achieved by the deadline, and the fourth planning period for water resources management begins in 2028.

The regional plans for water resources management describe the information concerning the current state of water bodies, the factors affecting it and the actions required in order to improve the state of the waters. The Olkiluoto sea area belongs to the Kokemäenjoki–Saaristomeri–Selkämeri river basin district. In particular, the state of the surface waters in the river basin district is degraded by eutrophication caused by scattered loads. The water resources management plan for the Kokemäenjoki–Saaristomeri–Selkämeri river basin district for 2022–2027 does not mention the Olkiluoto nuclear power plant as a pressure component that impacts the state of the surface waters. In terms of the environmental targets for surface waters, the most important actions in the river basin district are those aiming at reducing the nutrient load from field cultivation, in particular *(Westberg et al. 2022)*.

The 2022–2027 programme of measures for water resources management in Southwest Finland and Satakunta states that the load targeting coastal waters directly mainly originates from scattered loads. The Olkiluoto power plant is not mentioned as an industrial load source in the programme of measures *(Kipinä-Salokannel & Mäkinen 2022)*.

The sea area near Olkiluoto is divided into four water bodies: to the west and north, the Rauma and Eurajoki archipelago (3_Ses_038, surface area 8,220 ha), further to the west and south-west, Luvia–Rauma open sea (3_Seu_110, 48,380 ha), to the south Olkiluodonvesi–Haapasaarenvesi (3_Ses_040, 1,844 ha) and to the east, Eurajoensalmi strait (3_Ses_039, 803 ha). The Luvia–Rauma open sea water body is of the type “Outer coastal waters of the Bothnian Sea”, while the other three bodies are of the type “Inner coastal waters of the Bothnian Sea”.

All surface waters in Finland are classified according to their ecological and chemical status. The assessment provides information on the water bodies whose state requires improvement. The classification of the ecological status assesses biological quality factors, such as phytoplankton, aquatic vegetation, macroalgae and benthic fauna. The classification of the ecological status also assesses general variables that describe the physicochemical conditions, such as the nutrient concentration and visibility depth, as well as hydrological and morphological factors such as the changes caused by hydraulic engineering or changes to flows in the water stratification conditions. The classification of the ecological status is based on an assessment of by how much the state of the quality factors has been degraded by human activity. The potential status of a water body is classified as high, good, moderate, poor or bad. The classification of chemical status compares the concentrations of hazardous and harmful substances in the water and fauna to the environmental quality standards. Chemical status has only two classes: good and failing to achieve good *(Aroviita et al. 2019)*.

The ecological status of the outer coastal waters of the Bothnian Sea is mainly good. However, there are also areas with a moderate and poor status in the inner coastal waters, especially in the river estuaries where nutrient load carried by the rivers degrades the status classification (*Westberg et al. 2022, Ympäristöhallinto 2024a*).

During the 3rd planning period of water resources management, the water bodies of Rauma and Eurajoki archipelago and Luvia–Rauma open sea were assessed as good in terms of ecological status (Figure 38, Table 34). During the 2nd planning period, the ecological status of the Olkiluodonvesi–Haapasaarenvesi water body went from moderate to good, but fell back to moderate during the third period. Out of the biological quality factors, the degrading features where phytoplankton (described by the chlorophyll A variable in the classification), and total nitrogen and visibility depth that describe the physicochemical quality factor (Table 34). The ecological status of Eurajoensalmi has been moderate during all review periods. Out of the biological quality factors, phytoplankton (chlorophyll A) has been classified as poor, whereas out of the variables describing the physicochemical status, total nitrogen and phosphorus were classified as poor and visibility depth as bad (Table 34). Above all, the status of the Eurajoensalmi water body is degraded by the nutrient load carried by river water.

The water body of the Rauma and Eurajoki archipelago has been assessed as moderate in terms of its hydrological-morphological characteristics, and changes caused by human activity can be observed in the sea area (Table 34). The status of other water bodies has been assessed as good or excellent in terms of hydrology and continuity.

During the 1st and 2nd planning period for water resources management, the chemical status of all water bodies was assessed as good. During the third planning period, however, the chemical status of Finland's surface waters has been assessed as failing to achieve good due to the stricter environmental standard for polybrominated diphenylethers. For other substances, the chemical status is good in all water bodies *(Ympäristöhallinto 2024a)*

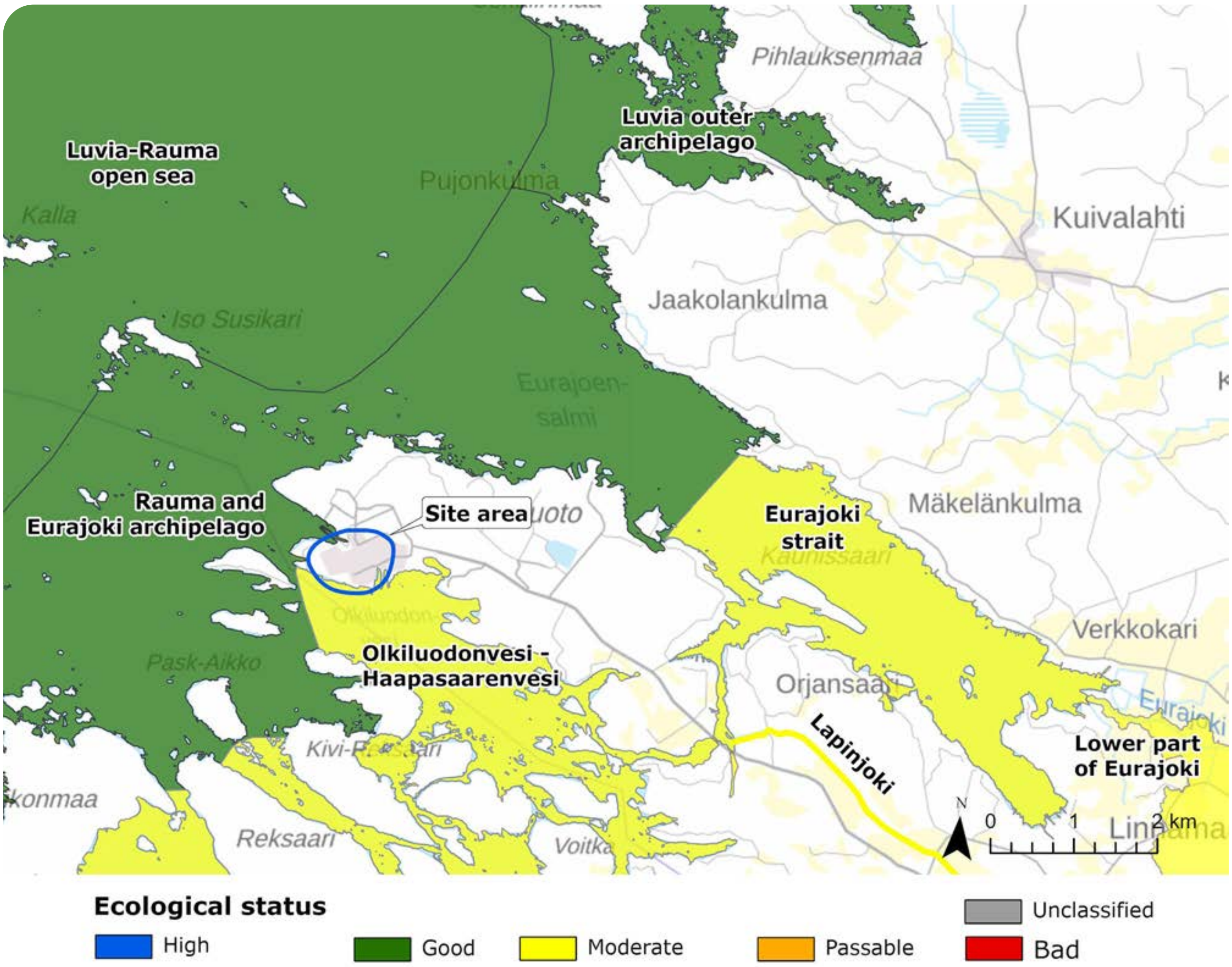


Figure 38. Water bodies in the Olkiluoto sea area and their ecological status during the 3rd planning period for water resources management.

Table 34. Water bodies in the Olkiluoto sea area and their ecological status during the 3rd planning period for water resources management. The table presents the number values and the scaled EQR (Ecological Quality Ratio) in brackets. The limit value of the good-moderate category shown in parentheses (Ses: Inner coastal waters of the Bothnian Sea, Seu: Outer coastal waters of the Bothnian Sea).

Water body	Rauma and Eura-joki archipelago	Luvia–Rauma open sea	Olkiluodonvesi–Haapasaarenvesi	Eurajoki strait
ID	3_Ses_038	3_Seu_110	3_Ses_040	3_Ses_039
Surface water type	Inner coastal waters of the Bothnian Sea	Outer coastal waters of the Bothnian Sea	Inner coastal waters of the Bothnian Sea	Inner coastal waters of the Bothnian Sea
River basin district	Kokemäenjoki – Archipelago Sea – Bothnian Sea river basin district			
Chemical status	**failing to achieve good**	**failing to achieve good**	**failing to achieve good**	**failing to achieve good**
Ecological status	**good**	**good**	**moderate**	**moderate**
Biological	**good (0.64)**	**good (0.62)**	**moderate (0.62)**	**moderate (0.38)**
Phytoplankton	good (0.60)	moderate (0.56)	moderate (0.55)	passable (0.38)
chlorophyll A (H/T Ses 2.7; Seu 2.1 µg l-1)	good 2.7 µg/l	moderate 2.5 µg/l	moderate 3.4 µg/l	passable 6.2 µg/l
Total biomass	-	good 0,32 mg/l	-	-
Other aquatic plants – macroalgae	moderate 2.6 m	-		
Benthic fauna	good 0.78	good 0.68	good 0.69	-
BBI-indeksi	good 0.9 ELS	good 0.7 ELS	good 0.7 ELS	-
Physicochemical	**good**	**good**	**moderate**	**passable**
Total phosphorus (H/T Ses 20; Seu 14 µg/l)	good 19.4 µg/l	moderate 14.2 µg/l	good 19.5 µg/l	passable 27.2 µg/l
Total nitrogen (H/T Ses 315; Seu 275 µg l-1)	moderate 318.3 µg/l	good 265.2 µg/l	moderate 325.5 µg/l	passable 436.3 µg/l
Visibility depth (H/T Ses 3.3; Seu 4.1 m)	moderate 3.2 m	good 4.2 m	moderate 2.6 m	poor 1.4 m
Hydro-morphological	**moderate**	**high**	**good**	**good**
Morphology	moderate	good	good	good
Continuity	high	high	high	high

In the third review period of water resources management, the water bodies of lower Eurajoki and Lapinjoki, which are subject to raw water intake, have been classified as moderate in terms of their ecological status. In both water bodies, the biological quality factors are in a good state, but the water bodies show the impact of human activity, which is manifested as a high nutrient load and hydromorphological changes (Table 35).

Table 35. Ecological and chemical status of lower Eurajoki and of Lapinjoki in the 3rd planning period of water resources management. The limit value of the good-moderate category and the numerical values of the ecological status quality factors are shown in parentheses. (Ssa: Large loam rivers, Kk: medium-sized heathland rivers).

Water body	Lower part of Eurajoki	Lapinjoki
ID	34.011_y01	33.001_y01
Surface water type	Large loam rivers	Medium-sized heathland rivers
River basin district	Kokemäenjoki – Archipelago Sea – Bothnian Sea river basin district	
Chemical status	**failing to achieve good**	**failing to achieve good**
Ecological status	**moderate**	**moderate**
Biological	**good**	**good**
Other aquatic vegetation – periphyton	good	good
Type-characteristic taxa (H/T Ssa 14.3; Kk 9.8)	moderate (13 lkm)	good (10 lkm)
Percentage of likeness to the model	high	high
Benthic fauna	good	good
Type-characteristic taxa	good (18.75 lkm)	high (19.30 lkm)
Type-characteristic EPT families (H/T Ssa 9.0; Kk 6.7)	high (12.82 lkm)	high (9.49 lkm)
Percentage of likeness to the model	good	moderate
Physicochemical	**good**	**moderate**
Total phosphorus (µg/l) (H/T SSa 60.0; Kk 35.0 µg/l)	good (53.57 µg/l)	moderate (47.1 µg/l)
Total nitrogen (H/T Ssa -; kk 800 µg l)	1,936.3 µg/l	passable (1,781.33 µg/l)
pH minimum (H/T Ssa -; Kk 5.6)	6.1 m	high (5.9 lkm)
Hydro-morphological	**moderate**	**moderate**
Continuity	high	passable
Hydrology	good	high
Morphology	passable	moderate

Marine strategy plan

National marine strategy plans are drawn up in all EU Member States with shorelines. The aim for Finland's marine strategy is to achieve a good status of the sea. The marine strategy plan concerns all of Finland's sea areas, from the shoreline to the outer border of the exclusive economic zone. The plan consists of three parts:

I. An assessment of the current status of the sea, the definitions of a good status and the general environmental goals and indicators (2018)
II. The monitoring programme for the Finnish Marine Strategy (2020)
III. Programme of measures of the Finnish Marine Strategy 2022–2027 (2021)

When determining the status of the sea environment, the 11 qualitative descriptors of a good status listed in the Marine Strategy are taken into account:

1. Maintaining biodiversity. The type and occurrence of habitat types and the distribution and abundance of species correspond to the prevailing physiographic and geographical conditions and climate conditions.
2. The amount of invasive species spreading as a result of human activity is at a level that does not adversely change ecosystems.
3. The populations of all commercially utilised fish, shellfish and molluscs are within safe biological limits, so that the age and size distribution of the population indicates that the stocks are in good condition.
4. All factors in the sea's food web, insofar as they are known, appear in ordinary numbers and at ordinary levels of diversity, at a level that ensures the long-term abundance of the species and the full preservation of their reproductive capacity.
5. Eutrophication due to human activities and especially its detrimental effects, such as the loss of biodiversity, the degradation of ecosystems, harmful algae blooming and oxygen deficiency in the seabed, have been minimised.
6. The integrity of the seabed is at a level where the structure and activities of ecosystems are secured and, in particular, no harmful impacts target the benthic ecosystems.
7. Permanent changes in hydrographic conditions do not have an adverse impact on marine ecosystems.
8. The concentrations of impurities are at levels that do not lead to contamination effects.
9. Levels of impurities in fish and other sea fauna used as human nutrition do not exceed the levels set in legislation or other standards concerning the matter.
10. The characteristics or volume of litter does not cause detrimental impacts on the coastal and marine environment.
11. Conducting energy, including underwater noise, into the sea is not at a level where it would have a detrimental impact on the marine environment.

Baltic Sea Action Plan HELCOM

Finland has signed the general convention concerning the conservation of the marine environment in the Baltic Sea region, also known as the Helsinki Convention, which obligates the signatories to reduce load from all pollution sources, protect the marine environment and maintain its biodiversity *(Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area)*. All coastal nations on the Baltic Sea are committed to the convention. The Helsinki Commission (HELCOM) monitors the implementation of the convention and also provides recommendations related to it. The Baltic Sea Action Plan *(HELCOM 2021b)* drawn up by the commission sets preliminary maximum limits for nutrient releases for the countries on the Baltic Sea coast. The aim for the action plan is to achieve a good status of the Baltic Sea. The action plan lists eutrophication and invasive species as the key pressures affecting the status of the Baltic Sea and has recommended management targets in order to minimise nutrient loads originating from human activity and preventing the spread of invasive species.

Maritime spatial plan

The EU's Maritime Spatial Planning Directive requires member states to draw up national maritime spatial plans aimed at promoting the sustainable growth of maritime economies, the sustainable use of marine resources and the protection of ecosystems in situations where the utilisation of marine areas and human pressure increase. A maritime spatial plan aims to fit together the interests targeting the marine areas and prevent conflicts between them. The coordination of different functions also aims for synergy benefits between the forms of marine utilisation. In Finland, maritime spatial planning is regulated by the Land Use and Building Act.

In the maritime spatial plan, a target status by 2030 has been created for each marine area. This target status describes the development to be achieved in the next ten years according to the maritime spatial plan, against which the impact assessment can also be compared.

The development picture of the Archipelago Sea and the southern part of the Bothnian Sea for 2030 is presented below:

- By 2030, the central location of the southern Bothnian Sea has enabled the area to develop into a major player in the Baltic Sea, and the planning area has strengthened its position in the Baltic Sea market area. According to the plan, marine activities will be developed in the area, promoting the good condition of the marine environment and the diversity of underwater nature.
- The area is home to a concentration of internationally competitive high-tech marine industry, which is connected to an extensive subcontracting network. The marine and technology industry has invested in technological solutions that improve the state of the marine environment, in product development and in next-generation products and services.
- Fishing is a vital means of likelihood in the sea area, and aquaculture has grown in importance alongside it. The food industry is of great importance in the region, and its growth and product development opportunities have been utilised productively.
- Comprehensive solutions for renewable forms of energy have been at the centre of regional development. The production and use of renewable energy and the related entrepreneurship have been promoted, and the region's extensive energy know-how has enabled the growth of the industry. The construction of offshore wind farms has combined the know-how of the energy, offshore and technology industries in a new way that is no longer tied to traditional industry boundaries.
- The area is home to an internationally unique combination of nature and landscape aspects. The nature and cultural heritage of the area's islands and coastal areas is vibrant and well-preserved, and constitutes intangible capital and an attraction factor for tourism. Tourism is coordinated and developed at the provincial level.
- The vibrant archipelago has high-quality services for residents and is very accessible.

The maritime spatial plan also identifies the positive and negative effects of the development picture on the diversity of marine nature.

Positive impacts:

- Identifying areas important for biodiversity has a positive effect on the marine environment, as identifying the locations of valuable underwater habitat types increases information about underwater nature values. The EMMA areas highlighted in maritime spatial planning and significant ecological connections help to take into account values that are important for the functioning of ecosystems in the planning of marine activities. Tourism also creates pressure for the protection and preservation of the cultural heritage sites of the Baltic Sea and the marine environment, as well as the Archipelago Sea and the southern Bothnic Sea. Recognising the significant potential of tourism and the cultural heritage sites indirectly supports the protection goals of the marine environment and the achievement of a good state.
- The plan shows the existing functional Turku–Stockholm connection, which is part of the Scandinavia–Mediterranean TEN-T core network corridor. The goal of the development of the TEN-T network is more environmentally friendly transport (e.g. the promotion of cleaner forms of transport, fast broadband connections, use of renewable energy), which will have a positive effect in the long term through the reduction of environmental emissions.
- The identification of areas suitable for dumping dredged masses may contribute to the state of the marine environment, if dumping areas that are currently in worse locations from a natural point of view are placed in the future in the more sustainable areas indicated in the survey.

- The designated areas with potential for aquaculture are further out in the sea from the current fish farming areas located in the inner archipelago, and the environmental impacts are locally milder there. If fish farming is increased or moved to outer areas, the effect can be locally positive in the inner archipelago. Increasing the production volumes of fish farming has been set as a national goal. Increasing production volumes will increase the nutrient load locally, so location control aims to minimise the harm caused by the increase. The starting point for the development of aquaculture is the opportunity brought by new technologies for locating fish farming in such a way that the load on the sea and the marine environment is as minimal as possible.

Negative impacts:

- The planning map shows areas suitable for offshore wind power south of the Archipelago Sea and in the southern part of the Bothnian Sea. Locally offshore wind power has a negative impact on water bodies, especially during their construction. The need to modify the seabed required for the construction of offshore wind power and the resulting impacts depend on the quality of the seabed in the available area (e.g. a possible need for dumping, blasting). The modification of areas located closer to the coast has greater environmental impacts when the sedimentary material of the seabed starts to move due to the already fundamentally weaker state of the marine environment at the coast. More permanent negative environmental impacts include potential visual impacts and noise. The effects of maintenance activities during the operation of offshore wind power depend on their scope (e.g. leaks of harmful substances).
- In the long term, an increase in maritime traffic volumes has been predicted. In addition, the development of archipelago tourism may increase traffic volumes in the archipelago. Increasing traffic causes a harmful erosion effect in the archipelago near the coast. In addition, noise and emissions to the air and water increase.
- The growing tourism industry may have negative effects on the marine environment due to possible increases in consumption, disturbances, waste and noise levels. The negative effects can be reduced by directing tourist flows and creating tourism packages. With regard to water, the impact is contradictory, as clean water can be seen as a key condition for tourism and for recreational activities.

In the maritime spatial plan, the Olkiluoto power plant area and nuclear fuel final disposal areas and their precautionary action zone are marked as a special area (Figure 39). The special area refers to special and unusual activities connected to the sea. According to the maritime spatial plan, when developing the environment of special areas, it is important to take into account the restrictions set by special activities on other activities and to find out the possibilities for multiuse of the areas. The maritime spatial plan states that seawater can continue to be used as cooling water for nuclear power plants, but the utilisation of thermal energy in the water should be examined in order to reduce the routing of unprocessed cooling water into the sea (*Merialuesuunnitelma* 2024).

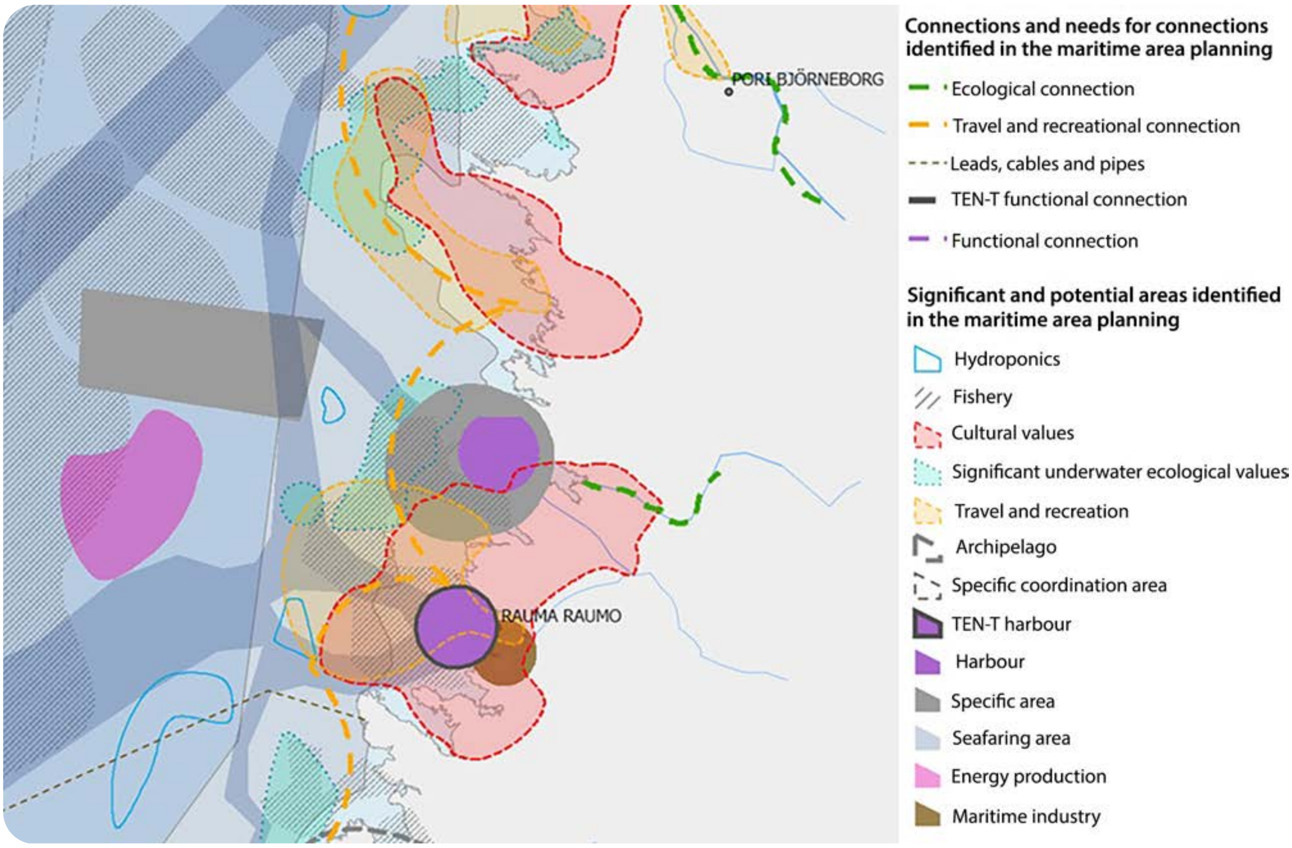


Figure 39. Extract from the maritime spatial plan for 2030, where the Olkiluoto sea area is marked as a special area.

6.8.2.11. Sensitivity of the affected aspect

Common factors affecting the sensitivity of surface waters are factors related to the value of the area, such as conservation values and the presence of protected or sensitive species in the affected area. In addition, the environmental factors of the affected area, such as the size of the catchment area; the volume of the water area; and the flow and mixing conditions affect how susceptible the affected aspect is to changes and how the area will recover from possible changes. A risk that weakens the ecological or chemical status of the water body and a risk that prevents the achievement of a good status are also considered to be criteria that increase sensitivity.

The operation of the OL1 plant unit began in 1978, so there are long time series from the impact monitoring of the power plant, based on which the effects of the Olkiluoto power plant on the nearby sea area can be comprehensively evaluated. Factors that reduce sensitivity in the Olkiluoto sea area are the good turnover of water and the favourable mixing conditions. There are no special or sensitive sites in the immediate vicinity of the affected area that would be affected by the water quality or by changes to it. The benthic fauna includes the usual species of soft soil sea beds.

Factors that increase the sensitivity of the sea area include the strong nutrient load brought by river waters; the observed eutrophication; and occasional low-oxygen conditions in the water layer near the bottom. In winter, the ice cover may weaken the mixing conditions in the cooling water discharge area. Not all of the water bodies in the affected area have reached a good ecological status yet, which is also seen as a factor that increases sensitivity. Therefore, the sea area near Olkiluoto is assessed as moderate in sensitivity.

6.8.3. Environmental impacts

6.8.3.1. Continuing operation

Impacts during construction

If the service life of the plants is extended, it is possible that the existing KPA storage will be expanded. The construction of the storage takes place inside the existing site area, and the work on its construction will not affect the surface water. The following describes the impacts which the service life extension of the OL1 and OL2 plant units would have during their operation.

Impacts on temperature and stratification conditions

The Olkiluoto power plant's most significant impacts on the surface water occur during its operation and are caused by the power plant's warm cooling water being conveyed into the sea. Cooling water is piped from the OL1 and OL2 plant units at a rate of 38 m^3/s per plant unit. The cooling water discharged from the nuclear power plant into the sea is clearly warmer than the surrounding seawater (Figure 40). The effects of the thermal load of the cooling water are mainly visible in the eplimnion, but in the vicinity of the discharge flow of the cooling water, also in the benthic water layer. Warm water cools down and quickly mixes with the cooler seawater, so the effects of the thermal load are local and concentrated in the sea area near Olkiluoto. In the current state, the effects of the thermal load of the cooling waters of all plant units are mainly directed to the Iso Kaalonperä bay west of Olkiluoto, which is located in the water body of the Rauma and Eurajoki archipelago. At its most extensive, the effects of the thermal load can sometimes also extend to the Luvia–Rauma open sea water body (Figure 40).

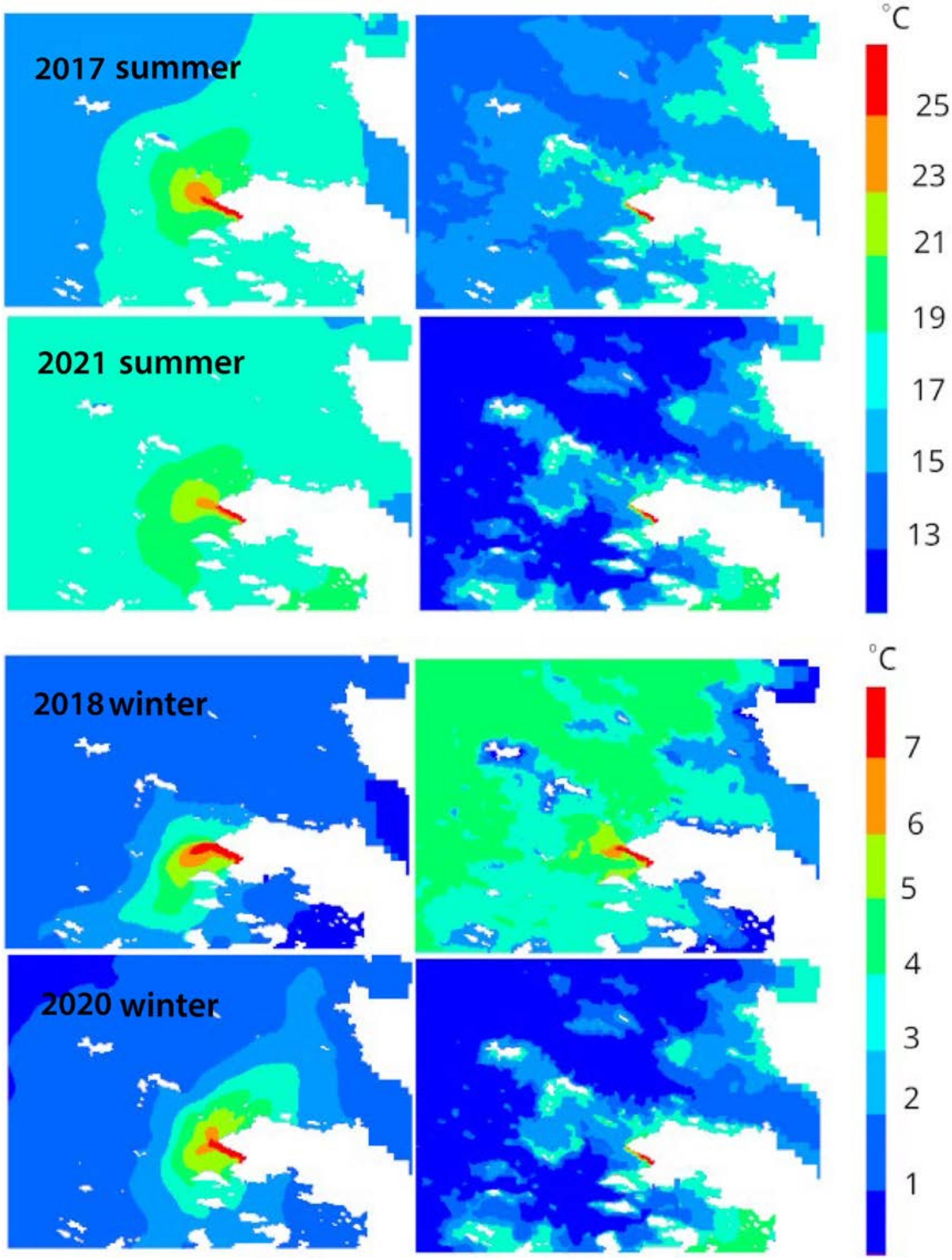


Figure 40. Average temperatures during the modelled reference periods. In the figure, the surface layer is on the left and the benthic water layer is on the right.

According to the hydrological modelling results, in July, when the temperature of the epilimnion is at its highest, temperatures above 30 °C can occur in the vicinity of the cooling water discharge flow in hot summers. According to the modelling, in the summer of 2021, the sea area where the temperature exceeded 30 °C was approximately 2.7 km^2 at its widest. In the cool summer of 2017, the 30 °C temperature limit was not exceeded in the sea area. Especially in summer, the thermal load of the cooling waters increases the stratification of the water, which, in turn, weakens the mixing of the water mass. At water quality monitoring point Olki 510, which is closest to the discharge flow, occasional low oxygen has been observed near the bottom during hot summers.

If the OL1 and OL2 plant units continue in operation, the effects of the thermal load of the power plant's cooling water will remain the same as currently, as the temperature and flow of the cooling water led from the power plant to the sea will not change. However, the continued operation will be long-term, so climate change will intensify the seawater warming. The hydrological modelling took into account climate change scenario SSP5-8.5 and the continuation of the operation of the OL1, OL2 and OL3 plant units similarly to the current operation.

As a result of climate change, surface temperatures in the Olkiluoto sea area may rise, on average, by approximately 0.5 °C by 2038, 1 °C by 2048 and approximately 1–1.5 °C by 2058 (Figure 41). In the open sea season, the rise in surface temperature is, on average, higher in cool months and lower in hot summers. With climate change, the surface temperature of more than 30 °C will be exceeded in the vicinity of the discharge flow of

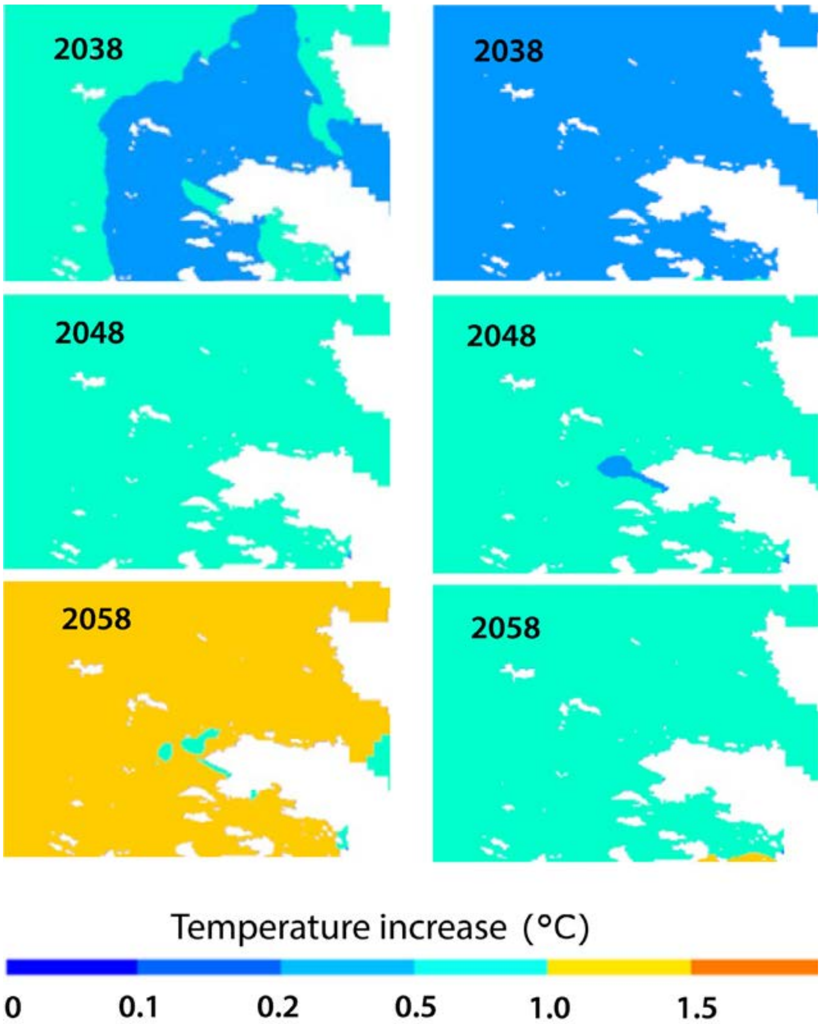


Figure 41. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units and climate change on temperatures in the sea water surface layer during a cool summer (left) and warm summer (right).

cooling waters even in cool summers. In hot summers, the sea area where the surface temperature limit of more than 30 °C is exceeded may be 5.2 km^2 at its largest by 2058. During warmer than average summers, surface temperatures of 32 °C may occur at the discharge flow as early as 2038.

Due to the stratification of seawater, the effects of climate change are most clearly visible in the surface layer. During the open water season, the warming of the epilimnion can increase the stratification of the water column. In the benthic water layer, the temperature rise is less than near the surface, but in cool summers in low-lying areas, the temperature of the hypolimnion can also rise by a maximum of 1.5 °C by 2058 (Figure 42). The warming of the benthic water layer also depends on the depth of the location, as the warming is stronger in shallow areas (Figure 42).

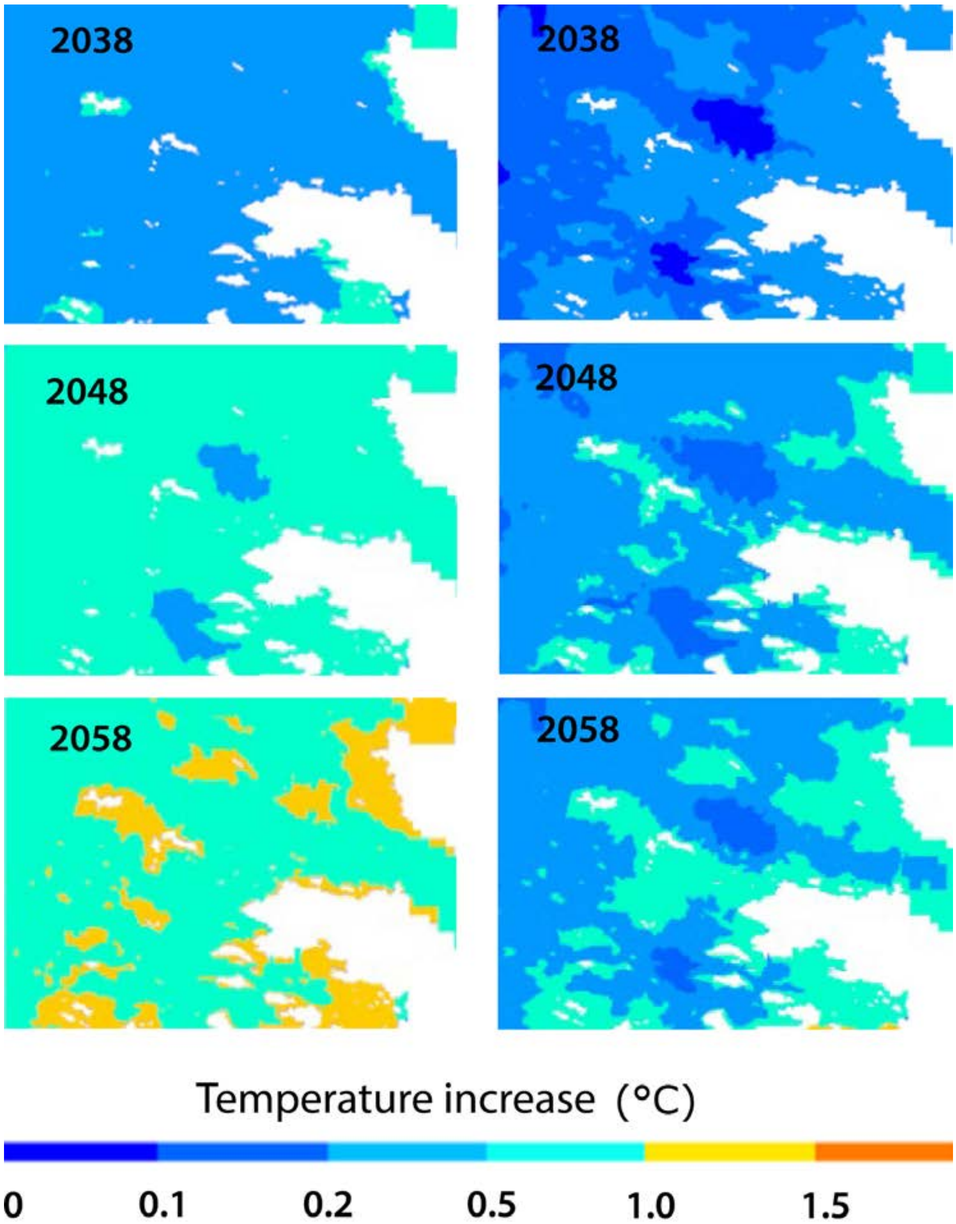


Figure 42. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units and climate change on temperatures in the benthic water layer during a cool summer (left) and warm summer (right).

During the ice cover period, the effects of climate change on seawater temperature are minor, as climate change mainly affects the formation of the ice cover. Thus the seawater temperature increase is greater in mild winters than in cold ones (Figure 43, Figure 44). In mild winters during the open water season, the temperature of the surface layer of seawater can rise by more than 1.5 °C and that of the benthic layer by 1–1.5 °C when compared to the current state. In cold winters during the open water season, the temperature rise in the surface water layer is 1 °C at most. No significant increase in temperature can be observed in the benthic water layer.

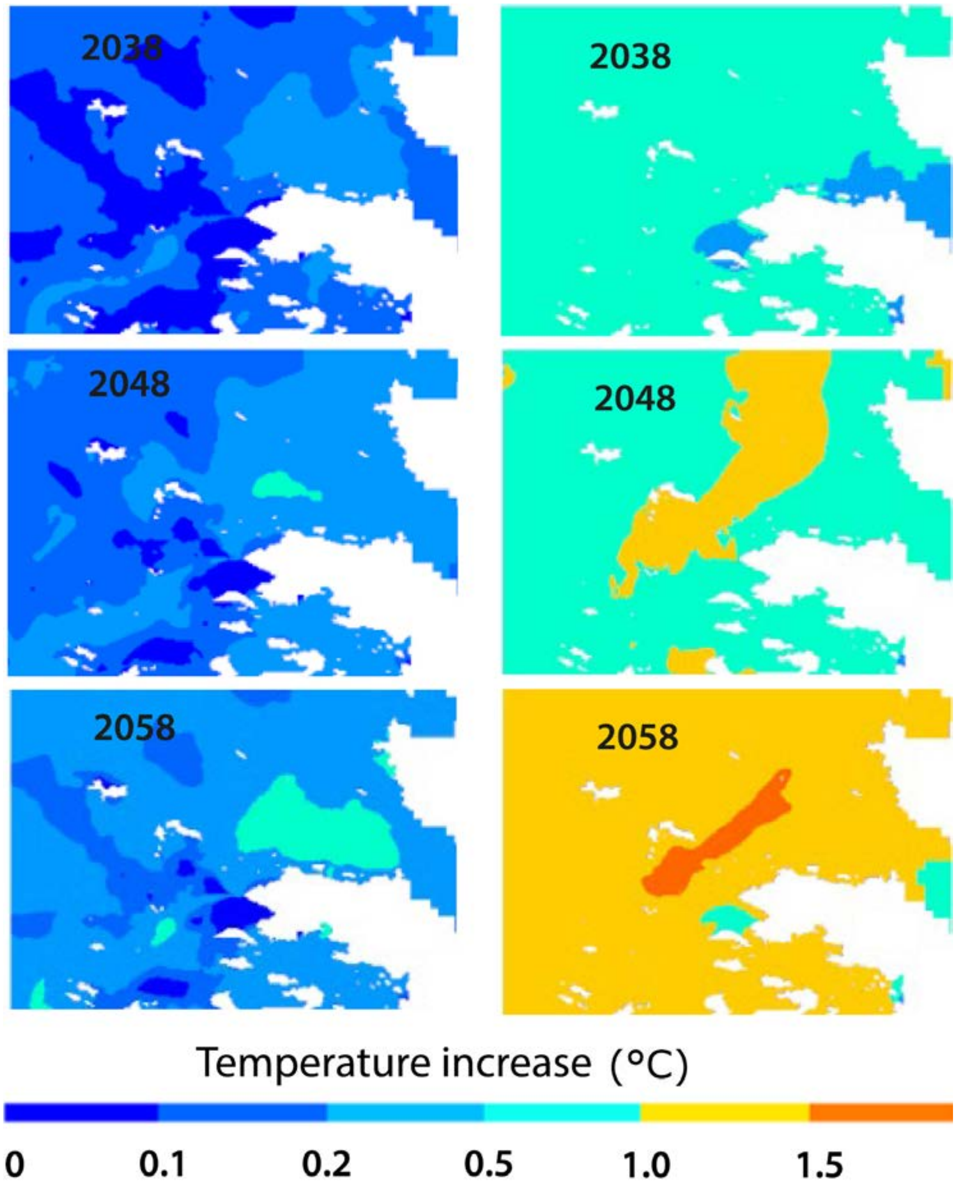


Figure 43. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units and climate change on temperatures in the sea water surface layer during a cold winter (left) and mild winter (right).

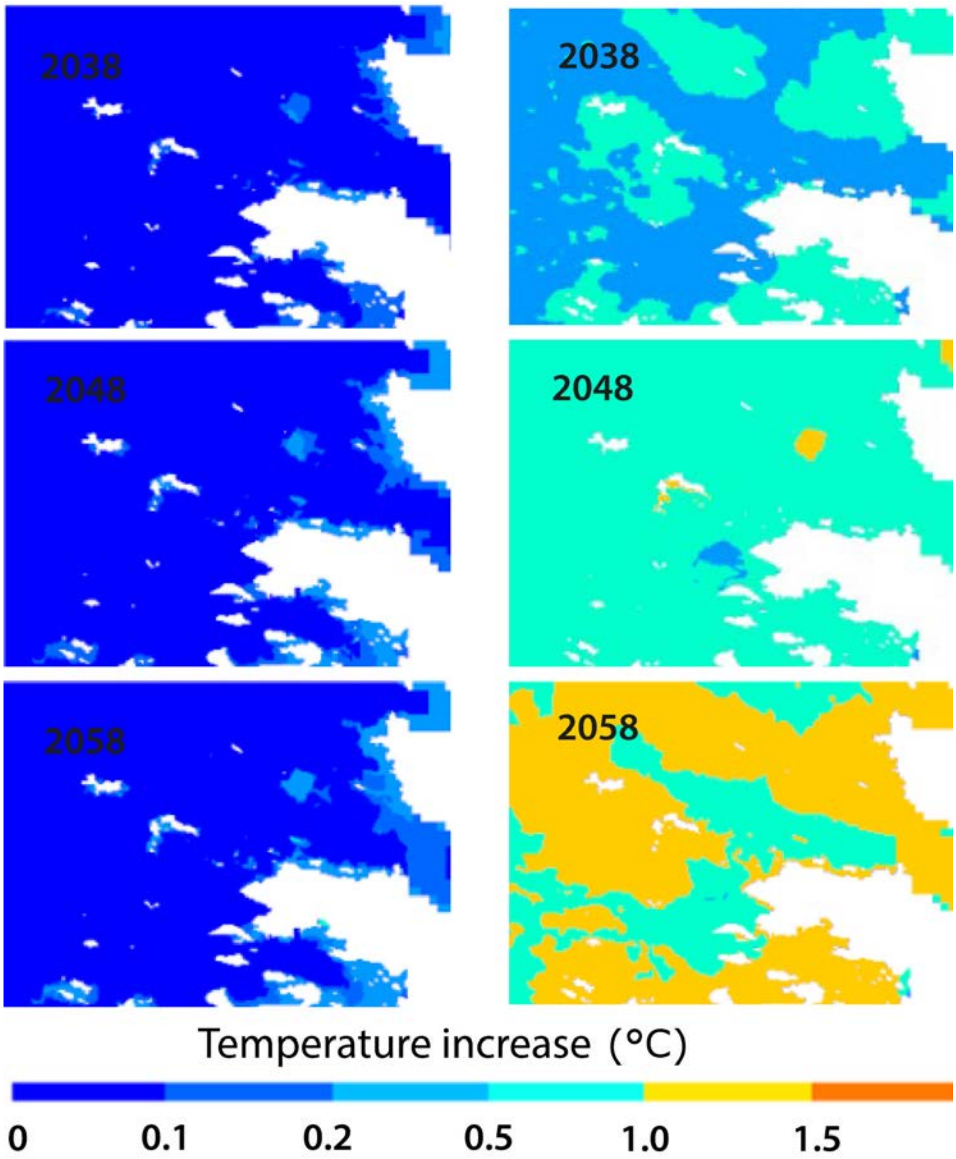


Figure 44. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units and climate change on temperatures in benthic water layer during a cold winter (left) and mild winter (right).

The operation of the OL1 and OL2 plant units will not change during the continuation of operation when compared to the current situation. It will, thus, not change the effect of the thermal load of the cooling waters or the extent of the impacted area. Climate change has a more significant effect on the warming of the sea area than the thermal load of Olkiluoto's cooling waters. In the case of continued operation, however, the effects of the thermal load will be long-lasting, as the operation will continue until either 2048 or 2058. For this reason, the effects on the temperature and the stratification of the sea area are estimated to be of a minor negative magnitude.

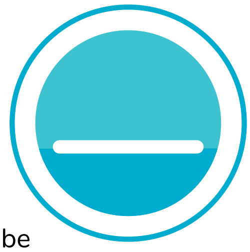
Effects on flows

The OL1 and OL2 plant units use seawater as their cooling water. A total of 76 m^3/s of water is taken and discharged. The cooling water is taken from the Olkiluodonvesi–Haapasaarenvesi water body in the sea on the south side of the power plant area, which causes a local northward flow near the mouth of the water intake tunnel. Several straits and narrows separate Olkiluodonvesi from the open sea, so the winds do not significantly change the flows caused by the cooling water intake.

The cooling waters of the OL1 and OL2 plant units are discharged into the sea on the west side of the power plant area, in the Iso Kaalonperä bay. The discharge of cooling water causes a strong westerly flow. Discharge of cooling water to the surface layer can intensify water stratification and affect ice conditions, which has slight effects on local flows.

In the case of continued operation, the seawater intake and discharge volumes of the OL1 and OL2 plant units will remain the same as in the current situation. Thus, the effects of continued operation on the currents of the sea area are estimated as insignificant.

Effects on ice conditions



The ice situation in the Olkiluoto sea area naturally varies a lot from year to year. In mild winters, the sea area of Olkiluoto remains completely thawed. In typical winters, the surroundings of the cooling water intake channels freeze, but the cooling water discharge side remains thawed. The solid ice area grows towards the sea if there are longer frost periods in the area. The effects of the thermal load of cooling water can be seen in the sea area west of Olkiluoto, where the extent of the area of thawed and weak ice varies from year to year.

According to the hydrological modelling (Appendix 5), the impact of climate change on ice conditions in the Olkiluoto sea area is greater than the impact of the thermal load of cooling waters. Climate change is estimated to reduce the area of the Baltic Sea ice cover and shorten the ice winter. Ice winters are predicted to shorten at both ends in the long term, but the date of the beginning will move more than the date of the end *(Ilmatieteen laitos 2022a)*.

Climate change is estimated to increase the seawater temperature and reduce the ice cover in the Baltic Sea *(Meier et al. 2022a & 2022b)*. Due to the effect of climate change, the extent of the ice cover in the Olkiluoto sea area may decrease slightly and the ice may become thinner, which may hinder walking on the ice in winter, for example (Figure 45). On the other hand, as a result of climate change, it is estimated that mild winters will become more common, which may reduce the use of the sea area in winter due to the lack of ice cover.

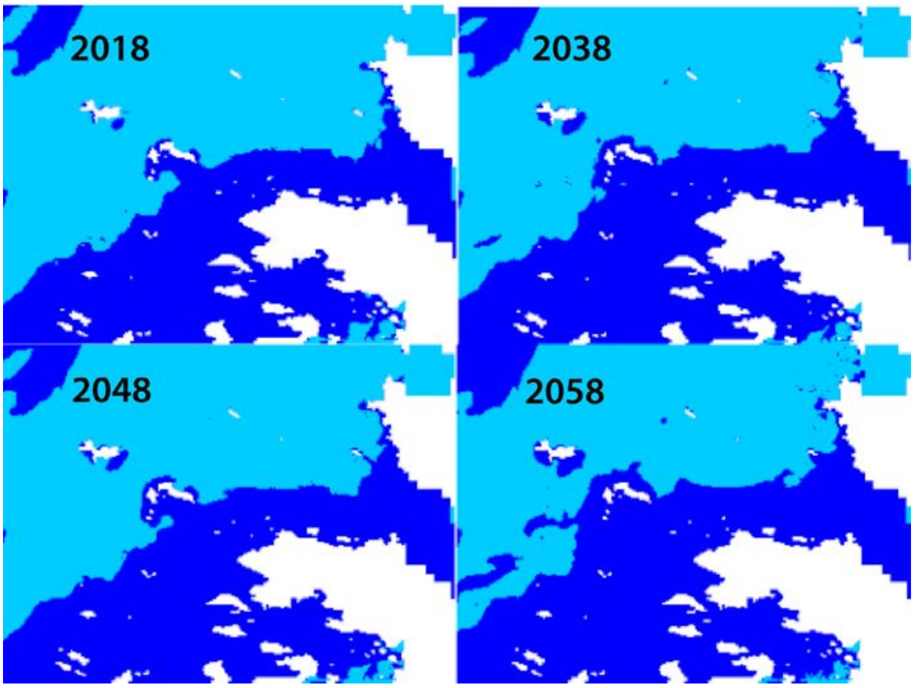


Figure 45. Areas where the modelling suggests that ice of more than 10 cm in thickness will occur in the current status (year 2018) and as climate change progresses (years 2038, 2048, 2058). Light blue colour indicates an ice cover of more than 10 cm in thickness, while dark blue colour indicates ice that is at most 10 cm in thickness or an open water area.

The continued operation of the OL1 and OL2 plant units is not estimated to have any impact on the ice conditions in the Olkiluoto sea area, which are estimated to remain as they are now. It is estimated that the high variability between one winter and the next will continue to be an inherent feature of the ice conditions. The continued operation of the OL1 and OL2 plant units will not change the magnitude or regional extent of the impact on the ice cover when compared to the current situation. However, climate change is intensifying the impacts on the ice cover. The magnitude of the impact on ice conditions in the sea area caused by continued operation is estimated as a minor negative, taking into account the additional impact caused by climate change.

Impacts on water quality

Since December 2023, wastewater from the Olkiluoto power plant has been routed to the treatment plant jointly operated by the City of Rauma and the forestry industry, which discharges it into the sea off Rauma. On average, approximately 78,900 m^3 of domestic water is generated from Olkiluoto every year. In the case of continued operation, the amount of domestic water will remain the same as before.

At the power plant, process wastewater is mainly generated from the leak, drain, rinse and purge water coming from the radiation controlled areas of the power plant buildings and storages. The average volume of process water from the OL1 and OL2 plant unit has been approximately 25,000 m^3 per year. Other wastewater generated in the power plant area includes, for example, water from the raw water treatment plant and demineralisation plant and rinse water from the travelling basket filters of the seawater pumphouses. Following appropriate processing, this water is routed into the sea via the discharge tunnel, along with the cooling water. The usual wastewater discharges into the sea from the OL1 and OL2 plant units have been estimated to be approximately 5 kg/year for phosphorus and 100 kg/year for nitrogen. Rainwater and stormwater from the plant area is also conveyed to the sea through the stormwater drainage network. Any possible oily rainwater is processed in oil separators before being routed into the sewer network. The concentrations of harmful substances measured in the power plant's cooling water discharge are very low and correspond to natural background concentrations (see Chapter 6.8.2.6). Radioactive discharges are discussed in Chapter 6.16.

Continued operation of the OL1 and OL2 plant units does not change the quantity, composition or treatment of cooling, household or process wastewater. Thus, the concentrations of harmful substances in the sea area are not estimated to increase. A small nutrient load is brought to the marine area with the process wastewater. The effects of continued operation on water quality are, thus, estimated to be a minor negative.

Impacts on phytoplankton

Eutrophication has been observed in recent decades both in the Olkiluoto sea area and elsewhere in the Bothnian Sea. The most significant source of nutrient loads in the Olkiluoto sea area are the river waters *(Laamanen et al. 2021)*. The operation of the power plant does not currently cause a significant nutrient load in the sea area, but the thermal load caused by the cooling waters lengthens the growth season of phytoplankton and has probably contributed to the eutrophication of the sea area near Olkiluoto *(HELCOM 2021a)*. The effects of eutrophication in the aquatic environment can include things such as changes in the colour of the water, a decrease in visibility depth and an abundance of cyanobacteria. As a result of the lengthened growing season and increased temperature, biological oxygen consumption increases, and the increased decomposition of organic matter can lead to the depletion of oxygen in the benthic water layer. The depletion of oxygen at the bottom causes nutrients to dissolve from the sediment into the water, i.e. internal loading, which accelerates eutrophication. However, it is difficult to assess the effect of Olkiluoto's cooling waters on the eutrophication of the sea area, as the impact of the thermal load is local and the eutrophication effect does not extend to the entire sea area.

The continued operation of the OL1 and OL2 plant units will not change the water quality of the sea area or the temperature of the seawater when compared to the current situation. However, the seawater temperature is rising due to climate change, and together with the thermal load of the cooling waters, the operation of the plant units may continue to contribute to the eutrophication of the sea area. The impacts of continued operation are long-lasting, considering the additional years of operation until either 2048 or 2058. The magnitude of the impact on phytoplankton caused by continued operation is estimated as a minor negative.

Effects on benthic fauna

The thermal load of the cooling water can raise the temperature of the hypolimnion and strengthen the stratification of the seawater in the Iso Kaalonperä bay, especially in summer. During hot summers, low oxygen levels have occasionally been observed on the seabed in the area affected by the cooling water discharge flow, but anaerobic conditions have not occurred. However, the effects are local and limited to the vicinity of the discharge flow. The densities of benthic fauna have declined in the sea area near the power plant during the past ten years (Figure 37). The changes in the benthic community are probably due to long-term changes in the conditions of the sea area, such as its general eutrophication.

The continued operation of the OL1 and OL2 plant units will not change the water quality or stratification conditions of the sea area when compared to the current situation, but climate change may intensify these impacts. Only a few benthic species tolerate low-oxygen conditions, as a result of which the benthic communities become less diverse and the state of the communities deteriorates.

The warming of the sea area can also contribute to the spread and abundance of alien species there *(Gollasch & Leppäkoski 1999)*. New alien species are often found in areas affected by the cooling waters of power plants, as the thermal load enables alien species to survive in the cold waters of the Baltic Sea *(Laine et al. 2006)*. Alien species may multiply and spread quickly in a new environment, as they often have no natural predators or competitors. Alien species can also compete for resources with native species, i.e. species naturally occurring in the area, and, in the worst cases, exterminate native species from their natural habitat (*Davis 2009*). Several established alien species occur in the sea area near the Olkiluoto power plant. The Caspian polyp (*Cordylophora caspia*) and dark false mussel (*Mytilopsis leucophaeata*), which spread to the area in 2006, cause harm by forming growths on the heat exchangers of the power plant, which is why any growths are removed. Furthermore, *Laonome xeprovala* was observed in the area for the first time in 2022 and the bryozoan *Conopeum chesapeakensis* in 2023.

The continued operation of the plant units is long-term, and the thermal load of the discharged cooling water may have a minor eutrophication effect on the sea area. As a result of eutrophication, the amount of primary production increases, and the decomposition of organic matter can weaken the oxygen conditions of the seabed even more. It is difficult to predict the spread of alien species in a sea area, so the situation is estimated to remain as it is now. The effects of continued operation on benthic fauna are, thus, estimated to be a minor negative.

Cooling water impact of the KPA storage

KPA-varastolla käytettyä ydinpolttoainetta jäähdytetään vesialtaissa. KPA-varaston altaiden jäähdytysvesi otetaan ja puretaan voimalaitosalueen eteläpuolelle Olkiluodonveteen omia otto- ja purkuputkia pitkin (Figure 32). The KPA storage cooling water intake and discharge occur at the Olkiluodonvesi–Haapasaarenvesi water body. Approximately 50 litres per second (l/s) of cooling water is extracted and discharged in current operation. The cooling system in the KPA storage is dimensioned for a maximum residual heat of 2,100 kW. At present, the residual heat generated by the spent fuel at the KPA storage is approximately 1,600 kW, in which case the thermal load of the cooling water returned into the sea is approximately 7.6°C higher than that of the extracted seawater.

If the KPA storage is expanded, the storage capacity can be increased by building three new pools as a continuation of the current pools and the additional cooling piping needed between the pools. In the sea, the cooling water extraction and discharge locations will remain as they are. With the additional pools, the need for cooling water intake increases by 50%, which also increases the amount of cooling water discharged into the sea. However, the temperature of the cooling water discharged from the KPA storage remains the same as in the current situation, i.e. the temperature of the cooling water is approximately 7.6 °C higher than the natural seawater temperature.

The amount of cooling water discharged from the KPA storage (50 l/s) is very small when compared to the amount of cooling water from the OL1 and OL2 plant units (38,000 l/s). Thus, the impacts of the KPA storage cooling water intake and discharge in the sea area are practically negligible when compared to those of the OL1 and OL2 plant units. The increase in the amount of cooling water caused by the expansion of the KPA storage is overall very small and is not estimated to cause changes in the sea area's water quality, currents or deposition conditions when compared to the current operation. Thus, the magnitude of the change caused by the expansion of the KPA storage is estimated to be insignificant.

Effects on Eurajoki and Lapinjoki

The nuclear power plant takes raw water from Eurajoki and Lapinjoki. The amount of raw water varies yearly. In 2023, 272,713 m^3 of water were taken from Eurajoki and 6,920 m^3 from Lapinjoki. The continuation of operation does not change the amount of raw water needed. The effects of continued operation of the OL1 and OL2 plant units on the water intake from Eurajoki and Lapinjoki are estimated to be insignificant in terms of magnitude, as the intake will remain as it is now.

6.8.3.2. Power uprating

Impacts during construction

The power uprating requires the construction of a new supplementary water system and battery energy storage system in the site area. The additional construction will take place in the immediate vicinity of the plant units in an already built-up area, and no major earthworks are required. The construction is, therefore, not estimated to have any impact on the quality of stormwater and, thus, on the surface water. The new supplementary water system does not affect the water intake or discharge of the OL1 and OL2 plant units. In addition, it is possible that the current KPA storage will be expanded. The storage extension will be built adjacent to the existing storage area inside the site area, and the construction is not estimated to have any impact on stormwater or the water bodies receiving it.

The following describes the impacts which the service life extension and power uprating of the OL1 and OL2 plant units would have during operation.

Impacts on temperature and stratification conditions

In the case of a power uprating, the temperature of the cooling water of the OL1 and OL2 plant units fed into the sea is, on average, approximately 11 °C higher than the natural temperature of the seawater, and the thermal load caused by the cooling water on the sea area is, on average, some 109,000 TJ/year. The temperature of the cooling water fed into the sea will, thus, rise by 1 °C when compared to the current operation or continued operation (Chapter 6.8.3.1).

According to the hydrological modelling results, the magnitude of the effect of the thermal load of the cooling water and the extent of the affected area do not significantly change in the case of a power uprating when compared to the current situation or to continued operation. If the power uprating is implemented. the effects of the thermal load of the cooling water will be directed to the water bodies of the Rauma and Eurajoki archipelago and the Luvian–Rauma open sea, as in the current situation (Figure 46, Figure 47). The thermal load caused by the power uprating mainly affects the surface layer of the seawater, because water that is warmer and lighter than its surroundings naturally stays on the surface. At a distance of approximately 2 km from the discharge point of the cooling waters, the power uprating increases the average seawater surface temperatures by 0.2°C and at a distance of 3–4 km by 0.1°C. Temperature differences smaller than 0.5°C cannot be distinguished from natural variation. The motion of the thermal load in the surface layer mainly depends on the wind situation. In the open sea season, the rise in surface temperature is, on average, higher in cool months and lower in hot summers (Figure 46, Figure 47, Figure 48, Figure 49).). In the benthic layer, the temperature increase is only noticeable in the immediate vicinity of the cooling water discharge point. In the rest of the sea area, there are no noticeable differences in the temperature of the hypolimnion when compared to the current state. In winter in the open sea season, the seawater temperature increase is greater in mild winters than in cold ones (Figure 48, Figure 49).

According to the hydrological modelling results, the sea area that can experience surface temperatures of 30°C or 32°C in summer will expand in the case of a power uprating compared to continued operation. Due to the combined effect of the power uprating and of climate change, surface temperatures of 30°C may occur in 8.0 km^2 and temperatures of 32°C in 1.3 km^2 of the sea area affected by the discharge current by 2058.

The power uprating of the plant units can occasionally amplify the temperature stratification of the sea slightly in the Iso Kaalonperä bay and, thus, reduce the exchange of water between the surface and bottom layers.

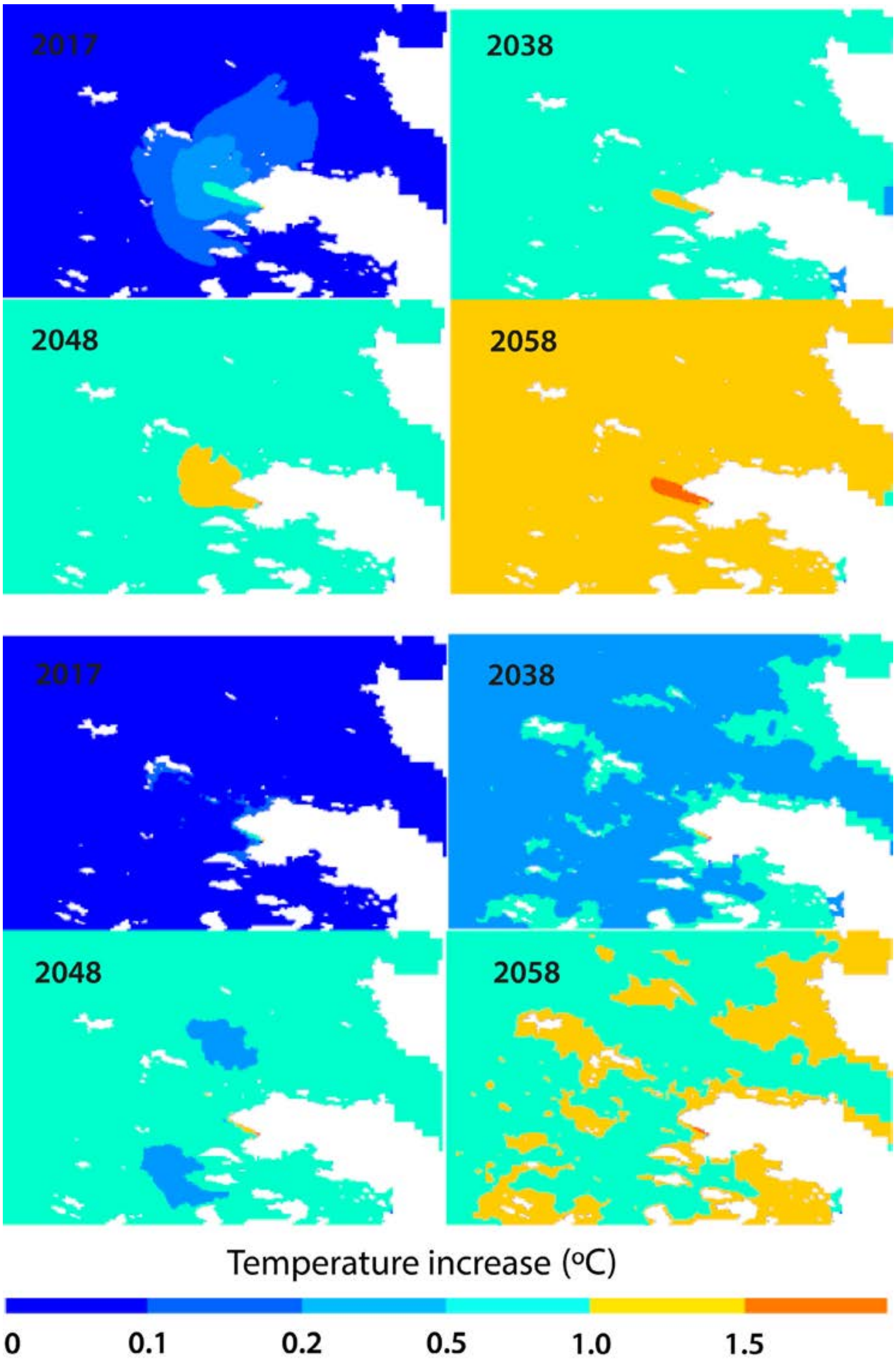


Figure 46. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units, uprating the power of the OL1 and OL2 plant units and climate change on sea water temperatures during a cool summer in the surface layer (top four images) and the benthic layer (bottom four images). Year 2017 describes the impacts on the sea water temperature of the power uprating for plant units OL1 and OL2 when compared to the current status; years 2038, 2048 and 2058 also consider the impacts of climate change.

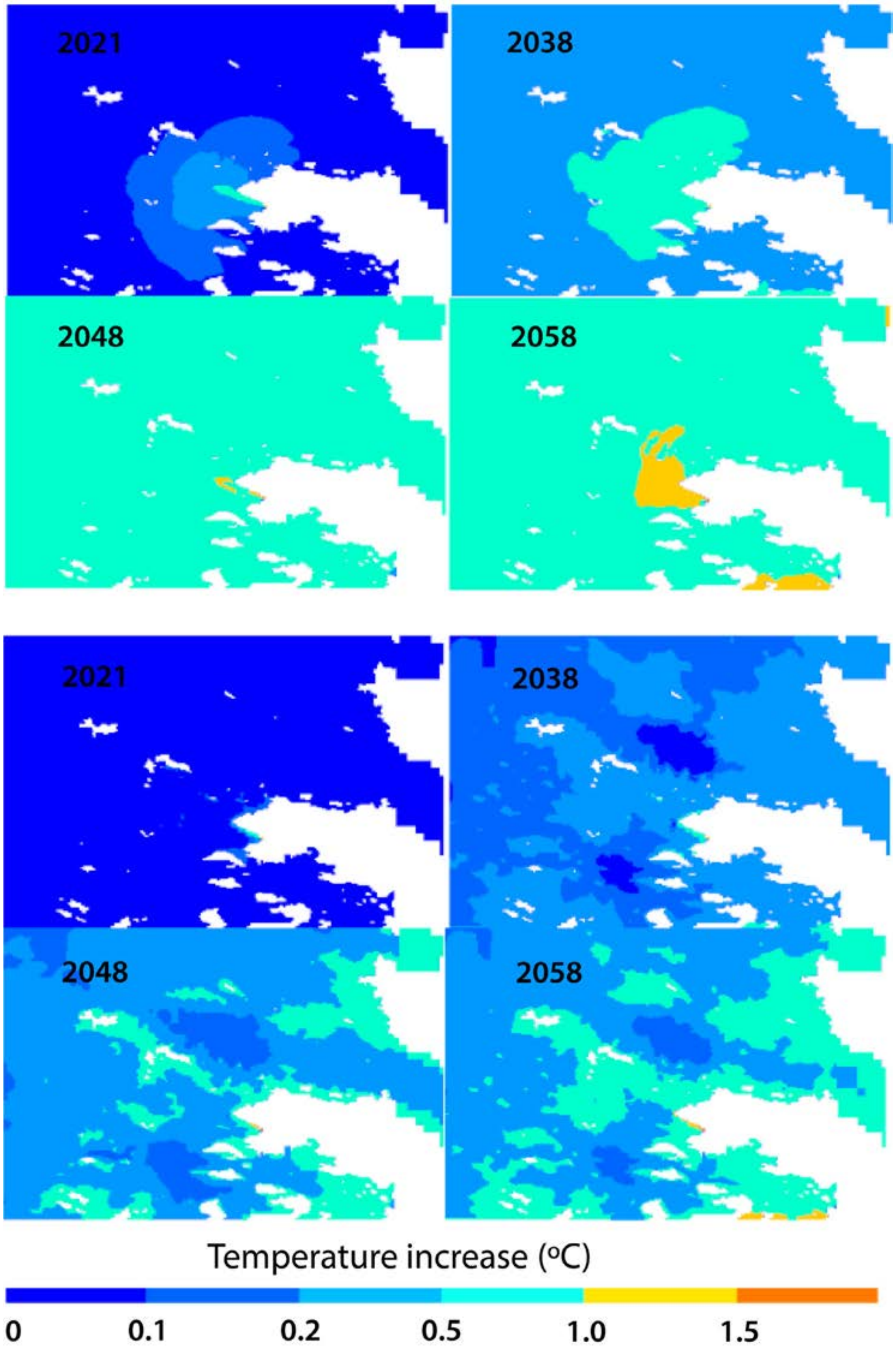


Figure 47. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units, uprating the power of the OL1 and OL2 plant units and climate change on sea water temperatures during a hot summer in the surface layer (top four images) and the benthic layer (bottom four images). Year 2021 describes the impacts on the sea water temperature of the power uprating for plant units OL1 and OL2 when compared to the current status; years 2038, 2048 and 2058 also consider the impacts of climate change.

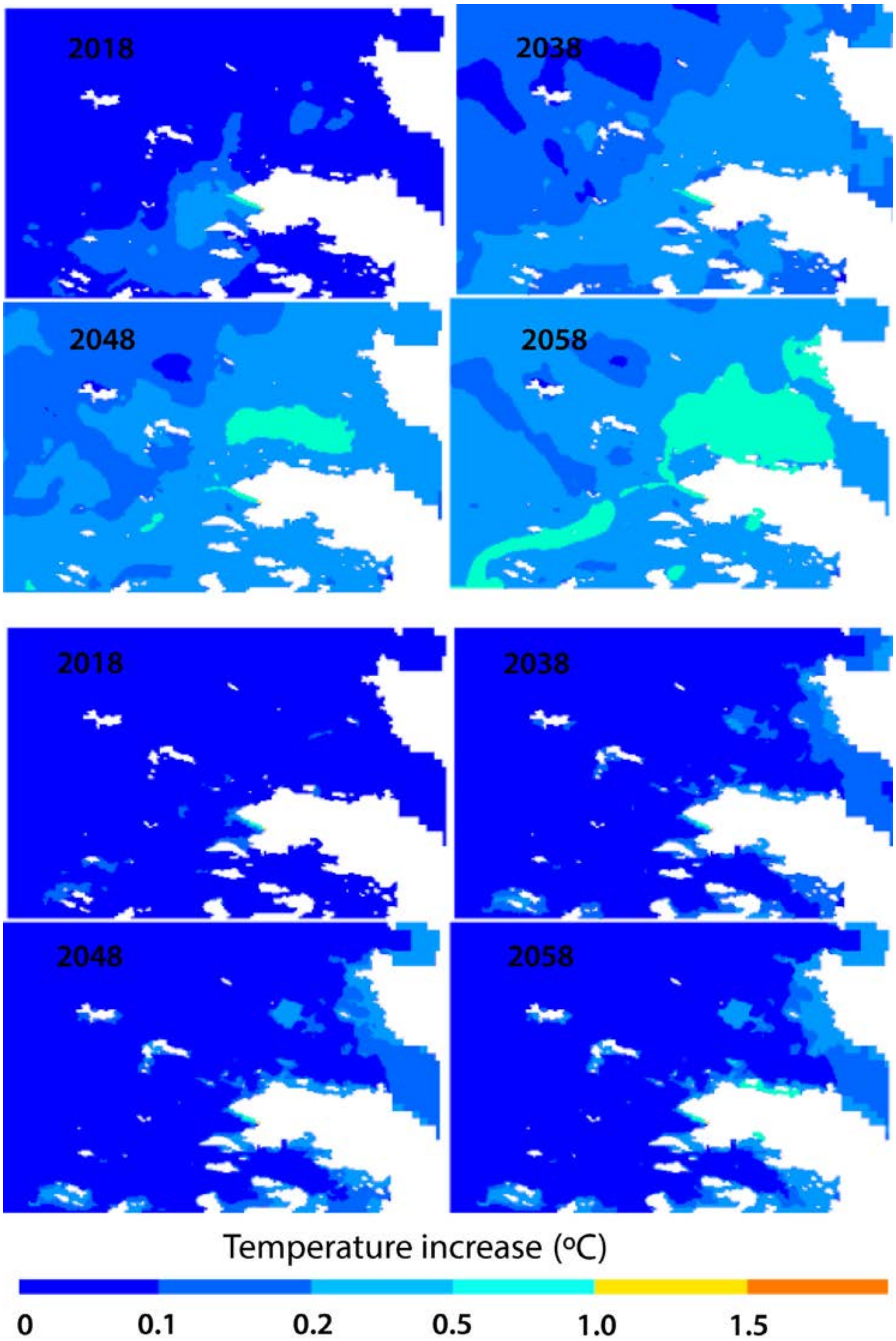


Figure 48. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units, uprating the power of the OL1 and OL2 plant units and climate change on sea water temperatures during a cold winter in the surface layer (top four images) and the benthic layer (bottom four images). Year 2018 describes the impacts on the sea water temperature of the power uprating for plant units OL1 and OL2 when compared to the current status; years 2038, 2048 and 2058 also consider the impacts of climate change.

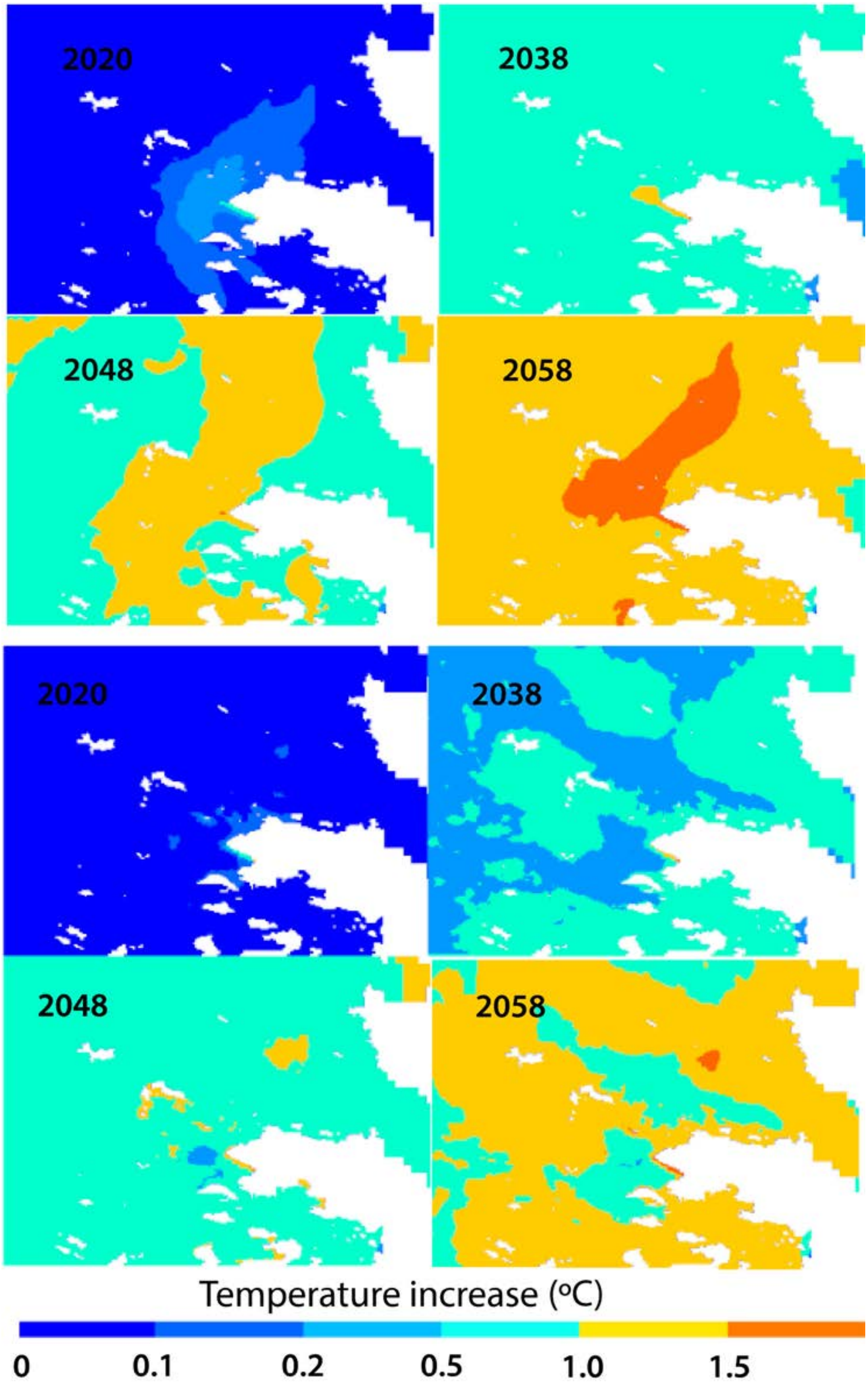


Figure 49. Modelled impacts of extending the operation of the OL1, OL2 and OL3 plant units, uprating the power of the OL1 and OL2 plant units and climate change on sea water temperatures during a mild winter in the surface layer (top four images) and the benthic layer (bottom four images). Year 2020 describes the impacts on the sea water temperature of the power uprating for plant units OL1 and OL2 when compared to the current status; years 2038, 2048 and 2058 also consider the impacts of climate change.

As a result of the power uprating, the temperature of the cooling water discharged into the sea will increase by 1 °C, but the magnitude of the thermal load effect or the extent of the impacted area in the sea area do not change significantly when compared to the current state or continued operation. However, climate change will intensify the warming of the sea area. Based on the modelling results, climate change has a greater impact on the temperatures of the Olkiluoto sea area than the power uprating of the plant units. The effects of climate change correspond to the effects described for the case of continued operation (Chapter 6.8.3.1). According to the modelling, by 2058 the surface temperatures of the entire Olkiluoto sea area will increase on average by approximately 1–1.5 °C. The change caused by the power uprating of the OL1 and OL2 plant units to the temperature and stratification conditions of the sea area near Olkiluoto when compared to the current situation is estimated to be of a minor negative magnitude when the extension of operation is taken into account.

Effects on flows

In the case of the power uprating, the amount of cooling water discharged into the sea remains the same as with the current operation. There are, thus, no direct changes to the currents in the sea area, but the temperature increase and density changes of the discharge water cause indirect effects on the currents there. It will take a little longer for the density differences to even out, and the flow paths to equalising the temperature will change.

The same temperature change in discharged water causes a greater density change in summer than in winter. This is why the currents change more in the summer. The biggest changes occur in the vicinity of the discharge flow and were in the range of several cm/s. Since temperature changes in seawater are concentrated in the surface layers, the flow changes are also greater in the epilimnion than in the benthic layer.

Overall, the power uprating can occasionally amplify the temperature stratification of the sea slightly in the Iso Kaalonperä bay and, thus, reduce the exchange of water between the surface and bottom layers. In winter, the thermal load can reduce the ice cover in the sea area and enable wind-induced currents in thawed areas. The change in the flow conditions of the sea area caused by the power uprating is estimated to be insignificant, as these changes are, nevertheless, minor when compared to the natural yearly variation in thermal and ice conditions.

Effects on ice conditions

The effects of the power uprating of the OL1 and OL2 plant units on the ice conditions of the sea area near Olkiluoto can be compared to the effects of the commissioning of the OL3 plant unit. OL3 was commissioned in March 2022, and ice monitoring was carried out every two weeks in the winter of 2022–2023. With the commissioning of OL3, the weak and partially open areas in the solid ice area on the cooling water intake side were estimated to have expanded (Figure 50). If the power uprating is implemented, it can be assumed that these areas will remain mostly thawed. Despite the operation of the new plant unit, in the winter of 2024 the open water area on the cooling water discharge side was the smallest in recent history. Thus, it can be stated that the natural yearly variation in the prevailing ice conditions is more significant for the extent of the ice cover than the effects of the plant units' cooling water intake or discharge *(Teollisuuden Voima Oyj 2024c)*.

Legend HO = Thin ice, partially open K = Fast ice

Figure 50. Average ice situation during the winter of 2022–2023 and changes in the ice situation in comparison to previous years, following the commissioning of the OL3 plant unit (Teollisuuden Voima Oyj 2024c).

In hydrological modelling, the impact of the temperature rise of the cooling water caused by the power uprating and by climate change on the ice cover of the sea area was illustrated as changes in the number of ice days. Based on the modelling results, the power uprating affects the ice cover only on a few individual days, which cannot be distinguished from the natural yearly variation. The effects of the power uprating shorten the ice cover time by an average of 2 days, but larger changes may occur in some places due to random weather conditions.

Climate change will clearly affect the ice cover more than the power uprating of the plant units. Due to the combined effect of the power uprating and of climate change, by 2058 the ice cover period of the Olkiluoto sea area will have shortened by 2–3 weeks (Figure 51). Unlike temperature changes, which spread evenly away from the cooling water discharge site, changes in ice days are more random. Changes to the ice days mainly occur in situations where the ice is just forming or thawing, so the prevailing wind conditions also play a major role in the ice situation at that time.

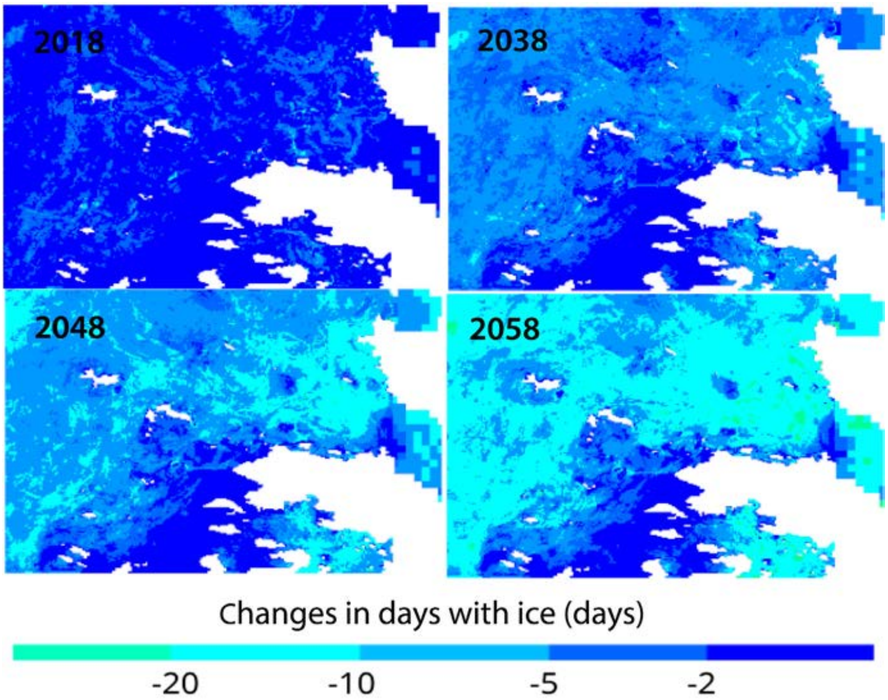


Figure 51. Changes in the number of days with ice as a result of the power uprating of the plant units (year 2018) and climate change (years 2038, 2048 and 2058).

The strength of the ice cover is important for the recreational use of the sea area. The effects of the thermal load of cooling waters on the recreational use of the sea area in winter were examined by modelling changes in an ice cover more than 10 cm thick, which was estimated to support a human's weight. According to the modelling results, the power uprating and climate change had only a minor effect on the thickness of the ice cover in the sea area near Olkiluoto (Figure 52). During a severe cold period, the cooling water fed into the sea cools quickly, so the ice also thickens quickly and load-bearing ice is formed to almost the same extent as today. However, the duration of the load-bearing ice area is shortened in the same way as with the ice days.

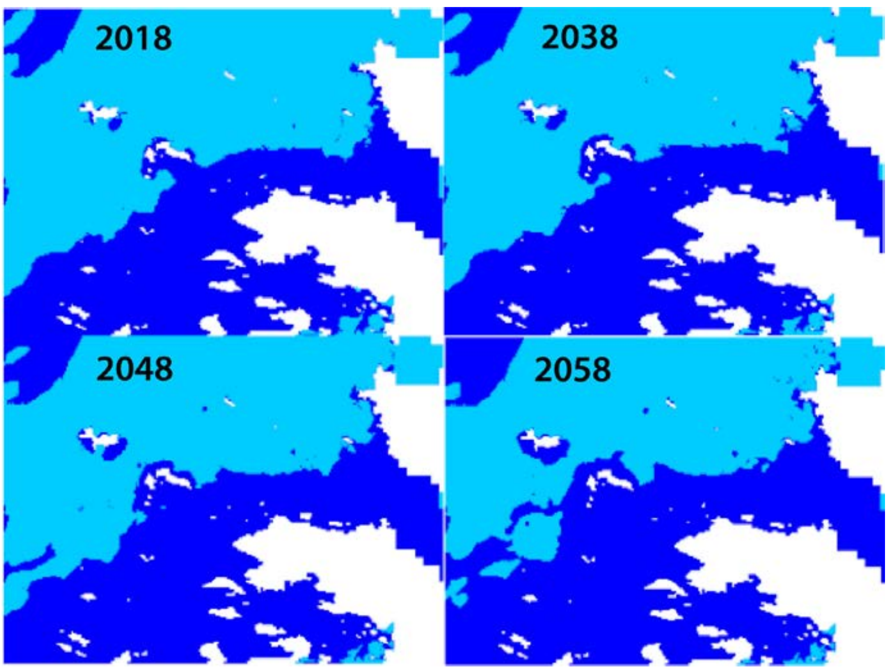


Figure 52. Areas where the modelling suggests that ice of more than 10 cm in thickness will occur in the current status and as climate change progresses. Year 2018 describes the current ice situation and the years 2038, 2048 and 2058 consider the impacts of uprating the power of the OL1 and OL2 plant units and climate change. Light blue colour indicates an ice cover of more than 10 cm in thickness, while dark blue colour indicates ice that is less than 10 cm in thickness or an open water area.

Changes in the ice cover time can affect the currents in the sea area, eutrophication and the spread of alien species. The effects of the power uprating will change the sea area's ice cover by a few days, while the effects of climate change are calculated in weeks. The effect of the cooling water is local, but the effect of climate change can be seen in the entire sea area. There is a lot of uncertainty about the effects of the cooling water thermal load and climate change on the ice cover, as the yearly variation is already currently large. Due to the long duration of the operation, the effects of the power uprating on the ice conditions of the sea area are estimated to be a minor negative.

Impacts on water quality

The effects of the power uprating of the OL1 and OL2 plant units on water quality correspond to the effects of continued operation, which are described in Chapter 6.8.3.1. The effects on water quality are estimated to be a minor negative, as the concentrations of harmful substances in the process wastewater discharged into the sea are very low. The radioactivity of cooling and process wastewater is discussed in Chapter 6.16. The nutrient load caused by process wastewater is minor. Wastewater from the Olkiluoto power plant is routed to the treatment plant jointly operated by the City of Rauma and the forestry industry, which discharges it into the sea off Rauma.

Impacts on phytoplankton

The nutrient load into the sea caused by the process wastewater of the OL1 and OL2 plant units is very minor (approximately 5 kg of phosphorus and 100 kg of nitrogen per year) and insignificant when compared to the load of river waters. The effects of the power uprating on phytoplankton are indirect and mainly caused by the impact of the thermal load. The lengthened growing season and the higher temperature during the season can increase the production of phytoplankton to a small extent, which is reflected as an increase in chlorophyll A concentrations and basic production. The increase in primary production can, in turn, weaken the visibility depth of the sea area. Cyanobacteria are likely to benefit from warming seawater, as their temperature optimum is higher than that of other species groups *(Kanoshina et al. 2003)*. The production of cyanobacteria is also not as dependent on the nutrient content of the water, as they are able to utilise the nitrogen in the atmosphere. As a consequence of climate change, icy winters are predicted to shorten in the long term, which also extends the growing season of primary producers.

As a result of eutrophication and increased seawater temperature, biological oxygen consumption and the decomposition of organic matter will increase, which can lead to the depletion of oxygen in the benthic water layer. In anoxic conditions, nutrients from the sediment dissolve into the water, which can cause internal loading and intensify eutrophication even more.

A development towards eutrophication has been observed in recent decades both in the Olkiluoto sea area and elsewhere in the Bothnian Sea. In the long term, the assessment of the effects on phytoplankton and aquatic vegetation includes uncertainty, as the development of primary production in the marine area depends on the realisation of both the climate change scenarios and the load-reducing measures. Eutrophication of the marine area has been predicted to accelerate as a result of climate change *(HELCOM 2021a)*. However, in the long term, the load on the sea area may also decrease if new measures are widely taken in agriculture. This is estimated to have positive effects on the state of the sea area, as the decreasing amount of nutrients restrains phytoplankton production and the increase of aquatic vegetation.

According to the hydrological modelling, the effects of the thermal load of the cooling water are limited to the sea area near Olkiluoto, the Rauma and Eurajoki archipelago, and the Luvia–Rauma open sea water bodies, so the extent of the area impacted by the power uprating of the OL1 and OL2 plant units will not change when compared to the current situation. Nutrient load and climate change have a greater impact on the development of primary production in the sea area than the thermal load from cooling waters. However, the thermal load of the cooling waters may promote eutrophication in the sea area near Olkiluoto. The magnitude of the change to phytoplankton and aquatic vegetation is, thus, estimated to be a minor negative.

Effects on benthic fauna

The effects of the power uprating on the benthic fauna are indirect and are caused by possible changes in the temperature and water stratification of the sea area. According to the hydrological modelling, the effects of the thermal load caused by the power uprating are local and mainly visible in the epilimnion. In the benthic water layer, temperature changes are minor. Thus, the potential effects of the power uprating on benthic fauna are local and concentrated in the vicinity of the cooling water discharge stream.

In the long term, the thermal load of the cooling waters, climate change and the nutrient load of the sea area can work together to weaken the oxygen conditions of the seabed. An oxygen deficit can develop on deep bottoms if strong stratification weakens the turnover in the hypolimnion and the increasing amount of organic matter due to eutrophication increases oxygen consumption. Only a few benthic species tolerate low-oxygen conditions, as a result of which the benthic communities become less diverse and the state of the communities deteriorates. On the other hand, the effects of climate change on benthic fauna can also be positive, depending on the realisation of climate scenarios and management measures in the sea area. If the ice cover period shortens or ice does not form in the sea area at all as a result of climate change, the mixing conditions in the sea area may improve. Taking into account the extended operating time of the plant units, the effects on the benthic fauna of the Olkiluoto sea area are estimated to be a minor negative in magnitude.

Cooling water impact of the KPA storage

In the case of power uprating, increasing the fuel burn-up will increase the residual heat generation of the fuel assemblies by approximately 10%. This will increase the demand for residual heat removal at the KPA storage by a corresponding amount. The flow rate of the cooling water extracted from the sea and returned there would be increased correspondingly, and the temperature of the water returned into the sea will not rise from it current level of approximately 7.6 °C, which is the natural temperature of seawater.

If the KPA storage is expanded, this will also increase the amount of cooling water to be taken and discharged. If three more pools were to be constructed at the KPA storage, this would increase the current thermal load by approximately 50%. The flow rate of the cooling water extracted from the sea and returned there will be increased, if necessary, in which case the temperature of the water returned into the sea will not rise from the current level.

With the power uprating and the possible expansion of the storage, the amount of cooling water used by the KPA storage will increase from the current amount, but the amount is still only a small fraction of the amount of cooling water used by the OL1 and OL2 plant units. The increase in the amount of cooling water does not change the effect of the operation of the KPA storage in the sea area when compared to the current situation. Thus, the impacts of the KPA storage cooling water intake and discharge on the temperature and stratification of the sea area are practically negligible when compared to those of the OL1 and OL2 plant units.

Effects on Eurajoki and Lapinjoki

The effects of the power uprating of the OL1 and OL2 plant units correspond to the effects of continued operation, which are described above in section 6.8.3.1. The power uprating does not affect raw water intake, so the effects on Eurajoki and Lapinjoki are estimated to be insignificant.

6.8.3.3. Impact on sea area strategies and policies

Water resources management and the ecological and chemical status of the sea area

The effects of continued operation and power uprating on water quality and the aquatic environment (phytoplankton, aquatic vegetation, benthic fauna) are assessed in Chapters 6.8.3.1 and 6.8.3.2. The ecological and chemical state of the water bodies off Olkiluoto is described in detail in Chapter 6.8.2.10.

The effects of the continued operation and power uprating of the OL1 and OL2 plant units concern the water bodies of the Rauma–Eurajoki archipelago and the Luvia–Rauma open sea. The ecological status of both water bodies has been assessed as good and their chemical status as failing to achieve good (Table 36).

Eutrophication has been observed in recent decades both in the Olkiluoto sea area and elsewhere in the Bothnian Sea *(KVVY Tutkimus Oy 2022b & 2023a)*. In the long term, the eutrophication of the Bothnian Sea is predicted to continue if the nutrient load in the marine area cannot be limited *(Westberg et al. 2022)*. The most significant factor influencing the state of water bodies in the Olkiluoto sea area is the nutrient load brought by river waters. The thermal load of the cooling water of the OL1 and OL2 plant units is estimated to contribute to eutrophication locally in the sea area near Olkiluoto.

In the long term, the assessment of the effects of eutrophication on biological and physico-chemical quality factors is challenging, as long-term predictions of both climate change and nutrient loads involve a lot of uncertainty. Mild eutrophication as a joint effect and the resulting deterioration of the Iso Kaalonperä bay cannot be ruled out, but the development of eutrophication in the long term depends mainly on the realisation of climate change scenarios and scattered-load measures. Overall, the continued operation of the OL1 and OL2 plant units or the power uprating is not estimated to weaken the ecological or chemical status of the water bodies in the affected area compared to the current status or prevent the achievement of a good status in the fourth planning period of water resources management (Table 36).

Table 36. The state of the biological and physico-chemical quality factors of water bodies in the 3rd planning period of water resources management, and an assessment of how the state of water bodies may develop in the long term and what is the effect of continued operation of plant units or power uprating on the ecological status.

Biological quality factors	Physicochemical quality factors	Estimated future developments
Rauma–Eurajoki archipelago (Ses), ecological status good in the 3rd period of water resources management		
Regarding biological factors, the condition of phytoplankton and benthic fauna is good, but the condition of macrophytes is moderate when examining the growth depth of the Fucus zone. Chlorophyll A concentration close to the limit value of good and moderate, so curbing the eutrophication of the sea area is important to maintaining it in a good state.	Total phosphorus content good, and total nitrogen content and visibility depth moderate. Curbing the eutrophication of the sea area is important to maintaining it in a good state.	The thermal load of the cooling water has affected the temperature and stratification of the water body and promoted eutrophication. The nutrient load of river waters has a significant effect on the state of the water body. The eutrophication of the sea area must be curbed in order to maintain it in a good state. Even in the long term, the continuation of operation or the power uprating will not weaken the classification of ecological quality factors or endanger the good state. In combination with the nutrient load of the sea area, the thermal load of the cooling waters can contribute to local eutrophication of the sea area. The development of the state of the water body is affected by the realisation of climate change scenarios and scattered-load measures.
Luvia–Rauma open sea (Seu), ecological status good in the 3rd period of water resources management		
Phytoplankton and chlorophyll A moderate, which reflects eutrophication. The chlorophyll content would have to be reduced by only 0.4 ug/L to achieve a good state. Benthic fauna in good condition according to the BBI index.	Total nitrogen content and visibility depth good. Total phosphorus content moderate, but very close to the limit value for good.	The thermal load of the cooling water has a minor effect on the temperature and stratification of the water body. The state of the water body is affected above all by the development of the total load in the sea area. The continuation of operation or the power uprating will not weaken the classification of ecological quality factors or endanger the good state.
Olkiluodonvesi–Haapasaarenvesi (Ses), ecological status moderate in the 3rd period of water resources management		
Among biological factors, the state of the sea area is influenced by the high chlorophyll content and the moderate state of phytoplankton, which reflect the eutrophication of the sea area. The status of benthic fauna assessed as good.	Total phosphorus content on the border between good and moderate, total nitrogen content and visibility depth both moderate.	The cooling water intake and the thermal load of the KPA storage have a minor effect on the state of the water body. The water body may be affected indirectly through eutrophication of the sea area and changes in ice conditions. The effect of climate change on seawater temperature is significant in shallow coastal sea areas. The continuation of operation or the power uprating will not weaken the classification of ecological quality factors or endanger the good state of the water body.

Biological quality factors	Physicochemical quality factors	Estimated future developments
Eurajoki strait (Ses), ecological status moderate in the 3rd period of water resources management		
Biological status estimated as poor in the 3rd period. Phytoplankton and chlorophyll A concentrations high. In order to achieve a good status, the chlorophyll A concentration should decrease by approximately 3.5 ug/l, and this will not happen if the nutrient load remains as it is now. The status of benthic fauna has not been assessed.	Physicochemical state poor, reflecting the effects of river water loads. Total nitrogen and phosphorus are assessed as poor and visibility depth as bad. The total nitrogen would need to decrease to 120 ug/L and phosphorus to approximately 7 ug/L to achieve a good status, which would be a significant decrease when compared to the concentrations observed during the water resources management periods.	The effects of the thermal load of the cooling water do not extend to this water body. The nutrient load of Eurajoki has a significant effect on the state of the water body. The development of the ecological state is affected by the realisation of climate change scenarios and agriculture-related measures. The continuation of operation or the power uprating will not weaken the classification of ecological quality factors or endanger the good state of the water body.
Lower Eurajoki (Ses), ecological status moderate in the 3rd period of water resources management		
The status of the biological factors is classified as good in terms of algae and benthic fauna.	Total phosphorus content good; state not assessed in terms of total nitrogen. Nutrients from the scattered-load catchment area.	The water body is subject to the water intake, which has no effect on its ecological or chemical classification. The effects of the thermal load of the cooling water do not extend to this water body. The continuation of operation or the power uprating will not weaken the classification of ecological quality factors or endanger the good state of the water body.
Lapinjoki (Ses), ecological status moderate in the 3rd period of water resources management		
The status of the biological factors is classified as good in terms of algae and benthic fauna.	Physicochemical factors moderate. Total phosphorus classified as moderate and total nitrogen as poor. The nitrogen content should be reduced by almost 1,000 µg/l to achieve a good state. Reducing the scattered load from the catchment area is essential to achieving a good state. Several dams and power plants lower the hydromorphological classification.	The water body is subject to the water intake, which has no effect on its ecological or chemical classification. The effects of the thermal load of the cooling water do not extend to this water body. The implementation of scattered-load measures plays an important role in achieving a good state. The continuation of operation or the power uprating will not weaken the classification of ecological quality factors or endanger the good state of the water body.

Marine strategy plan

The possible effects of continued operation or power uprating on indicators of the good state of the marine environment are mainly caused by the thermal load of the cooling waters and the possible spread of alien species.

In the action programme of the Finnish marine strategy plan for the years 2022–2027, excessive nutrient loads and eutrophication, which endangers both the preservation of biodiversity and the functioning of the food web, have been identified as the most significant problems in the Bothnian Sea. The project does not increase the nutrient load of the sea area, but the thermal load of the cooling water can contribute to eutrophication of the sea area locally, and climate change will intensify the effect further. In the action programme of the marine strategy plan, it is also stated that the cooling waters of the Olkiluoto nuclear power plant enhance the production of phytoplankton and aquatic plants and may intensify eutrophication. However, the effects of the thermal load are seen as local, and the thermal effect is not estimated to have an impact on the state of the sea on any wider scale (*Laamanen et al. 2021*). In the case of power uprating, the increase in the amount of phytoplankton (chlorophyll A concentration) is very slight at the water body level. The thermal load of the cooling waters can benefit cyanobacteria, but the effect on mass occurrences of cyanobacteria is estimated to be minor, and the occurrence of cyanobacteria is not estimated to change when compared to the current situation.

The objective of the action programme of Finland's marine strategy plan for 2022–2027 for combatting harmful alien species is to prevent the arrival of alien species or to slow down the rate of arrival. Since it is practically impossible to eradicate alien species from the sea, the prevention of harm is focused on preventing the arrival of new alien species. Ship traffic is the most significant entry route for marine species. The most important measures are the EU Alien Species Regulation; the Act on the Management of Risks Arising from Alien Species; and the national alien species list approved as a Government Decree. Management plans for the control of harmful alien species are also key tools guiding the implementation of alien species legislation. The International Maritime Organization (IMO) convention on the monitoring and treatment of ships' ballast water and sediments entered into force internationally in 2017. On the whole, the current measures are considered to be sufficient to prevent the arrival of harmful alien species and to promote the fight against harms.

Sea areas where the water temperature remains warmer than natural all year round may function as areas receiving alien species. Thermal loads can facilitate the adaptation of a foreign species to a new habitat and promote the spread of the species. Among the recent alien species occurring in the Olkiluoto sea area, the Caspian polyp *(Cordylophora caspia)*, the dark false mussel *(Mytilopsis leucophaeata)* and the bryozoan *(Conopeum chesapeakensis)* can cause harm by forming growths in the power plant's seawater systems. Of these, especially the dark false mussel benefits from the thermal effect *(Laine et al. 2006)*. It is difficult to predict the spread of possible new alien species, so it is estimated that the situation in the Olkiluoto sea area will remain as it is now.

The continued operation or power uprating of the OL1 and OL2 plant units does not prevent or endanger the achievement of the long-term goals of a good state for the marine environment.

Baltic Sea Action Plan HELCOM

The general convention concerning the conservation of the marine environment in the Baltic Sea region, also known as the Helsinki Convention, obligates the signatories to reduce loads from all pollution sources, protect the marine environment and maintain its biodiversity. As with the water resources management plan and marine strategy plan, the aim for the Baltic Sea Action Plan *(HELCOM 2021b)* is to achieve a good status for the Baltic Sea.

The action plan lists eutrophication and invasive species as the key pressures affecting the status of the Baltic Sea and has recommended management targets in order to minimise nutrient loads originating from human activity and preventing the spread of invasive species. The effects of the project alternatives on the eutrophication of the sea area and the spread of alien species have been discussed above. Based on the surface water impact assessment, it could be concluded that the project does not conflict with the goals of water resources management or marine management, and does not weaken the good ecological state of the Rauma–Eurajoki archipelago or the Luvia–Rauma open sea.

The continued operation and the power uprating do not conflict with the goals of the HELCOM conservation programme.

Maritime spatial planning

The purpose of the maritime spatial plan is to promote the sustainable development and growth of the different uses of the marine area; the sustainable use of natural resources in the marine area; and achieving a good state for the environment. In the maritime spatial plan, the Olkiluoto marine area is marked as a special area, and the precautionary action zone of the nuclear power plant must be taken into account in the planning of the surrounding marine areas. It is not estimated that the continued operation of the OL1 and OL2 plant units or the power uprating will cause any conflict with the maritime spatial plan of the southern Bothnian Sea.

Both the continuation of operations and the power uprating are feasible from the point of view of maritime spatial planning.

6.8.3.4. Significance of the impacts

The sensitivity of the sea area off Olkiluoto was estimated as moderate. The mixing conditions of the sea area are generally good, but the area receives nutrient loads from the river waters. Eutrophication and occasional low oxygen levels on the seabed can be observed in the area.

In continued operation (VE1), the operation of the OL1 and OL2 plant units will not change when compared to the current situation. Continued operation does not have an impact on the temperature or stratification conditions of the sea area that differs from the current state, and will not change the ecological or chemical status of the sea area. In case of continued operation, the thermal load of the cooling waters in the sea area will, however, continue. Together with the nutrient load coming into the marine area, the thermal load can promote eutrophication locally. Regardless, the effects of climate change on the warming of the sea area will be more significant than the effects of the thermal load of the cooling water. When the additional years of operation of the plant units are taken into account, the magnitude of the effects is estimated to be a minor negative. The possible expansion of the KPA storage is not estimated to have an effect different from the current one. As a whole, the significance of the effects of continued operation on the surface water is assessed to be a minor negative.

As a result of the power uprating (VE2), the temperature of the cooling water discharged into the sea rises by 1 °C when compared to the current situation. At a distance of approximately 2 km from the discharge point of the cooling waters, the power uprating increases the average seawater surface temperatures by 0.2°C and at a distance of 3–4 km by 0.1°C. The extent of the thermal load impact area does not change when compared to the current state. In the vicinity of the cooling water discharge point, the power uprating can occasionally amplify the temperature stratification of the sea slightly and, thus, reduce the exchange of water between the surface and bottom layers. In winter, the power uprating affects the ice-covered period only for a few days, and its effect cannot be distinguished from the yearly fluctuation. According to the modelling results, the effects of climate change on the seawater temperature, stratification and ice conditions in the Olkiluoto sea area are clearly greater than those of the thermal load of the cooling waters. Due to the combined effect of climate change and the nutrient load of the sea area, the thermal load of the cooling waters can locally promote the eutrophication of the sea area, which can have effects on the phytoplankton and benthic communities of the Iso Kaalonperä bay. However, in the long term, the power uprating is not expected to cause a change in the ecological status of the water bodies in the affected area. The development of the state of the sea area is essentially affected by the realisation of climate change scenarios and scattered-load measures. When the additional years of operation of the plant units are taken into account, the magnitude of the effects on the surface waters of the power uprating of the OL1 and OL2 plant units is estimated to be a minor negative. The possible expansion of the KPA storage and the increased amount of cooling water is not estimated to have an effect different from the current one. As a whole, the significance of the effects of the power uprating on surface water is assessed as a minor negative. (Table 37)

Table 37. Significance of the impacts: surface water.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Moderate	Minor negative	Minor negative
VE2	Moderate	Minor negative	Minor negative

6.8.4. Mitigation of harmful impacts

The impacts of the nuclear power plant units on the quality of the seawater off Olkiluoto and the biological environment of the sea area are monitored regularly in order to obtain up-to-date information on possible changes in the state of the sea area and to react to them, if necessary. In the environmental permit for the plant units, limit values are given in relation to the cooling water discharged into the sea. The limit values have been set in such a way that the operation of the power plant does not create significant harm to the sea area. According to the environmental permit, the thermal load from the cooling water to the sea may not exceed 205,000 TJ per year, and even after the power uprating, the load remains clearly below the limit value.

From December 2023, the wastewater from Olkiluoto has been directed to the wastewater treatment plant in Rauma. The concentrated processing of wastewater in a larger unit allows for its more efficient purification and reduces the load caused on the water systems. Reducing the nutrient load is key to achieving a good ecological state for the water bodies in the Olkiluoto sea area. The most significant part of the marine area's nutrient load comes from the Eurajoki river. The most effective measures include the measures taken in the river's catchment area, for example, reducing the nutrient load from agriculture.

The efficiency of the OL1 and OL2 plant units has been improved in the past, which has had a minor positive effect on the thermal load. The efficiency ratio can still be slightly improved in connection with future replacements of equipment.

6.8.5. Uncertainty factors

The assessment of the impacts of cooling water is based on modelling. The hydrological model is a compromise between descriptions of natural processes, accuracy in differentiation and the calculation time required by the model. The model includes the most common equations used in hydrological models affecting flows, convection and mixing, and in the most accurate model area, the horizontal differentiation accuracy was 40 m. Processes on a scale smaller than the differentiation accuracy or the internal distribution of flows and concentrations cannot be taken into account very precisely in the model. In addition to the simplifications of the model, the reliability of the model results is affected by the reliability of the model validation input data, such as meteorological data. Inaccuracies in local weather data also increase the uncertainty of the model. By choosing different simulation years, it was ensured that the possible future weather would be located between these extreme periods. The ice calculation in the model has been simplified in such a way that it does not take into account the movement of ice, so the phenomena resulting from this cannot be determined with the model. The simulated maximum winter ice thicknesses were similar to the ice observations, but, in general, ice is generated in the model over too large an area.

However, comprehensive observational data available from the sea area which could be used to assess the validity of the model were available from the sea area. Based on a comparison, the modelled values correspond fairly well to the temperatures measured in the sea area.

The effects on water bodies were evaluated over a long period of time, because if operation continues and the power uprating is implemented, the warming effect would continue until 2058 at most. The climate change scenario with the strongest warming, i.e. a situation where greenhouse gas emissions are not limited at all, has been used in the modelling. Regarding the resulting seawater temperatures, the uncertainty is related to the realisation of the climate change scenarios and the uncertainty involved in different scenarios. It is difficult to predict the exact effects of climate change in the long term. With climate change, it is estimated that precipitation will increase, which can lower the salinity of seawater. The average sea level is also estimated to rise, but in the Bothnian Sea, land uplift may negate the effect of the rising water level. Increasing runoff can also increase the amount of solid matter washed from the land into the sea, which can contribute to the eutrophication of the marine area.

The effects of continued operation and power uprating have been compared to the effects of climate change. A scenario was chosen for the modelling in which the effects of climate change on the warming of the sea area are accentuated (SSP5-8.5). If the effects of the operation of the plant units had been compared to a less conservative scenario, the effects of the plant could be more significant when compared to climate change, but, overall, there would be clearly less warming in the seawater.

The assessment of the effects on the sea area's temperature, phytoplankton, aquatic vegetation and benthic fauna involves uncertainty, as the development of primary production in the sea area depends on the realisation of both climate change scenarios and load-reducing measures. It is also not possible to predict the spread of alien species in the sea area, so there is uncertainty in assessing the effects.

6.9. Fish stocks and fishery

6.9.1. Initial data and assessment methods

Fishery monitoring reports created for the Olkiluoto sea area have been utilised while assessing the impacts targeting fish stocks and fishery. Fish stocks and fishery in the sea areas near the Olkiluoto power plant have been monitored since the 1980s. The latest fish stock analyses in the sea area off Olkiluoto were implemented in 2020–2023 (commercial fishing, catch records and recreational fishing), 2022 (catch records, test fishing with nets and age and growth analyses for fish) and 2023 (commercial fishing).

The impact assessment also utilised cooling water monitoring which determines the number and biomass of fish and fingerlings carried into the power plant with the cooling water. The juvenile habitats for fish in the Olkiluoto sea area were examined on the basis of the underwater biodiversity inventory programme (VELMU). The impact assessment also utilised studies into the power plant's screenings, i.e. the solid matter recovered from cooling water, and the physico-chemical monitoring studies of the Olkiluoto sea area. In addition, public documentation from the Ministry of the Environment's administrative branch regarding fish stocks and fishery in the Bothnian Sea as well as scientific publications on the fish stock impacts of thermal loads and the impacts of invasive alien species outside of the project area were utilised.

The assessment of the impact targeting fish stocks and fishery also utilises the results from the impact assessment targeting surface waters (see chapter 6.8), including the cooling water modelling (Appendix 5). The indirect impacts that the activities with an impact on the quality of water would have on the fish and fishery have been assessed in the form of an expert assessment to a distance of approximately 10 km from the site area.

6.9.2. Current status

6.9.2.1. Fish stocks

Fish stocks and fishing in the sea area off Olkiluoto are monitored as part of the nuclear power plant's environmental monitoring. The fishery monitoring methods used are test fishing with nets, age and growth measurements for fish, catch records and fishing surveys aimed at commercial and recreational fishers *(KVVY Tutkimus Oy 2022a & 2023b)*. Coastal test fishing with nets has been performed in three different fishing areas: near the cooling water intake and KPA storage cooling water discharge area (fishing area 1), near the discharge point for cooling water and treated wastewater for the OL1 and OL2 plant units (fishing area 2) and in a reference area which is not targeted by the impacts of cooling water extraction or discharge (fishing area 3) (Figure 53). Test fishing with nets has been performed in the same areas in 2010, 2014, 2018 and 2022.

In 2022, the caught species included perch, ruffe, pikeperch, roach, white bream, bleak, bream, dace, Baltic herring, pike, powan, three-spined stickleback, greater sandeel, smelt, eelpout and round goby. In terms of biomass, perch was the most abundant species in all fishing areas during the test fishing with nets in 2010, 2014, 2018 and 2022. In 2022, roach was the second most abundant species of fish. When examining the catch in the cooling water discharge area in terms of numbers, fishing area 2 had substantially larger catches of perch than fishing areas 1 and 3. There was no statistically significant difference in the numbers of perch caught between the different fishing areas, but the share of perches classified as predatory fish (>15 cm in size) was clearly smaller in the reference area than in the other two areas. *(KVVY Tutkimus Oy 2023b)*

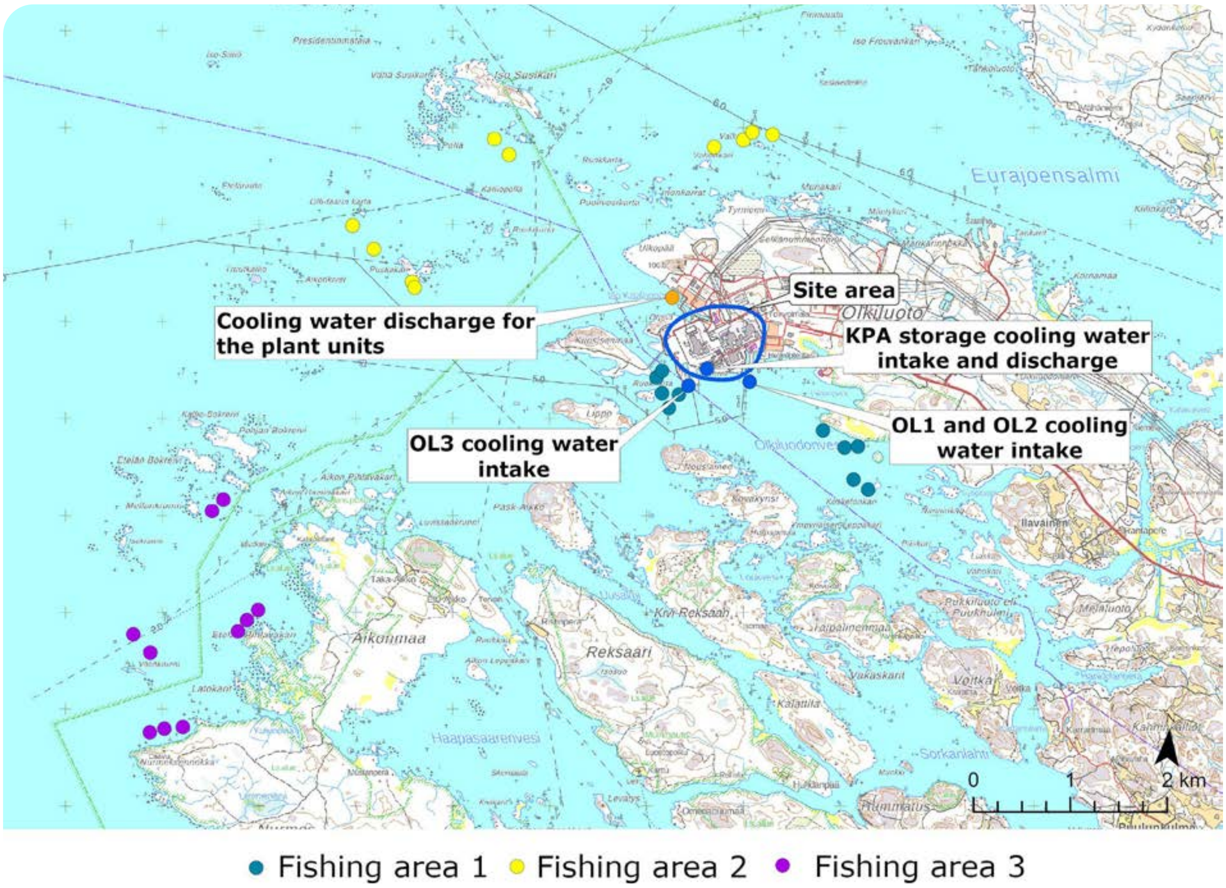


Figure 53. Test fishing with nets has been undertaken in three different fishing areas. The figure presents the net locations for the Coastal test fishing performed in the various fishing areas. (KVVY Tutkimus Oy 2022a & 2023b)

Based on the modellings presented in the map service for the underwater biodiversity inventory programme (VELMU), the area off Olkiluoto and near the power plant houses favourable and very favourable juvenile habitats for perch, smelt, Baltic herring and goby. The very favourable juvenile habitats for perch and smelt are located in the sheltered bay areas, while habitats for goby are spread more widely across the sea area. The sea area off Olkiluoto is also a favourable juvenile habitat for Baltic herring, but the very favourable juvenile habitats are located clearly further from the coast.

Juvenile habitats for trout, salmon and powan have been observed in the lower and middle reaches of Eurajoki, which runs into Eurajoensalmi to the north of Olkiluoto *(Ministry of the Environment's Administrative Branch 2024b, Eurajoki water protection association 2024)*. In order to revive the populations of migratory fish in Eurajoki, migratory whitefish, sea trout and salmon have been planted in the area *(Sähköinen istutustietojär-jestelmä 2024)* and the river has undergone restorations of rapids; fish passages have also been constructed where barriers exist for fish running.

The amount of fish and fingerlings carried into the power plant with the cooling water from the inlet water channels has been analysed by collecting samples from the screenings scavenging ducts at the seawater plants of all plant units *(Teollisuuden Voima 2024a)*. At the OL1 and OL2 plant units, a strainer plate is used to collect fish samples, while a strainer plate basket is used at the OL3 plant unit. In 2023, a plankton net was used to catch fingerlings of less than 1 cm in size and samples were taken from the inlet water channels of the OL1, OL2 and OL3 plant units. At the OL1 and OL2 plant units, the lengths of fish carried into the power plant varied between 1.1 cm and 50.8 cm. The smallest fish were goby fingerlings, while the largest were adult pikes. In addition to gobies, the samples contained fingerlings for Baltic herring, sticklebacks and smelt, but they were typically more than 2 cm in length. Very few of the fingerlings carried into the inlet water channels were less than 2 cm in length. Fingerlings of less than 1 cm in length were not observed during a separate catch for fingerling samples, either. Therefore, it is possible that the inlet water channel has very few sheltered habitats that are suitable for use as hiding places and feeding for small fish fingerlings, and fish are not using the cooling water intake area as a spawning area due to its lack of protection and sparse vegetation. On the other hand, fingerlings of less than 1 cm in size may be caught by other fish before they are carried into the power plant's water intake structures, which will make them undetectable in the samples.

6.9.2.2. Fishery

Based on the fishing survey targeting recreational fishers, 113 households engaged in fishing off Olkiluoto in 2021. Their total catch was an estimated 16,250 kg, consisting mainly of perch (47%), pike (14%) and powan (10%). The other reported species caught were roach, bream, orfe, Baltic herring, burbot, trout, salmon and pikeperch. The catch per household was 144 kg, the largest in monitored history. According to recreational fishers, factors disturbing fishing included an excess number of cormorants and seals, abundance of aquatic vegetation, rapid soiling of nets and the clouding of water. *(KVVY Tutkimus Oy 2022a)*

In 2020 and 2021, the monitoring of fishery comprised catch records from fishers in the sea area off Olkiluoto, a fishing survey aimed at recreational fishers and an interview with a commercial fisher operating in the area in 2021. Furthermore, four fishers kept a record of the nets used and their amounts, the duration of the catch, the fishing area and the fish caught. Most of the fishing took place in the intake area for cooling water used at the Olkiluoto power plant (fishing area 1). During all the years on record, perch was commercially the most important species and also the one caught in the most numbers (Table 38). *(KVVY Tutkimus Oy 2022a)*

Based on the catch information received, commercial fishing in the Olkiluoto area in 2018–2022 mostly took place using passive gear, such as fykes and nets. If trawling were engaged in, the catch share of Baltic herring and Baltic sprat would be substantially higher when compared to the shares of pike, roach, perch and powan, for example. Based on catch information, powan is a commercially significant species of fish in the area. The catch also includes some salmon and trout. *(Natural Resources Institute Finland 2024c)*

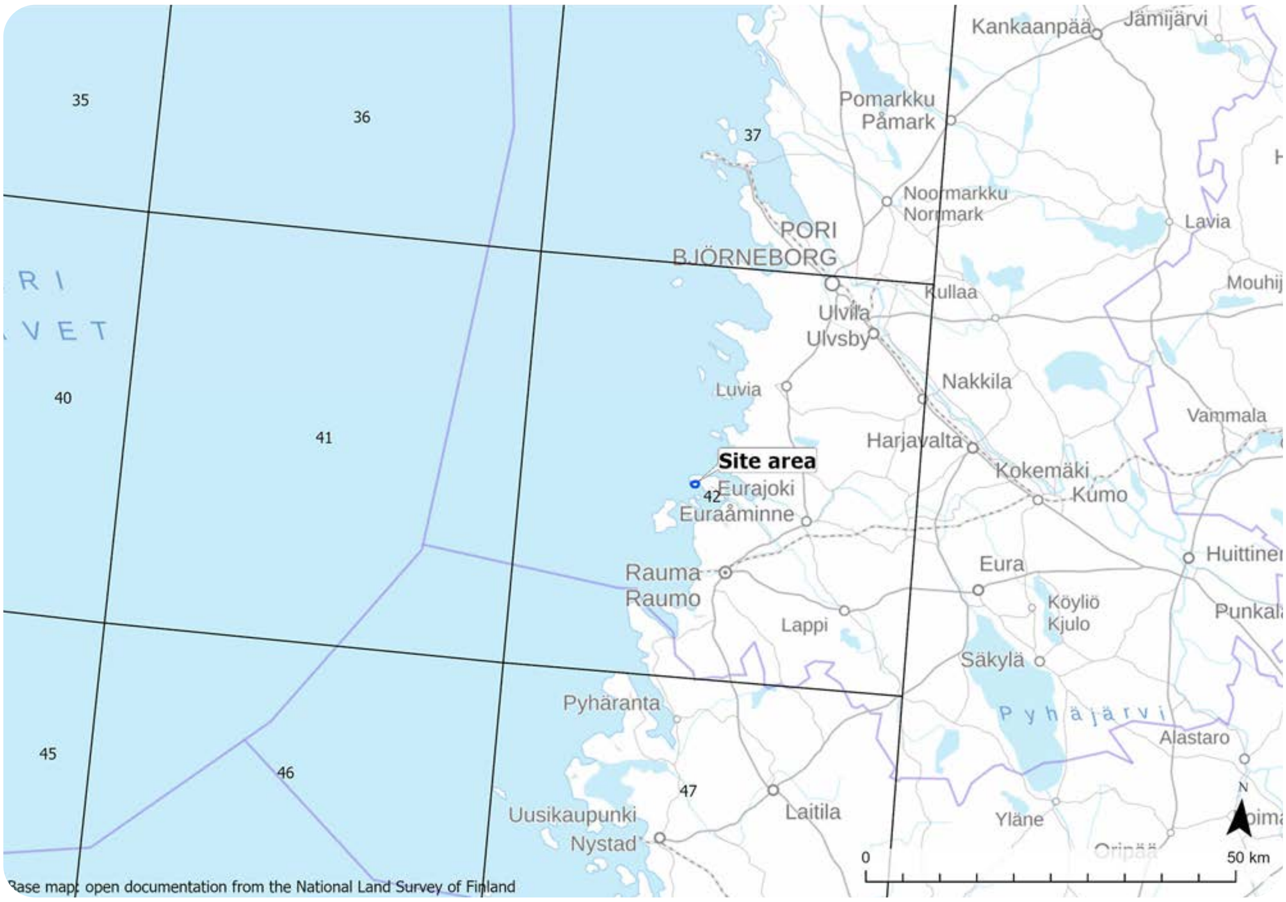


Figure 54. The sea area in front of Olkiluoto is located in ICES fishing rectangle 42, and the total catch for commercial fishing in 2018–2022 for this rectangle is presented in the enclosed table (Table 38).

Table 38. Total catch for Finnish commercial fishery in ICES fishing rectangle 42 during 2018–2022 (1,000 kg). (Natural Resources Institute Finland 2024c)

Year	Total	Baltic herring	Baltic sprat	Powan	Salmon	Trout	Smelt	Bream	Orfe	Roach	Pike	Perch	Pike-perch	Other
2018	469	412	0	6	5	1	2	4	1	13	3	20	2	1
2019	320	267	0	7	5	1	1	4	1	12	4	17	1	0
2020	937	870	0	10	6	1	1	3	0	23	4	10	1	9
2021	366	313	0	9	5	1	3	4	1	13	3	12	1	2
2022	532	483	2	10	5	0	1	3	0	8	2	16	0	1

In 2023, one full-time commercial fisher operated in the sea area off Olkiluoto, as was the case in 2021, 2019 and 2017. In 2023, commercial fishing took place almost all year long, and it utilised fyke nets, herring nets and nets with mesh sizes of 30–60 mm. In 2023, there were a total of 4,643 net days; the number was clearly lower than in 2021 when there were a total of 11,581 net days. In 2023, nets were used for fishing 65% of the time and most of the catch was also caught using nets. In 2023, the total catch was 6,960 kg and slightly higher than two years earlier, even though the fishing effort was now substantially lower. The most common species caught in 2023 was perch, of which the fisher caught a total of 3,390 kg. Other significant species caught in 2023 were roach and pike. The catch of Baltic herring was low due to a low amount of fishing. Roach was the most plentiful species of fish caught by the fisher in 2017, 2019 and 2021. It is also noteworthy that the professional fisher has not recorded trout or salmon in their catch since the monitoring in 2009. In the interview with the professional fisher operating in the Olkiluoto sea area, the population of cormorants was brought up as the largest detrimental factor. The cloudiness of the water and lush aquatic vegetation also made fishing difficult at points. The soiling of the nets has clearly increased in comparison to previous years. When asked about the detrimental impacts to fishing, the fisher did not bring up any matters that could be unambiguously linked to the power plant's impacts. *(KVVY Tutkimus Oy 2024b & 2022a)*

6.9.2.3. Sensitivity of the affected aspect

The sensitivity of fish stocks and fishery as an affected aspect was estimated on the basis of the fish populations occurring in the area and the placement of the spawning areas in relation to the site area and the fishing being undertaken in the area. The area is home to species of fish that are typical of the Baltic Sea and not significantly different from fish populations occurring elsewhere. The vicinity of the power plant houses favourable and very favourable juvenile habitats for species of fish that are found in Finland's sea areas, such as perch, smelt and goby. The area has no important spawning area and the status of the commercially utilised fish stocks in the project area is at a sustainable level. The area features some commercial fishery and an amount of recreational fishery. The sensitivity of the affected aspect is estimated to be moderate.

6.9.3. Environmental impacts

6.9.3.1. Continuing operation

Impacts during construction

Any possible construction work will not impact the surface waters or, thereby, the fish stocks and fishery. The following describes the impacts which the service life extension of the OL1 and OL2 plant units would have during operation.

Impacts of cooling water intake on fish stocks and fishery

The intake of cooling water for the OL1 and OL2 plant units causes a northbound flow near the mouth of the water intake tunnel. During the monitoring performed in 2023–2024, cooling water carried a total of 15.4 ± 7.1 t of fish per year into the OL1 and OL2 plant units (*Teollisuuden Voima 2024a*). 95% of the fish carried into the plant units weighed less than 3 g. Of the fish carried into the seawater plant of the OL1 plant unit, most were three-spined sticklebacks, nine-spined sticklebacks and gobies weighing less than or equal to 3 g. At plant unit OL2, for its part, most fish were three-spined and nine-spined sticklebacks weighing less than 3 g as well as smelt and Baltic herring fingerlings. The vast majority of fish carried into both plant units were three-spined sticklebacks, a species that is not subject to recreational or commercial fishing. However, the three-spined stickleback, similarly other fingerlings carried into the plant units that are not commercially utilised for fishing, constitutes a significant part of the food web and acts as food for larger predatory fish which are desirable catches for recreational fishers.

Fish being carried into the seawater plants of the OL1 and OL2 plant units may have a minor reducing effect on the recreational fishing catch in the cooling water intake area. Over time, the elimination of fingerlings being carried into the plant units may also have a somewhat negative impact on the spawning of fingerlings in the area. However, the impact is limited to Olkiluodonvesi near the cooling water intake area, since fingerlings carried into the plant units mostly originate from the juvenile habitats in nearby areas due to their limited swimming ability. Further away from the water intake area, the potential for spawning is also regulated by mechanisms other than the number of recruits from the Olkiluodonvesi area, such as the predation pressure caused by predatory fish and fishing, the amount of nutrition and mutual competition. Fish being carried into the plant unit may cause detriments for local recreational fishing in the form of reduced catches; however, determining the magnitude of the impact is challenging. Catches are impacted by various factors such as weather conditions, the fishing methods applied and spawning during earlier years, where variation between species will occur even due to reasons not attributable to human activities.

In the Coastal net test fishing performed in 2010, 2014, 2018 and 2022, the averages for the annual total perch caught were almost the same on the cooling water intake side (40 pcs/net) as on the cooling water discharge side (40 pcs/net) and higher than in the reference area (28 pcs/net). The average per test net of predator-sized perch, over 15 cm in size, for these same years was also higher on the cooling water intake side (18 pcs/net) than in the cooling water discharge area (15 pcs/net) or in the reference area (12 pcs/net) *(Ministry of the Environment's Administrative Branch 2024b)*. The numbers of individual fish caught in the net test fishing do not allow for drawing the direct conclusion that cooling water intake would not have a reducing impact on the potential catches in the area, since the fish stocks and the structures of the population may naturally differ from each other. Based on the result, however, the opportunities for fishing on the cooling water intake side are no worse than in the surrounding sea areas in terms of potential catch.

The effect of the intake of cooling water on fish is local and minor as a whole, and it is estimated to be insignificant in terms of commercial fishing. For local recreational fishing, the reduction in fingerlings caused by cooling water intake may be visible as reduced catches when compared to the time period preceding the operation of the plant unit. Continuing the operation will not change the present state, but the current reducing impact on fish volumes will continue further into the future. Due to the temporal extension of the impact, the change caused by cooling water intake on fish stocks and fishery is assessed to be a minor negative.

In the case of a potential expansion of the KPA storage, the volume of cooling water extracted for the KPA storage will increase by approximately 50%, which will also strengthen the flow at the mouth of the water intake pipe. Water flows into the KPA storage water extraction system through a screen, which means that no fish are able to enter the system. Therefore, water intake into the KPA storage will not have any impacts on fish stocks.

Impacts of cooling water discharge on fish stocks and fishery

In the Iso Kaalonperä bay, where cooling water is discharged, eutrophication can be observed in the current state (chapter 6.8). The structure of the fish stocks also indicates eutrophic conditions, since cyprinids are much more dominant species near the discharge area and the number of predatory perches (≥ 15 cm) and other predatory fish is much lower than in the cooling water intake area *(Ministry of the Environment's Administrative Branch 2024b)*. On the other hand, pike has been observed to be more abundant near the discharge area. The impacts on fish stocks are limited to a distance of approximately 3 km from the discharge area, to the east of Iso Susikari, Püllä and Puskakari. The fishery being engaged in within the area of impact is minor in scale. In 2021, one of the fishing areas for the only commercial fisher operating in the sea area off Olkiluoto was located between Iso Susikari and Olkiluoto *(KVVY Tutkimus Oy 2022a)*.

During the extension of the operation of the OL1 and OL2 plant units, cooling water will be warmed up by approximately 10°C in the process and water will be discharged back into the sea to the west of Olkiluoto, in Iso Kaalonperä bay, as is also done currently. Continued operation of the OL1 and OL2 plant units does not have an impact on the temperature or stratification conditions of the sea area that differs from the current state. The continued operation of the plant units will not change the ecological or chemical state of the sea area. Overall, the concentrations of harmful substances in the power plant's cooling water are very low and correspond to natural background concentrations (see chapter 6.8.2.6). of radioactive substances are discussed in chapter 6.16. Process waste water is not estimated to cause impacts on fish stocks or fishery. The impacts on fish stocks that result from changes in water quality, water temperature and oxygen conditions will remain as they are; however, climate change may strengthen these impacts in the long term.

The temporally extended thermal impact caused by extending the operation of the power plants, together with the added impact brought about by climate change, may result in a situation that favours species of fish that are adapted to warmer water. Species that spawn in the spring and summer, such as perch, pikeperch and cyprinids, will benefit from an increase in water temperatures at the cost of the salmoniforms, such as powan and trout, which are accustomed to cooler, oxygen-rich waters.

Increased water temperature will accelerate metabolism in fish and increase their need for nutrition. Generally speaking, high temperatures are assumed to increase fish growth unless other factors limiting growth occur *(Balkuvienė & Pernaravičiūtė 1994, Hakala et al. 2003, Marttila et al. 2005, Keskinen et al. 2011)*. An increase in temperature may also increase stress levels in fish, since parasites and diseases become more common when temperatures increase. It is likely that fish populations in the cooling water discharge area will continue to be more dominated by cyprinids, and that it will remain a more unfavourable living environment than the surrounding sea area for salmoniforms such as trout and powan, which favour cooler water.

The warming of the water system, strengthened by climate change, may contribute to invasive alien species such as round goby spreading and becoming more abundant in the sea area. In the monitoring of fishery for the sea area off Olkiluoto, round goby was observed for the first time in 2018. In 2022, round gobies amounted to 2.8% of the number of individual fish in the total catch from the cooling water discharge area, which is slightly lower than in the reference area where the figure was 5.5% *(KVVY Tutkimus Oy 2023b)*. The round goby competes with indigenous species and may cause a decline in the other species of goby, thereby changing the structure of the fish stocks. The round goby has good temperature tolerance (-1–30°C) *(Moskalkova 1996)*. On the other hand, pikeperch may feed on round gobies, for example. In practice, the round goby has spread across the entire Finnish coast up to the Bay of Bothnia, and it may be considered an established invasive species. The round goby is likely to further increase in numbers across the entire coast of the Bothnian Sea, regardless of the operation of the Olkiluoto nuclear power plant. However, it is possible that the local warming of sea water caused by the warm cooling water will also cause a local abundance of round goby in the cooling water discharge area. The cooling water discharge area may also act as a suitable spreading area for other invasive species, but the spreading of potential species into the Olkiluoto sea area is difficult to predict.

The discharge of cooling water from a nuclear power plant may be estimated to cause minor local detriment to fishing, as the share of predatory fish from the catch will be lower near the discharge area when compared to the surrounding sea area. If the operation continues, the same impact will last for longer. The ice situation in the Olkiluoto sea area naturally varies a lot from year to year. In mild winters, the sea area of Olkiluoto remains completely thawed. In typical winters, Olkiluodonvesi freezes around the cooling water intake channels, but the cooling water discharge side remains thawed. The continued operation of the OL1 and OL2 plant units is not estimated to have any impact on the ice conditions in the Olkiluoto sea area, which are estimated to remain as they are now (chapter 6.8.2.5, 6.8.3.1). It is estimated that the high variability between one winter and the next will continue to be an inherent feature of the ice conditions. Therefore, fishing opportunities during the winter season are also estimated to remain at the present level.

When operation continues, the impacts of cooling water from the plant units on the nearby sea area and, thereby, on fish stocks and fishery will remain as they are but continue for longer. Climate change may strengthen the impacts of the thermal load concentrated in the affected area. In the current state, the fish populations in the cooling water discharge area have been found to be more dominated by cyprinids than the cooling water extraction area or the reference area; it can be assumed that the environmental conditions will favour cyprinids for as long as the operation continues. Due to the prolongation of the current impacts on the fish stock, the impacts on fish stocks and fishery during the operation are estimated to be a minor negative.

A possible expansion of the KPA storage will increase the volume of cooling water discharged from the storage. The temperature of the discharged water will remain the same as it is currently. According to an assessment of the surface water impacts, the volume of cooling water at the KPA storage is very low when compared to the cooling water volume discharged from the OL1 and OL2 plant units, and its impacts on sea water temperature are minor and local. A minor increase in the volume of cooling water is not estimated to have impacts on fish stocks that differ from the current status.

6.9.3.2. Power uprating

Impacts during construction

Any possible construction work will not impact the surface waters or, thereby, the fish stocks and fishery. The following describes the impacts which the service life extension and power uprating of the OL1 and OL2 plant units would have during operation.

Impacts of cooling water intake on fish stocks and fishery

The power uprating will not change the volume of cooling water extracted from the sea for the OL1 and OL2 plant units when compared to the current state. Therefore, the impacts of cooling water extraction on fish stocks and fishery will remain as they are and correspond to the impacts of continued operation, which are described in chapter 6.9.3.1. When considering the long duration of the continued operation, the magnitude of the impacts is estimated to be a minor negative.

In the power uprating case, the volume of cooling water required by the KPA storage will increase by 10% and, with a potential expansion of the storage, the need for cooling water will increase by 50%. However, this will not have an impact on fish stocks, since fish are not carried into the water extraction system.

Impacts of cooling water discharge on fish stocks and fishery

In the power uprating, the temperature of the cooling water routed into the sea from the plant units will increase by approximately 1°C when compared to the current operation or continued operation. The volume of cooling water being routed into the sea will remain similar to the current operation (38 m^3/s per plant unit). According to a water system model, the power uprating will increase seawater surface temperatures by an average of 0.2°C at a distance of 2 km and 0.1°C at a distance of 3–4 km from the cooling water discharge point. The impacts from the thermal load are, therefore, local and limited to the vicinity of the discharge flow. In practice, temperature changes smaller than 0.5°C cannot be distinguished from the natural temperature variation of the sea area.

According to an estimate on surface water impacts, the power uprating may amplify the temperature stratification in the sea during the summer on sea areas near Olkiluoto. Heavier stratification may reduce the circulation of water between the benthic and surface layers, which may, in turn, have an indirect impact on fish stocks through a degradation of the oxygen conditions in the hypolimnion layer, for example. The magnitude of the effect of the thermal load caused by the power uprating and the extent of the affected area do not significantly change when compared to the present state, so the effects on fish stocks will also remain as they are.

In the power uprating case, the thermal load of the cooling waters may advance the eutrophication of the sea area. However, the magnitude of the impact of the eutrophication and the size of the affected area will remain as they are, so the impacts on fish stocks and fishery will also correspond to the impacts observed in the present state. In the current state, the fish populations in the cooling water discharge area have been found to be more dominated by cyprinids than the sea area surrounding it, and it can be assumed that the environmental conditions will favour cyprinids in the Iso Kaalonperä area for as long as the operation of the nuclear power plant continues. Similarly to previous years, the invasive alien species round goby is also estimated to become more abundant in the Olkiluoto area regardless of human activity, but the power uprating of the plant units may do its part in promoting the spreading of the species in the area off Olkiluoto.

The impact of warm cooling water will generally favour *species of fish adapted for warmer water, such as cyprinids and pikeperch. In the current state, test fishing (Ministry of the Environment's Administrative Branch 2024b)* has revealed that cyprinids have become more abundant in the cooling water discharge area, at the cost of larger predatory fish, which will also have a negative impact on fishing in the area. An increasing thermal load may potentially affect fish stocks by increasing the domination of cyprinids even further or by increasing opportunities for the reproduction of the invasive alien species round goby in the area, or it may degrade opportunities for fishing in winter by reducing the length of ice cover in the affected area. Warm discharge water has also been estimated to potentially cause detrimental impacts on fish that are attributable to stress on their metabolism and an increase in parasites and diseases. However, a study performed at Forsmark nuclear power plant in Sweden did not observe increased occurrences of diseases or parasites in the local fish populations *(Sandström 1990)*.

Based on modelling results, the power uprating will affect the ice conditions in the sea area by reducing the time of ice cover by an average of 2 days, which will have minor negative impacts on opportunities for winter fishing. Climate change, for its part, will reduce the time of ice cover by several weeks by 2058.

According to a water system modelling (Appendix 5), climate change has a clearly greater impact on the rise in seawater temperature than the operation of the power plant. The joint impacts of climate change and power uprating on the temperature and stratification conditions as well as ice conditions are described in chapter 6.8.3.2. The magnitude of the impacts caused by cooling water discharge on fish stocks and fishery is estimated to be a minor negative.

In the power uprating and potential KPA storage expansion case, the temperature of the KPA storage cooling water discharged into the sea will not increase from the present level, but the volume of water will increase. However, the amount is very small when compared to the amount of cooling water discharged from the OL1 and OL2 plant units. The effects of the cooling water discharge from the KPA storage are minor and local, and the increased amount of cooling water is not estimated to have an effect on fish stocks that differs from the current one.

6.9.3.3. Significance of the impacts

The sensitivity of the fish stocks and fishery in the Olkiluoto sea area has been estimated to be moderate since, while species of fish that are typical of the Baltic Sea are encountered in the area, favourable or very favourable juvenile habitats for some species occur in the vicinity of the power plant. The area features some commercial fishery and an amount of recreational fishery.

In the continued operation alternative (VE1), the amount of cooling water extracted, the temperature of the cooling water routed into the sea and the flow will not change and, therefore, no impacts that differ from the current status will target fish stocks and fishery. The potential expansion of the KPA storage will also not change the impacts on fish stocks, since the increase in cooling water amounts will be minor. The current impacts on the nearby sea areas, such as the potential increased domination of cyprinidss jointly brought about by the cooling water's thermal load, the nutrient load from the rivers and climate change, will continue. The elimination of fish stocks caused by the extraction of cooling water will also continue with the additional years of operation. Due to the prolongation of the current impacts on the fish stock, the impacts on fish stocks and fishery are estimated to be a minor negative.

In the power uprating (VE2) case, the thermal load in the cooling water will be higher than at present, but the increase in water temperature will be limited to the vicinity of the discharge flows and the size of the affected area and the magnitude of the impact will remain at the present level. A power uprating does not increase the need for cooling water extraction, so the carrying over of fish into the plant units on the Olkiluodonvesi side will have a similar impact as in the continuing operation case (VE1). The increase in cooling water amount in the KPA storage will be minor, and it is not estimated to cause impacts on fish stocks that differ from the current situation. Overall, the magnitude of the impacts of power uprating on the fish stocks and fishery in the area has been estimated to be a minor negative.

For both alternatives, the significance of the impacts has been estimated to be a minor negative (Table 39).

Table 39. Significance of the impacts: fish stocks and fishery.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Moderate	Minor negative	Minor negative
VE2	Moderate	Minor negative	Minor negative

6.9.4. Mitigation of harmful impacts

The impacts targeting fish stocks are the result of the thermal load caused by routing cooling water into the sea and the fish deaths caused by cooling water extraction. The mitigation of surface water impacts is described in chapter 6.8.4. In practice, the impacts of eutrophication on fish stocks cannot be mitigated. The fish stock impacts of cooling water from the power plant are compensated by means of an annual fishery fee that is used towards planting fish in the area, among other things. As regards fish stocks, the invasive alien species round goby will become more abundant in Finnish sea areas regardless of the implementation of the project, and the spreading of the species cannot be prevented by means of technical solutions. As a result of the thermal load from the cooling water, other invasive alien species may spread into the area that may affect the food webs and the structure of the fish stock. In the current status, the entry of larger fish into the plant unit with the cooling water intake is prevented by means of a coarse screen (100 mm mesh) at the mouth of the tunnel leaving the channels; this is the smallest technically feasible screen mesh size.

6.9.5. Uncertainty factors

Uncertainties related to the impact assessment of the physical and chemical state of the sea area and the aquatic life also affect the reliability of the estimated impact on fish stocks. The assessment also involves uncertainty due to the uncertainty related to impacts caused by climate change. The sea water temperature in the project area is estimated to increase due to climate change, but there is no certainty regarding the amount of the increase. Furthermore, there is uncertainty related to the ecosystem impacts caused by the spreading of round goby, for example. The interaction processes between species are complicated and difficult to predict. Generally speaking, it may be difficult to distinguish changes occurring further away (> 1 km) from the discharge area from changes caused by climate change even by measuring them, and assessing them in advance is also uncertain.

The fish stock analyses used as the basis of the assessment, such as test net fishing, also involves uncertainty, and chance may affect the catch amounts observed each year. The estimate on the mass of fish carried into the OL1 and OL2 plant units with the cooling water is based on an estimate of total mass created on the basis of systematic sampling and its 95% level of confidence, so the result mostly provides an indicative magnitude of the amount of fish carried into the plant units. In spite of these uncertainty factors, the analyses are usable as a basis for the impacts assessment.

6.10. Flora, fauna and conservation areas

6.10.1. Initial data and assessment methods

The impact assessment has involved describing the current status of the natural environment in the area and preparing an expert assessment on the impacts which the project may have on flora, fauna, habitats, endangered and noteworthy species and Natura 2000 areas, nature reserves and other locations of interest in terms of nature. Impacts were also examined as regards biodiversity and interactions between species.

The impacts on flora, fauna and conservation areas were examined from as extensive an area as the impacts were estimated to reach. The impact assessment examined analyses performed in the area, such as the biodiversity analysis *(Ramboll 2014)* as well as the nature surveys and results from the bird counts conducted in connection with it, and data available from public sources, the most important of which included the databases of the Ministry of the Environment's administrative branch and the Finnish Environment Institute as well as data from the BirdLife Finland association on important bird areas (FINIBA and IBA), and other reports on bird areas deemed to be regionally important. In addition, the assessment has utilised, among other things, the results from the noise, dust and traffic impact assessments and the impact assessment targeting surface waters, including the results from the cooling water modelling (Appendix 5).

As regards impacts affecting the sites of the Natura 2000 network, it has been assessed whether there may be significant impacts on the natural values that form the basis for the protection of the nearest Natura areas. As regards other nature reserve and nature conservation programme sites, it has been assessed whether there are significant impacts in terms of the sites' conservation objectives. Impacts affecting Natura 2000 areas and nature reserves were assessed by utilising existing data on habitat types and species that form the basis for the protection and, in particular, results from the impact assessment targeting surface waters. In connection with the assessment, a report was drawn up on the necessity of a Natura assessment pursuant to Section 35 of the Nature Conservation Act (9/2023) for the Rauma archipelago Natura area (Appendix 6).

6.10.2. Current status

6.10.2.1. Vegetation and animals

General description of terrestrial habitat types and vegetation

The site area is located on Olkiluoto Island, which has an area of approximately 900 ha and is located in the south boreal vegetation zone. The sea area surrounding Olkiluoto is part of the archipelago and sea area of the Bothnian sea, which is characterised by rapid land upheaval in the coastal areas and distinct zones in the shore vegetation.

Part of Olkiluoto Island has been heavily modified by human activity, but several natural habitats occur in the unconstructed areas. According to the latest biodiversity analysis covering the entire Olkiluoto Island *(Ramboll 2014)*, approximately 50% of the forests on the island are fresh heaths of the Vaccinium myrtillus type (MT), 20% are grovelike heaths of the Oxalis-Myrtillus type (OMT) and 20% are rather dry heaths of the Vaccinium vitis idaea type (VT). The island also has smaller areas of dry heaths of the Calluna type (CT), rocky soil and groves, which are mainly alder- and spruce-dominated, moist and fresh coastal groves. Most of the island's forests are intensively managed commercial forests. The noteworthy forest locations on the island's land areas are the black alder meadow of Flutanperä, the old-growth forest of Kornamaa and the Liiklankari nature reserve. The island also has a small area of open bog with few trees, which is a habitat of special importance under Section 10 of the Forest Act. At Olkiluoto, old-growth forest patterns are, at present, mainly found only in Liiklankari and Kornamaa.

The endangered alternateleaf archidium moss *(Archidium alternifolium)* and luminous moss *(Schistostega pennata)* have been found in the Liiklankari nature reserve, but no observations of endangered species have been made in the Tyrniemi area or its immediate surroundings *(Finnish Biodiversity Info Facility 2024)*.

Known threatened species in the Olkiluoto coastal zone include the endangered (EN) chaffweed *(Anagallis minima)* and the vulnerable (VU) fourleaf mare's tail *(Hippuris tetraphylla)*, which is a species listed in Annex IV(b) to the Habitats Directive and among the species for which Finland has a particular international responsibility. In the Olkiluoto area, chaffweed habitats are known in the Liiklankari nature reserve. Chaffweed and fourleaf mare's tail have last been found on the island 30 years ago, although inventories of them were taken also in 2013 *(Ramboll 2014)*. However, the coastal meadows and semi-open shallow coves favoured by fourleaf mare's tail can still provide a habitat for the species.

In the vicinity of the planned location of the battery energy storage system for the power uprating is young (under 45 years) fresh heath forest of the Vaccinium myrtillus type *(Ramboll 2014, MS-NFI 2021)*, which is not suitable as a flying squirrel habitat based on forecast maps *(Natural Resources Institute Finland 2024a)*. Based on the Corine Land Cover data *(Ministry of the Environment's Administrative Branch 2018)*, the tree stand in the immediate surroundings of the planned battery energy storage system area is sparse, predominantly coniferous area on mineral soil (canopy cover 10–30%). Further away from the planned location of the storage system is rocky pine forest, grove-like heaths and fresh mesotrophic groves *(Ramboll 2014)*. The immediate surroundings of the planned battery energy storage system location are not in their natural state and the site has gravelly soil modified by humans, with predominantly deciduous saplings and tall grass growing there in the early stages of succession. The planned ground cable route is also located in the site area, in an environment modified by humans.

Fauna of land areas

The Olkiluoto area has a relatively strong population of game animals, but not many noteworthy species of mammal. The island only has a few areas suitable for the flying squirrel. The database of the Finnish Biodiversity Info Facility (2024) contains no reported observations of species listed in Annex IV(a) to the Habitats Directive, such as the moor frog, flying squirrel or bats, in the site area or its immediate surroundings in the western parts of Olkiluoto Island.

In the southeastern part of the island, the most recent observation of the clouded Apollo *(Parnassius mnemosyne)* is from 1999; it is classified as vulnerable (VU) and is one of the species listed in Annex IV(a) to the Habitats Directive. No observations of the clouded Apollo were made in connection with the 2013 inventory, but habitats suitable for the species as well as *Corydalis solida*, a food plant used exclusively by its larvae, were still found on the island *(Ramboll 2014)*. Habitats suitable for the clouded Apollo were found in the eastern parts of Olkiluoto Island. *Corydalis solida*, a food plant suitable for the clouded Apollo, was found in the grass in the project area next to the parking area and, as a conservation measure, the area will not be mowed *(Saralehto 2023)*. Suitable habitats are not located in the site area or its immediate surroundings.

Aquatic vegetation

The macrophytes, i.e. aquatic vegetation and macroalgae, of the sea area near Olkiluoto have been surveyed regularly during the operation of the power plant, and the most recent surveys by means of transect line diving were carried out in 2016 and 2022 *(Leinikki 2017 & 2022)*. Surveys are conducted on six lines (B-G), of which lines B, C and D are located in the area of impact of the cooling water discharge flow (Figure 55). The monitoring line closest to the mouth of the cooling water discharge channel was excluded from the surveys already in 2010, as the powerful flow generated by the cooling water made performing the survey more difficult *(Laaksonen ja Oulasvirta 2010)*.

Aquatic vegetation in the areas surrounding Olkiluoto varies from the vascular plant-dominated communities in the inner archipelago to the macro algae-dominated communities of the open sea *(Leinikki 2017 & 2022)*. According to the surveys, at least 37 algae or plant species are found off Olkiluoto, the most common of which being *Ectocarpus siliculosus* or *Pilayella littoralis*, *Cladophora glomerata*, *Hildenbrandia rubra*, *Myriophyllym spicatum* and *Stuckenia pectinata*. In addition, two species occur in the sea area off Olkiluoto that are listed as near threatened species in the Finnish assessment of endangered species, *Fucus vesiculosus* and *Rhodomela confervoides (Hyvärinen et al. 2019)*.

Figure 55. The location of the aquatic vegetation transect lines (B-G) and the cooling water discharge point in the area near Olki-luoto in 2010, 2016 and 2022 (Leinikki 2017 & 2022).

In 2022, a total of 37 species were discovered along the investigated lines. The number of species was the same as in 2010, but higher than in 2016 *(Leinikki 2022)*. The effects of eutrophication can be seen along the aquatic vegetation lines in the area of impact of the power plant's cooling waters *(Leinikki 2017 & 2022)*. The largest changes in aquatic vegetation were again observed on transect line B, which is located closest to the discharge point of the cooling waters. In 2010, the dominant species on line B was *Ranunculus circinatus*, in 2016 *Myriophyllum spicatum* and in 2022 *Chara globularis (Leinikki 2017, 2022)*. *Chara globularis* is a common type of algae in soft soil at a depth of 1–5 metres, and it can tolerate more eutrophic conditions than other *Charophyta (Guiry & Guiry 2023)*. The changes in dominant species that have taken place on line B indicate possible eutrophication. On the outer transect lines, eutrophication had not increased when compared to the situation six years ago *(Leinikki 2022)*.

Fourleaf mare's tail *(Hippuris tetraphylla)* has been observed in the Olkiluoto sea area in the 1960s. The species is rated as vulnerable (VU) in the Finnish classification of endangered species *(Hyvärinen et al. 2019)* and it is listed in Annexes II and IV(b) to the EU Habitats Directive. Inventory of fourleaf mare's tail was last taken in the area in 2014, at which time no observations were made *(Ramboll Finland 2014)*. Also based on the VELMU data, fourleaf mare's tail does not occur in the sea area.

Based on the VELMU data, *Fucus vesiculosus* occurs especially around the Kalla and Susikari islands and mainly to the south from there, while *Rhodomela confervoides* is found a little further west (Figure 56, Figure 57). *Fucus vesiculosus* was discovered in 2016 and 2022 on the outer transect lines D, F and G. On lines F and G, the coverage and growth depth of the *Fucus vesiculosus* zone have increased. Furthermore, the separately growing dwarf variant of the species was discovered on line B during both years; this variant is very rare on the Finnish coast and special attention should be paid to its occurrence *(Leinikki 2017 & 2022)*. In 2022, *Rhodomela confervoides* was also discovered along lines C, F and G, where it has not been observed before.

Over the past five years, the amount of loose sediment has increased, especially on the transect lines located on the Iso-Kaalonperä bay, which may be indicative of eutrophication. However, the amount of sediment varies a lot by year, depending on, for example, the phytoplankton production and the solid matter carried by the rivers, as well as the mixing caused by currents *(Leinikki 2022)*. On the outer transect lines, the eutrophication of the sea area was considered to be at the same level as in 2010 and 2016 *(Leinikki 2017 & 2022)*.

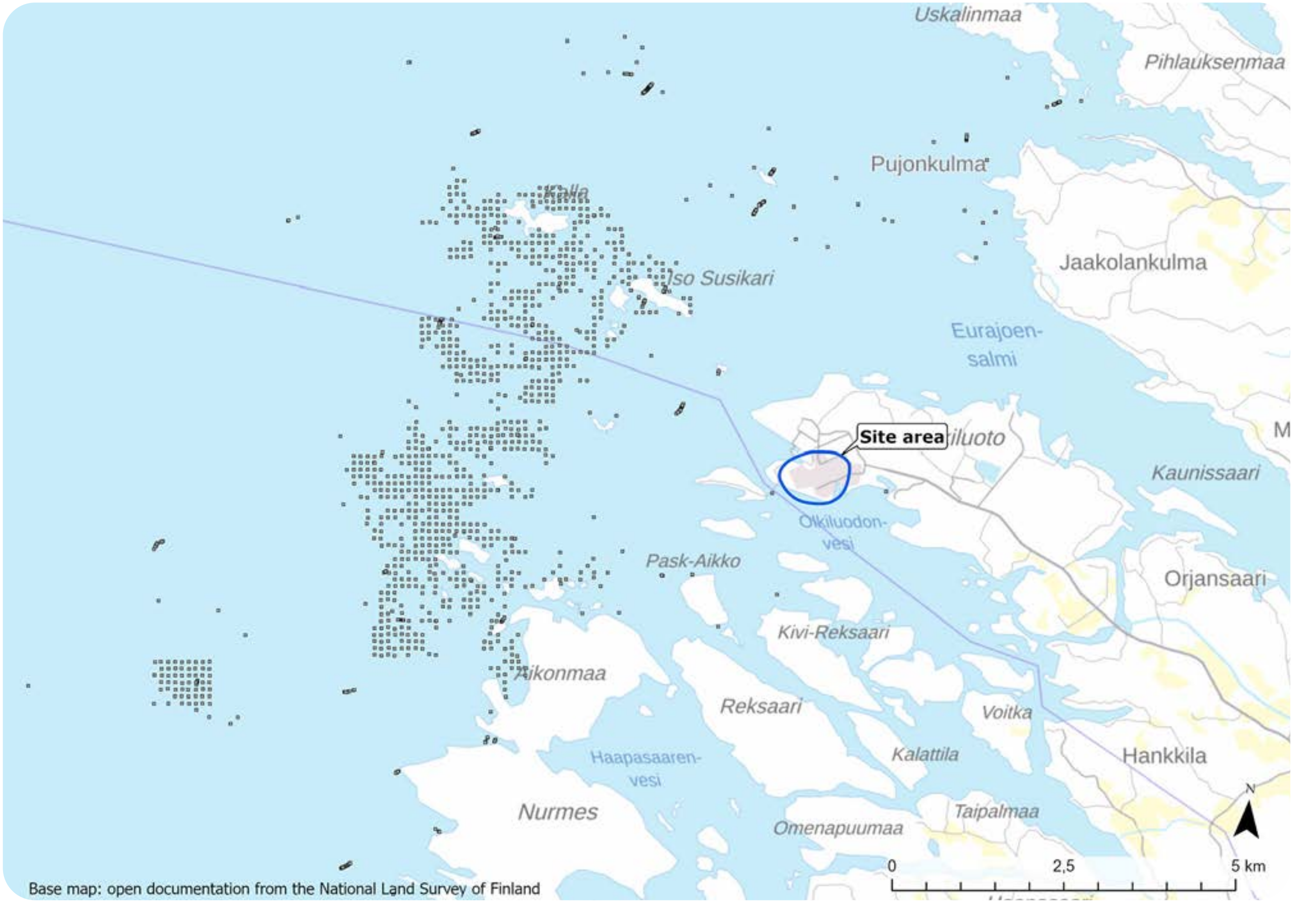


Figure 56. The occurrence of Fucus species (black spots) in the sea area off Olkiluoto. (Ministry of the Environment's administrative branch, Velmu map service 2024)

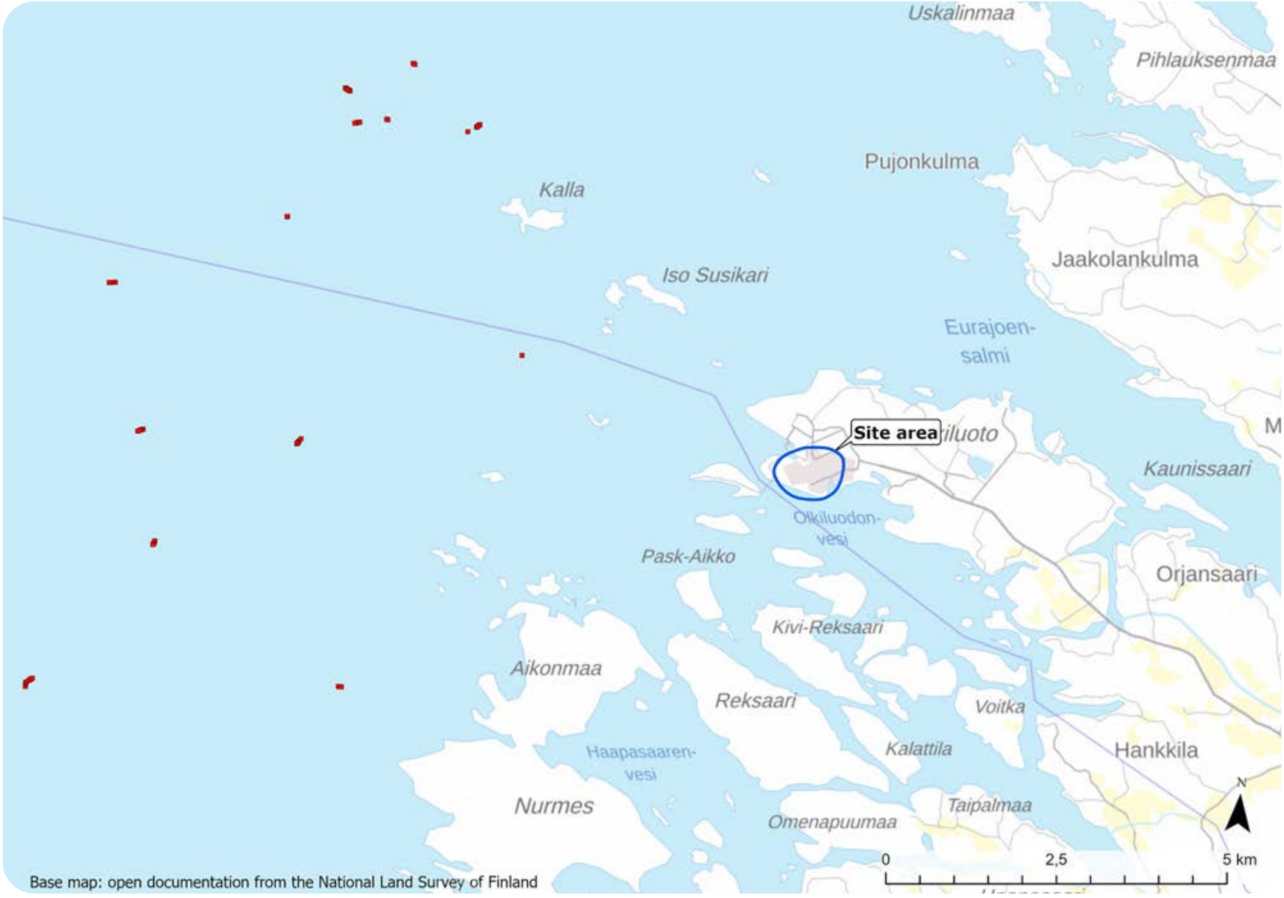


Figure 57. The occurrence of Rhodomela confervoides (red spots) in the sea area off Olkiluoto. (Ministry of the Environment's administrative branch, Velmu map service 2024)

Marine mammals

The Bothnian Sea is a habitat of both the Baltic ringed seal *(Pusa hispida botnica)*, which is rated as near threatened, and the grey seal *(Halichoerus grypus)*, which is classed in the category of least concern.

The main habitats of the Baltic ringed seal on the Finnish coast are the Bay of Bothnia, the Archipelago Sea and the Gulf of Finland *(Kunnasranta 2018)*. The Baltic ringed seal population is not monitored regularly in the Bothnian Sea. The species needs a solid ice cover to reproduce, so the Bay of Bothnia is an important habitat and breeding ground for the Baltic ringed seal. However, in summer, individual seals may also wander to the Bothnian Sea in search of food.

In the 2014 biodiversity analysis *(Ramboll 2014)*, there was one sighting of the grey seal in the Olkiluoto sea area. Grey seal sightings are also mentioned regularly in interviews with commercial fishermen of the Olkiluoto sea area *(KVVY Tutkimus Oy 2024b)*. The grey seal is one of the species subject to protection in the Rauma archipelago Natura area. Based on the 2023 counts by Natural Resources Institute Finland, the Bothnian Sea grey seal population was 520 individuals in the Bothnian Sea seal protection area and 563 individuals on the Swedish side *(Natural Resources Institute Finland 2024b)*. In addition to the ice, the grey seal can also give birth to its young on the shore or on islets, so the grey seal population is evenly distributed along the coast of Finland. Thus, the outer islets located in the sea area near Olkiluoto are also potential breeding grounds for the grey seal. However, the annual grey seal population monitoring by Natural Resources Institute Finland does not target the sea area near Olkiluoto and no significant grey seal densities have been reported from the area. There are no known moulting or resting islets used by the grey seal in the Olkiluoto sea area *(Natural Resources Institute Finland 2024b)*.

Birds

The nesting birds of Olkiluoto were surveyed as part of the biodiversity analysis in 2013. The land birds at Olkiluoto were surveyed by using the line transect method, and the birds of small islands and the nearest islets were surveyed by using the round count method. There were a total of six line transect routes and the lengths of the lines varied from approximately one kilometre to just under two kilometres. In the round count method, a boat was driven slowly near the counting location (islet, island, other shore area) while, at the same time, counting the birds, mainly by observing them with binoculars. Munakari, Mäntykari and Tyrnikari were also visited ashore, and the water and coastal birds of Kornamaa Island were surveyed by walking along its shores. At Olkiluodonjärvi, the survey was conducted by applying the instructions for territory mapping *(Koskimies & Väisänen 1988)*.

The nesting bird population of Olkiluoto and its surrounding water areas is quite abundant and rich in species. The island's most abundant bird areas in terms of the number of species and pair density are located on the islets to the northwest of Olkiluoto, Tyrniemenkari and the Tyrniemi shore areas. No bird areas of particular value are known to exist on Olkiluoto Island. The land bird population includes mainly common species found in commercial forests and the built environment that tolerate the disturbance caused by human activities *(Ramboll 2014)*.

In the bird surveys conducted in 2013, a total of 82 species of bird were observed at Olkiluoto and on its nearby islands and islets, of which 80 were interpreted as nesting species *(Ramboll 2014)*. Approximately a quarter of these are waterfowl nesting in the vicinity of the area, while the rest are mainly species typical of forest environments. A total of 24 noteworthy species, i.e. endangered or listed in Annex I to the Birds Directive, were found. The assessment of endangered birds has been updated *(Hyvärinen et al. 2019)* since the survey date, and the information mentioned in the report is no longer correct in that respect. For example, the population of the eider, which nested commonly in the waters near Olkiluoto and was rated as near threatened (NT) during the survey period in 2013, has declined sharply and the species is now classed as endangered (EN) nationwide *(Hyvärinen et al. 2019)*. Of the species listed in Annex I to the Birds Directive, the barnacle goose, hazel grouse, black grouse, Slavonian grebe, grey heron, crane, corncrake, common tern, Arctic tern, eagle owl, black woodpecker and red-backed shrike have been found in the surveys in the area.

The most significant areas in terms of bird species and number of pairs were located on the islets to the northwest of Olkiluoto as well as Tyrniemenkari and the Tyrniemi shore areas. Noteworthy species of bird occur in these areas, the most important of which are the velvet scoter (VU), black-backed gull (EN), tufted duck (EN) and the horned grebe (EN) *(Ramboll 2014, Hyvärinen et al. 2019)*.

6.10.2.2. Conservation areas

There are archipelago and open sea areas to the northwest of Olkiluoto that simultaneously meet several criteria for conservation or protection. Partially overlapping areas include the Rauma archipelago SAC area (FI0200073), Bothnian Sea National Park (KPU020037), the Rauma–Luvia IBA area, Rauma–Luvia–Pori FINIBA area, Laukkari nature reserve (YSA024635) and the Raumanmeri Nature and Hiking Area (YSA236619). A part of the Rauma archipelago Natura area is also located within the Rauma archipelago coastal protection programme area (RSO020020). A part of the Rauma archipelago SAC area is located in the southern parts of Olkiluoto Island.

The closest Natura area (FI0200073) is located approximately one kilometre southeast from the site area. Natura areas, nature reserves, nature conservation programme sites as well as other nationally valuable nature sites located within a radius of around 5 km from the site area are shown in the figure (Figure 58) and table (Table 40) below.

Table 40. Natura 2000 areas (green), nature reserves (yellow) and other nationally valuable nature sites (white) within a range of around 5 km from the site area.

Number	Description	Areas at sea (yes/no)	Distance from the site area (km)
1.	Rauma archipelago Natura area (FI0200073, SAC)	Yes	1,2
2.	Liiklankari Nature Reserve (VMA020001)	No	1,2
3.	Rauma–Luvia archipelago IBA area	Yes	1,3
4.	Rauma–Luvia–Pori archipelago FINIBA area	Yes	1,3
5.	Rauma archipelago coastal protection programme area (RSO020020)	Yes	1,4
6.	Bothnian Sea National Park (KPU020037)	Yes	1,8
7.	Kääntentila Nature Reserve (YSA239598)	No	2,1
8.	Ympyriäinen Nature Reserve (YSA239819)	No	2,4
9.	Vasikkakari Nature Reserve (YSA239926)	No	2,8
10.	Raumanmeri Nature and Hiking Area (YSA236619)	Yes	3
11.	Mäntyrinne Nature Reserve (YSA206416)	No	3,1
12.	Kornamaa old-growth forest protection programme site (AMO000093)	No	3,6
13.	Laukkari Nature Reserve (YSA024635)	Yes	3,7
14.	Kuivalahti FINIBA area	Yes	4,4
15.	Eurajoki estuary FINIBA area	Yes	5
16.	Vähämaa Nature Reserve (YSA239599)	No	5,1

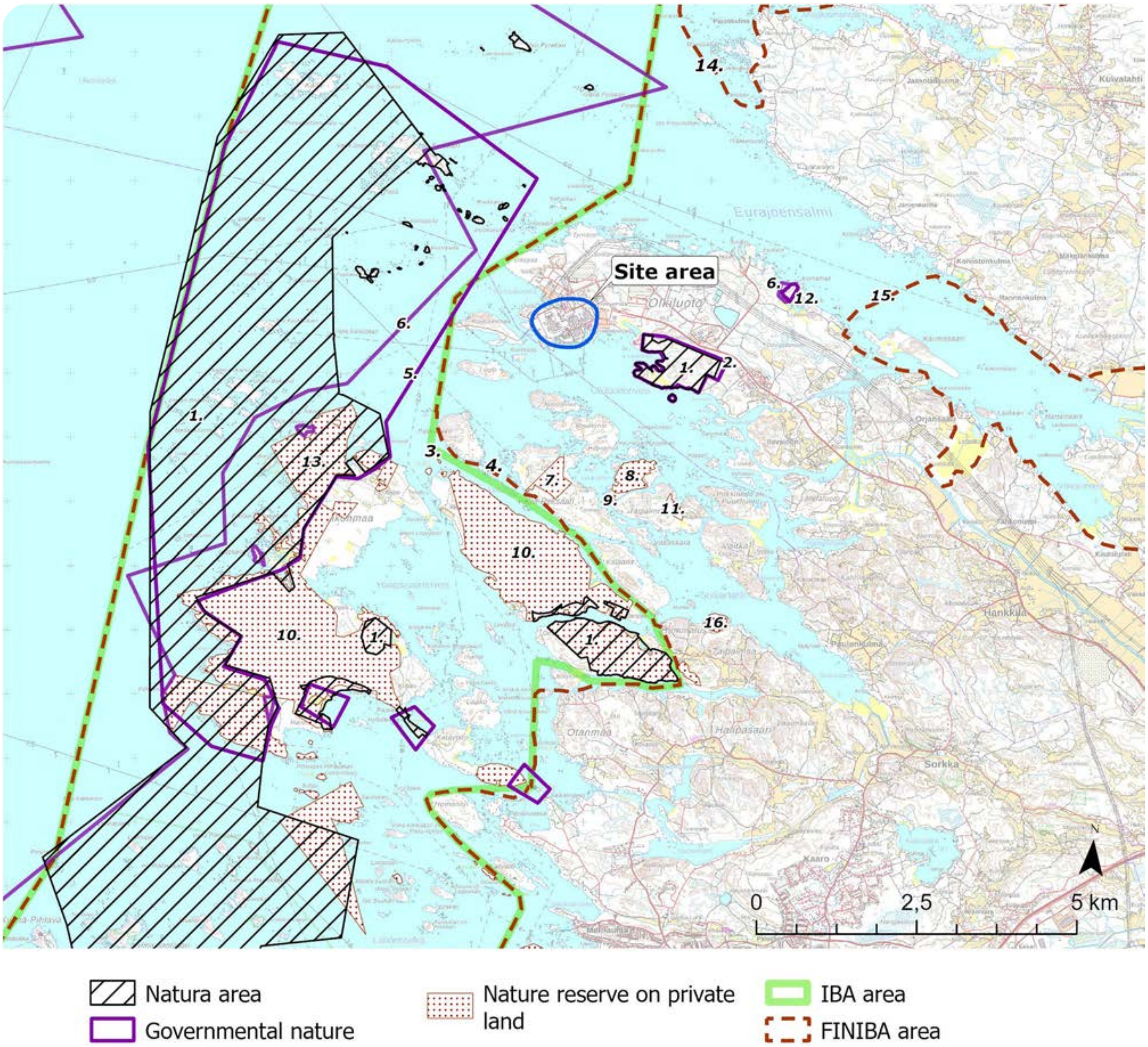


Figure 58. Natura areas, other conservation areas and IBA and FINIBA areas located within a range of five kilometres from the site area. The numbered locations are described in the following table (Table 40).

Rauma archipelago Natura area

The Rauma archipelago SAC area (FI0200073), part of the Natura network, is located near Olkiluoto Island; a separate Natura screening has been drawn up regarding this area (Appendix 6). It has a total area of 5,350 ha, but the area is not unified and comprises several locations, most of which are in the sea area. The nearest of the locations in the Natura area is 1.2 km away from the site area. The outer archipelago meadows are significant in terms of both landscape and nature values. The area is a valuable complex of archipelago landscape, bird life and vegetation. Many nationally threatened species occur in the area.

The Natura area has a total of 15 protected habitat types, of which reefs (more exactly, reefs and the underwater parts of rocky shores featuring algal zones) form the largest marine habitat type to be protected in terms of surface area. The representativeness of this habitat type in the Rauma archipelago is good. Representativeness is described as the clarity of the algal zones and the well-being of *Fucus vesiculosus* (*Airaksinen & Karttunen 2001*). The *Fucus vesiculosus* zone is exceptionally wide in the outer archipelago of the Rauma archipelago Natura area due to the purity of the water, the shallow depth and the quality of the bottom. The closest potential reef locations covered by the Natura area are located at a distance of approximately 3 km, to the northwest of the site area. Other habitat types subject to protection are the coastal lagoons or flads, gloe lakes and lagoon-type bays, of which the last-mentioned represents a habitat type subject to special protection. The nearest coastal lagoons belonging to the Natura area are on the islands of Iso Susikari and Pöllä, located approximately 2.5 km northwest of the site area *(Finnish Environment Institute 2024b)*. The Rauma archipelago Natura area protects one animal species, the grey seal *(Halichoerus grypus)*.

The northern part of the Natura area is also included in the coastal protection program (RSO020020). The aim of the coastal protection programme is to protect diverse coastal habitats and keep the shore areas covered by the programme natural and undeveloped.

Nature reserves on government land

The conservation area closest to the site area is the Liiklankari nature reserve (VMA020001) located on Olkiluoto Island. The reserve is also included in the old-growth forest protection programme (AMO020001). At its nearest, it is located approximately 1 km east-southeast of the site area. The nature reserve does not include underwater areas at sea.

The Bothnian Sea National Park (KPU020037) is a sea area spanning 912 km^2 that is, at its nearest, at a distance of less than 2 km from the site area to the northwest. Furthermore, the Kornamaa (AMO000093) old-growth forest reserve located to the northeast of Olkiluoto Island is part of the Bothnian Sea National Park. The Act on the Bothnian Sea National Park (326/2011) was drawn up when establishing the national park “for the protection and management of the underwater nature, archipelagos and islets, coastal wetlands and related species of the Bothnian Sea, the conservation of natural and cultural heritage…”. The protection provisions in Section 49 of the Nature Conservation Act (9/2023) apply to the national park.

Nature reserves on private land

The southern side of Olkiluoto Island has several nature reserves on private land. Of these, the closest is the Ympyriäinen nature reserve (YSA239819) located on the island of Ympyriäinen, approximately 2.4 km southeast from the power plant area. Nearly the entire island is protected, but the reserve has no underwater parts. Vasikkakari nature reserve (YSA239926) is located immediately to the southwest of Ympyriäinen nature reserve. The island to the southeast of Ympyriäinen also houses the Mäntyrinne nature reserve (YSA206416) that is located entirely on land. Kivi-Reksaari Island has the Käänteentila nature reserve (YSA239598). Vähämaa nature reserve (YSA239599) is approximately 5 km from Olkiluoto; its two parts are located in the northern and southwestern parts of Taipalmaa cape. A part of Vähämaa nature reserve is located on the sea shore, but the reserve includes no underwater parts.

Laukkari nature reserve (YSA024635), located to the southwest of Olkiluoto Island, is largely included in the Rauma archipelago Natura area, and part of the reserve is at sea. The Laukkari nature reserve features gloe lakes and flads, characteristic of land upheaval coast, that are almost in their natural state. The reserve has been established to protect a type of habitat (coastal laguuns). The protection decision prohibits any kind of activity that destroys the landscape, vegetation or fauna.

The Raumanmeri Nature and Hiking Area (YSA236619) established in 2016 is also located in the surroundings of the site area. It includes several islands off Rauma. The area overlaps in part with the Rauma archipelago Natura area. The reserve has been established to ensure the favourable conservation of habitat types and species; the area has coastal and small water system habitats. All activities that may cause a deterioration in the aforementioned natural values are prohibited in the area.

Talvitie nature reserve (YSA257369), established in 2022, is located to the northeast of the site area. The nature reserve is located on land but includes some shoreline.

Valuable areas in terms of bird species

The Rauma–Luvia archipelago IBA area, which spans 27,371 ha and is also included in its entirety as part of the Rauma–Luvia–Pori archipelago FINIBA area, is near the site area. At its nearest, the IBA area is at a distance of approximately 1.3 km from the site area. The area's role is significant for seabirds that nest on islands and islets, such as gulls and skuas. Furthermore, significant numbers of resting migratory birds (e.g. tufted duck, greater scaup, common scoter, Caspian tern) gather in the area.

In addition, the FINIBA areas of the Eurajoki estuary and Kuivalahti are located near the site area. The Eurajoki estuary is a diverse estuary containing wetlands, agglomerations, fields and coastal groves where migrating geese, swans, cranes and waders flock. Kuivalahti, in turn, is a diverse coastal area located on the Eurajoki coast that rapidly changes from a shallow open-sea shoreline to a sheltered cove and extensive flads. Migrating swans and velvet scoters, among others, rest in the area.

Valuable marine habitats

The Rauma outer archipelago area, which is classified as an ecologically significant underwater marine habitat (EMMA) in Finland and spans 51.2 km^2, is also located to the northwest off Olkiluoto Island at a distance of approximately 1.5 km from the power plant area *(Finnish Environment Institute 2024b)*. The Rauma outer archipelago is a valuable archipelago and traditional landscape with abundant birdlife. The area features land upheaval coast with groves and traditional biotopes, as well as old primeval forests *(Lappalainen et al. 2020)*. The EMMA area of the Rauma outer archipelago is mapped well. The EMMA classification is based on the red algae and bladder wrack communities that are abundant and healthy in the Rauma outer archipelago *(Lappalainen et al. 2020)*. The red algae and bladder wrack communities habitat type is classified as endangered (EN) in the Finnish habitat assessment, while benthic habitats characterised by Zannichellia and Ruppia as well as open benthic habitats characterised by Charophyta were rated as near threatened (NT) habitat types *(Kontula & Rainio 2018)*.

The EMMA area of the Rauma outer archipelago partially overlaps the Bothnian Sea National Park, the Rauma archipelago Natura area and the Laukkari nature reserve, which means that its nature is protected fairly comprehensively. The Bothnian Sea National Park holds a special position in the network of Finnish national parks in terms of the protection of underwater habitats, such as reefs and sandbanks, as well as the fish stocks and other species that occur there. It is considered to be one of the most significant nature reserves of the Baltic Sea with regard to the conservation of underwater nature *(Hakala 2011)*.

6.10.2.3. Sensitivity of the affected aspect

Vegetation and animals on land

The affected areas located in the land areas of Olkiluoto Island are largely under the influence of human activity and have no endangered species, species listed in Annex IV to the Habitats Directive or other noteworthy species. The vegetation and animals on land are, therefore, assessed as being of minor sensitivity.

Conservation areas, vegetation and animals at sea

The sensitivity of the affected aspect is assessed as large because the area of impact of the cooling waters contains a Nature 2000 area with sensitive and representative habitat types subject to protection in its marine and coastal zones. Furthermore, noteworthy or endangered underwater species are found in the area. The area houses an ecologically significant EMMA area as well as two nature reserves on private land, which include areas at sea. In addition, IBA and FINIBA areas valuable in terms of bird species are located in the affected area. The most valuable sites are located near the edges of the affected area.

6.10.3. Environmental impacts

6.10.3.1. Continuing operation

Impacts on land

The modification work required by the service life extension will be implemented inside the OL1 and OL2 plant units. In addition, it is possible that the current KPA storage will be expanded. The construction work for the storage will be carried out in the immediate vicinity of the current storage and the work is not estimated to cause significant changes to the flora or fauna in the area because the KPA storage surroundings are already a built-up industrial area.

The continued operation of the plant units will have no impact on the flora or fauna of the land area. The fauna occurring in the area affected by the power plant can be estimated to be accustomed to human disturbance (e.g. noise, movement of people and machinery).

Impacts at sea

The impacts of the continued operation of the OL1 and OL2 plant units on the sea area consist of the routing of warm cooling water into the sea. The impact of the plant units on the seawater temperature has continued since 1978, enabling the environment to adapt to this change. With continued operation, the impacts caused by the thermal load of the power plant's cooling water will remain the same as currently, as the temperature and flow of the cooling water routed into the sea will not change. Eutrophication has been observed in the sea area near Olkiluoto due to the thermal load of the cooling waters and the nutrient load of river waters. The thermal load raises the seawater surface temperatures on the Iso-Kaalonperä bay and intensifies stratification. Furthermore, in summer, occasional low oxygen levels have been observed in the benthic water layer. Climate change may further intensify the warming of the sea area in the long term. Due to the joint impact of the highest climate change warming scenario SSP5-8.5 (*IPCC 2022*) and the OL1, OL2 and OL3 plant units, the surface temperatures of the Olkiluoto sea area would increase by approximately 1–1.5°C by 2058 (Appendix 5).

In the case of a possible expansion of the KPA storage, the impacts of the extraction and discharge of the KPA storage's cooling water in the sea area will still remain very minor and localised. The amount of cooling water used by the KPA storage is a fraction of the amount of cooling water used by the plant units.

Impacts on aquatic vegetation

The direct impacts of thermal load on aquatic vegetation relate to the physiological effects of temperature. There are large differences between species in what the optimal temperature for them is and what temperatures they can tolerate without it affecting growth, reproduction or survival. As the temperature rises, the level of metabolism increases and growth accelerates up to a certain point, but if tolerance is exceeded, rising temperatures can even increase mortality. The tolerance of a species to fluctuating temperatures decreases if it is subjected to several simultaneous stress effects from the environment *(Sumelius et al. 2024)*. In the Baltic Sea, low salinity already weakens the tolerance of most species, i.e. increases their sensitivity to environmental changes. This is because only a few species are perfectly adapted to brackish water. Most of the species in the Baltic Sea have adapted to either seawater or freshwater, in which case the water is constantly either too fresh or too salty for them *(Ahlvik et al. 2021)*.

In the service life extension case, the impact of the thermal load from the cooling waters of the OL1 and OL2 plant units in the Olkiluoto sea area will continue and the possible expansion of the KPA storage will increase the amount of cooling water discharged from the storage very slightly. The temperature of the discharged cooling water will remain the same as it is currently. Annual filamentous algae and vascular plants, in particular, may benefit from the warmer water and longer growing season, increasing their numbers and densities. Of vascular plants, especially species that tolerate thermal load well, such as Stuckenia pectinata and Myriophyllym spicatum, will benefit. Increases in filamentous algae can reduce the amount of light received by other aquatic plants and algae, thus causing other aquatic plant populations to decline. Aquatic plant and macro algae species that are sensitive to eutrophication and high temperatures, such as *Fucus vesiculosus*, can in turn decline in the area of impact of the cooling water discharge flow. However, according to the Natura screening and hydrological modelling, the thermal load of the cooling water would not impact the occurrences of *Fucus vesiculosus* in the Rauma archipelago Natura area because the area of impact of the thermal load does not currently extend to the Natura area (Figure 60, Appendix 5 & Appendix 6).

Increased periphyton abundance may cause a slime build-up on shores and aquatic vegetation. As a result of the lengthened growing season and increased temperature, biological oxygen consumption increases, and the increased decomposition of organic matter can lead to the depletion of oxygen in the benthic water layer. The depletion of oxygen at the bottom causes nutrients to dissolve from the sediment into the water, i.e. internal loading, which accelerates eutrophication. Accelerated decomposition due to the breakdown of temperature stratification and the warming of the hypolimnion may accelerate nutrient cycling during the growing season and, thus, increase phytoplankton production. This can be seen as clouding of the water and a decrease in visibility depth, which can impact the depth of occurrence of macrophytes.

Eutrophication has been observed both in the Olkiluoto sea area and elsewhere in the Bothnian Sea, which is significantly affected by the nutrient load carried by river water. In the long term, the assessment of the impacts on aquatic vegetation includes uncertainty, as the development of primary production in the sea area depends on the realisation of both the climate change scenarios and the load-reducing measures. Eutrophication of the sea area has been predicted to accelerate as a result of climate change *(HELCOM 2021a)*. However, in the long term, the load on the sea area may also decrease if new measures are widely taken in agriculture. This is estimated to have positive effects on the state of the sea area, as the decreasing amount of nutrients restrains the increase of aquatic vegetation.

In the service life extension case, the current impacts of the cooling waters on aquatic vegetation will not change in terms of scope or intensity. Climate change intensifies the current impacts and the duration of the impact will be extended. When the additional years of operation of the plant units and the impact of climate change are taken into account, the eutrophication of aquatic vegetation may increase. The effects of continued operation on aquatic vegetation are estimated to be a minor negative.

Impacts on marine mammals

The weakening of the ice cover may have minor impacts on the reproduction of the grey seal or the Baltic ringed seal, as they give birth to their young on the ice. The grey seal, however, can also give birth on islets or shores. Nevertheless, there are no known important grey seal moulting islets or pack ice areas used for breeding in the Olkiluoto sea area, so as animals that move around in a large area, the sea seals in the area are not estimated to be dependent on the sea area off Olkiluoto. The main habitat of the Baltic ringed seal is in the Bay of Bothnia, and the species is not known to reproduce in the Olkiluoto sea area. The sea area off Olkiluoto already has highly variable ice conditions and areas that remain unfrozen in winter, and continued operation will not cause significant changes to the ice cover, excluding the effects of climate change. Thus, continued operation is not estimated to have any impacts on sea seals.

Impacts on birds

In the case of continuing operation, it is not estimated that the impact on birds will differ from at present. The continuation of the thermal load can have both positive and negative effects on some species. The formation of an open water area in winter may increase the number of wintering birds and improve the survival of some species. On the other hand, an increased *Cyprinidae* stock, for example, may compete for the same benthic food with some water birds, such as the goldeneye or the tufted duck *(Nummi et al. 2016)*. However, the impact is estimated to be minor. On the other hand, an increase in *Cyprinidae* stocks may improve the wintering of some species that feed on fish, such as the goosander. With the thermal load from the cooling water of the plant units remaining the same, however, the open water impacts during the winter are not estimated to change significantly in terms of wintering birds. A greater impact on the ice situation in a wider area is likely to occur as a result of climate change.

Impacts on Natura 2000 areas, nature reserves and EMMA areas

The possible impacts of the project on the Rauma archipelago Natura area have been discussed in more detail in the Natura screening (Appendix 6, Figure 59, Figure 60). Due to the joint impact of the highest climate change warming scenario SSP5-8.5 *(IPCC 2022)* and the OL1, OL2 and OL3 plant units, the surface temperatures of the Olkiluoto sea area would increase by approximately 1–1.5°C by 2058.

The conclusion of the screening was that the possibility of significant impacts on the Natura area's protected habitat types or the grey seal can be ruled out in terms of continuing operation. The joint impact with climate change on habitat types indirectly through eutrophication is minor at most, and it is affected more by climate change or plans to curb emissions from agriculture than the project. Continuing operation will not cause a change in the current status of the Natura 2000 area or nature reserves. Since continuing operation will not significantly change the ecological status of surface waters, there will also be no impacts targeting the natural conditions of nature reserves on government or private land that would conflict with their protection decisions.

Continuing operation will not cause a change in the viability of the bladder wrack and red algae communities to be considered in the EMMA area of the Rauma outer archipelago when compared to the current status. The impacts will remain the same as before, and the viability of the communities may increase after the end of the project as the temperature impact decreases. For this reason, it is not estimated that there will be changes to the bladder wrack and red algae communities and the habitat types formed by them compared to the current status.

Continuing operation is not estimated to have any impacts on Natura 2000 areas, nature reserves and EMMA areas, as the current impacts will not change.

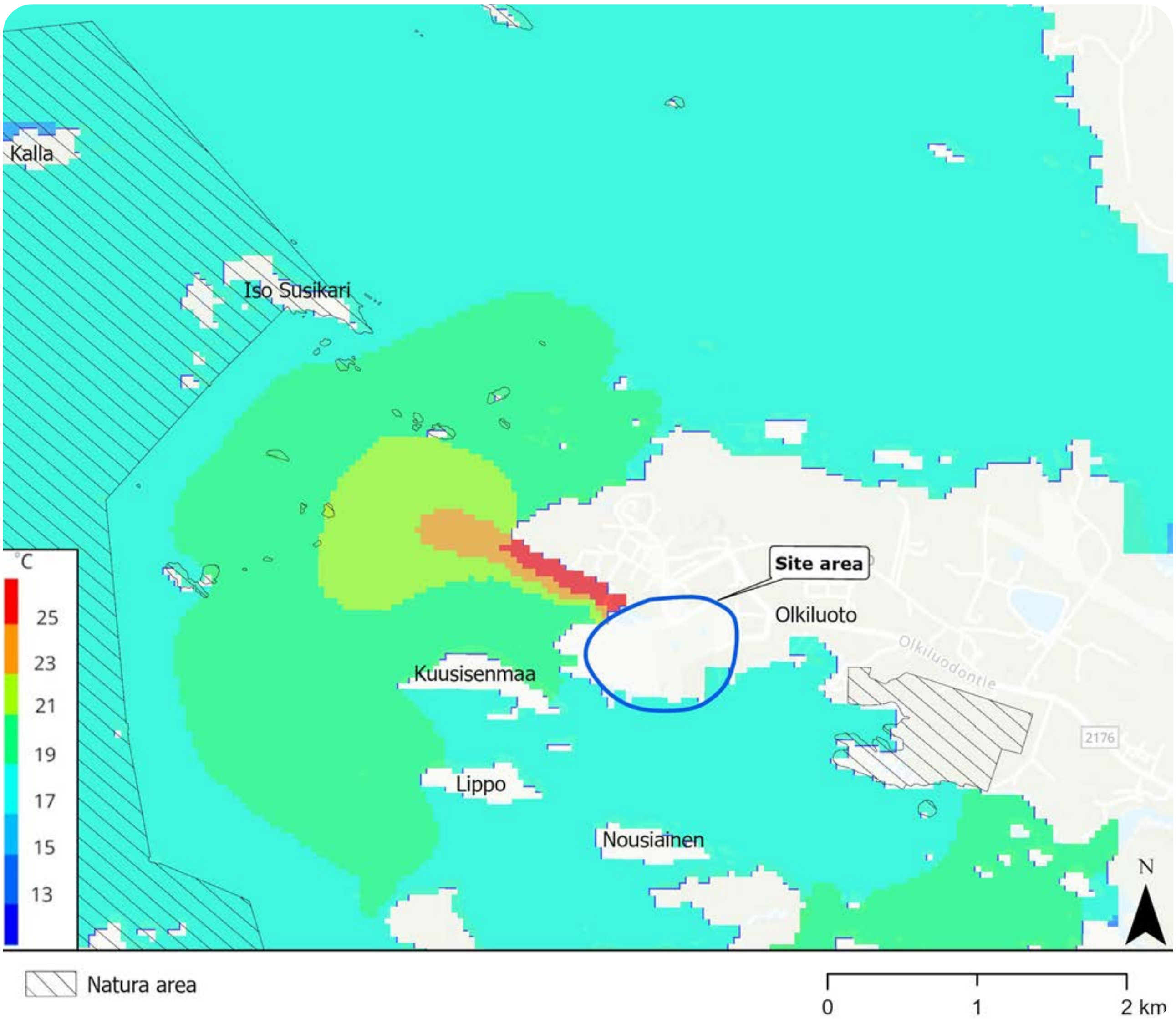


Figure 59. Modelling of the temperature of surface water in the Olkiluoto water areas at the current power level. The figure also shows the location of the Rauma Archipelago Natura area.

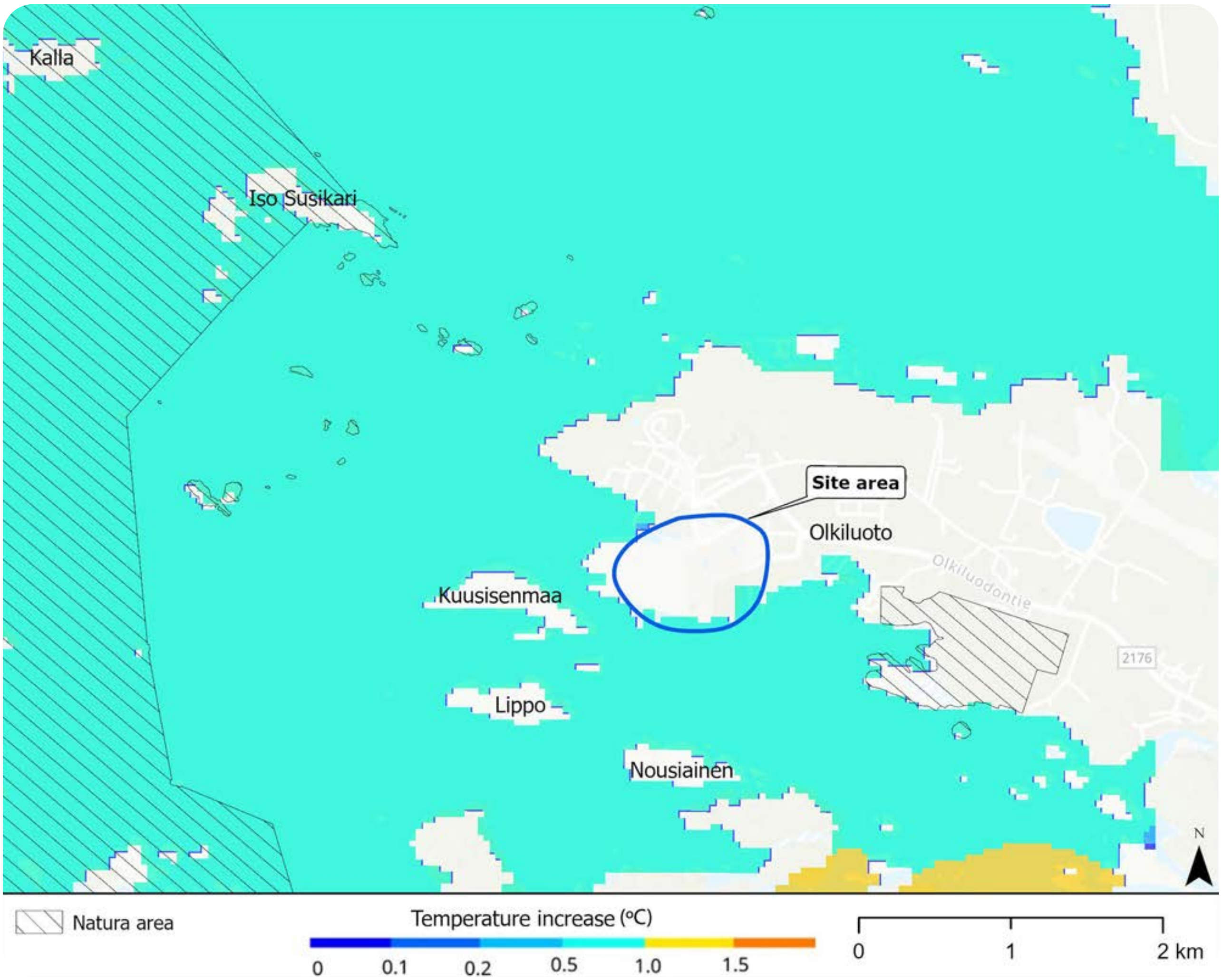


Figure 60. Modelled impacts of extending the operation of the plant units and climate change on temperatures in the sea water surface layer in 2058. The figure also shows the location of the Rauma Archipelago Natura area.

6.10.3.2. Power uprating

Impacts on land

The modifications required by the power uprating will mainly be implemented inside the OL1 and OL2 plant units. Furthermore, a new make-up water system and battery energy storage system will be constructed in the site area. The make-up water system will be located in the immediate vicinity of the plant units in an already built-up area. The area of the planned battery energy storage system will be located to the northwest of the site area, approximately 500 m away and next to the parking area for the OL3 plant unit, in the vicinity of which there is currently a small (10,000 m^2) rocky forest area and hall buildings. The area reserved for the battery energy storage system is approximately 1.2 ha. In connection with the construction, saplings and tall grass will be removed from the area, which is already under the heavy influence of human activity.

According to the results obtained in the most recent nature analysis *(Ramboll 2014)*, no significant natural values or noteworthy species are located at the location of the planned battery energy storage system and the ground cable route. The environment is a gravel field modified by humans, with deciduous saplings and tall grass growing there. Species listed in Annex IV(a) to the Habitats Directive that may occur in the area, such as the flying squirrel, moor frog, bats or otters, would not be subject to impacts from the construction work because the construction will not take place in an environment suitable for these species or their known places of occurrence. Noteworthy land areas in terms of nesting birds have not been observed, so the impacts on the species typical of commercial forests in the area are minor. The birds of the land areas are common and abundant in terms of the number of pairs, the main species being the chaffinch and the willow warbler *(Ramboll 2014)*. The construction work of the battery energy storage system may cause temporary noise. Furthermore, the construction of the ground cable will modify the ground surface, but it is not estimated to have any impacts on the natural values of the environment that has already been modified by humans.

In addition, it is possible that the current KPA storage will be expanded. The construction work will be carried out in the immediate vicinity of the current storage and the work is not estimated to cause significant changes to the flora or fauna in the area because the KPA storage surroundings are already a built-up industrial area.

The impacts of the construction on vegetation, habitat types and animals on land are estimated to be a minor negative in magnitude overall.

The continued operation of the plant units at an uprated power level will have no impact on the flora or fauna of the land area. The fauna occurring in the area affected by the power plant can be estimated to be accustomed to human disturbance (e.g. noise, movement of people and machinery).

Impacts at sea

The impacts on the sea area related to the continued operation of the OL1 and OL2 plant units at an uprated power level are similar to what has been described under continuing operation (Chapter 6.9.3.1). In the case of a power uprating, the temperature of the cooling water routed into the sea will increase by 1°C from the current level. At a distance of approximately 2 km from the discharge point of the cooling waters, the power uprating will increase the average seawater surface temperatures by 0.2°C, and by 0.1°C at a distance of 3–4 km. The impacts from the thermal load are, therefore, local and limited to the vicinity of the discharge flow. Temperature changes smaller than 0.5°C cannot be distinguished from the natural temperature variation of the sea area. When the warming caused by climate change is taken into account, the surface temperatures of the Olkiluoto sea area will increase by approximately 1–1.5°C by 2058, i.e. the same amount as in the service life extension case (Figure 61).

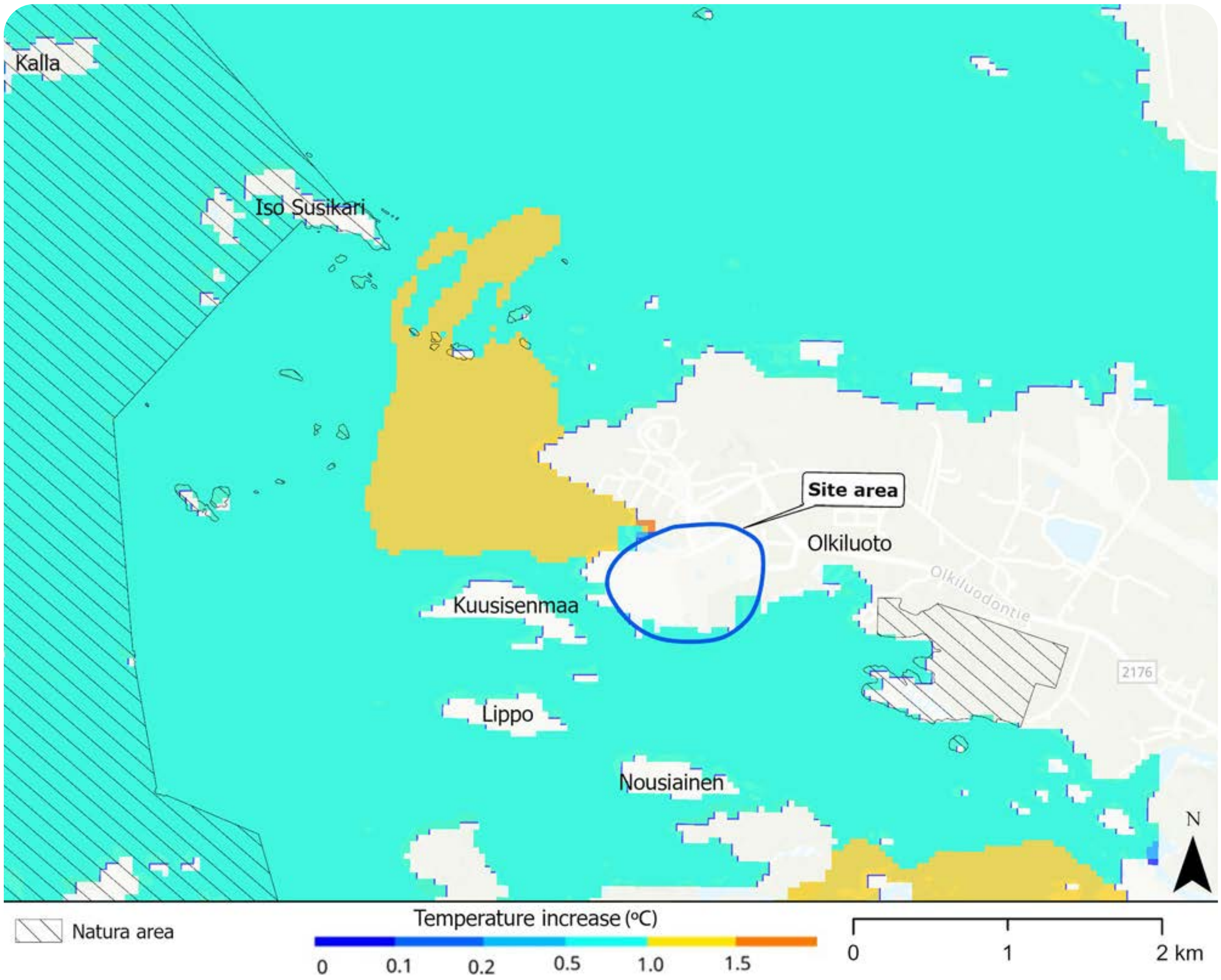


Figure 61. Increase in cooling water temperature in 2058 in a power uprating scenario, while climate change is considered, near the Rauma archipelago Natura area.

Based on the modelling results, however, the power uprating will affect the ice cover by shortening the ice cover period by an average of 2 days when compared to the service life extension, but larger changes may occur in some places due to random weather conditions. Due to the joint impact of the power uprating and of climate change, by 2058 the ice cover period of the sea area will have shortened by 2–3 weeks, which means that climate change has a greater impact than the power uprating. According to the surface water impact assessment, the impacts on water quality and sediments are insignificant. Eutrophication of the Bothnian Sea has been predicted to accelerate as a result of climate change. Due to the joint impact of the increase in temperature and the eutrophication of the sea area, chlorophyll concentrations and phytoplankton biomass may increase slightly in the areas off Olkiluoto, which is reflected as a decrease in visibility. Cyanobacteria may also benefit from the warming of the seawater.

The amount of cooling water used by the KPA storage will increase as a result of the power uprating, in addition to which the possible expansion of the KPA storage will increase the amount of cooling water required. Even following this increase, the amount of cooling water discharged from the KPA storage and its impacts in the sea area are negligible when compared to the cooling water from the OL1 and OL2 plant units.

Impacts on aquatic vegetation

The impacts on macrophytes, i.e. aquatic vegetation and macroalgae, are mainly caused by the thermal load from the cooling water. The nutrient load to the sea caused by the plant units is very small.

Based on the aquatic vegetation surveys carried out in the Olkiluoto sea area in 2022, *Fucus vesiculosus* occurs on transect lines D, F and G (Figure 55), of which the coverage and growth depth of *Fucus vesiculosus* have increased on the outer transect lines *(Leinikki 2017 & 2022)*. Thus, up to a certain point, *Fucus vesiculosus* may benefit from the thermal load, which promotes its growth. It has been found in experimental studies that *Fucus vesiculosus* tolerates a rise in temperature up to 27°C, but its growth starts to slow down in water warmer than 24°C *(Graiff et al. 2015a & 2015b)*. At water quality monitoring point 505, which is located in the vicinity of transect line D for aquatic vegetation, the highest measured temperature of the epilimnion has been 21.5°C in summer. According to the hydrological modelling, due to the joint impact of the power uprating and climate change, the average surface temperature of the sea water at this point may increase by 1.5°C by 2058. It is, therefore, possible that, during hot summers, the surface temperatures in the area affected by the cooling water discharge flow will rise to the critical temperature of 24°C for *Fucus vesiculosus* and its growth will weaken. The significance of the temperature impact is materially affected by the growth depth of *Fucus vesiculosus* and the mixing conditions. Furthermore, abundant periphyton growth, cloudiness of the water and substantial sedimentation of organic matter weaken the growth of *Fucus vesiculosus*. According to the Natura screening, the power uprating would not impact the occurrences of *Fucus vesiculosus* located in the Rauma archipelago Natura area because the area of impact of the thermal load from the cooling water does not extend to the Natura area and will not change when compared to the current status (Figure 61, Appendix 6).

The extent of the area impacted by the power uprating of the OL1 and OL2 plant units will not change compared to the current status. The sea area's nutrient load and climate change have a greater impact on the development of primary production in the sea area than the thermal load from cooling waters. However, the thermal load of the cooling waters may promote eutrophication in the sea area near Olkiluoto. The magnitude of the change to aquatic vegetation is thus estimated to be a minor negative.

Impacts on marine mammals

The Baltic ringed seal needs sea ice to reproduce, but the main breeding ground of the species is located in the Bay of Bothnia. The grey seal can give birth to its young on the ice, shores or islets. Although the ice cover period will be shortened by a few days in the power uprating case, the impacts on sea seals will remain mostly the same as with continued operation, as yearly variation in the ice conditions is greater than the impact of the power uprating. There are no known important breeding grounds of the grey seal in the area of impact of the thermal load from the cooling waters. The grey seal can potentially use the outer islets off Olkiluoto for reproduction, but the thermal load of the cooling water has no impact on this. Consequently, the power uprating is not estimated to have any impacts on marine mammals.

Impacts on birds

The deterioration of ice conditions in the power uprating case may facilitate the wintering and nutrition of seabirds. The power uprating is not estimated to significantly change the benthic fauna or fish stock that seabirds feed on, so it is not estimated that there will be any indirect impacts on birdlife through changes to the food web. Thus, the bird population is not estimated to change as a result of the power uprating.

Impacts on Natura 2000 areas, nature reserves and EMMA areas

The thermal load of the cooling water can affect the underwater marine habitat types or aquatic vegetation of nature reserves by increasing the eutrophication of the sea area or promoting the growth of filamentous algae, as the growing season of phytoplankton and aquatic plants is lengthened *(HELCOM 2021a)*. The rise in temperature can also affect the formation of ice in the area impacted by the cooling waters. The sea ice that forms every year plays an important role in shaping the habitat types of the Baltic Sea. These include reefs and seaside meadows, in particular. Species dependent on ice conditions may also be impacted.

The temperature changes caused by the power uprating to the Rauma archipelago Natura area are so minor that they are barely distinguishable from the natural variation in seawater temperature. Together with the rise in seawater temperatures caused by climate change, the power uprating will increase the temperature of the seawater by approximately 1–1.5°C in parts of the Rauma archipelago Natura 2000 area. In these areas, the temperature will rise by the same amount even without the power uprating. The possible impacts of the power uprating on the conservation criteria of the Rauma archipelago Natura area have been discussed in more detail in the Natura screening. The conclusion of the screening was that the possibility of significant impacts on the Natura area's protected habitat types or the grey seal can be ruled out in terms of the power uprating (Appendix 6).

The Raumanmeri Nature and Hiking Area is not impacted by the cooling waters as its marine parts are located outside the affected area. The marine parts of the Laukkari nature reserve, in turn, are the same as those of the Natura 2000 area. Thus, the uprating is not estimated to be in conflict with its protection criteria in the sea area.

The power uprating is not estimated to have any impacts on Natura 2000 areas, nature reserves or EMMA areas.

6.10.3.3. Significance of the impacts

Vegetation and animals on land

The sensitivity of the flora and fauna located in the land areas of Olkiluoto was assessed to be minor, as no endangered species, species listed in Annex IV to the Habitats Directive or other noteworthy species occur in the area. The nature in the affected area is ordinary and under the influence of human activity.

In the service life extension (VE1) case, the possible additional construction related to the expansion of the KPA storage will take place adjacent to the existing storage in the site area, and the construction will not have any impacts on vegetation or animals. Continuing operation will have no impact on the flora or fauna of the land area.

As a result of the additional construction required by the power uprating (VE2), it will be necessary to remove saplings and tall grass from the area. The impacts of the construction work on vegetation and animals on land were estimated to be minor negative, as the earthworks are small in scale and the impacts concern ordinary nature that is already under the heavy influence of human activity. The impacts of the construction on vegetation, habitat types and animals on land are estimated to be a minor negative in magnitude. The possible expansion of the KPA storage will not cause any impacts on the flora or fauna of the land area. The continued operation of the plant units at an uprated power level will have no impact on the flora or fauna of the land area. (Table 41)

Table 41. Significance of the impacts: vegetation and animals on land.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	No impact	No impact
VE2	Minor	Minor negative	Minor negative

Vegetation and animals in the sea area as well as conservation areas

The sensitivity of the affected aspect is assessed as large because the area of impact of the cooling waters contains a Nature 2000 area with sensitive and representative habitat types subject to protection in its marine and coastal zones. Furthermore, noteworthy or endangered underwater species are found in the area. The area houses an ecologically significant EMMA area as well as two nature reserves on private land, which include areas at sea. In addition, IBA and FINIBA areas valuable in terms of bird species are located in the affected area. The most valuable sites are located near the edges of the affected area.

In the service life extension (VE1) case, the current impacts of the cooling waters on aquatic vegetation will not change in terms of scope or intensity. Climate change intensifies the current impacts and the duration of the impact will be extended. When the additional years of operation of the plant units and the impact of climate change are taken into account, the eutrophication of aquatic vegetation may increase. The effects of continued operation on aquatic vegetation were estimated to be a minor negative. Continuing operation was not estimated to have any impacts on marine mammals, birds or Natura 2000 areas, nature reserves and EMMA areas.

In the power uprating case (VE2), the extent of the area of impact of the cooling water will not change compared to the current state. The sea area's nutrient load and climate change have a greater impact on the development of primary production in the sea area than the thermal load from cooling waters. However, the thermal load of the cooling waters may promote eutrophication in the sea area near Olkiluoto. The magnitude of the change to aquatic vegetation was, thus, estimated to be a minor negative. The power uprating was not estimated to have any impacts on marine mammals, birds or Natura 2000 areas, nature reserves and EMMA areas.

In the case of both alternatives, the overall significance of the impacts was reduced from moderate to minor negative based on the expert assessment, as the identified minor impacts do not target the most sensitive sites in the affected area, but ordinary nature (Table 42).

Table 42. Significance of the impacts: flora, fauna and conservation areas of the sea area..

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Large	Minor negative	Minor negative
VE2	Large	Minor negative	Minor negative

6.10.4. Mitigation of harmful impacts

Although the negative impacts on marine and coastal nature are estimated to be minor, the development of the ice situation and eutrophication, in particular, should be monitored regularly in the Olkiluoto area through follow-up research. Continuous monitoring enables environmental changes that develop more slowly to be observed and intervened in, if necessary. Monitoring can, thus, act as a mitigating measure, especially in terms of those natural values for which impacts are difficult to predict accurately (see uncertainty factors in Chapter

6.8.5). The viability of *Fucus vesiculosus* communities, for example, can be monitored through videography in the most important habitats, such as around the Kalla and Susikari islands. The status of birds nesting and wintering in the nearby areas can be monitored through bird surveys carried out during the nesting and winter seasons.

6.10.5. Uncertainty factors

Climate change, which increases the temperature of the sea water together with the cooling waters, adds uncertainty to the assessment. Increased eutrophication and changes in the ice cover due to the rise in temperature cause indirect and yearly varying impacts on marine nature that are difficult to predict accurately.

The decrease in ice cover can increase the number of wintering areas suitable for waterfowl in the waters near Olkiluoto and along the coast. Due to the poor predictability of ice conditions, assessing the significance of the possible positive and negative impacts on birds is challenging. For this reason, the possible positive impacts on birdlife have been given less attention in the assessment. In addition, it should be noted that small changes may have occurred in the bird population of the area since the time of the previous surveys. However, with regard to land birds, it is estimated that the status of the nesting bird population is unlikely to have improved due to the continuous human activities on the island, but the status is estimated to mainly correspond to the situation at the time of the survey.

Increased eutrophication due to the rise in temperature, may weaken the growth conditions of *Fucus vesiculosus* and, ultimately, affect not only the vitality of the *Fucus vesiculosus* communities on reefs, but also the development of drift lines formed by drifting *Fucus vesiculosus* and, thus, terrestrial vegetation. Due to the uncertainties caused by complex indirect impacts, in terms of mitigating measures, it is recommended to continue long-term monitoring to enable slow processes to be intervened in if the impacts turn out to be greater than estimated over time.

6.11. People's living conditions and comfort

6.11.1. Initial data and assessment methods

The assessment of social impacts reviews the potential impacts on humans, the community or society as follows:

- impacts on the comfort and safety of the residential and living environment;
- impacts on traffic and mobility;
- impacts on the outdoor and recreational use of nearby areas;
- impacts on community spirit and local identity;
- impacts on services and economic life;
- impacts on demographics; and
- impacts on the use of tangible property and real estate in the nearby area.

Social impacts are tightly linked to other impacts (such as the regional economy, noise, emissions, traffic and landscape), either directly or indirectly. In addition, social impacts – in the form of residents' concerns, fears, wishes, and uncertainty about the future – may emerge as early as during the planning and assessment stage of the project, for example. The assessment of social impacts is performed as an expert assessment that is based on the following initial data:

- the results of other impact assessments;
- TVO's and Posiva's stakeholder survey concerning Olkiluoto and nuclear power;
- statements issued on the EIA programme essential with respect to social impact;
- other feedback received during the assessment procedure (e.g. public event in the EIA programme phase and monitoring group meeting arranged in the EIA report phase);
- population data, map data and other statistical data.

No opinions on the EIA programme were received from private individuals or associations. Following the completion of the EIA programme, an open public event concerning the project and the EIA procedure was arranged on 6 February 2024 at the Olkiluoto Visitor Centre in Eurajoki. The event was also streamed for remote attendance. Three members of the public attended on site, and 20 did so remotely. At the event, the audience presented questions related to subjects such as risks and safety, as well as seawater temperature rises and the ice situation.

A monitoring group was set up during the EIA report stage (see Chapter 4.5), intended to promote the transfer and exchange of information between the project owner, the authorities and the key stakeholders in the area while drawing up the EIA report. The monitoring group convened on 23 April 2024. The meeting discussed topics such as the continuation of operations in the area; the safe operation of plant units and risk management, the current situation of the water bodies in the area; and the impacts of the project on water. In particular, the importance of local interaction between the area's fishing cooperatives and water protection associations and the person in charge of the project was emphasised, so that information on the area can be exchanged in the future as well.

The opinions, feedback and comments presented at the public meeting and the monitoring group have been taken into account when preparing this EIA report. In addition, the feedback received has been reviewed for the social impact assessment, so that any concerns or expectations possibly related to the project could be taken into account.

The impact on people's living conditions and comfort was assessed with the aid of guidelines prepared by the National Research and Development Centre for Welfare and Health *("Ihmisiin kohdistuvien vaikutusten arvioiminen", Kauppinen & Nelimarkka 2007)* and a handbook of the Ministry of Social Affairs and Health *("Ympäristövaikutusten arviointi, Ihmisiin kohdistuvat terveydelliset ja sosiaaliset vaikutukset", Ministry of Social Affairs and Health 1999)*. The assessment considers that impacts can reach a radius of approximately 20 km, with the main focus being on the nearest residential and holiday buildings, sensitive locations and the recreational areas.

6.11.2. Current status

Eurajoki parish village is located approximately 16 km east of the site area. In 2017, Luvia became part of Eurajoki after a consolidation of municipalities. As a result, the municipality of Eurajoki has two centres, Eurajoki and Luvia. The centre of Luvia is located approximately 16 km northeast of the site area. The closest cities are Rauma (13 km south) and Pori (32 km northeast). The closest village centres are Hankkila and Linnamaa, at a distance of approximately 6–8 km from the site area. Kuivalahti village centre is located to the north of

Eurajoensalmi, approximately 9 km from the site area. On the Rauma side, the nearest village centre is Sorkka, which is located approximately 9 km southeast from the power plant.

The nuclear power plant is surrounded by a precautionary action zone extending to a distance of 5 km, in which land use restrictions are in force *(STUK Y/2/2024)*. The precautionary action zone must not contain, for example, facilities inhabited or visited by a considerable number of people, such as schools, hospitals, care facilities, shops, or significant places of employment and accommodation that are not related to the nuclear power plant *(YVL A.2)*.

The residential buildings nearest to the site area are located at a distance of approximately 3 km, to the southeast in the direction of Ilavainen. In 2023, approximately 50 to 60 people permanently lived within a distance of 5 km from the site area. Holiday housing is located in the coastal areas and islands near Olkiluoto. The nearest holiday houses are at a distance of approximately 0.5 km from the power plant, on the island of Ruokarta (Leppäkarta) to the southwest of the site area. A total of approximately 550 holiday houses are located within a distance of 5 km from the power plant. The residential buildings and holiday houses are marked in the figure below (Figure 62) and the distribution of the population within a distance of 5 and 20 km from the site area is indicated in the second figure (Figure 63).

No sensitive locations such as schools, day nurseries, healthcare services or significant exercise or recreation routes are located near the power plant area. Four elementary schools (Kuivalahti school, Linnamaa school, Lapijoki school and Kaaro school) are located at a distance of approximately 10 km.

There are restrictions on land use and mobility within the power plant area. In the power plant area, there is the Olkiluoto Visitor Centre, where one can learn about the operation of the nuclear power plant and view a science exhibition with the theme ”Electricity from Uranium”. The Visitor Centre is visited by approximately 15,000–18,000 guests each year. In the immediate vicinity of the Visitor Centre is the Olkiluoto Observation Trail, where one can learn about the special characteristics of the surrounding nature at Olkiluoto and the environmental research conducted in the area. Approximately 1 km long, the Observation Trail borders the Liiklankari conservation area. The Bothnian Sea National Park, located northwest of the power plant area, is at a distance of approximately 1.5 km at its nearest. The national park also includes a part of the western edge of Kornamaa, located approximately 2.9 km east of the site area. The Rohela–Uussalmi hiking route is approximately 2.8 km southwest of the site area, while the Vuorisola route is approximately 3.8 km away. The Kaunissaari cultural path is located approximately 5 km east of the site area. There are also leantos and campfire sites on the island. The Lahdenperä area, featuring a beach and a disc golf course, among other things, is located across Eurajoensalmi from Kaunissaari. Safety functions are discussed in more detail in Chapter 6.9.

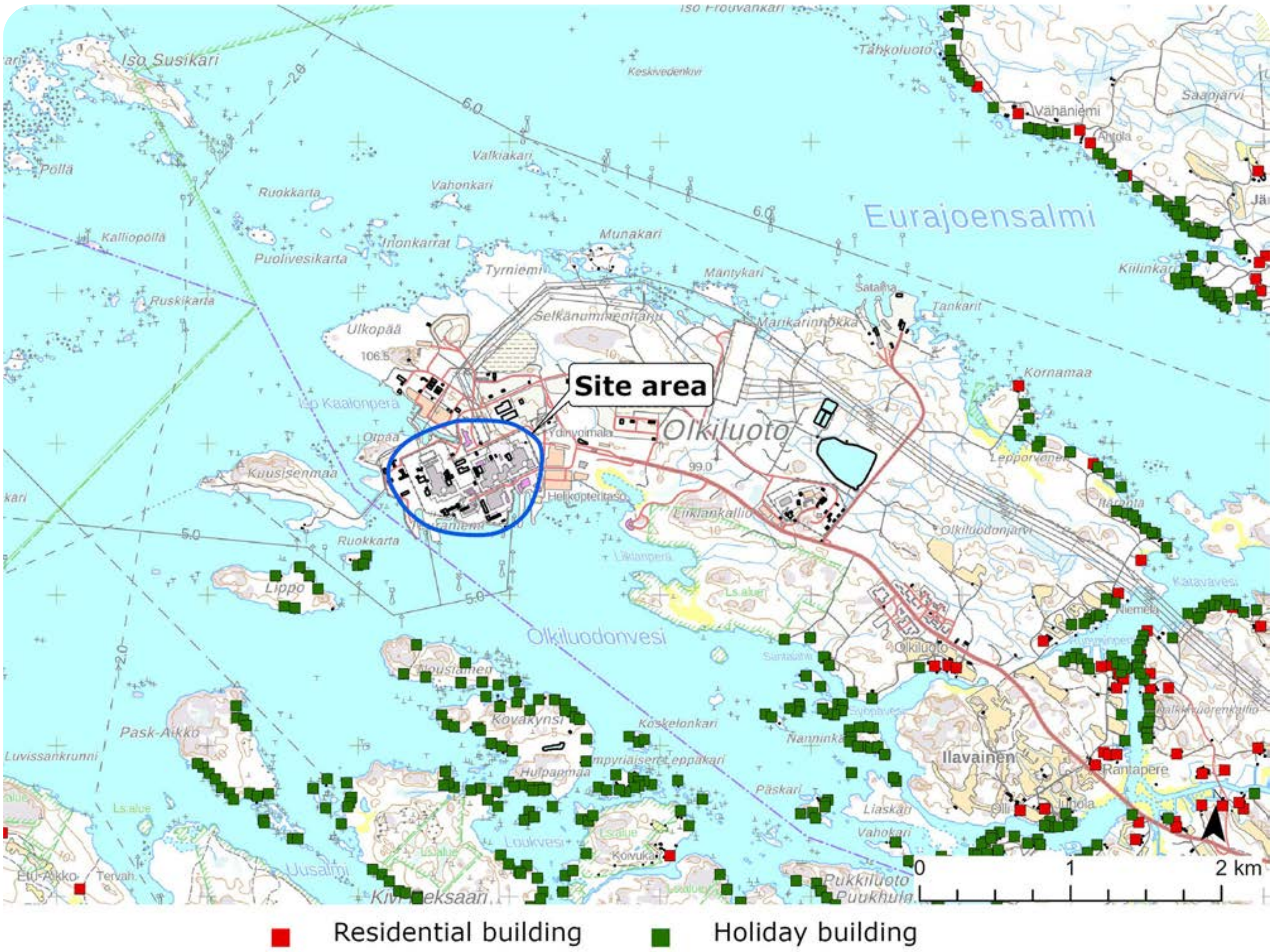


Figure 62. Residential and holiday buildings closest to the site area.

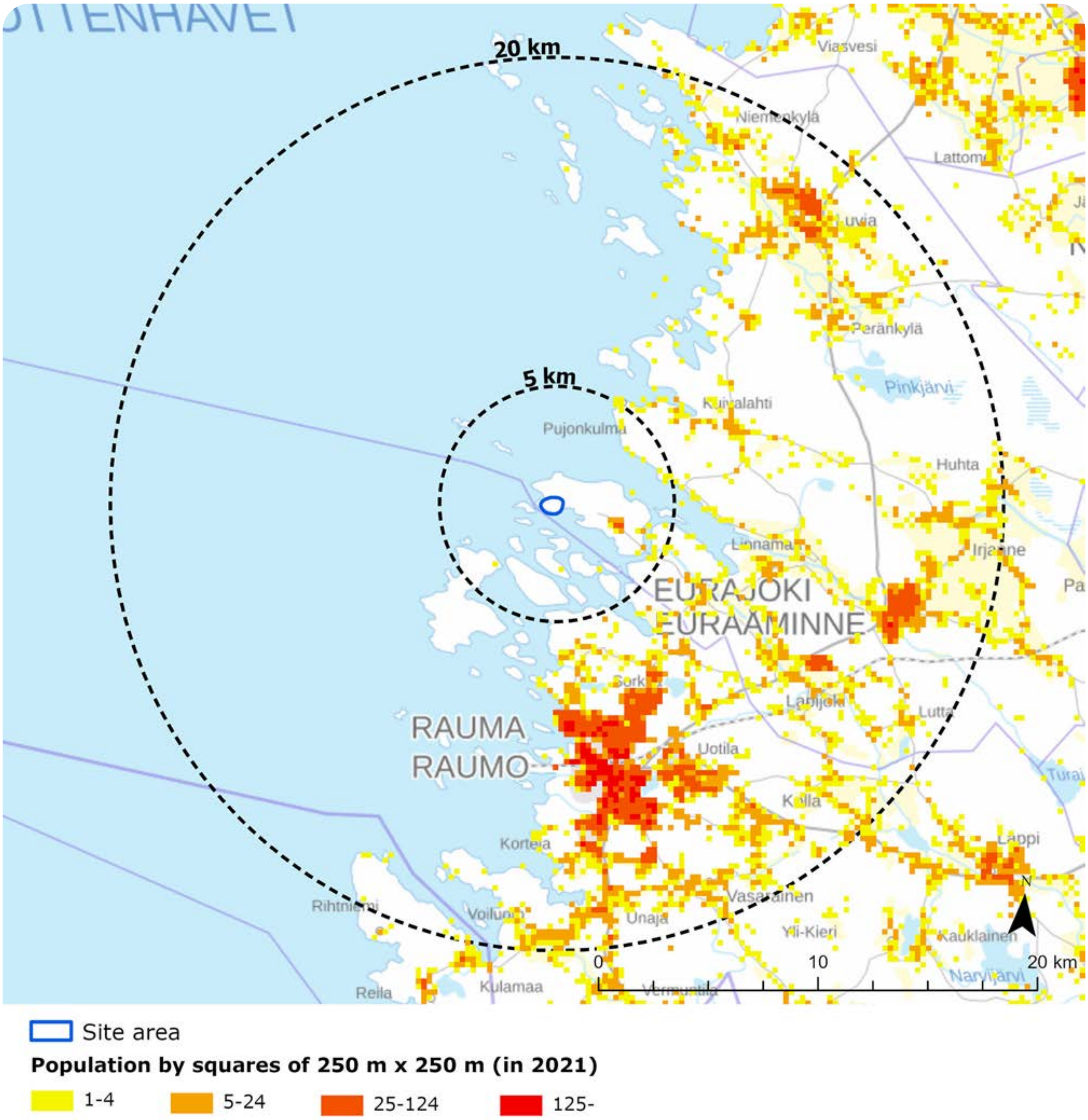


Figure 63. Distribution of the population within a distance of 5 and 20 km from the site area in 2021.

In 2022, the population of Eurajoki was 9,211. The population was down by approximately 120 from 2021. *(Statistics Finland 2024a)*. Population is forecast to continue to decline *(Statistics Finland 2023)*. In the demographics of Eurajoki, people aged 15 to 64 accounted for 56.8%, people over 64 accounted for 27.0% and people under 15 accounted for 16.2% *(Statistics Finland 2024a)*.

For several years, the unemployment rate in the municipality of Eurajoki has been between 4% and 6%. In 2021, the unemployed accounted for 6.6% of the workforce. In 2020, the average unemployment rate in Satakunta was 12.5%. *(Eurajoki 2021)*

In addition to the Olkiluoto nuclear power plant, industrial functions within the municipality of Eurajoki are focused in the Köykkä, Kuusimäkelä and Takila regions. In 2023, the income tax rate for the municipality of Eurajoki is 5.36% *(Tax Administration 2023)*. The enclosed table presents key figures for Eurajoki (Table 43).

Table 43. Key figures for Eurajoki in 2021/2022. (Statistics Finland 2024a)

Eurajoki	Indicator
Degree of urbanisation, %, 2022	64.3
Population, 2022	9,211
Population change from previous year, %, 2022	-1.3
Population share of residents under 15 years old, %, 2022	16.2
Population share of residents aged 15 to 64, %, 2022	56.8
Population share of residents aged over 64, %, 2022	27.0
Population share of Swedish-speaking residents, %, 2022	0.3
Population share of foreign nationals, %, 2022	3.0
Excess of births, persons, 2022	-40
Net migration/emigration between municipalities, persons, 2022	-93
Number of families, 2022	2,688
Number of households, 2022	4,096
Share of households living in terraced houses and single-family houses, %, 2022	93.8
Share of households living in rented apartments, %, 2021	12.2
Share of those with at least an upper secondary degree out of residents over 15 years of , %, 2021	71.8
Share of those with at least a tertiary degree out of residents over 15 years of age, %, 2021	27.9
Amount of employed workforce living in the area, 2021	3,885
Share of people working in their municipality of residence, %, 2021	42.1
Share of unemployed individuals in the workforce, %, 2021	6.6
Population share of pensioners, %, 2021	29.6
Economic dependency ratio, 2021	140.3
Number of jobs in the area, 2021	3,833
Share of jobs in primary production, %, 2021	4
Share of jobs in secondary production, %, 2021	49.6
Share of jobs in services, %, 2021	45.8
Self-sufficiency for jobs, 2021	98.7

The sensitivity of the affected aspect is influenced by the number of potentially harmed parties and the placement of especially sensitive locations, such as schools, day nurseries and significant recreational areas. The sensitivity increases if the area has recreational use value or scenic values and no alternative areas are available. In addition to the potentially exposed locations, sensitivity is affected by the current situation in the area regarding environmental disturbances (e.g. traffic, noise) and the changing status of the environment.

There is a precautionary action zone stretching to a distance of 5 km around the nuclear power plant site area, where limitations on land use are in effect. The precautionary action zone must not contain, for example, facilities inhabited or visited by a considerable number of people, such as schools, hospitals, care facilities or shops. There are no residential buildings in the immediate vicinity of the site area, but there are some holiday homes on nearby islands. No sensitive locations such as schools, day nurseries or health care services are located near the power plant area. No recreational use takes place in the site area, but there are some recreational locations near the area. The structures of the power plant have been located in the area for a long time, and its construction has already shaped the island of Olkiluoto and its surroundings. Current environmental disturbances have been minor, and the adaptability of the area is good. The sensitivity of the area in its current state is assessed as minor in terms of people's living conditions and comfort.

6.11.3. Environmental impacts

6.11.3.1. Continuing operation

Impacts during construction

The maintenance and modification work required by continued operation is carried out inside the plant units and has no impact on people's living conditions and comfort, for example, in terms of noise, air quality, traffic, vibration or landscape.

The additional construction related to the expansion of the KPA storage will necessitate excavating the bedrock, and the drilling and blasting during this work may cause temporary noise. Mild vibration may also occur in the nearby areas of the construction work. Earthmoving, additional construction and equipment installation will cause normal, short-term construction noise. Traffic volumes will not increase significantly during construction, which is not estimated to have a significant impact on the traffic volumes of the roads in the area or on traffic safety. The noise and vibration impact of the traffic will stay the same as it is now. Possible additional construction related to the expansion of the KPA storage may cause local dusting to a small extent when the bedrock is quarried and the surface layers of the earth are processed in the construction area. The impacts of dust on air quality affect the immediate surroundings of the construction area. Any possible momentary change to the current situation is very local and will end when the earthworks and excavation work is finished. The construction works will not significantly change the traffic volumes in the area, and, thus, the impacts of exhaust gas and dust emissions on air quality will not change.

If the KPA storage is expanded, the size of the storage building located in the area will be slightly extended at one end of the building. The appearance or height of the building will not change and, therefore, the expansion will not affect the landscape image in the area. In terms of landscape, the expansion of the building will only affect the landscape image within the area, where the change will not be significant. The expansion of the KPA storage will not result in impacts on the landscape, its categorised areas or locations or the archaeological cultural heritage during construction.

Impacts during operation

The social impacts of the continued operation of the plant units are mainly generated as in the current operation, but will continue for approximately 10–20 years after the end of the currently valid permit period.

The impacts of continued use of the plant units on the community structure, land use and zoning are similar to those of current operations, although the impacts were assessed as a minor negative, considering the continuation of restrictions on land use. There will be no impacts on the use of tangible property and real estate in the nearby area.

Since the 1970s, the construction of the power plant area has shaped the island of Olkiluoto and its surroundings, and the OL1 and OL2 plant units have been a visible element in the landscape already for several decades. Over the years, those living and holidaying in the area have become accustomed to the sight of the power plant in the landscape. The impacts of the service life extension of the plant units on the landscape, its valuable areas and locations and the archaeological cultural heritage are similar to those of the current activities. The continuation of operation will not cause any change in the landscape, but the plant units will stand out from the landscape during the additional years of use, which is why the significance of the landscape impacts has been estimated to be a minor negative at most.

The traffic impacts of the current operation are greatest at the time of the annual outage. The duration of the annual outage of one plant unit is 1–8 weeks. As regards continuing the operation of the power plant, traffic volumes and their impact on traffic safety will remain at the present level. It is estimated that the air and noise emissions and vibration impacts affecting people's living conditions and comfort will remain unchanged. The harm possibly experienced by local residents will remain as is.

The cooling water of the OL1 and OL2 plant units has been discharged into Iso Kaalonperä bay for several decades, which has been experienced as a factor affecting the comfort of people living and holidaying in the nearby area. According to the assessment of surface water impacts, if the OL1 and OL2 plant units continue in operation, the effects of the thermal load of the power plant's cooling water will remain the same as currently, as the temperature and flow of the cooling water led from the plant to the sea will not change. If the power uprating is implemented, the effects of the thermal load of the cooling water will be directed to the water bodies of the Rauma and Eurajoki archipelago and the Luvian–Rauma open sea. In the case of extended operation, climate change has a more significant effect on the warming of the sea area than the thermal load of Olkiluoto's cooling waters. Due to climate change, the extent of the ice cover in the Olkiluoto sea area may decrease slightly during the additional years of operation and the ice may become thinner, which may hinder walking on the ice in winter, for example. On the other hand, as a result of climate change, it is estimated that mild winters will become more common, which may reduce the use of the sea area in winter due to the lack of ice cover. The continued operation will not change the water quality of the sea area or the temperature of the seawater when compared to the current situation. The operation of the power plant does not create a significant nutrient load in the sea area, but the thermal effect caused by the cooling water may to a small extent intensify eutrophication in the long term, mainly in the sea area off Olkiluoto. Climate change and the nutrient load in the sea area, which originates mainly from rivers, have a greater impact on the eutrophication of the sea area than the thermal load of the cooling waters.

Based on the assessment of the impacts on the fish stock, the effect of the intake of cooling water on fish is local and minor as a whole, and has no significance for the fishing industry. When the impact of climate change is taken into account, the environmental conditions in the cooling water discharge area may favour roach-dominated fish stocks. Due to the prolongation of the current adverse effects on the fish stock, the effects on fish during the operation are estimated to be a minor negative.

There are restrictions on land use and mobility within the power plant area, which affect the potential for recreational use. The continuation of operational does not change the recreational use of the power plant area or its vicinity.

According to the regional economic impact assessment, continued operation would have positive impacts on employment and the regional economy both in the Rauma region and outside it (see Chapter 6.12.3.1).

No opinions were submitted on the project's EIA programme, but in the public meeting and the monitoring group, concern was raised regarding the combined impact of the continued operation of the plant units and climate change on the rise in seawater temperature and the ice situation. The effects on the fish stocks and fishing in the surrounding area were particularly of concern. Risks related to the operation of the nuclear power plant can cause concern about the safety of nuclear energy in the immediate area; more broadly at the level of the population of Finland; and also outside national borders. Nuclear safety is described in more detail in Chapter 2; the effects of a serious reactor accident in Chapter 6.18.3; and other exceptional or accident situations in Chapter 6.18.4. As operations continue, the concern about accident risks will continue, and it may increase as the plant ages.

According to a stakeholder survey commissioned by TVO and Posiva and completed in 2024, the trust of stakeholders in nuclear power is strong and has grown from previous years *(Prior Konsultointi Oy 2024)*. Attitudes to nuclear power are also generally higher than before in Finland: 68% of Finns have a positive attitude towards nuclear power *(Finnish Energy 2023)*.

The impacts of continued operation are mainly the same as those of the current operation of the power plant. Activities that affect people's living conditions and comfort include, in particular, the impact of the discharge of warm cooling waters on the recreational use of water bodies; the visibility of the power plant structures in the landscape; restrictions on the use of nearby areas caused by the operation; traffic on the roads leading to the power plant area; and the impacts on employment and the regional economy, which are also reflected in the population structure. Social impacts also include the concerns and expectations that continued operation may cause in residents, as well as any possible impacts on local identity. The magnitude of the change in the social impacts of continued operation is assessed as a minor negative overall when the additional years of operation of the plant units are taken into account.

6.11.3.2. Power uprating

Impacts during construction

The construction work of the additional water system and battery energy storage system required by the power uprating, as well as the possible expansion of the KPA storage, may cause slight, local and momentary noise, vibration and dusting in the immediate vicinity of the construction area, but these will cause harm outside the site area. During the construction of the additional buildings, traffic volumes on the roads may temporarily increase slightly, but there will be no significant change to the total traffic volumes or to traffic safety. The new additional buildings will be located in the power plant area, which has a strongly industrial appearance already, so the landscape impact will be a minor negative at most.

Impacts during operation

The impacts of the power uprating project on people's living conditions and comfort during the use of the plant units are mainly similar to the current operation, and as have been described regarding continued operation in Chapter 6.11.3.1.

The cooling water of the OL1 and OL2 plant units has been discharged into Iso Kaalonperä bay for several decades, which has been experienced as a factor affecting the comfort of people living and holidaying in the nearby area. Due to the power uprating, the temperature of the cooling water increases by 1 °C when compared to the current operation. According to the hydrological modelling, the effects of the thermal load of the cooling water are limited to the sea area near Olkiluoto, the Rauma and Eurajoki archipelago and the Luvian–Rauma open sea water bodies, so the extent of the area impacted by the power uprating will not change when compared to the current situation. Based on cooling water modelling, climate change has a clearly greater impact on the rise in seawater temperature than the operation and power uprating of the power plant. In winter, the thermal load may reduce the ice cover in the sea area and enable wind-induced currents in thawed areas. The effects of the power uprating shorten the ice cover time by an average of 2 days, but larger changes may occur in some places due to random weather conditions. The changes are small when compared to the yearly fluctuation. The operation of the power plant does not create a significant nutrient load in the sea area, but the thermal effect caused by the cooling water may, to a small extent, intensify eutrophication in the long term, mainly in the sea area off Olkiluoto. Eutrophication, which originates mainly in the nutrient load from nearby rivers, can be seen as local clouding of water and an abundance of aquatic vegetation in the surroundings of Iso Kaalonperä. Climate change and the nutrient load which originates from nearby rivers have a greater impact on the eutrophication of the sea area than the thermal load of the cooling waters.

As the discharge of warm cooling water continues, the recreational use value of the area's water bodies and the residential comfort of the coastal areas will remain mostly as they are now, but when the possible effects of climate change are also taken into account, the situation may deteriorate slightly in the future, especially regarding the ice cover. Deteriorating ice conditions may reduce the possibilities for moving around on the ice and winter fishing. Based on the assessment of the impacts on the fish stocks in the sea area near Olkiluoto, the share of roach in the fish population and the sliminess of fishing nets may slightly increase in the case of a power uprating when compared to the current situation.

According to the regional economic impact assessment, a power uprating would have positive impacts on employment and the regional economy both in the Rauma region and outside it (see Chapter 6.12.3.2).

In the case of a power uprating, the other activities during operation that affect people's living conditions and comfort, such as the visibility of the power plant structures in the landscape; restrictions on the use of nearby areas caused by the operation; and traffic on the roads leading to the power plant area will remain as they are now. Social impacts also include the concerns and expectations that continued operation may cause in residents, as well as any possible impacts on local identity. The magnitude of the change is assessed as a minor negative overall when the power uprating and additional years of operation of the plant units are taken into account.

6.11.3.3. Significance of the impacts

The sensitivity of the affected aspect in terms of people's living conditions and comfort is estimated to be low, as there is a precautionary action zone stretching to a distance of 5 km around the nuclear power plant site area, where no sensitive entities may be located. There are no residential buildings in the immediate vicinity of the site area, but there are some holiday homes on nearby islands. The structures of the power plant have been located in the area for a long time, and their construction has already shaped the island of Olkiluoto and its surroundings.

The magnitude of change in the impacts of continued operation (VE1) and power uprating (VE2) is assessed as a minor negative as a whole, because if operation continues, the impacts on people's living conditions and comfort will continue over the additional years of use for approximately 10–20 years. In both alternatives, potential concerns among people regarding safety risks will continue to exist. In the power uprating case (VE2), the discharge of warm cooling water combined with the changes brought about by climate change may affect the recreational value of the water systems in the nearby sea area. The impacts and detrimental effects experienced by people will, otherwise, mainly remain as they are. The possible additional construction work may temporarily cause some additional inconvenience.

Taking into account the extended operating time of the plant units, the significance of the impacts on people's living conditions and comfort are assessed to be a minor negative (Table 44).

Table 44. Significance of the impacts: living conditions and comfort.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.11.4. Mitigation of harmful impacts

In general, safety concerns can be associated with nuclear energy. With good dissemination of information and interaction, it is possible to reduce uncertainty and unfounded worries. TVO publishes the Uutisia Olkiluodosta (News from Olkiluoto) magazine, communicates on electronic channels and talks with the residents of the surrounding area, for example, at coffee events and various other events.

Depending on the weather conditions, an increase in temperature can be observed at an approximate distance of 3–5 km from the cooling water discharge location. Warnings about the unfrozen area are issued to the local residents in newspapers and with ice warning signs.

Harm during operation can be partially reduced by planning, and various means of mitigating harmful impacts have been examined in more detail in the chapters of the impact assessment dealing with noise, dust, vibration, traffic, emissions of radioactive substances, radiation, etc.

6.11.5. Uncertainty factors

The impacts on living conditions and comfort are subjective and linked to both the object of experience and the person having the experience, as well as the time and place. During the impact assessment, the views and thoughts of the individual residents, i.e. the objects of the impacts, have to be lifted to a more general level. On the other hand, impact assessment would be impossible to do individually, so some level of generalisation of data is necessary. Based on the feedback received from the EIA procedure, the aim is to identify the essential impacts on matters such as the comfort of the residential environment; safety; and recreational use of the area, as well as the concerns or wishes of the residents and other actors in the area in this respect. In this EIA procedure, no statements were received about the EIA programme, but feedback was sought in connection with the public meeting and the monitoring group. The small amount of statements and feedback may indicate that the project does not cause concern, especially for the residents of the nearby area. If the project caused any major concerns, conflicts or expectations, then some feedback would probably have been received on this.

The continuation of operations far into the future brings uncertainty to the impact assessment. Uncertainty is increased by future global phenomena and by technological development, for example. The uncertainties of other impact assessments can be repeated in the assessment of social impacts inasmuch as they affect people's living conditions and comfort.

6.12. Regional economy

6.12.1. Initial data and assessment methods

Data describing the current operation of OL1 and OL2 plant units; plans drawn up on the different alternatives; and the latest indicators taken from regional and national accounting were all used as initial data in the assessment.

The assessment of the regional economic impacts was based on the resource flow model, which was developed on behalf of SITRA in cooperation between Ramboll Finland Oy and the Natural Resources Institute of Finland in 2013–2015 *(Hokkanen et al. 2015)*. The model has been developed based on the input-output method. It expresses how resource flows of money and materials are directed in the region to production; intermediate product use and consumption between industries (private and public); and exports out of the region. The model enables the examination of impacts at the local level, the regional level and for all of Finland.

In the modelling, the examination focused on describing the current socioeconomic and regional economic situation; identifying the interactions between industries; and evaluating the economic impacts based on this. The modelling took into account the local level (Rauma region), the regional level (Satakunta) and the national level (Finland as a whole). Before the impact assessment, information in the resource flow model was updated with the latest available statistics concerning the state of the regional economy and business life (such as jobs and turnover by field of industry). The assessment analyses the direct impacts of the project alternatives and the multiplicative effects that production and consumption have on employment, total output, added value and tax income as a result of the operations. The assessment of the impacts on the regional economy, thereby, also considered the production impacts that are indirectly linked to the operations, as well as changes in consumption caused by the changed compensation of employees and their associated impacts. In addition, it has been assessed what kind of direct and indirect effects of a temporary nature the investments required for the continuation of operations and the power uprating will have.

The impact of extending the operation on revenue and on labour needs was assumed to be the same as during the latest year for which statistics for regional accounting are available, i.e. 2021. The quantitative impacts of continued operation were assessed as regional summations, where the impacts on the whole of Finland are obtained by adding up the impacts on the Rauma region, the rest of Satakunta and the rest of Finland.

The presented modelling results include the turnover generated as a result of the OL1 and OL2 plant units' own operations, as well as the multiplicative effects, added value, annual investments, production-related labour needs and taxes for the period of operation of the power plant units. The results during the continued operation of the plant units, thus, describe the overall impacts of the operation, which would vanish if the operation were to be terminated. Regarding the power uprating, the impacts of the additional investments required have been taken into account in the modelling. A possible power uprating would create a temporary need for new investments higher than the current average annual investments. However, the extension of service life and the power uprating were not estimated to increase the need for labour in the power plant's operating organisation, although some of the current personnel are expected to work temporarily in the event of a power increase, if it is implemented.

6.12.2. Current status

The TVO nuclear power plant has a significant role in maintaining the vitality of the Rauma region. Its current operation maintains and increases financial activity both locally, regionally and at the national level in Finland. The local level means the Rauma region, which is the economic region formed by Rauma and its nearby municipalities in the province of Satakunta. The Rauma region comprises the city of Rauma and the municipalities of Eura, Eurajoki and Säkylä. The regional level means the province of Satakunta.

According to the national economy, regional accounting and business statistics data of Statistics Finland, the impact of the energy industry (field-of-business class 35) on the region's vitality and economic flows is especially large in the Rauma region. In the Rauma region, approximately 19% of the annual investments take place in the energy sector on average. This is a notably large share when compared to the national average, where the energy industry's share of annual investments is approximately 4.6% *(Statistics Finland 2024c)*. The role of the capital-intensive energy industry is also evident in the Rauma region in light of other indicators concerning the regional economy, such as turnover; added value; wages and salaries; and employment. The share of the energy industry varies between 6.0% and 19.0% for the euro-denominated economic indicators, while the corresponding figure for jobs is approximately 3.4% (Table 45, *Statistics Finland 2024c). However, the employment impact of the energy industry is clearly greater in the Rauma region than on average in Finland or at the provincial level of Satakunta, where the energy industry's share of employment is, on average, approximately 0.5%–1.5%, depending on the regional level examined.*

Table 45. Average share of annual direct impacts of the energy industry (field-of-business class 35) in regional economies (5-year average) at different regional levels. (Statistics Finland 2024cc)

	Rauma region	All of Satakunta	Rest of Finland
Investments (€)	19.0%	12.2%	4.6%
Turnover (€)	7.0%	4.1%	2.2%
Added value (€)	6.4%	4.1%	2.2%
Wages and salaries (€)	6.0%	2.7%	0.8%
Employment (persons)	3.4%	1.5%	0.5%
Places of business (pcs)	0.6%	0.5%	0.3%

The total output for Satakunta in 2021 was approximately EUR 17.9 billion. Of the output, approximately 4% was created in primary production, 42% in secondary production, 7% in construction and 47% in other fields *(Statistics Finland 2024c)*. In the Rauma region and in Satakunta, the importance of secondary production as a whole is larger in the regional economy than in the rest of Finland (Figure 64).

Of the approximately 100,000 employed persons in Satakunta in 2021, approximately 74% worked in the private sector. Of the employed persons as a whole, approximately 5% worked in primary production, 19% in secondary production, 8% in construction and 57% in other fields *(Statistics Finland 2024c)*. Employment is focused on services clearly more than the total output, due to the sector's labour-intensive nature. In the Rauma region and Satakunta, the importance of secondary production in employment is emphasised in the regional economy clearly more than in the rest of Satakunta (Figure 65).

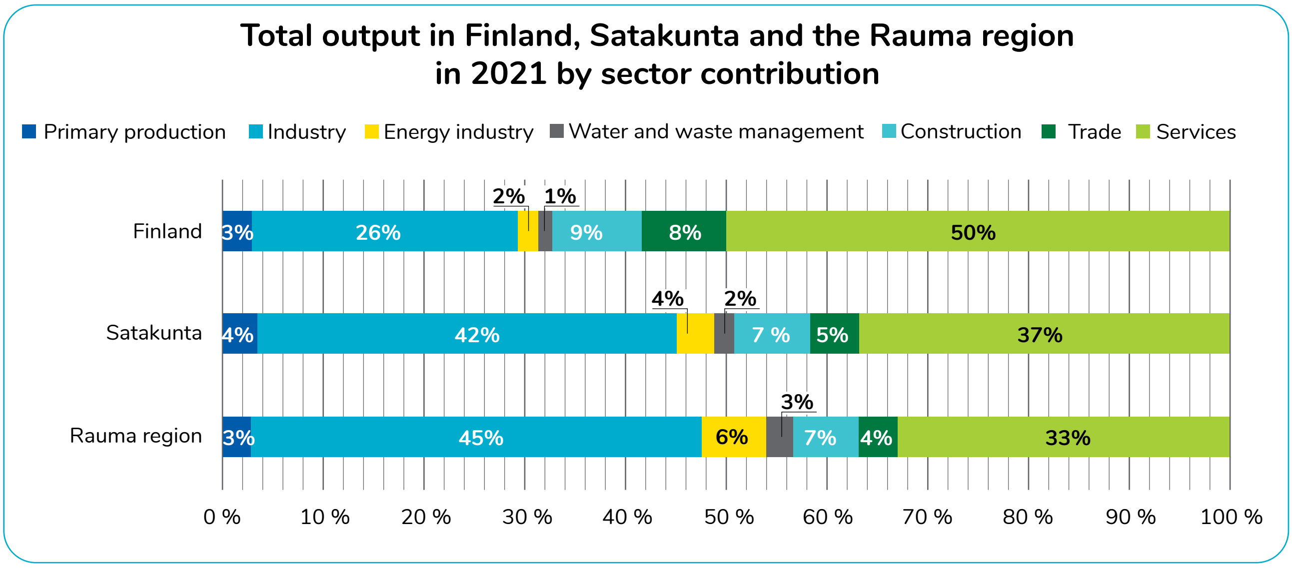


Figure 64. Total output in Finland, Satakunta and the Rauma region in 2021 by sector contribution. (Statistics Finland 2024c)

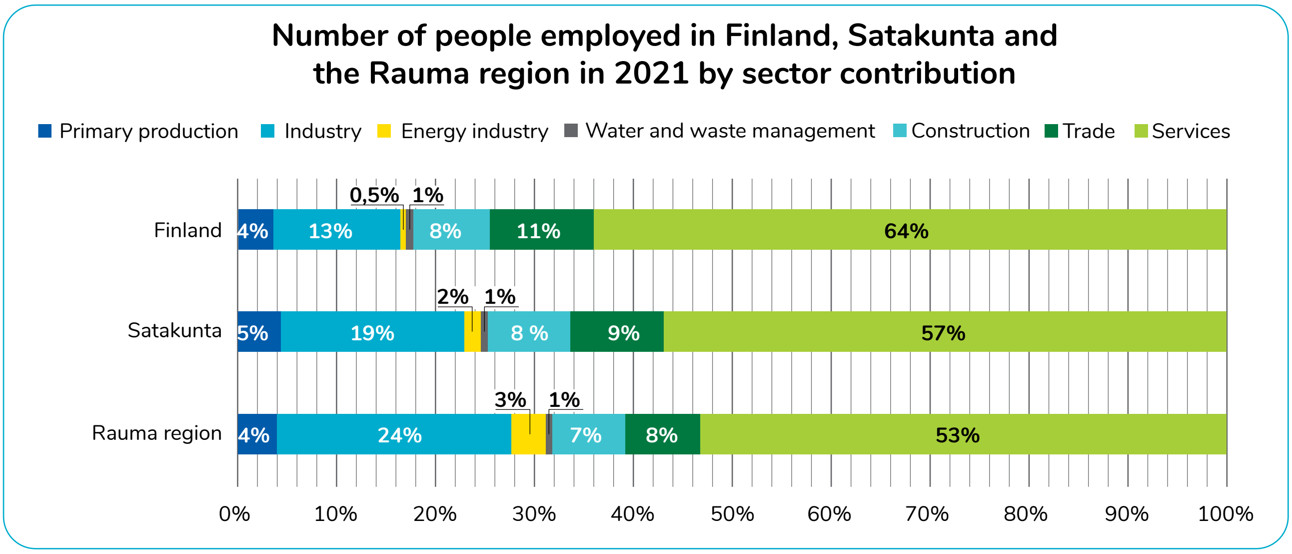


Figure 65. Number of people employed in Finland, Satakunta and the Rauma region in 2021 by sector contribution. (Statistics Finland 2024c)

In 2021, the unemployed accounted for 8.4% of the workforce. Commuting was significant, as 33.9% of the labour force travelled outside their municipality of residence for work. According to the indicators of Statistics Finland (2024), the Rauma region itself nevertheless had some 27,755 jobs in 2021. In the same year, approximately 61% of the region's labour force worked in trade or in service industries, which is clearly below the national average (75%). In 2021, the number of places of business was 3,363. Of the employment in the region, the share of processing industries was 35%, exceeding the national average (22%) (Statistics Finland 2024c). One of the most significant employers in the region's processing industry is TVO, which had approximately 1,000 employees in 2023. TVO's operations can be seen especially at Eurajoki in the electricity, gas and heating supply industry, whose employment is significantly affected by its direct operation in the municipality. (Table 46)

Table 46. Key indicators on the operations of Teollisuuden Voima Oyj, 2023. Includes plant units OL1, OL2 and OL3. (TVO 2024)

	Turnover	Investments	Balance sheet total	Personnel on average	Electricity delivery
Operations in 2023	€873 million	€449 million	€7,714 million	1,055 person years	24,633 GWh

As a whole, the energy industry plays a central role in the economy of the Rauma region. In addition, the energy sector is significantly larger in the Rauma region than on average in Finland (Table 45), largely due to TVO's operations in the region. In the region, the industry's annual investments are more than 4 times higher and its employment impact more than 6 times higher than the average in Finland. The role of the energy industry as a pillar of the region's economy is emphasised through its direct impacts. In addition, the activity creates multiplicative effects that are reflected locally, regionally and nationally.

With regard to the regional economy, the sensitivity of the affected aspect was evaluated with the help of factors such as the region's economic structure, unemployment, public finances, population development and economic dependence ratios. At the level of Finland as a whole, sensitivity is estimated as low, which reflects the varied economic structure, low unemployment, growing population development and versatile public and private services. At the Satakunta regional level, sensitivity was assessed as moderate, as the region has a balanced economic structure, stable municipal economy, stable employment situation and sufficient service provision despite the declining population and weak financial dependency ratio. At the local level, in the Rauma region, sensitivity is high, as the area has a rather one-sided economic structure, a decreasing population, limited service provision and a financial dependency ratio weaker than the national average, despite the employment situation being better than average.

6.12.3. Environmental impacts

6.12.3.1. Continuing operation

If the KPA storage is expanded, continued operation will have regional economic impacts in two different phases: through the alteration work required by the expansion of the KPA storage, and through the extension of the service life of the plant units. The impacts on the regional economy during construction of the KPA storage extension would arise at different regional levels as a result of new temporary demand. However, the impacts would not last long, as the construction will take approximately 2 years.

In the case of continued operation after 2038, turnover in Finland would cumulatively be around 5.2–10.6 billion euros, and the employment effects would be around 22,400–44,900 person years, depending on whether operation is continued until 2048 or 2058 (Table 47). The impacts would mainly affect the same actors as in the current operation. For example, in terms of employment effects, the existing jobs would continue in existence until 2048 or 2058.

Table 47. Continuing operation at the current power level until 2048 or 2058: regional economic impacts at the local, regional and national level. The presented impacts describe the overall impacts of TVO's operations, including the direct impacts of the operation as well as the multiplicative effects caused by it. Taxes describe taxes generated at different regional levels, not where the generated taxes are paid.

	Rauma region	Rest of Satakunta	Rest of Finland
Duration	**10 years (2038–2048)**		
Turnover	€3,383 million	€209 million	€1,707 million
Added value	€1,529 million	€118 million	€806 million
Employment	7,080 person years	3,070 person years	12,277 person years
New investments	€68 million	€59 million	€493 million
Taxes	€1,367 million	€161 million	€452 million
Duration	**20 years (2038–2058)**		
Turnover	€6,765 million	€418 million	€3,413 million
Added value	€3,059 million	€235 million	€1,612 million
Employment	14,161 person years	6,141 person years	24,553 person years
New investments	€136 million	€118 million	€985 million
Taxes	€2,735 million	€323 million	€905 million

The magnitude of the impacts was assessed at different levels: local (Rauma region), regional (Satakunta) and national (Finland as a whole). These impacts were described in relation to the most recent indicator data taken from the regional accounts, which made it possible to compare their significance with key indicators concerning the regional economy, such as turnover, added value, employment, investments and taxation (Table 48).

The regional economic impacts of continued operation were found to be quite significant, especially at the local level. The overall cumulative impacts of the activities were seen to correspond to approximately 53.5–106.9% of the current annual total output (turnover) of the Rauma region, depending on the period under review. The average annual impacts were estimated to remain roughly the same as they are today.

Table 48. Continued operation with the current power until 2048 or 2058: the magnitude of the regional economic impacts, described as the ratio of the regional economic impacts to the most recent annual indicators taken from the regional accounts at different regional levels. The presented impacts describe the overall impacts of TVO's operations, including the direct impacts of the operation as well as the multiplicative effects caused by it. Taxes describe taxes generated at different regional levels, not where the generated taxes are paid.

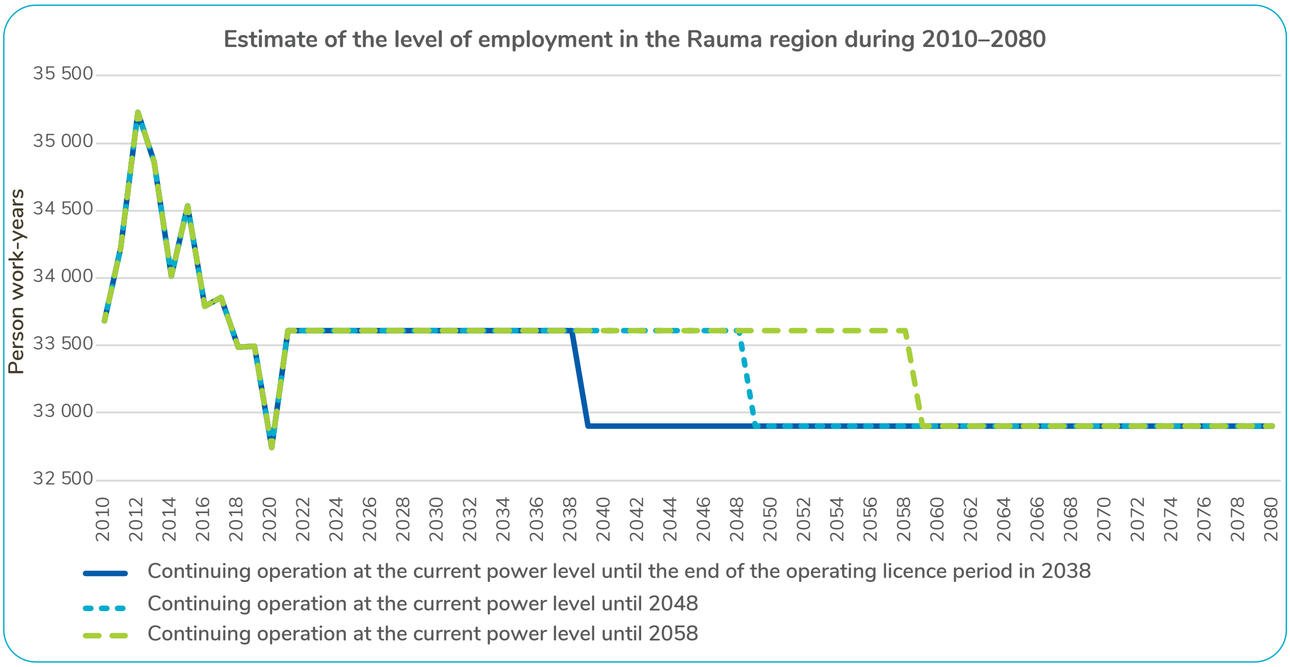
	Rauma region	Satakunta	Finland
Cumulative impacts from the entire reviewed period in relation to the most recent regional accounting year			
Duration	**10 years (2038–2048)**		
Turnover	53.5%	1.2%	0.4%
Added value	57.6%	1.6%	0.4%
Employment	21.1%	3.1%	0.5%
New investments	14.0%	4.2%	0.8%
Taxes	121.4%	5.1%	0.4%
Duration	**20 years (2038–2058)**		
Turnover	106.9%	2.3%	0.7%
Added value	115.3%	3.2%	0.7%
Employment	42.1%	6.1%	0.9%
New investments	28.1%	8.3%	1.7%
Taxes	243.0%	10.3%	0.8%

The accompanying figure (Figure 66) illustrates the regional economic impacts of continued operation in the Rauma region and their realisation over time in the different alternatives. The figure shows that if the operation of the OL1 and OL2 plant units ends in 2038, the annual turnover of the Rauma region will decrease by approximately 338 million euros as a result of the loss of the overall impacts of the operation. If operation is continued until 2048, the cumulative impact will be approximately 3,383 million euros, and, if it is continued until 2058, approximately 6,765 million euros.

Following the extension of service life, new added value would accumulate in the Rauma region as a result of the overall impacts for a total of 1,529–3,059 million euros and a need for labour for a total of 7,080–14,161 person years. The impacts would mostly be distributed evenly between years, and would appear as annual spikes in connection with larger-scale maintenance work, as is the case currently. The continuation of operation would enable the preservation of hundreds of direct and indirect jobs in Satakunta and more broadly in Finland well into the future. As overall impacts elsewhere in Satakunta (Satakunta excluding The Rauma region), new turnover would accumulate to other actors a total of 209–418 million euros; added value for a total of 118–235 million euros; and a need for labour for a total of 3,070–6,141 person years. Elsewhere in Finland (Finland excluding Satakunta), new turnover would accumulate to other actors a total of 1,707–3,413 million euros; added value for a total of 806–1,612 million euros; and a need for labour for a total of 12,277–24,553 person years. Tax revenues would accrue at different regional levels a total of 1,981–3,962 million euros, most of which would be paid to the Finnish state.

The magnitude of the impacts was estimated to be large positive at the level of the Rauma region. For Satakunta as a whole, the magnitude of the impacts will remain a minor positive. The same applies to the level of Finland as a whole.

After the end of the operation of the OL1 and OL2 plant units, regional economic impacts will be generated during the decommissioning phase of the plant units. As a result of the end of production, the overall impacts will decrease significantly; however, they will not cease completely, as the decommissioning of the plant units will in reality be carried out gradually, as described in Chapter 6.21.



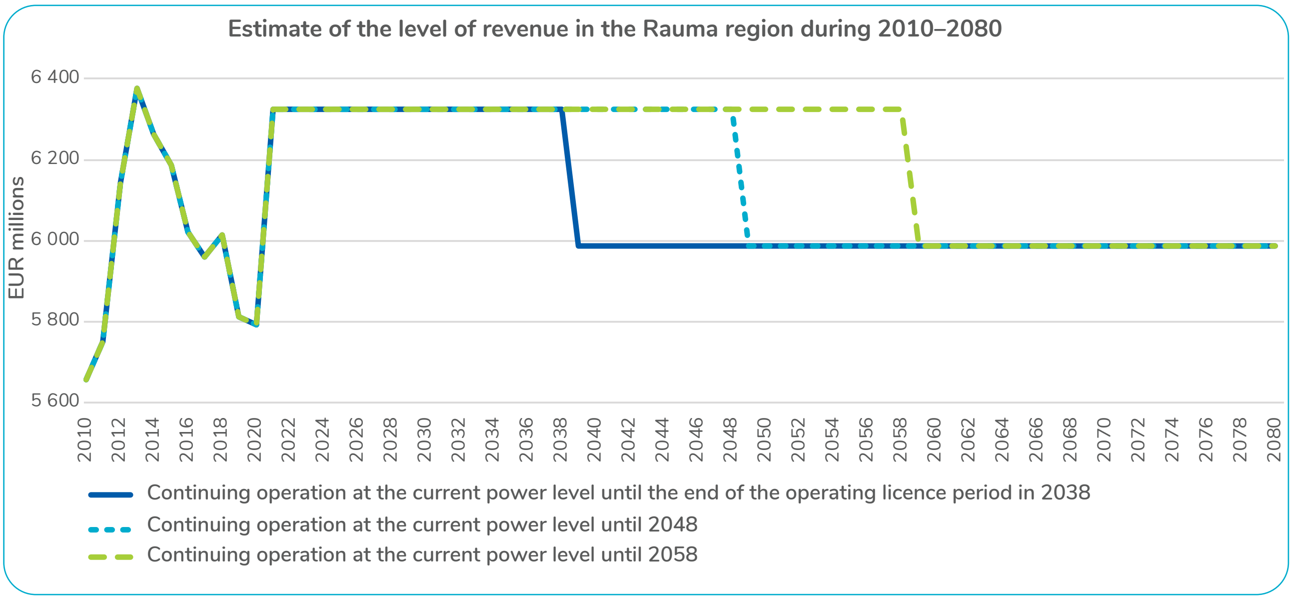


Figure 66. Estimate of the level of employment and revenue in the Rauma region during 2010–2080. The period 2020–2021 is based on the actual numbers reported by Statistics Finland. The impact on revenue of extending the operation of the OL1 and OL2 plant units was assumed to be the same as during the latest year for which statistics for regional accounting are available, i.e. 2021. The revenue impacts of ending the operation depict the total impacts of the activities based on the results of the modelling (multiplicative effects) and TVO's own operations. In practice, the decommissioning of the production facilities will take place in stages, which means that the impacts caused by the activity will not disappear completely.

6.12.3.2. Power uprating

The regional economic impacts of the power uprating occur in two different phases: through the modifications required by the power uprating and through the extension of the service life of the plant units. The changes resulting from the extension of service life mainly affect the amount of energy produced in Finland, as well as the turnover generated as a result of its sale and the financial indicators derived from this.

The impacts on the regional economy from the alteration work required by power uprating would arise at different regional levels as a result of new temporary demand (Table 49). It is likely that the power uprating could be commissioned in 2028 at the earliest. Part of the required alteration work would be carried out before this and part in connection with it and after it. The magnitude of the impacts was assessed at different levels: local (Rauma region), regional (the rest of Satakunta) and national (Finland as a whole) a (Table 50). These impacts were described in relation to the most recent indicator data taken from the regional accounts, which made it possible to compare their significance with key indicators concerning the regional economy, such as turnover, added value, employment, investments and taxation.

Table 49. Alteration work required by power uprating: regional economic impacts at the local, regional and national level. The presented impacts include the multiplicative effects following from the power uprating, as well as the personnel who will work on the power uprating project during its implementation.

	Rauma region	Rest of Satakunta	Rest of Finland
Duration	Arviolta noin 6 vuotta		
Turnover	€19 million	€13 million	€119 million
Added value	€9 million	€6 million	€55 million
Employment	118 person years	83 person years	689 person years
New investments	€2 million	€1 million	€12 million
Taxes	€4 million	€3 million	€26 million

Table 50. The magnitude of the cumulative regional economic impacts of the changes required by the power uprating for the entire reviewed period, described as the ratio of the regional economic impacts to the most recent annual indicators taken from the regional accounts at different regional levels. The presented impacts include the multiplicative effects following from the power uprating, as well as the personnel who will work on the power uprating project during its implementationa.

	Rauma region	Satakunta	Finland
Duration	Cumulative impacts from the entire reviewed period in relation to the most recent regional accounting year		
Turnover	0.31%	0.07%	0.03%
Added value	0.34%	0.09%	0.03%
Employment	0.59%	0.12%	0.03%
New investments	0.32%	0.08%	0.02%
Taxes	0.38%	0.09%	0.02%

Based on the results of the modelling, it was found that as a result of the changes required by the power uprating, there would be clear temporary impacts that would affect several actors at different regional levels. The cumulative total impacts of the power uprating during the entire reviewed period would correspond to approximately 0.31% of the current total annual output (turnover) of the Rauma region at the local level; approximately 0.07% of the current total annual output (turnover) of Satakunta at the regional level; and approximately 0.03% of the current total annual output in Finland (turnover) at the national level. Some of the impacts of the alteration work required by the power uprating would affect the same actors as the impacts during operation, but some would probably affect actors who do not belong to the current value chains of the operation of the OL1 and OL2 plant units. However, the power uprating does not require the hiring of new employees, but can be implemented by reorganising the company's internal resources.

After the power uprating, the annual direct turnover generated from the operation of the OL1 and OL2 plant units should increase, but the employment impacts are estimated to remain the same as before the uprating. In other words, the personnel who work on the power uprating project during the uprating will continue to work at other tasks after the project is implemented, just like they did before the project. The accompanying table (Table 51, Table 52) describes a situation where the current operation is continued with increased power until 2048 or 2058, also taking into account the temporary impacts that result from the power uprating.

Table 51. Continuing operation with uprated power until 2048 or 2058: regional economic impacts at the local, regional and national level, including the temporary impacts of the power uprating. The presented impacts describe the overall impacts of TVO's operations, including the direct impacts of the operation as well as the multiplicative effects caused by it. Taxes describe taxes generated at different regional levels, not where the generated taxes are paid.

	Rauma region	Rest of Satakunta	Rest of Finland
Duration		**10 years (2038–2048)**	
Turnover	€3,654 million	€222 million	€1,826 million
Added value	€1,651 million	€124 million	€860 million
Employment	7,199 person years	3,153 person years	12,965 person years
New investments	€70 million	€60 million	€505 million
Taxes	€1,442 million	€164 million	€479 million
Duration		**20 years (2038–2058)**	
Turnover	€7,287 million	€431 million	€3,532 million
Added value	€3,294 million	€242 million	€1,667 million
Employment	14,280 person years	6,224 person years	25,242 person years
New investments	€138 million	€119 million	€997 million
Taxes	€2,880 million	€326 million	€931 million

Table 52. Continued operation with uprated power until 2048 or 2058: the magnitude of the cumulative regional economic impacts, including the temporary impact of the changes required by the power uprating, described as the ratio of the regional economic impacts to the most recent annual indicators taken from the regional accounts at different regional levels. The presented impacts describe the overall impacts of TVO's operations, including the direct impacts of the operation as well as the multiplicative effects caused by it. Taxes describe taxes generated at different regional levels, not where the generated taxes are paid.

	Rauma region	Satakunta	Finland
Cumulative impacts from the entire reviewed period in relation to the most recent regional accounting year			
Duration	**10 years (2038–2048)**		
Turnover	57.8%	1.2%	0.4%
Added value	62.2%	1.7%	0.4%
Employment	21.4%	3.2%	0.5%
New investments	14.4%	4.2%	0.9%
Taxes	128.1%	5.2%	0.4%
Duration	**20 years (2038–2058)**		
Turnover	115.2%	2.4%	0.7%
Added value	124.2%	3.3%	0.8%
Employment	42.5%	6.2%	0.9%
New investments	28.4%	8.4%	1.7%
Taxes	255.8%	10.4%	0.8%

The accompanying images (Figure 67, Figure 68) illustrate the regional economic impacts of continued operation with uprated power in the Rauma region and their realisation over time in the different alternatives. The images also show a temporary spike from the temporary impacts of the modification work required by the power uprating.

Following the extension of service life together with the power uprating, new added value would accumulate in the Rauma region as a result of the overall impacts to a total of 1,651–3,294 million euros and a need for labour to a total of 7,199–14,280 person years. The impacts would mostly be distributed evenly between years, and would appear as annual spikes in connection with the power uprating and any larger-scale maintenance work, as is the case currently. The continuation of operation would enable the preservation of hundreds of direct and indirect jobs in Satakunta and more broadly in Finland well into the future. As overall impacts elsewhere in Satakunta (Satakunta excluding The Rauma region), new turnover would accumulate to other actors for a total of 222–431 million euros; added value for a total of 124–242 million euros; and a need for labour for a total of 3,153–6,224 person years during the extended service life. Elsewhere in Finland (Finland excluding Satakunta), new turnover would accumulate to other actors for a total of 1,826–3,532 million euros; added value for a total of 860–1,667 million euros; and a need for labour for a total of 12,965–25,242 person years. Tax revenues would accrue at different regional levels for a total of 2,085–4,137 million euros, most of which would be paid to the Finnish state.

The magnitude of the impacts was estimated to be a large positive at the level of the Rauma region. For Satakunta as a whole, the magnitude of the impacts will remain a minor positive. The same applies to the level of Finland as a whole.

After the end of the operation of the OL1 and OL2 plant units, regional economic impacts will be generated during the decommissioning phase of the plant units. As a result of the end of production, the overall impacts will decrease significantly; however, they will not cease completely, as the decommissioning of the plant units will in reality be carried out gradually, as described in Chapter 6.21.

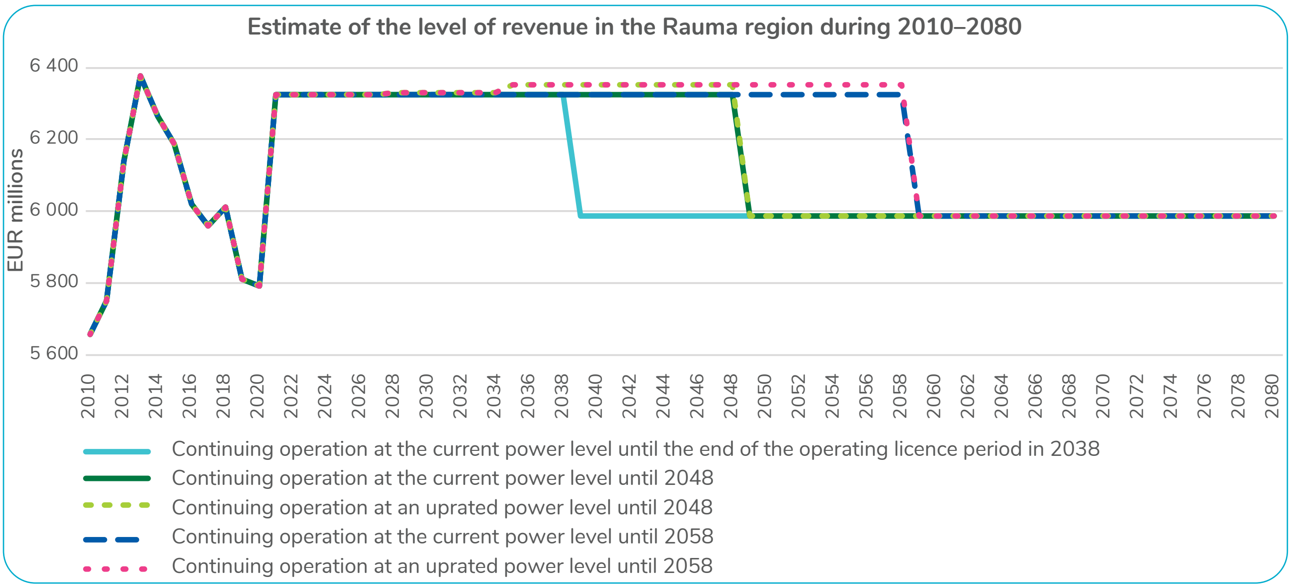


Figure 67. Estimate of the level of revenue in the Rauma region during 2010–2080. The period 2020–2021 is based on the actual numbers reported by Statistics Finland. The impact on revenue of extending the operation of the OL1 and OL2 plant units was assumed to be the same as during the latest year for which statistics for regional accounting are available, i.e. 2021. The revenue impacts of ending the operation depict the total impacts of the activities based on the results of the modelling (multiplicative effects) and TVO's own operations. In practice, the decommissioning of the production facilities will take place in stages, which means that the impacts caused by the activity will not disappear completely. The impact of the power uprating on future revenue has been considered as an increase in direct revenue from the operation of the OL1 and OL2 plant units.

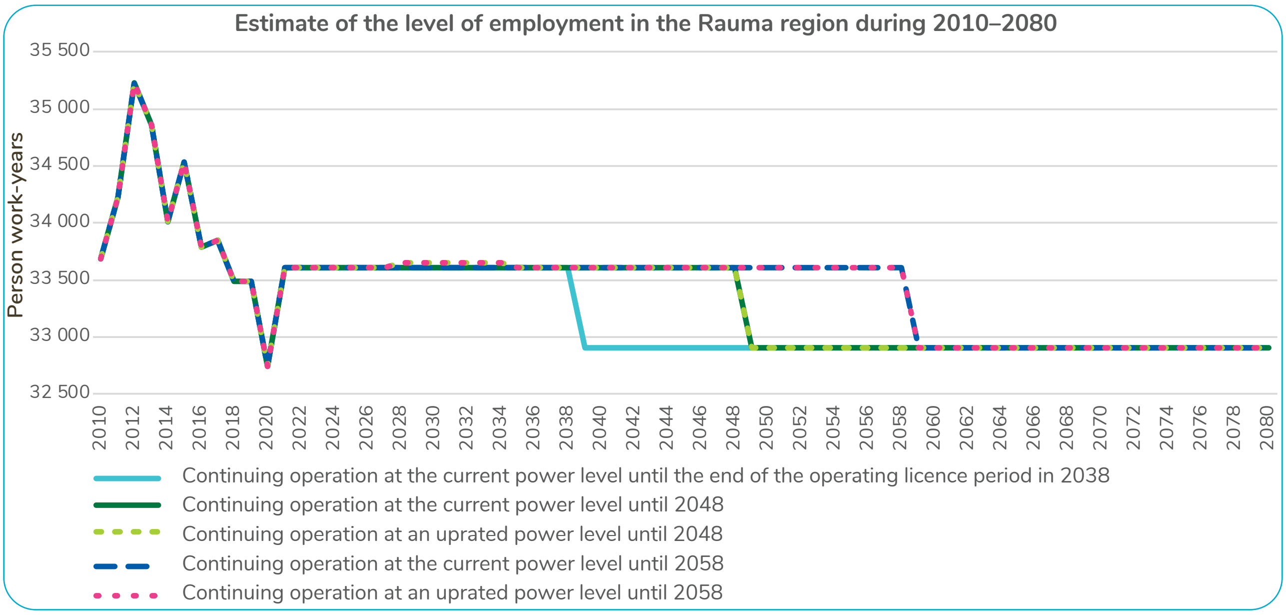


Figure 68. Estimate of the level of employment in the Rauma region during 2010–2080. The period 2020–2021 is based on the actual numbers reported by Statistics Finland. The impact on employment of extending the operation of the OL1 and OL2 plant units was assumed to be the same as during the latest year for which statistics for regional accounting are available, i.e. 2021. The employment impacts of the power uprating are based on modelling results, in which case the number has been supplemented by the temporary multiplicative impacts caused by the power uprating in 2028–2034. The power uprating does not alter the direct employment impacts, even though part of TVO's personnel will be working for the project for the duration of the power uprating. The employment impacts of ending the operation depict the total impacts of the activities based on the results of the modelling (multiplicative effects) and TVO's own operations. In practice, the decommissioning of the production facilities will take place in stages, which means that the impacts caused by the activity will not disappear completely.

6.12.3.3. Significance of the impacts

Local level (Rauma region)

At the local level, in the Rauma region, the sensitivity was assessed as high, as the area has a rather one-sided economic structure, a decreasing population, limited service provision and a financial dependency ratio weaker than the national average, despite the employment situation being better than average. In the options of both continued operation and power uprating, the significance of the impacts on the Rauma region has been assessed as very positive, as significant direct regional economic impacts and multiplicative effects accumulate during the additional years of operation of the plant units (Table 53). The total impacts in the region will amount to more than €3,380 million in turnover, €1,520 million in added value and more than 7,080 person years in labour demand. The evaluation has not taken into account the impacts of decommissioning and dismantling the plant units.

Table 53. Significance of the impacts: Regional economy. Local level (Rauma region).

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Large	Large positive	Large positive
VE2	Large	Large positive	Large positive

Regional level (Satakunta)

At the Satakunta regional level, sensitivity was assessed as moderate, as the region has a balanced economic structure, stable municipal economy, stable employment situation and sufficient service provision despite the declining population and weak financial dependency ratio. In the options of both continued operation and power uprating, the significance of the impacts on Satakunta has been assessed as a minor positive, as a large amount of regional economic impacts would accumulate in the province during the additional years of operation of the plant units, but they would be small when compared to the size of the area under review (Table 54). The total impacts in Satakunta are more than €3,590 million in turnover, €1,640 million in added value and more than 10,150 person years in labour demand.

Table 54. VSignificance of the impacts: Regional economy. Regional level (Satakunta).

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Moderate	Minor positive	Minor positive
VE2	Moderate	Minor positive	Minor positive

National level (all of Finland)

At the level of Finland as a whole, sensitivity is estimated as low , which reflects the varied economic structure, low unemployment, growing population development and versatile public and private services. In the options of both continued operation and power uprating, the significance of the impacts on the level of Finland as a whole has been assessed as a minor positive, as very large regional economic impacts would accumulate in during the additional years of operation of the plant units, but they would be small when compared to the size of the Finnish economy (Table 55). The total impacts in Finland are more than €5,290 million in turnover, €2,450 million in added value and more than 22,420 person years in labour demand.

Table 55. Significance of the impacts: Regional economy. All of Finland.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor positive	Minor positive
VE2	Minor	Minor positive	Minor positive

6.12.4. Mitigation of harmful impacts

Adverse impacts are created on the regional economy when the operation of the OL1 and OL2 plant units ceases and the economic activity around the plant units ends at the same time. This impact is transferred to the future by continuing operation in accordance with the alternative plans presented. However, this does not mitigate the impacts of the shutdown and decommissioning, but only postpones them to the future. When the OL1 and OL2 plant units are at the end of their life cycle, there will also be economic impacts during decommissioning, which will mitigate the harmful impacts and transition to a new economic balance from the viewpoint of the regional economy. The impacts of decommissioning are described generally in Chapter 6.21.

During the continuation of operations, the adverse impacts on the regional economy and business life are mainly problems related to an employment mismatch. Employment mismatch refers to a situation where open jobs and jobseekers do not correspond to each other, for example, because the skills of the jobseekers do not match the needs of the employers or because the jobs and jobseekers are located in different areas. This can be particularly pronounced in an area where one large employer has a significant influence on the demand

and supply of labour. In addition, as regional demand increases, from the point of view of employers in the region there may be a possible increase in the cost of labour and competition for labour if alternative labour resources are not found in the nearby area to an equally significant extent. The same phenomenon can be observed temporarily during the possible power uprating, when certain labour resources are needed more. These harmful effects can be mitigated, for instance, by purchasing services and by procuring them widely from different operators and regions, as a result of which there will be no sudden local changes in the matching between labour supply and demand.

6.12.5. Uncertainty factors

In the modelling, the realisation of the situations according to the current plans has been evaluated in accordance with the alternatives presented, and, thus, the realisation of the regional economic impacts depends on whether the operation of the OL1 and OL2 plant units continues according to the current plans and whether the operation in the future is as predicted. The multiplier effects are formed through the products and services that are purchased, and their price level, thus, influences the resulting multiplicative effects. In the future, it would be good to carry out an assessment of the regional economic impacts on the basis of the implemented activities at regular intervals, enabling the estimated effects to be verified and future-oriented scenarios and plans to be updated with current information.

6.13. Energy market

6.13.1. Initial data and assessment methods

The impacts on the energy market and availability of electricity were assessed on the basis of statistics on the electricity markets of Finland and other Nordic countries as well as projections and reports, taking into account Finland's objective of carbon neutrality by 2035. Impacts on the energy market have been examined while taking into account the schedule for the various project alternatives. The initial data used are presented in more detail in the following chapters.

6.13.2. Current status

The total electricity production of the OL1 and OL2 plant units of TVO's Olkiluoto nuclear power plant was approximately 14.3 TWh in 2023. TVO also generates electricity at the OL3 plant unit, whose commercial electricity production started in May 2023. TVO's three plant units generate a total of approximately 25 TWh of electricity per year.

The Olkiluoto power plant produces electricity for the Nordic wholesale electricity market, which comprises Finland, Sweden, Norway and Denmark. In 2022, the net production of electricity in the Nordic electricity market totalled 427 TWh, while electricity consumption amounted to 373 TWh *(Finnish Energy 2024, Energimyndigheten 2024, Statistisk sentralbyrå 2024, Danish Energy Agency 2024)*. The Nordic market also carries out electricity trades with other market areas.

Finland's electricity production by energy source and net imports in 2023 are shown in the figure below (Figure 69) Finland's electricity production in 2023 was 78 TWh, while the total consumption of electricity was 80 TWh. Electricity production has increased significantly from the level before the energy crisis. From 2022 to 2023, there was a 13% increase. At the same time, electricity consumption fell by a little over 2%. The increase in production and decrease in consumption led to a significant decrease in the need for imported electricity. In 2023, net imports accounted for 2.2% of electricity consumption. Electricity production has been increased by investments in wind power and the completion of Olkiluoto 3. In 2023, wind power production increased by 25% and nuclear power production by 35% when compared to 2022. 32.7 TWh of electricity was generated by nuclear power, which corresponded to a share of 41% of the electricity consumption. According to a preliminary estimate, carbon dioxide emissions from electricity production amounted to 2.5 Mt CO_{2e} in 2023. Emissions fell by approximately 38% when compared to the previous year. *(Finnish Energy 2024)*

Finland depends on imports in peak electricity consumption situations. For example, on a cold winter day, the electricity consumption peak has been estimated to be approximately 14,300 MW, while, at the same time, the available domestic market-based production capacity has been estimated to be around 12,800 MW in total. To cover the demand during the consumption peak, Finland needs approximately 1,500 MW of imported electricity. The import capacity from neighbouring countries to Finland via transmission connections totals approximately 3,400 MW. *(Energy Authority 2024)*

The sensitivity level of the affected aspect is determined based on the current situation of Finland's energy markets and electricity availability, which is influenced by, among other things, electricity production capacity, electricity consumption as well as the import and export of electricity. The sensitivity of the affected aspect is estimated to be minor, as Finland's electricity production and consumption are almost at the same level, and the need for imported electricity has decreased. However, Finland depends on imports in peak electricity consumption situations.

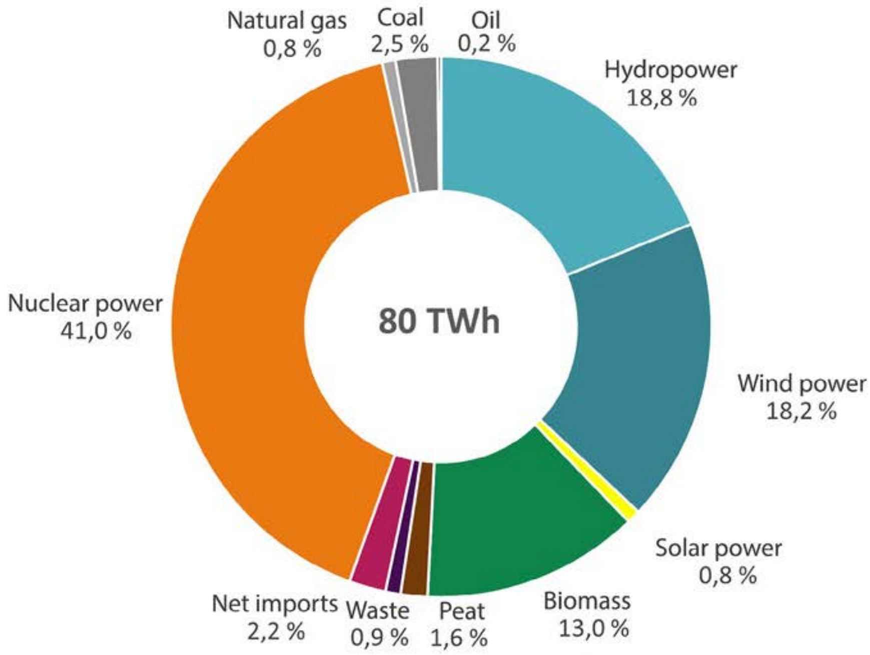


Figure 69. Electricity production by energy source and net imports in 2023. (Finnish Energy 2024)

6.13.3. Environmental impacts

6.13.3.1. Continuing operation

The current Government Programme in Finland aims to achieve carbon neutrality in 2035 and carbon negativity quickly thereafter *(Government 2023)*. Electricity can replace the use of fossil fuels and raw materials which lead to carbon dioxide emissions in the industrial sector, transport and heating. At the same time, the good efficiency of electrical processes improves energy efficiency. In addition to the electricity's direct end use, electricity can also be used for the production of synthetic fuels and the industrial sector's raw materials with what is referred to as Power-to-X technology, by producing hydrogen from water with the help of electrolysis. Electricity consumption is, therefore, estimated to grow markedly in the future, both in Finland and in the other Nordic countries. According to the low-carbon roadmaps published by the MEAE, Finland's climate objectives could translate into a 100% growth in the industrial sector's electricity consumption and a more than 50% growth in Finland's electricity consumption by 2050 (*Ministry of Economic Affairs and Employment 2020*, Figure 70).

Nordic electricity consumption is also estimated to grow significantly. In the scenarios drawn up by European transmission system operators, electricity consumption in the Nordic countries would be in the range 436–472 TWh in 2030 and in the range 468–558 TWh in 2040 *(EN-TSO-E & ENTSOG 2020)*.

In respect of the security of supply of Finland's electricity production, nuclear power is of central importance based on the electricity production available, independent of the weather and the fuel stocks at nuclear power plants. This importance is set to grow as coal power plants are decommissioned due to the use of coal for energy becoming prohibited as of May 2029, and as the energy use of peat and peat stocks decreases in line with climate targets.

The opportunities to increase hydropower in Finland are small, nor can Finland increase the availability of woodfuel for power plant use to any significant degree from the current level. While the production of wind and solar power is growing, they are constrained by their dependence on the weather and the small production of solar power during winter. As the consumption of electricity increases, both existing and new nuclear power plants will support the security of supply of Finland's energy system and reduce the need to import electricity. At the same time, nuclear power plants enable the export of electricity, which can replace fossil-based electricity production and reduce the attendant carbon dioxide emissions, especially in the Baltic countries and Poland. Given that emission reduction targets increase the costs of fossil-based electricity production through emissions trading, Finland's increasing nuclear and wind power capacity, combined with the flexible Nordic hydropower capacity, will provide the conditions needed for both Finland's increasing electricity consumption and the export of electricity.

If the operation of the OL1 and OL2 plant units is not extended, the outgoing share of zero-carbon electricity generation must be replaced either by building new emission-free electricity production capacity in Finland or with imported electricity. The construction of new replacement electricity production capacity would cause additional costs and environmental impacts. The use of fossil fuels could also increase in Finland, which would impair the achievement of Finland's carbon neutrality objective. Additional investments in carbon dioxide recovery would also be needed. If the amount of electricity generated by the OL1 and OL2 plant units were replaced by imported electricity, it would weaken the self-sufficiency of Finland's electricity production, as the share of electricity imports would increase. The possibilities for exporting electricity from Finland would also decrease, which would reduce export earnings and impede the reduction of fossil-based electricity production, especially in the Baltic countries and Poland. The reduction of nuclear power at the level of the EU as a whole as well would result in additional costs were the EU to achieve its emission reduction targets.

Based on the above, the magnitude of the change of the continued operation of the OL1 and OL2 plant units can be estimated to be large positive.

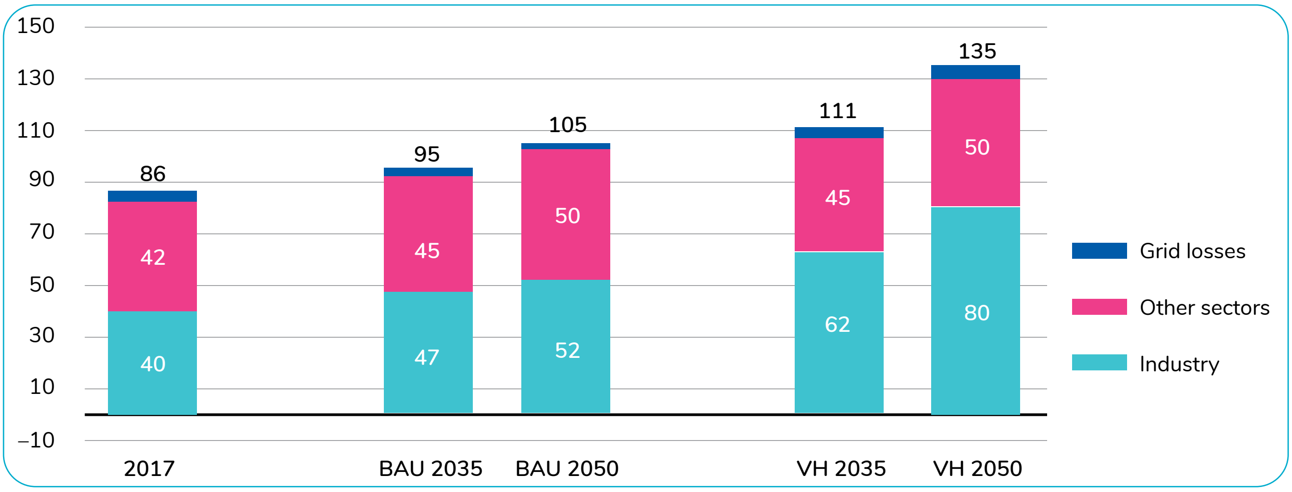


Figure 70. Electricity demand for the industry and other sectors in the background analysis scenarios for Finnish Energy's roadmap (Ministry of Economic Affairs and Employment 2020).

6.13.3.2. Power uprating

In the power uprating case, the impacts on energy markets and the availability of electricity are similar to those described in the service life extension case (Chapter 6.13.3.1). However, with the power uprating, 1.2 terawatt hours more electricity would be produced per year (TWh/year) than with continued operation, with a total production of approximately 15.2 TWh/year. Based on these, the magnitude of the change with the continued operation of the OL1 and OL2 plant units at an uprated power level can be estimated to be large positive.

6.13.3.3. Significance of the impacts

The sensitivity of the affected aspect was estimated to be minor, as Finland's electricity production and consumption are almost at the same level, and the need for imported electricity has decreased. However, Finland depends on imports in peak electricity consumption situations. Both in the service life extension and the power uprating case, the magnitude of the change was estimated to be a large positive with the operation of the functional plant units not ending in 2038, but, instead, being extended in Finnish energy production until 2048 or 2058. The significance of the impacts is a large positive because, as electricity consumption grows in the future, extending the operation of the plant units will support the security of supply of Finland's energy system and reduce the need to import electricity (Table 56). Nuclear power plants also enable the export of electricity to replace fossil-based electricity production.

Table 56. Significance of the impacts: Energy markets.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Large positive	Large positive
VE2	Minor	Large positive	Large positive

6.13.4. Mitigation of harmful impacts

In the case of the service life extension and power uprating of the nuclear power plants, the significance of the impact has been estimated to be positive, in which case no adverse impacts will occur.

6.13.5. Uncertainty factors

The impact assessment is an indicative assessment, given that it is based on projections of the electricity market's future development, among other things. Projections always involve a degree of uncertainty. In addition, uncertainty factors are related to estimates of the replacement of electricity produced by nuclear power by other forms of electricity production in the future. The preparation of more precise reviews of Finland's energy markets and security of supply is the responsibility of the Finnish Government.

6.14. Use of natural resources

6.14.1. Initial data and assessment methods

The impact assessment has reviewed the impacts caused by the use of natural resources in the project. In the case of the service life extension and power uprating, the procurement of nuclear fuel required by the nuclear power plant has been examined. The impact assessment describes on a general level the availability of nuclear fuel and its supply chain, transport and use, based on the power plant's nuclear fuel procurement practices and on information published by nuclear fuel producers concerning the impacts of the fuel supply chain. An assessment on the utilisation of natural uranium has also been presented, based on, among other things, estimates concerning the current status of uranium reserves and related forecasts *(OECD/NEA & IAEA 2023)*. In addition, the impact assessment has briefly discussed the impacts related to the construction of possible additional buildings by describing, for example, the reuse of soil.

6.14.2. Current status

The power plant area has been in its current use since the late 1970s, so there is no direct use of natural resources in the area. The VLJ repository located in the power plant area's bedrock was commissioned in 1992. The rock material generated in the quarrying of the VLJ repository has been used mainly in the power plant area.

The nuclear fuel used in the power plant, produced from uranium ore through various chemical and mechanical stages, is procured from a nuclear fuel supplier (see Chapter 3.2.5). The nuclear fuel cycle can be open or closed. Finland applies an open fuel cycle principle where spent nuclear fuel is placed in final disposal inside durable canisters that are buried deep in the bedrock. In a closed fuel cycle, the spent nuclear fuel is reprocessed. In reprocessing, uranium and plutonium are chemically separated from the spent fuel and reused in the production of new nuclear fuel. The high-level waste and other waste from the reprocessing are placed in final disposal. Natural uranium is a non-renewable natural resource and, at the current global levels of consumption, uranium reserves have been estimated to last for more than 130 years in an open fuel cycle *(OECD/NEA & IAEA 2023)*.

The sensitivity level of the affected aspect has been estimated to be moderate. Sensitivity is determined on the basis of whether there are impediments for the use of natural resources in the project area. The power plant restricts the direct use of the area's natural resources, but the rock engineering and quarrying closely associated with the power plant's operations can be carried out in the area by TVO. The power plant area has been in its current use since the late 1970s, so there is no use of natural resources in the area. The nuclear fuel is procured from its supplier, and the sensitivity of the affected aspects is not assessed within the frame-work of this EIA.

6.14.3 Environmental impacts

6.14.2.1. Continuing operation

Continued operation does not change the power plant area's current limitations on the utilisation of natural resources. If the KPA storage is expanded, the existing surface layers will be removed to make room for the pools to be built, and some rock material will also have to be excavated. The quantities to be excavated are small and have no impact on the use of natural resources in the area. The aim is to reuse the excavated rock material in the power plant area.

In the service life extension case, the impacts on the procurement of nuclear fuel are similar to the current operation. The environment is burdened by mining operations as well as by the production processes and transports of fuel. The majority of harmful impacts related to the nuclear fuel cycle are attributable to the mining operations. The following describes the main characteristics of the Olkiluoto power plant's nuclear fuel supply chain.

The fuel the Olkiluoto power plant uses is fissionable nuclear fuel made from uranium ore through various chemical and mechanical stages. The annual fuel requirement of the OL1 and OL2 plant units totals approximately 36 tU (in the form UO_2). The production of this volume of fuel requires approximately 260 tU of uranium concentrate (in the form U_3O_8).

Availability

The fuel used by the nuclear power plant can be procured either as complete entities, as fuel assemblies or by buying the uranium and each stage of the fuel's supply chain separately. The uranium markets are global, and currently the largest producers of uranium concentrate are Kazakhstan, Canada, Namibia and Australia. The other stages of the supply chain (conversion, enrichment and the production of fuel assemblies) can be bought from Sweden, Germany, France or the United States, among other countries.

The annual requirement for uranium concentrate among the world's nuclear power plants totals roughly 67,000 tU, of which approximately 75% is currently covered by primary production. The rest of the market's uranium need is met by using stocks and reprocessing spent nuclear fuel *(OECD/NEA & IAEA 2023)*.

Given the ubiquity of uranium, the uranium reserves will last far into the future. The adequacy of the uranium reserves depends on the cost level of economically profitable uranium production. The more expensive the alternative forms of energy are, the more profitable it is to produce uranium expensively, and the larger the disposable reserves of uranium are. The globally identified recoverable natural uranium resources amounted to approximately 6,100,000 tU in 2021. In addition, estimates put the undiscovered reserves that can be mined by traditional methods at roughly 7,200,000 tU. Currently, the annual production volume of uranium is around 50,000 tU. The volume of uranium required for nuclear power production is expected to increase to up to 76,000 tU by 2030 and to up to roughly 90,000 tU by 2035. At these consumption levels, the uranium reserves will last for approximately 100–200 years. New methods for the exploitation of uranium reserves can be adopted in the future if the price of uranium increases. For example, seawater has been estimated to contain more than 4,000,000,000 tU of uranium, but its cost-effective exploitation is not possible with current methods. *(OECD/NEA & IAEA 2023)*

The need for primary production can be reduced with the widespread adoption of reprocessing. The use of alternative fuels such as thorium is also being investigated, as are reactors employing the uranium-238 isotope, which could replace the use of the uranium-235 isotope in the future. These measures allow the securing of the adequacy of the reserves for a considerably longer period of time than mentioned.

TVO procures the fuel elements used in the OL1 and OL2 plant units from Germany, Spain and Sweden. The uranium contained in them has been produced in Kazakhstan, Canada, Namibia and Australia, among other countries. The various operators in the supply chain apply an environmental system pursuant to the ISO 14001 standard or equivalent in their operations, requiring the companies to investigate all their environmental impacts and to continuously improve the level of environmental protection. If the service life of the OL1 and OL2 plant units is extended, the fuel procurement will be implemented in accordance with TVO's established procurement procedures.

Supply chain

The supply chain for the nuclear fuel is composed of the mining, enrichment and conversion of uranium, and the production of the fuel assemblies. What follows provides a description of TVO's fuel supply chain at a general level.

Uranium mining and ore enrichment

Uranium is mined from underground mines, open-pit mines and by means of solvent extraction (with the uranium leached from the ore chemically). Uranium can also be separated as a by-product of other mining products such as gold, copper or phosphate. The uranium ore quarried from bedrock by traditional means is crushed and pulverised, after which the uranium is separated from the rock by a chemical leaching method in a separate flotation plant. Following this, the uranium is precipitated, and the precipitate is separated, washed and dried. The result is enriched uranium (U_3O_8, or yellowcake), the uranium concentration of which is 60–80%.

Uranium mining operations account for a significant portion of the environmental impact of the production process of nuclear fuel. The reason for this is that, while the radioactive waste generated in the mining operations is of a low level in nature, its volume is relatively large. Uranium mining operations are characterised by the consideration of radiation impacts, but in other respects, they are part of the normal extractive industry. The most significant environmental impact of uranium's mining stage is related to radiation exposure and the waste generated by the quarrying and ore enrichment. Quarrying also often damages landscapes. The magnitude of the environmental impact of uranium mining also depends on the quarrying method.

The radiation doses arising during uranium's quarrying and enrichment stages are primarily derived from three sources: the radiation of the uranium ore and dust when the ore is being quarried and handled; the radiation of the radon released from the uranium ore and the radon's decay products; and the radiation of the uranium mill tailings. The radiation emitted by the uranium itself is weak alpha radiation, which is halted by clothes or the skin alone. Indeed, the highest radiation doses are derived from uranium's radioactive decay products, such as radium and radon.

Of uranium's decay products, radon is a gaseous substance released into the air wherever the soil contains uranium. Radon is known to contribute to lung cancer. Uranium mines release more radon than usual, because the uranium concentration in the mines is greater than its average concentration in the soil or bedrock (*Vuori et al. 2002*). It should, nevertheless, be noted that radon is not only a problem associated with uranium mines. Rather, it concerns all mining operations, because the soil always contains some uranium. The radiation exposure caused to workers by radon in open-pit mines is markedly lower than in underground mines. Exposure to radiation in underground mines can be considerably reduced by efficient ventilation. The detrimental effects of quarrying have been successfully reduced as quarrying techniques have developed and operations have been automated. The control of workers' radiation exposure has improved in step with the development of working methods, and radiation exposure is monitored extensively and efficiently *(OECD/NEA 2014)*.

The environmental damage caused to landscapes is smaller when using the solvent extraction method, especially when compared to open-pit mines. In this method, the uranium is leached into a chemical solution drilled directly into the soil, and the solution is recovered with the help of pumping wells. The uranium is separated from the chemical solution, after which it is used for the production of enriched uranium, and the solution is reused in leaching.

The waste generated by uranium mining is composed of fine uranium dust, process waters, and radioactive soil and rock. The enrichment process also generates solid and liquid waste, which, in addition to radioactive radium, also contains other harmful substances, including arsenic and heavy metals.

When temporarily storing the soil and rock left over from uranium mining on the surface of the ground, it must be ensured that any piles of soil or rock containing radioactive substances have no opportunity to disintegrate or emit dust. The piles are often covered with a layer of clay. If the quarrying takes place underground, the aim is to redeposit any solid waste in the mining shafts.

The sludge generated in the ore enrichment is placed in dammed storage and evaporating pools, in which the suspended solids settle at the bottom of the pool and the water separated from them can be conducted away. Radioactive substances and heavy metals are separated from the water with chemical precipitation, after which the water is reused as process water as far as possible. The evaporation waste is collected in the form of sludge or a crystalline mass for treatment and final disposal. The environmental risks of the waste handling are mainly related to the breaking of the sludge pool dams, the carry-over of radioactive substances to groundwater, and the dusting of the soil and rock.

Conversion and enrichment

The operation of a light water reactor is based on a chain reaction. The reactor physical properties required to maintain the chain reaction require the enrichment of the fuel's uranium to 3–5%

as regards the fissile isotope uranium-235. For the enrichment, the uranium concentrate (U_3O_8) is converted, by way of chemical conversion, into natural uranium (uranium hexafluoride, UF_6), which is a compound that gasifies directly from a solid state at a low temperature. Conversion plants use the same chemicals as the conventional chemicals industry. The use of harmful chemicals, such as fluorine compounds, requires special and precautionary measures.

The enrichment is based on the differences in the mass of the various uranium isotopes, which allows for separating isotope uranium-235 from uranium's other isotopes with a centrifugal method. During the enrichment, the chemical form of uranium remains the same, UF_6. The uranium in conversion and enrichment plants is isolated within the process equipment and does not have a radiation impact on employees or the environment. Wastewaters and waste gases are treated appropriately, due to which they have no significant impact on the environment in normal conditions.

Production of fuel assemblies

For the production of fuel pellets, the uranium hexafluoride (UF_6) enriched in relation to the isotope uranium-235 is converted into uranium oxide powder (UO_2) by means of a chemical conversion process. In modern fuel plants, this conversion process takes place mainly as a dry process, due to which the liquid emissions resulting from the process are lower than in a conversion based on the traditional wet process.

The uranium oxide powder is compressed into fuel pellets which are treated in an oven at a high temperature to become a ceramic material. The fuel pellets are then ground into their ultimate dimensions and placed inside cladding tubes made from a zirconium alloy. The tubes are pressurised with helium, which improves the fuel's heat transfer, and sealed hermetically. The finished fuel rods are bundled into fuel assemblies, consisting of approximately 100 rods depending on the fuel type, which are stored for transport.

Each work phase takes place according to detailed procedures and strict quality control. The radiation impacts of the work phases are low, because enriched uranium contains hardly any of the decay products that are most harmful in terms of radiation, such as radium, radon and polonium. The production facilities' radiation levels and uranium dust concentration are monitored with continuous measurements.

Transports

The transports between different stages of the fuel chain are carried out as supervised maritime, rail and road transports, relying on special containers and normal transport equipment. The greatest transport capacity is required at the beginning of the fuel chain, given that, as the fuel's degree of processing grows, the amount of material to be moved decreases.

The transport packages and transport of radioactive substances are regulated by the International Atomic Energy Agency's (IAEA) regulations and the national regulations based on the IAEA's regulations. Uranium transports require an official permit, and they must be guarded and supervised to prevent their unauthorised seizure.

In all stages of transport, the transport packages have been designed with criticality safety in mind, i.e. that the initiation of a chain reaction producing heat and radiation is not possible. This is realised with the help of protections, and by dimensioning the size and shape of the transport packages so that a chain reaction would not be initiated, even in the event of an accident. Transport packages must withstand strong collisions and fires, among other things.

It is nowadays typical for transports to be included in deliveries as a whole. Uranium concentrate is bought delivered to the conversion plant, and the converted uranium (UF_6) delivered to the enrichment plant. The enriched uranium (UF_6) is either bought delivered to a plant which produces fuel assemblies, or the transport of the enriched uranium is included in the fuel's production agreement, as is the finished fuel assemblies' transport to the power plant. Transports do not impact the health of the transport staff or members of the public residing along the transport routes, because the transported materials are not highly radioactive.

The nuclear fuel intended for Olkiluoto is delivered to Finland by sea, and to the power plant by road. The annual fuel need of the OL1 and OL2 plant units is approximately 36 tU, i.e. equivalent to a few truck loads. At the Olkiluoto power plant, the fresh fuel is stored in dry storage. The licence to possess nuclear fuel requires guarding, which prevents unauthorised persons from gaining access to the nuclear material.

Use

The use of uranium as fuel is based on the splitting of the nucleus of the atom of the uranium isotope uranium-235, or fission. In a fission reaction, the heavy atom splits into two or more lighter atomic nuclei – called fission products – when it is hit by a free neutron. The reaction also releases some neutrons and a large amount of energy. The neutrons released in the reaction may cause new fissions, which enables the initiation of a chain reaction. Chemical elements which capture and consume the extra neutrons are used for the management of the chain reaction.

Other nuclear reactions besides fission also occur in the reactor. A majority of the fuel's uranium is made up of isotope uranium-238, which is not as fissionable as isotope uranium-235. A neutron moving with a suitable energy may be absorbed in the uranium-238 atomic nucleus. When a neutron turns into a proton, the result is plutonium (Pu). In addition to plutonium, other transuranic elements – i.e. elements heavier than uranium – are also created in the reactor. Some of the transuranic elements, like plutonium-239, participate in the reactor's energy production.

Fuel assemblies which have reached their planned service life – currently around a quarter of the fuel every year – are removed from the reactor during refuelling outages and replaced with fresh fuel assemblies. The places of the fuel assemblies remaining in the reactor are also switched for the achievement of optimal power density. Due to the decay products and transuranic elements emerging in the nuclear fuel during operation, the radioactivity of spent fuel is so high that its handling and storage require special measures.

In addition to actual use, the stress to which the fuel assemblies are subject during handling and transport, including the handling phases related to long-term storage and final disposal, is accounted for as early as during the design of the fuel assemblies.

Magnitude of change

In the service life extension case, the volume of the procured nuclear fuel will remain at the same annual level (roughly 260 tU of uranium concentrate), but its total volume will increase. Estimates put the increase in total volume at around 2,600 tU of uranium concentrate by 2048 and around 5,200 tU by 2058.

Uranium concentrate is classified as a non-renewable natural resource, due to which its use reduces natural resource deposits. At an annual level, the volume of uranium concentrate required by the OL1 and OL2 plant units in the case of extended operation would be around 0.5% of the current annual production volume of uranium. If the operation of the plants is extended by 20 years, the increase in their requirement for uranium concentrate would be approximately 5,200 tU in total, which corresponds to roughly 0.1% of the currently known uranium reserves. In addition to the aforementioned, when accounting for estimates concerning uranium reserves yet to be discovered, uranium reserves to be exploited at a higher price, and forecasts on the growth of uranium's global demand, the impact that extended operation would have on the uranium reserves is estimated to be very minor.

Continued operation does not change the power plant area's current limitations on the utilisation of natural resources.

6.14.2.2. Power uprating

In the power uprating alternative, the supply chain of nuclear fuel and the resulting impacts are similar to those described in connection with continuing operation (Chapter 6.14.3.1). In the power uprating case, the volume of the procured nuclear fuel will increase slightly at the annual level (amounting to roughly 280 tU of uranium concentrate). Estimates put the increase in total volume at around 3,020 tU of uranium concentrate by 2048 and 5,820 tU by 2058. When compared to the current global uranium reserves, the increase in the amount of uranium concentrate procured is very low.

Power uprating does not change the power plant area's current limitations on the utilisation of natural resources. In the power uprating case, the additional buildings to be built will not change the area's natural resources, as the construction work mainly only concerns the surface layers of earth. The resulting loose soil and the rock material generated in the excavation of the possible expansion of the KPA storage will be utilised in the power plant area, where possible.

6.14.2.3. Significance of the impacts

The sensitivity of the site area in terms of the use of natural resources was estimated to be moderate, as there are limitations on the utilisation of natural resources in the area. With continued operation and the power uprating, there will be no impacts on the site area as the alternatives do not change the site area's current limitations on the utilisation of natural resources.

As regards the procurement of nuclear fuel, the sensitivity of the affected aspect cannot be determined within the framework of this EIA because the nuclear fuel is procured from its supplier, who is responsible for assessing the environmental impacts of their production in accordance with the legislation of the country in which they are located. When compared to the current global uranium reserves, the amount of uranium procured during the operation of the plant units is very low, on the basis of which the significance of the impacts is estimated to be, at most, a minor negative (Table 57).

Table 57. Significance of the impacts: Use of natural resources.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1 and VE2: power plant area	Moderate	No change	No impact
VE1 and VE2: procurement of nuclear fuel	Cannot be determined	Very minor	Minor negative

6.14.3. Mitigation of harmful impactsn

The uranium used by the Olkiluoto power plant is not estimated to have an impact on the uranium reserves, but the production of nuclear fuel has an environmental impact. TVO employs a supplier evaluation process and only procures uranium and nuclear fuel refining services from suppliers who have passed the evaluation. The purpose of the evaluation and monitoring of suppliers is to ensure not only the supplier's ability to deliver and reliability, but also that matters related to sustainability and the environment are in order. Among other things, the evaluations focus on the quality and effectiveness of suppliers' environmental and quality management systems. In addition, the production of the fuel assemblies is monitored by making regular production control visits to the fuel plants, thereby ensuring that the fuel meets the safety and operability requirements set for it.

TVO's opportunities to influence the procedures of different operators in the supply chain delivering nuclear fuel to the company are related to the selection of suppliers and the obligations agreed in the fuel agreements. These operations are subject to their own environmental and other regulations in each country. In accordance with TVO's environmental policy, the management of environmental matters emphasises the principles of continuous improvement and open interaction in cooperation with suppliers.

6.14.4. Uncertainty factors

The assessment of the availability of uranium concentrate is based, in respect to production and use, on projections and estimates concerning the next few decades and on assumptions about the price of uranium. The assessment has not considered reactor types using another kind of fuel or the large-scale introduction of reprocessing in the long term. Part of the exploitation of the reserves requires new technology. The current (04/24) market price of uranium has risen to a level such that new mining projects and ore prospecting are estimated to be profitable again, but the opening of new mines usually takes many years.

6.15. Waste and its handling

6.15.1. Initial data and assessment methods

The impact assessment reviewed the volume, quality and handling of the very low, low and intermediate-level, and conventional waste generated during extended operation and power uprating in the power plant area. The impacts related to waste handling were assessed on the basis of the characteristics and handling techniques of the waste. The assessment accounted particularly for any radiation doses of the personnel caused by waste containing radioactivity, in addition to judging whether the handling, storage and final disposal of the waste could have impacts beyond the power plant area.

The handling and interim storage of spent nuclear fuel in the site area are described and their environmental impact are assessed on the basis of, among other things, the plant's action plans. Transfers of spent nuclear fuel from the power plant to Posiva's encapsulation plant and disposal facility were reviewed on the basis of Posiva's transport risk and implementation method analysis *(Suolanen et al. 2004)* and environmental impact assessment (Posiva Oy 2008). Posiva has later updated the analyses and the matter is described at a general level in Posiva's operating licence application *(Posiva Oy 2021b)*. The main principles and long-term safety of the spent nuclear fuel's final disposal concept were reviewed at a general level based on Posiva's publications *(e.g. Posiva Oy 2008, 2012 & 2021b)*.

6.15.2. Current status

The waste generated in the power plant's current operations and its handling are described in Chapters 3.2.6–3.2.9 as regards spent nuclear fuel, very low, low and intermediate-level waste as well as conventional waste. The operation of Posiva's encapsulation plant and disposal facility for spent nuclear fuel located in the Olkiluoto power plant area is described in the following chapters.

The sensitivity level of the affected aspect is determined on the basis of the adequacy of the operational capacity related to the area's waste handling. Functional waste management methods are in place for the waste generated in the power plant area. The possible need for increasing storage capacity has been considered in the plans for the area. The sensitivity of the affected aspect was estimated to be minor.

6.15.3. Environmental impacts

6.15.3.1. Continuing operation

Spent nuclear fuel

The extension of operation would not change the quantity of the spent nuclear fuel generated annually, but the total quantity of spent nuclear fuel would increase by approximately 380 tonnes over 10 additional years of operation and by approximately 760 tonnes over 20 additional years of operation. For current operation, the total volume of spent nuclear fuel generated during the entire operating period is 2,483 tU (by 2038). If the service life is extended until 2048, the total amount of spent nuclear fuel accumulated will be approximately 2,861 tU; by 2058, it will be approximately 3,240 tU.

Handling in the site area and interim storage

Once spent fuel has been removed from the reactor, it is stored underwater in the pool of the reactor building for a few years, after which its radioactivity and heat generation will be substantially reduced. Water acts as a radiation shield and cools the spent fuel. Following this, the spent fuel is transferred to the interim storage for spent nuclear fuel (KPA storage) located in the site area, where it is stored inside water pools. Fuel transfers between the reactor building and fuel storage are carried out by using a special transfer cask that protects against radiation. In the KPA storage, the fuel assemblies are stored inside water pools for several decades, until their activity and heat generation are low enough to allow them to be transferred to Posiva's encapsulation plant and disposal facility for spent fuel.

If the KPA storage is expanded, new pools will be constructed as an extension of the current pools. In practice, this corresponds to the KPA storage extension completed in the 2010s where three new pools were added to the KPA storage. The construction and modifications at the KPA storage will be implemented such that the radiation protection of personnel and the environment is taken into account as in the current operation. The increase in storage capacity also does not affect the personnel's radiation doses during operation.

The service life extension will not have an impact on the handling of the fuel after its removal from the reactor. The safety of the fuel storage is maintained in the same manner as during the power plant's operation, by ensuring the fuel's sufficient cooling, subcriticality and radiation shielding, and by securing the fuel's integrity. During interim storage, the condition of the spent fuel is regularly monitored by e.g. implementing a long-term storage condition monitoring programme for specific assemblies selected for follow-up. The aim is to ensure that the spent fuel will remain in acceptable condition during long-term storage, also as regards the fuel handling required for final disposal. The chemical environment of the storage pools is also relevant for maintaining the fuel's integrity, among other things. The chemical state of the storage pools is monitored in accordance with the technical specifications of the plant units. The activity of the water in the pools is likewise monitored.

The effect that the growth in the total volume of spent nuclear fuel would have on the personnel's radiation doses is negligible when compared to current operation. The subcritical state of the nuclear fuel is ensured during every stage of the handling and storage of spent nuclear fuel, so that an uncontrolled fission chain reaction cannot take place. This is ensured with regard to the transfer casks, storage spaces and handling equipment, for example. The impacts that the handling and interim storage of spent nuclear fuel have on the environment in normal operation are very minor compared to the power plant's emissions, and the statutory limit values are not exceeded. The limit value for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the handling and interim storage of spent nuclear fuel, is 0.1 mSv.

Transfers to the encapsulation plant

The spent nuclear fuel is packaged at the KPA storage into transfer casks while it is under water, due to which the prevalent radiation levels (a maximum of 0.03 millisieverts per hour (mSv/h)) do not increase during packaging. Nor does the packaging have any radiation or emission impacts on the environment which would depart from the power plant's normal operation. The fuel's handling and transfers from the storage pools to the transfer casks correspond with the power plant's current fuel handling methods. The fuel assemblies to be placed in the transfer casks will be selected according to their residual heat production, dose rate and reactivity. The aim of this is to ensure that both the final disposal canisters' and the transfer cask's heat production and criticality safety meet the required level, and that the dose rate outside the cask remains within the confines of the set limits.

The spent nuclear fuel from the Olkiluoto nuclear power plant units is transported to the encapsulation plant as internal transfers within the power plant area, by using a transfer cask. Once Posiva's final disposal activities start, it is estimated that there will be approximately 12 transfers of spent nuclear fuel per year (1 transfer cask at a time). STUK's approval must be sought for the transfers of spent nuclear fuel. STUK inspects and approves the transfer plan, the structure of the transfer cask, the security arrangements and the preparedness for accidents. The transfer of spent nuclear fuel in Olkiluoto will be accompanied by the necessary escort personnel, such as security guards.

Encapsulation and final disposal

Posiva Oy is responsible for the final disposal of spent nuclear fuel generated at the power plants of its owners: TVO (Olkiluoto NPP) and Fortum (Loviisa NPP). In 2021, Posiva applied for an operating licence for a total of 6,500 tU, which includes the spent nuclear fuel from the OL1, OL2 and OL3 plant units as well as from the

LO1 and LO2 plant units. Posiva will license the capacity of its disposal facility to match the needs of its owners' nuclear power plants. Posiva has previously carried out an EIA procedure for 12,000 tU of spent nuclear fuel, which also included the OL4 and LO3 plant units that were being planned at the time *(Posiva 2008)*. Based on Posiva's environmental impact assessment, the impacts on the environment will not substantially increase even if more fuel is placed in final disposal.

According to the current plan, the final disposal of spent fuel at Posiva is to begin in the 2020s, in which case the capacity of TVO's KPA storage will be sufficient to accept the spent fuel from the OL1 and OL2 plant units in the service life extension case. If the start of final disposal activities at Posiva were to be substantially delayed for some reason, the storage capacity at the KPA storage will need to be increased.

The spent nuclear fuel is delivered to the encapsulation plant, where it is safely enclosed within the final disposal canisters. The encapsulation plant is connected to the underground disposal facility via a canister lift, which transports canisters down to the underground reception station on the final disposal level at a depth of approximately 430 m. From there, they are transferred into deposition tunnels by using transfer and installation vehicles. The long-term safety of the final disposal of spent nuclear fuel is based on a final disposal system that is based on a multi-barrier principle. In it, the radioactive substances are contained inside multiple release barriers which support each other but are as independent from one another as possible, so that the failure of a single release barrier will not compromise the effectiveness of the isolation. The engineered release barriers include the state of the fuel, the final disposal canister, the buffer bentonite, and the backfilling of the tunnels. The bedrock functions as a natural release barrier. In the final disposal solution, the spent nuclear fuel is packed in watertight durable final disposal canisters, the interior of which is cast iron and the exterior of which is copper. The canisters are deposited at a depth of approximately 430 metres within the bedrock, where they are separate from people and in which they will remain sealed without maintenance for as long as their contents could cause material harm to organic nature. In addition to nuclear and radiation safety criteria, the basis for designing the long-term safety of geological final disposal consists of various assessments of changes taking place in nature. Among other things, it has been analysed in the long-term safety case how

the final disposal solution will withstand earthquakes, future ice ages up to a million years and the stress caused by inland ice. The long-term safety case also addresses uncertainties related to the behaviour of the final disposal solution and to the assessment of various possible events and developments. When assessing risks, the probability of events is taken into account.

Posiva has been engaged in long-term work to assess the long-term safety of the final disposal of spent fuel for several decades now. Posiva's long-term safety case obtains most of its initial data from the description of the final disposal site, which is based on all the studies conducted since the 1980s in which the area and bedrock of Olkiluoto have been investigated from the perspective of the final disposal of nuclear waste. The construction of an underground research facility, which has made underground studies an increasingly important source of information, began in 2004. In addition, studies conducted above ground have provided a comprehensive picture of the final disposal site's characteristics and processes. The site description includes descriptions of the final disposal site's geology, hydrology, hydrogeology, hydrogeochemistry and rock mechanics, and estimates of their future development.

Posiva has examined the long-term safety of the final disposal of spent nuclear fuel during both the construction licence stage and the operating licence stage by drawing up a long-term safety case. The safety cases have been submitted to STUK for approval in connection with the application. For the licence to be granted, an approving decision from STUK is required also on the safety case. Among other things, the reports of Posiva's long-term safety case describe the design bases, the final disposal system's initial stage, the status of the low and intermediate-level waste to be deposited in the disposal facility, the analysis concerning the operating capability of the engineered release barriers, the formation of scenarios, the release and transport of radionuclides, the calculation models and their initial data as well as complementary reviews. These form the basis for the presentation of a summary of the principal results and conclusions, an estimate of the fulfilment of official regulations and an assessment of the reliability of the long-term safety of the final disposal of spent fuel and the safety assessment.

The long-term safety case finds that the annual radiation doses resulting from developments that are considered likely will remain clearly below the limit provided in the Nuclear Energy Decree over the course of the next 10,000 years, even for the most exposed people, and the doses incurred by other people will remain negligible. It is estimated that, after this time, the releases of radioactive substances resulting from developments that are considered likely will, at most, remain under one-thousandth of the maximum values specified by STUK. Furthermore, based on an assessment of typical radiation doses, the radiation exposure of the current fauna of the final disposal site will remain clearly under the reference value proposed in international projects. The resulting radiation doses and release rates of radioactive substances have been assessed, taking into account the possible random deviations from the operability requirements for the final disposal system as well as the uncertainties in the calculation models and initial data used in the assessment.

Very low, low and intermediate-level waste

The operation of the OL1 and OL2 plant units of the Olkiluoto nuclear power plant generates a total of approximately 50 m^3 of very low, low and intermediate-level waste per year. Extended operation would not change the amount of very low, low and intermediate-level waste generated annually, but their total volumes would increase. The total volume generated by the end of the valid operating licences is estimated to amount to approximately 8,250 m^3. If operation is extended by 10 years until 2048, the total volume of very low, low and intermediate-level waste generated will be approximately 8,750 m^3. If operation is extended by 20 years until 2058, this volume will be approximately 9,250 m^3. The VLJ repository has a total capacity of 15,500 m^3.

There are existing handling methods, as well as storage and final disposal locations, for very low, low and intermediate-level waste. In the service life extension case, the waste management methods would remain largely unchanged. In order to optimise the existing space in the VLJ repository, TVO has been analysing the implementation of a separate near-surface final disposal project for very low-level waste in Olkiluoto which, according to the current schedules, will begin in the mid-2020s. The total capacity of the VLJ repository and the near-surface final disposal project is estimated to be sufficient for the final disposal of the additional waste generated by the service life extension.

The measures related to waste management are part of the power plant's normal operations and cause only a small part of the personnel's radiation dose. The limit value for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the various stages of the handling of very low, low and intermediate-level waste, is 0.1 mSv. The limit value for the annual dose resulting from the normal operation of a nuclear waste facility is 0.01 mSv. The handling of very low, low and intermediate-level waste in normal operation does not result in emissions of radioactive substances into the environment, regardless of the amount of waste generated or stored within the site area. During final disposal, it is ensured that waste packages are intact and in good condition, and that there is no contamination on their surface that could become loose. This means that no radioactive substances are released outside the waste packages in normal operations, and that no waters accumulating in the disposal repositories can be contaminated by radioactive substances. The principle of final disposal is to keep the radioactive substances contained by the waste separate from organic nature so that the safety of the environment is not compromised at any stage.

Waste to be cleared from regulatory control and conventional waste

Different types of service waste (such as insulation material, old work clothes, parts of machinery and equipment as well as used tools and packaging material) that may contain small amounts of radioactivity are generated within the nuclear power plant's radiation controlled area. The activity of service waste is analysed with several consecutive measurements. Provided that the activity of a waste batch is low enough, it can be cleared from regulatory control pursuant to Section 27 c of the Nuclear Energy Act. The limit for the annual dose incurred by individuals of the population or employees handling waste as a result of materials cleared from regulatory control is 0.01 mSv. In addition, the radiation exposure attributable to waste cleared from regulatory control must also be kept as low as reasonably achievable in every respect. The further treatment of waste cleared from regulatory control can be identical with that of conventional industrial waste. No waste to be cleared from regulatory control has been generated in current operations at the OL1 and OL2 plant units after 2018 because the collec-tion and storage of very low level waste was started in 2019. However, approximately 29 t of metal and mixed scrap were cleared from regulatory control for recycling in 2023. The annual volume of waste to be cleared from regulatory control is not expected to increase significantly in the future.

The power plant's service life extension would not especially change the annual volume of conventional waste generated. Waste volumes can vary from one year to the next, depending on the construction, service and maintenance work carried out in the power plant area, for example. The handling of conventional waste will also continue in line with the current methods. All waste generated is sorted and recycled as materials whenever possible, or reused as energy. Of the waste generated, 64% was recycled as materials and 30% was reused as energy in 2023. No landfill waste has been generated in recent years.

The volumes of waste generated are kept as low as possible, and the aim is to increase the share of waste that is recycled as materials. The goal is for 60% of the waste generated to be recycled as materials by 2030. Waste sorted by type is forwarded for treatment, reuse or final disposal as required by waste legislation and the environmental permit decisions. Hazardous waste is stored appropriately and delivered to plants which treat hazardous waste.

The handling of conventional waste carried out within the power plant area does not have an environmental impact. The impact is primarily attributable to the transport of waste as well as the processes of the operators responsible for the further treatment of the waste.

Magnitude of change

The limit value for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the handling and interim storage of spent nuclear fuel as well as the various stages of the handling of very low, low and intermediate-level waste, is 0.1 mSv. The limit value for the annual dose resulting from the normal operation of a nuclear waste facility is 0.01 mSv. The personnel's radiation doses resulting from the handling of spent nuclear fuel or very low, low and intermediate-level waste are very low and remain below the limit values set for a nuclear power plant's normal operation. The total volumes of waste would increase as a result of the additional years of operation, but methods for their handling are already in place or planned. In terms of the service life extension, the magnitude of the change is expected to be a minor negative at most.

6.15.3.2. Power uprating

Spent nuclear fuel

Changes to fuel technology will be implemented in connection with the power uprating that are related to, among other things, increasing the enrichment and burn-up of the fuel removed from the reactor. During the increase of enrichment, which is performed by the fuel manufacturer, the amount of fissile uranium contained in the fuel is increased. This will allow for increasing the thermal power extracted from the fuel used at the plant by 10%. As a result of the changes, the number of fuel assemblies removed from the reactor each year will remain at the current level. Increasing the fuel burn-up will increase the residual heat generation of the fuel assemblies by approximately 10%.

Following their removal from the reactor, fuel assemblies will be stored in the fuel storage pools of the reactor building until they can be moved to the KPA storage. The increased residual heat will increase the demand for residual heat removal at the KPA storage by a corresponding amount. The flow rate of the cooling water extracted from the sea and returned there will be increased, if necessary, in which case the temperature of the water returned into the sea will not rise from the current level. Once the decay heat power of the fuel assemblies has been reduced to an adequate level, they can be moved to Posiva's encapsulation plant and disposal facility. The increased decay heat power has no impact on Posiva's fuel handling, since the thermal calculations for Posiva's final disposal take into account heat generation that is even higher than the value following the power uprating, and the final disposal can be performed according to current plans.

The annual accumulation of spent nuclear fuel will remain the same as in current operation, but the total volume will increase with additional years of operation. The handling in the site area, interim storage, transfers to the encapsulation plant, and encapsulation and final disposal of spent nuclear fuel will be implemented as described in Chapter 6.15.3.1 and the impacts will remain similar.

Very low, low and intermediate-level waste, waste to be cleared from regulatory control and conventional waste

At an annual level, the volumes of waste will remain the same as in the current operation, but the total volumes will increase with additional years of operation. The handling methods, storage, transport and final disposal of waste will be implemented as described in Chapter 6.15.3.1 and the impacts will remain as they are.

Magnitude of change

The limit value for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the handling and interim storage of spent nuclear fuel as well as the various stages of the handling of very low, low and intermediate-level waste, is 0.1 mSv. The limit value for the annual dose resulting from the normal operation of a nuclear waste facility is 0.01 mSv. The personnel's radiation doses resulting from the handling of spent nuclear fuel or very low, low and intermediate-level waste are very low and remain below the limit values set for a nuclear power plant's normal operation. The total volumes of waste would increase as a result of the additional years of operation, but methods for their handling are already in place or planned. In terms of the service life extension, the magnitude of the change is expected to be a minor negative at most.

6.15.3.3. Significance of the impacts

The sensitivity of the affected aspect was estimated to be minor, as functional waste management methods are in place for the waste generated in the power plant area. The possible need for increasing storage capacity has been considered in the plans for the area.

The significance of the impacts is a minor negative because with the additional years of operation, the volume of spent nuclear fuel as well as very low, low and intermediate-level waste being processed will increase and the radiation exposure caused to the processing personnel by the waste management activities will continue. However, the increase in total waste volumes will not significantly increase the radiation doses of the personnel when compared to current operations. The limit value for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the various stages of waste management for the spent nuclear fuel and the very low, low and intermediate-level waste, is 0.1 mSv. During normal operation, the impacts caused by waste management activities are very minor and the statutory limits will not be exceeded (Table 58)

Table 58. Significance of the impacts: Waste and its handling.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.15.4. Mitigation of harmful impacts

With regard to radioactive waste, adverse impacts can be mitigated by minimising the waste volume, appropriate radiation protection measures, and functional and safe handling and final disposal methods, for example. These are already being utilised in current operations, and TVO uses, for example, an operating waste management manual that contains the procedures and instructions for the handling, storage and final disposal of radioactive waste. Employees receive training on the operating waste management on the basis of separate training requirements and induction programmes.

All conventional waste is handled in accordance with valid legislation, and the waste materials do not cause harm or pose a risk to the environment or people. The collection and transport of waste takes place as planned. With regard to conventional waste, the waste materials are delivered to waste handlers permitted to handle the waste in question. This means that the waste management operators are responsible for ensuring that the adverse impacts are as small as possible.

6.15.5. Uncertainty factors

In the long term, the volumes of waste generated may be subject to changes or additions due to service activities, for example. The adequacy of the capacity of the VLJ repository and the KPA storage is examined proactively according to the actual volumes of waste generated.

6.16. Releases of radioactive substances and radiation exposure

6.16.1. Initial data and assessment methods

The radiation exposure of employees and the impacts of releases of radioactive substances was assessed on the basis of the actual releases of radioactive substances from the power plant and the radiation doses received by the employees.

The releases from the normal operation of the OL1 and OL2 plant units have been used as the basis to calculate the radiation dose incurred by the residents in the vicinity of the power plant. The calculated radiation doses have been presented in the annual report for environmental radiation safety. The radioactive releases into the air and water system resulting from the current operations and the calculated radiation doses incurred by the surrounding population are presented and compared with the set emissions limits and dose limitations. The area used for examining the impacts was the environmental radiation monitoring area (approximately 10 km from the site area) and the radiation dose calculation area (100 km from the site area).

The radiation doses incurred by the personnel as a result of the handling and final disposal of radioactive waste as well as radioactive releases and their impacts have been described in more detail in chapter 6.15.

6.16.2. Current status

6.16.2.1. Releases of radioactive substances

Small amounts of radioactive substances are generated during the operation of the Olkiluoto nuclear power plant that may be released into the air and sea in a controlled manner, in adherence with the legislation and the permits and regulations concerning the operation. The releases are carefully measured by using methods approved by STUK and it is verified that they clearly fall below the set limit values. Data on the releases is reported to STUK for each quarter and presented each year in the annual report for environmental radiation safety.

Radioactive releases into the air and sea from the Olkiluoto power plant have remained well below the limits set for them (Figure 71, Figure 72, *STUK 2024e*). In 2022, noble gas releases from the Olkiluoto power plant into the atmosphere amounted to 0.0106% and iodine releases (at Olkiluoto, an emissions limit is set for I-131) amounted to 0.0744% of the limits set for them. Tritium releases into the sea were approximately 2.85% and releases of activation products into the sea were approximately 0.0404% of the emissions limits set. *(STUK 2023)*

Typical radionuclides originating from the Olkiluoto power plant that can be observed in the nearby areas include H-3, Mn-54, Co-58 and Co-60. All radionuclides observed during environmental monitoring do not originate from nuclear power plants. The environment also has natural radioactivity and artificial radionuclides, such as H-3, Sr-90 and Cs-137, which originate from the nuclear weapons tests in the 1950s and 1960s and, in particular, from the Chernobyl nuclear power plant accident that occurred in 1986. The main nuclides that cause the largest calculated dose on a representative individual in the most exposed population group are C-14 for releases into the air and Co-60 or Cs-137 for water effluents. *(STUK 2023 & 2024e)*

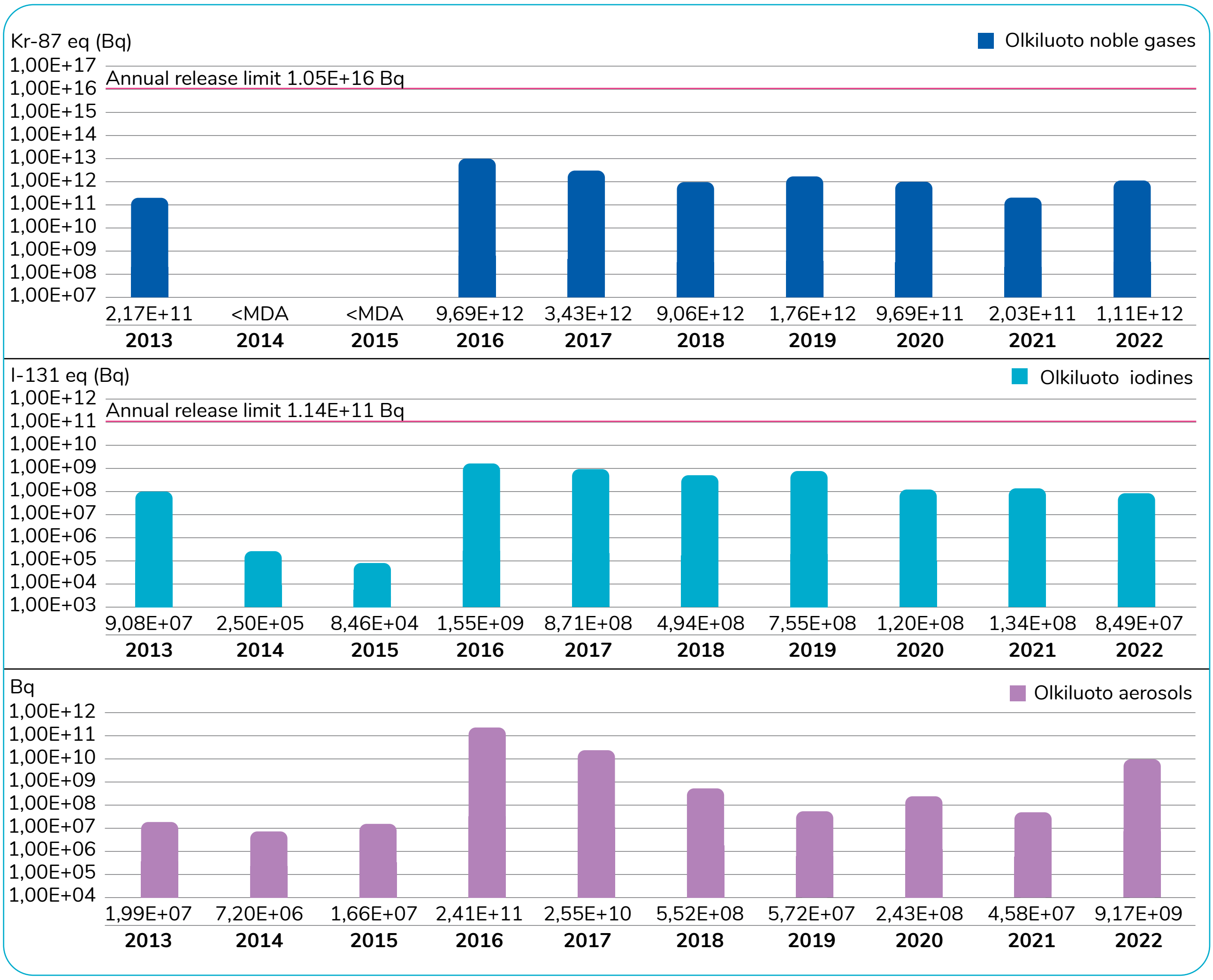


Figure 71. Release limits and actual annual radioactive releases into the air from the Olkiluoto nuclear power plant in terms of noble gases, iodine and aerosols in 2013–2022. No separate release limit has been defined for aerosols or other release types. (STUK 2024e)

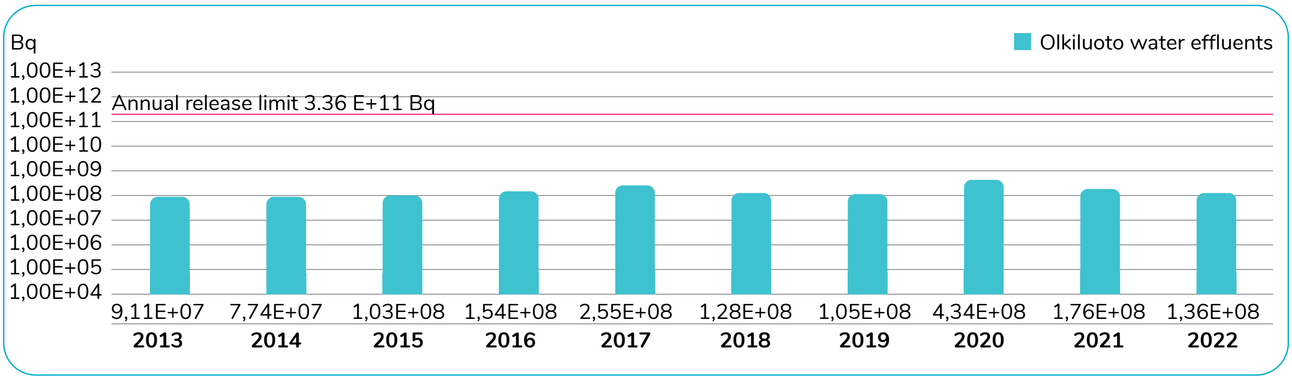


Figure 72. Annual release limit and actual annual radioactive releases into the water system from the Olkiluoto nuclear power plant in 2013–2022. (STUK 2024e)

6.16.2.2. Radiation exposure

The goal for monitoring the radiation safety of the Olkiluoto nuclear power plants is to ensure that the total radiation exposure of the employees and residents of nearby areas attributable to the operation of the nuclear facility is kept as low as practically achievable.

Employees' radiation exposure

The personal radiation doses of employees and the collective (total) radiation dose of all employees are tracked at Olkiluoto nuclear power plant. Each month, the radiation exposure date is entered into the dose register maintained by STUK, and the results are presented annually in the power plant's annual report.

The effective dose incurred by an employee due to radiation work must not exceed 20 mSv per year (Government Decree on Ionizing Radiation, 1034/2018). At the individual level, radiation exposure is kept clearly below the dose limits. Furthermore, in the ALARA action programme, TVO has set a lower personal dose limit pursuant to Guide YVL C.1 and a dose limit on the collective radiation dose pursuant to Guide YVL C.2.

The radiation doses for employees are mainly generated during annual outages, when employees work near opened process systems and radioactive components. The length of the outage and the scope of maintenance work performed during the outage that is significant in terms of radiation protection will affect the magnitude of the employees' total dose during the year in question.

In 2002–2022, the largest annual dose for an employee of the Olkiluoto nuclear power plant has been 6.47–12.95 mSv and the average dose for all radiation workers has been 0.72–1.54 mSv. The figure (Figure 73) presents the collective doses for the employees of the Olkiluoto nuclear power plant since the start of the power plant's operation. The OL3 plant unit did not yet have an annual outage in 2022, which is why its share of the radiation doses at Olkiluoto in 2022 was still less than 1%. *(STUK 2024e)*

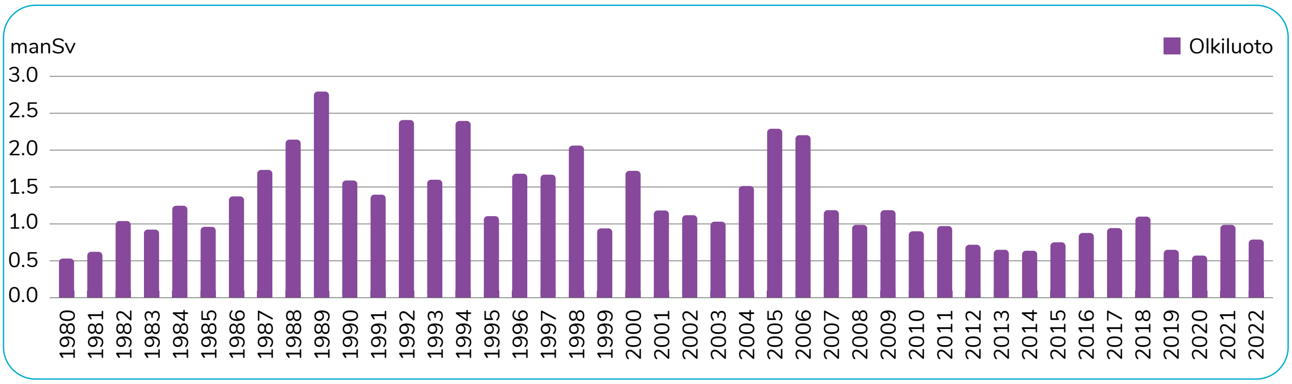


Figure 73. The collective (total) radiation doses of employees at the Olkiluoto nuclear power plant in 1980–2022. (STUK 2024e)

Radiation exposure of the population in the surrounding areas

Releases from nuclear power plants are effectively diluted by the vast volume of air and water around the power plant, that is, the atmosphere and the sea. As a result, only very small concentrations of radioactive substances accumulate in the areas surrounding nuclear power plants, and they can only be observed by using very sensitive measurement methods. The releases from normal operation are so low that the radiation dose incurred by the population as a result of them is impossible to measure. Because of this, the radiation doses for the population are determined by means of calculation.

The radiation exposure of the residents in nearby areas is assessed each year on the basis of release data from the Olkiluoto nuclear power plant, environmental samples and meteorological measurements. In Finland, the Government has set the limit for the radiation dose incurred by an individual resident in the surrounding areas, attributable to normal operation of nuclear power plant units, at 0.1 mSv per year. *(STUK 2024g)*. This is approximately one sixtieth of the average radiation dose of 5.9 mSv that Finns receive from different sources during the year *(STUK 2024b & 2024g)*.

In 2013–2022, the calculated dose for the most exposed individual in the vicinity of Olkiluoto has been very low, being below 1% of the limit of 0.1 mSv set in the Nuclear Energy Decree (161/1988), which corresponds to 100 microsievert (μSv) (Figure 74, *STUK 2023 & 2024e*).

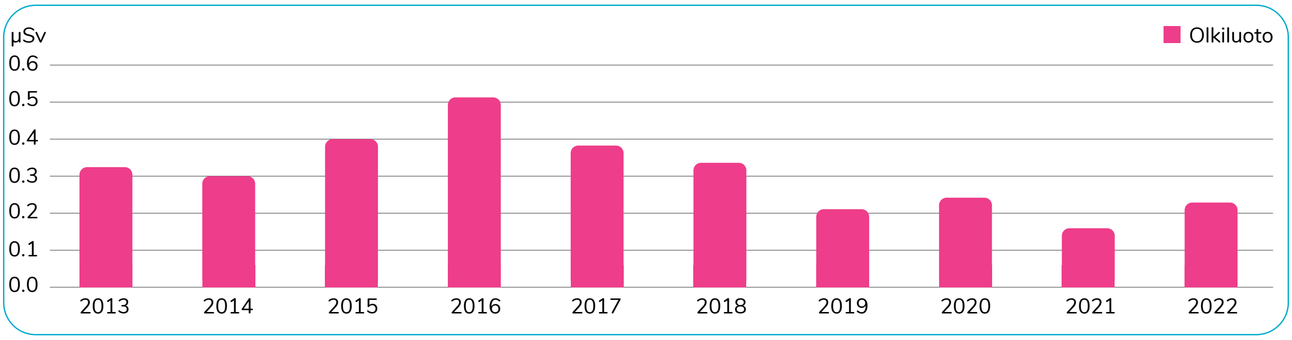


Figure 74. The calculated dose for the most exposed individual in the vicinity of Olkiluoto in 2013–2022. (STUK 2024e)

6.16.2.3. Environmental radiation monitoring

The purpose of the environmental radiation monitoring programme (2023–2027) is to monitor and determine any possible radiation burden caused to humans by the surroundings of the nuclear facility. The aim is to use the measurement results to determine the critical radionuclides, their spread routes and the doses incurred by the critical population. The environmental radiation monitoring programme covers using fixed instruments to measure the radiation level in the environment, gathering samples of soil, air, household water, sea water, landfill drain water, groundwater, plants etc. and performing whole body counts on the residents of the surrounding areas. *(Kalliomaa & Sojakka 2022)*

In 2023, a total of 410 samples were collected and analysed from the land and sea around the Olkiluoto power plant. Of these, 130 were samples related to STUK's monitoring and the rest were part of TVO's own monitoring programme. *(STUK 2024g)*. Nuclides originating from the Olkiluoto power plant are observed rarely, and the observed concentrations are very low. The samples collected from the land environment in 2023 mostly showed traces of fallout from the nuclear accident in Chernobyl. No nuclides originating from releases at the Olkiluoto power plant have been found in plants, milk or meat that is used as human nutrition. The concentrations observed in samples from the water environment have been low, and observations have chiefly been made in the matter that settles at the bottom layer and in indicator organisms that efficiently collect activity but are not part of human nutrition. No radioactive substances originating from the plant unit have been observed in fish.

The amounts of radioactive substances observed in the environment were so low that they are insignificant in terms of the radiation exposure of the environment or humans. Based on measurements, no radioactive substances originating from the plant unit were observed in the residents of the areas near the power plant. The amounts of radioactive substances correspond to the amounts observed in the vicinity of the plant unit in recent years and they follow a longer-term declining trend that is affected by the development of release controls at the power plant. *(STUK 2024g)*

In connection with STUK's radiation monitoring programme, residents in the nearby areas of the nuclear power plant are provided with the opportunity to participate in a measurement that determines the amount of radioactive substances accumulated in the human body. The invitation letter is sent by mail primarily to persons whose permanent address is within a range of 5 km from the power plant during the year when the measurement is arranged.

6.16.2.4. Sensitivity of the affected aspect

The sensitivity level of the affected aspect is determined on the basis of the radiation dose incurred by an individual resident in the power plant's vicinity as a result of normal operation. In Finland, the annual dose constraint for an individual of the population arising from the normal operation of a nuclear power plant is 0.1 mSv per year (161/1988). In recent years, the radiation dose caused by the Olkiluoto nuclear power plant to the residents of the surrounding areas has been clearly below one per cent of the dose constraint. The sensitivity of the affected aspect is estimated to be minor.

6.16.3. Environmental impacts

6.16.3.1. Continuing operation

If the KPA storage is expanded, the construction and modifications will be implemented such that the radiation protection of personnel and the environment is taken into account as in the current operation. The increase in storage capacity does not affect the personnel's radiation doses.

During the operation of a nuclear power plant, radioactive substances are generated the radiation of which may affect human health. The amount of radioactive substances released into the environment is effectively limited by filtering and delaying the releases in a manner where their radiation impact in the environment is very small when compared to the impact of radioactive substances that normally occur in nature. The radiation doses for the plant's employees are mainly generated during annual outages, when employees work near radioactive components and opened systems.

The OL1 and OL2 plant units have had a very low number of fuel failures, which indicates that the fuel is of high quality and that it is being used safely. For its part, this greatly assists in keeping radiation doses for the personnel as well as the releases of radioactive substances and the resulting radiation doses incurred by the population as low as possible.

The Olkiluoto power plant monitors the development of technology and carries out development actions aiming at reducing contamination levels, radiation levels, release amounts and radiation doses in accordance with the principle of continuous improvement. TVO also actively aims to develop its activities in a direction that reduces the radiation doses of the personnel and releases into the environment. This will also continue in the future if the service life is extended. Several improvements have already been implemented during the operation of the power plant, which have reduced the radiation doses of the personnel and the environment. In particular, the ALARA and BAT principles are considered when assessing the feasibility of the development activities. The ALARA action programme discusses the short and long-term goals which aim at optimising the radiation doses of the employees as well as minimising environmental releases in order to reduce the radiation doses of the surrounding population.

Even when extending the service life, the aim is to keep radiation doses to the personnel, the releases of radioactive substances and the resulting radiation doses to the personnel as low as possible. Development actions in order to reduce contamination levels, radiation levels, release amounts and radiation doses will also be implemented going forward. The radiation doses incurred by the personnel during the normal operation of the OL1 and OL2 plant units are expected to still remain significantly below the set dose limits. Furthermore, the releases of radioactive substances into the environment caused by normal operation are estimated to remain low and to continue to fall below the release limits set for them in the future. When the releases remain at the present level, the impact of the releases on the radiation exposure of the residents in the surrounding areas and the radiation-induced load are estimated to remain very low, as in the current situation.

When considering the additional years of operation for the OL1 and OL2 plant units, the impacts are estimated to remain similar even when service life is extended, but the magnitude of the change is estimated to be a minor negative as a result of the time frame being extended.

6.16.3.2. Power uprating

If the KPA storage is expanded, the construction and modifications will be implemented such that the radiation protection of personnel and the environment is taken into account as in the current operation. The increase in storage capacity does not affect the personnel's radiation doses.

In the power uprating case, radiation protection activities and the limitation of releases of radioactive substances will be continued and developed similarly to the present situation. The annual releases of radioactive substances or conventional releases into the air will not change materially as a result of the power uprating, and will, instead, remain below the release limits set for them. The impact of the releases on the radiation exposure of the residents in the surrounding areas and the radiation-induced load are also estimated to remain very low, as in the current situation.

Changes to fuel technology will be implemented in connection with the power uprating that are related to, among other things, increasing the burn-up of the fuel removed from the reactor by 10% and increasing the enrichment of the fuel. As a result, the number of fuel assemblies removed from the reactor each year will remain at the current level. The power uprating will increase the residual heat power of fuel assemblies freshly removed from the reactor.

The uprating of the reactor's thermal power from the current 2,500 MW to 2,750 MW will affect the activity inventories of radioactive substances at the plant units. Uprating the thermal power will affect the rate at which nuclides are generated, in which case the equilibrium concentration of short-lived nuclides will increase at roughly the same ratio. The fuel's discharge burn-up, in turn, will affect the amount of longer-lived nuclides in relation to the change in burn-up.

Dose rates are likely to increase near the steam lines, on the liquid waste lines and near the primary circuit lines and equipment, among other places. Following the power uprating, the actual radiation level will be verified by means of room measurements. No major changes are expected in the calculated environmental radiation doses during normal operation, and they will remain below the constraint values set forth in the Nuclear Energy Decree.

In the power uprating case, the magnitude of the change is estimated to be a minor negative as a result of the operation being extended.

6.16.3.3. Significance of the impacts

The sensitivity of the affected aspect was estimated to be minor, since the radiation dose caused by the Olkiluoto nuclear power plant to the residents of the surrounding areas has been clearly below one per cent of the dose limit of 0.1 mSv per year set by the Government. In both the service life extension (VE1) and power uprating (VE2) case, the releases of radioactive substances into the environment caused by normal operation are estimated to remain low and to continue to fall below the release limits set for them in the future. The impact of the releases on the radiation exposure of the residents in the surrounding areas and the radiation-induced load are also estimated to remain very low, as in the current situation, but the impact will continue with the additional years of operation. The significance of the impacts is estimated to be at most a minor negative. (Table 59)

Table 59. Significance of the impacts: Releases of radioactive substances and radiation exposure.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	Minor negative	Minor negative
VE2	Minor	Minor negative	Minor negative

6.16.4. Mitigation of harmful impacts

The limitation of releases of radioactive substances into the air and water is described in more detail in chapter 6.16.3.1, and protection measures related to radiation are described in chapter 3.2.1.

6.16.5. Uncertainty factors

The assessment of the impacts is based on the current operation of the nuclear power plant, and the releases resulting from it are monitored, measured and reported in accordance with the authority guidelines. The release amounts or radiation exposure will not change in the service life extension or power uprating cases, so their impacts have been estimated on the basis of current operations. The information will be specified as the planning progresses.

6.17. People's health

6.17.1. Initial data and assessment methodst

6.17.1.1. Assessment methods

The purpose of the assessment of health impacts is to analyse the likely indirect and direct health detriments which the service life extension and power uprating could cause. The Health Protection Act (763/1994) defines a significant health detriment as a disease diagnosed in a human, another health disorder, or a factor that can reduce the healthiness of the population's or an individual's living environment. Common identification criteria for significant health impacts include:

- degree of severity (death, injury, threat of epidemic, disease, symptoms of a disease, sleep disorders)
- variation over time (hourly, daily and seasonal variation)
- duration (permanent, years, months)
- focus on special groups (children, the elderly, the infirm, individuals sensitised to various predisposing factors)
- manner of exposure (dermal, inhaled, swallowed, via the sensory organs)
- number of exposed people (one person – the population across the entire impacted area).

Some projects may also cause mild and/or temporary impacts on people and their living environment. For example, these include detrimental impacts on comfort caused by noise and smell that are, nevertheless, not considered to be detrimental health impacts.

Health impacts may be deterministic or stochastic. The exposure route for a deterministic detrimental health impact may be, for example, digestion, the respiratory organs, sensory organs, circulatory organs, bones and muscles as well as the viscera and nervous system. The exposure route for a stochastic detrimental health impact may be the air, household water, foodstuffs, living conditions, mobility, rest and relaxation and hobby activities. When understood this way, health is a very broad concept.

Conventional health impacts were mainly assessed on the basis of results from the assessment of noise, vibration and air quality impacts. The magnitude of the impacts was compared to limit and guideline values that were known in advance as well as to other indicators. The limit values and guideline values based on research determine the exposure and concentration limit for preventing health detriments. Exceeding the limit values and guideline values is likely to cause health impacts for parts of the exposed population, whereas impacts are unlikely if the values are not exceeded. The review considered that the impacts will mainly target nearby residential areas and holiday accommodation. Impacts targeting health were assessed as an expert assessment up to a radius of approximately 20 km.

The releases of radioactive substances and radiation have been described in chapter 6.16. This chapter briefly describes the theoretical radiation exposure caused on the basis of the above chapter and its health impacts. The impact assessment examines the radiation dose caused by normal operations by comparing it to the limit value for the annual dose incurred by an individual in the population (0.1 mSv). Any possible accidents and incidents and the detriments caused by them have been separately assessed in chapters 6.18.3 and 6.18.4.1.

6.17.1.2. Background information on health impacts

Noise

Exposure to noise may affect people's health or comfort. The recipient's characteristics, such as age, gender, sensitivity to illness or other sensitivity will affect how disturbing the noise is considered to be. Noise that is considered to be disturbing may cause negative health impacts. Alongside air pollution, environmental noise is one of the largest environmental problems in Europe, since it is a stress factor and its modes of action are not yet fully known. However, exposure to noise is known to cause physiological stress that has been linked with risk of cardiovascular diseases and sleep disorders. A stress reaction is often unconscious, but it may be reinforced by a conscious experience that the noise is bothersome.

According to a Government decision (993/1992), the A-weighted equivalent continuous sound level (LA_{eq}) in a residential area may be 55 dB during the day (7:00–22:00) and 50 dB during the night (22:00–7:00). For holiday housing, the corresponding average sound levels are 45 dB during the day and 40 dB during the night. The guideline values for residential areas are considered to be health-based, since exposure in these areas is constant. The lower guideline values for holiday housing areas are based on detrimental impacts on recreational use and expectations concerning the soundscape in an area of holiday housing.

Vibration

In addition to the magnitude of the vibration alone, the perceived disturbance caused by the vibration is also affected by the surrounding conditions. For example, vibration is more disturbing during the night. This is affected by the time of day and the fact that vibration is easier to observe when resting in a horizontal position. Simultaneous noise and vibration may cause a joint impact where vibration is perceived to be stronger than in cases where no noise is heard. Vibration can also cause impacts in the surrounding building, such as items shaking, windows rattling etc. which will significantly increase the perceived disturbance among residents.

How vibration is perceived is individual. Some people perceive vibration that barely exceeds the threshold of observation as very unpleasant, whereas some people have become accustomed and are unaffected by even major vibration. Vibration is easily perceived as detrimental in cases where noise caused by the source of the vibration is also perceived as detrimental.

Air quality

The particles spreading in the air are a mixture of particles of various types and sizes that originate from several different sources. Human activities which result in particles and/or gaseous compounds that disperse as air pollution include industrial processes, traffic and domestic wood burning. Up to more than half of the fine particles in the air in Finland have been carried here over long distances. The smallest, ultra-small particles and nanoparticles are mainly deposited near their source, such as the combustion process. The limit values for inhalable particles in terms of air quality are provided in Government Decree 79/2017.

Changes in air quality will mainly affect the respiratory and circulatory organs, but they may also contribute to the emergence or worsening of various different diseases. As regards particles, the emergence of detrimental health impacts is affected by their concentration, physical and chemical properties and size. The concentrations of particles in the air, as well as how detrimental they are, will vary according to the season. Infection is the main mechanism of influence of particles within the body. Extended exposure to fine particles is known to increase the risk of contracting a cardiovascular or respiratory disease or lung cancer. Fine particles have also been shown to be connected to the emergence of many other diseases, such as asthma, as well as neurological diseases. It has also been estimated that the joint impact of exposure to particles with noise, for example, may increase the risk of emergence of new diseases. The most sensitive population groups in terms of air pollution are children, the elderly and persons with pre-existing respiratory or circulatory diseases.

Radiation

Ionising radiation can damage the genetic material in living cells. In terms of cytopathic effects, whether the person receives the radiation dose over a long or short period of time is significant.

The average annual radiation dose for Finns is approximately 5.9 mSv, of which approximately 4 mSv is caused by radon in the indoor air and approximately 1.1 mSv is caused by other natural background radiation. The radiation dose caused by medical investigations is in the region of 0.76 mSv on average. The table (Table 60) presents examples of annual radiation doses incurred by Finns and doses caused by medical imaging when compared to the annual radiation dose incurred by residents in the surrounding areas as a result of the normal operation of the Olkiluoto nuclear power plant.

Table 60. Examples of radiation doses (STUK 2020a & 2020b).

Radiation dose	Description
0.0002 mSv	The annual effective radiation dose incurred by an individual in the vicinity of the Olkiluoto nuclear power plant as a result of the power plant's operation.
0.01 mSv	Average effective dose incurred by the patient during a dental X-ray.
0.01 mSv	Average annual effective dose incurred by a Finn from the fallout of the Chernobyl accident and nuclear weapons testing. The impact of the Fukushima accident is negligible in Finland.
0.1 mSv	Average effective dose incurred by the patient during a lung X-ray.
0.3 mSv	Average annual internal radiation dose incurred by Finns as a result of naturally occurring nuclides.
0.45 mSv	Average annual effective dose incurred by Finns as a result of external background radiation (soil and construction materials). The values vary between 0.17 and 100 mSv depending on location.
0.76 mSv	Average annual effective dose incurred by Finns as a result of the medical use of radiation (X-ray examinations cause an average of approx. 0.72 mSv per year, while isotope studies cause approx. 0.04 mSv).
1.1 mSv	Average annual effective dose incurred by Finns as a result of natural background radiation (exclusive of dose caused by radon).
4.0 mSv	Average annual effective dose incurred by Finns as a result of indoor radon (varies between 2 and 100 mSv depending on place of domicile and type of housing).
5.9 mSv	Average annual effective radiation dose incurred by Finns.

In practice, the cancer risk caused by small radiation doses cannot be observed in the population, since cancer is such a common disease. Any possible small additions caused by radiation are statistically lost in the natural variation. For example, the fallout from Chernobyl which causes an average total dose of 2 mSv for Finns over 80 years has been estimated to cause a few cancer deaths in Finland during this time. However, during the same period, a million people will die of cancer due to other reasons. *(STUK 2024c)*

The detrimental impacts of ionising radiation may be due to an internal dose caused by radioactive substances inside the body or an external dose, and they may be further divided into two groups. Direct or deterministic impacts are certain and caused by extensive cell damage. Random or stochastic impacts are statistical detrimental effects that are due to a random genetic mutation in one or more cells. Stochastic detrimental impacts may be understood as long-term impacts.

Direct impacts of radiation

Direct (deterministic) impacts are certain detrimental effects that are related to sudden, very high single radiation doses. Direct detrimental impacts of radiation include, for example, radiation sickness, burns caused by radiation, cataract or foetal damage. In principle, stochastic long-term impacts may originate from minor radiation exposure.

Direct impacts are related to sudden, very high single radiation doses and the effects will typically appear within a short period of time. Detrimental radiation impacts will not occur at small radiation doses, but when a certain level is exceeded, impacts are sure to occur (Table 61). The severity of detrimental impacts will increase when the radiation dose increases, and the effect can typically be linked with a specific exposure. *(STUK 2009)*. The consequences of radiation exposure depend on a number of things. For example, the consequences are different in case of a full-body exposure or the exposure of an individual organ. In a full-body exposure, for example, the threshold value is in the region of 0.5 Sv, whereas for skin exposure, it may be an order of magnitude higher. *(STUK 2009)*

Radiation sickness is a life-threatening condition that is due to a sudden and large full-body exposure to ionising radiation. Such cases have not occurred in Finland, but during the accident at the Chernobyl nuclear power plant, for example, some of the persons working in the power plant area contracted radiation sickness. *(STUK 2009)*

Table 61. Radiation dose threshold values for direct impacts. The detrimental impact of radiation will not occur at radiation doses below the one presentede (STUK 2009 & 2019a).

Full-body dose	
0.5 Sv	Change in blood count within a few days
1.0 Sv	Nausea within a few hours
4.0 Sv	Life-threatening dose, person can be saved with good treatment
10.0 Sv	Death, person can no longer be saved
Local skin dose	
6.0 Sv	Redness within a few hours
15.0 Sv	Blisters -> ulceration in a couple of weeks
20.0 Sv	Necrosis
Foetal dose	
0.1 Sv	Impact on the operation of the brain, mildly reduced intelligence, microcephaly
0.5 Sv	Severe mental retardation
1.0 Sv	Other intellectual disability

Stochastic impacts of radiation

Stochastic impacts are statistical detrimental impacts, and the risk of a detrimental impact will typically increase as the radiation dose increases. The stochastic impacts of radiation include various forms of cancer and hereditary mutations.

In principle, stochastic long-term impacts may originate from minor radiation exposure. Therefore, there is no threshold value for stochastic impacts. Contrary to the deterministic impacts of radiation, the severity of the detrimental impact will also not increase with the dose. It is typical of stochastic impacts that they will only appear several years after the exposure, and that linking the detrimental effect to a specific case of exposure is very difficult or impossible. The dose rate also has a much smaller impact on the risk of stochastic detrimental impacts than that of deterministic impacts. *(STUK 2009)*

The stochastic impacts of radiation include various forms of cancer and hereditary mutations. The increase in cancer risk caused by radiation is usually difficult to observe at the individual level. The detrimental impacts are assessed by using the population's (collective) radiation dose, even if the increase in the occurrence of the disease cannot be seen in the various statistics. The most significant material available for assessing the stochastic impacts of radiation is based on survivors from the nuclear bombings of Hiroshima and Nagasaki. Study material has also been obtained regarding people exposed during the medical use of radiation, people exposed to radiation in their work and people exposed to higher than normal environmental radiation doses. *(STUK 2009, UNSCEAR 2000)*

It is typical of stochastic impacts that the probability of cancer will increase as the radiation dose increases. However, the risk of a person contracting cancer as a result of radiation doses is low when radiation doses are low. *(STUK 2009 & 2024e)*. It may take a very long time for cancer to develop, and the occurrence of cancer is not necessarily a consequence of a potential radiation exposure; it may also be due to errors in cell divisions attributable to other reasons, which become more common as the body ages. Cancer is one of the most common causes of death among the elderly.

However, the risks and detrimental impacts of radiation are different for children and adults. For example, in the years following the Chernobyl accident, the occurrence of thyroid cancer in children increased clearly in the nearby areas. *(STUK 2009)*. According to the International Commission on Radiological Protection (ICRP), a radiation dose of 1 Sv will increase the risk of cancer by 5.5% on average, but the risk for adults is 4.1%. As regards hereditary impacts, the risk of illness will grow by 0.2% for the entire population and by 0.1% for adults with a radiation dose of 1 Sv. *(ICPR 2007)*

6.17.2. Current status

The morbidity index of the Finnish health and wellbeing database Sotkanet.fi maintained by the National Institute for Health and Welfare (THL) was drawn up to function as an indicator of regional variation in morbidity and changes in the morbidity of individual regions. The database takes into account seven different categories of illness, such as the cardiovascular diseases that are common among Finns as well as musculoskeletal diseases, accidents and dementia. An elevated index indicates a higher rate of morbidity within the area.

The age standardised morbidity index for Eurajoki in 2021 was 81.5, which is lower than 100, the average for the rest of the country. Therefore, morbidity at Eurajoki has been clearly lower than elsewhere in the country on average. Similarly, within the welfare services district of Satakunta, age standardised morbidity has been higher (96.6) in 2021. In Eurajoki, values higher than the average age standardised morbidity index for the entire country were seen in 2021 in cerebrovascular diseases (105.1) and cancers (106.2). In the Satakunta region, correspondingly, cancers were slightly less common (98.9). *(THL 2024)*

In connection with the Radiation and Nuclear Safety Authority's radiation monitoring programme, residents in the nearby areas of the nuclear power plant are provided with the opportunity to participate in a measurement that determines the amount of radioactive substances accumulated in the human body. The invitation letter is sent by mail primarily to persons whose permanent address is within a range of 5 km from the nuclear power plant during the year when the measurement is arranged. The group of invitees is also supplemented with a sample of persons who have their residential address within 5 to 7 km from the nuclear power plant. The gamma-emitting radionuclides contained in the bodies of residents in the vicinity of the nuclear power plant are determined by means of direct gamma spectrometry from the outside of the body.

No radioactive substances originating from the power plants were observed in the residents of the areas near the Olkiluoto power plant in 2022. No radioactive substances originating from the plant unit have been observed during whole body counts in earlier years, either. Radiation monitoring in the vicinity of the Olkiluoto nuclear power plant is discussed in chapter 8.1.2. The amounts of radioactive substances originating from the operation of the Olkiluoto power plant that were observed in areas surrounding the plant are so low that they are insignificant in terms of the radiation exposure of the environment or humans. In 2023, the radiation dose calculated on the basis of the releases to the most exposed individual in the vicinity of the Olkiluoto nuclear power plant was less than 1% of the constraint value set in the Nuclear Energy Decree (161/1988) of 0.1 mSv. *(STUK 2024g)*

The sensitivity of the impacted area is determined according to the characteristics of the housing and living environment, such as the area's housing, services, population structure and the recoverability or adaptive capacity of the environment. The sensitivity level is affected, among other things, by the location of the sensitive locations, the number of inhabitants and the detrimental impacts targeting people at the present time.

A precautionary action zone extends to a distance of 5 km from the nuclear power plant area; it must not contain, for example, facilities inhabited or visited by a considerable number of people, such as schools, hospitals, care facilities or shops. Furthermore, this area does not contain other sensitive locations such as schools or day care centres. There is no permanent housing within a distance of less than 3 km from the power plant. Approximately 50 to 60 people live all year long within a distance of less than 5 km from the power plant. Some leisure settlements are located at a radius of approximately 5 km around the power plant area. There is no significant activity that negatively affects air quality in the Olkiluoto area. The calculated dose incurred by the most exposed individual at Olkiluoto as a result of the operation of the power plant has remained clearly below 1% of the constraint limit of 0.1 mSv set in the Nuclear Energy Decree (161/1988). No radioactive substances originating from the power plants were observed in the residents of the areas near the Olkiluoto power plant in 2022. The sensitivity of the area of impact was estimated to be minor.

6.17.3. Environmental impacts

6.17.3.1. Continuing operation

In the continued operation case, conventional health impacts are mainly related to the noise, air releases and vibration resulting from the operation of the power plant and traffic. If the operation continues in the current manner, exposure to conventional health impacts will be minor, as is currently the case. Exposure to impacts will mainly be limited to the power plant area and the vicinity of the roads leading there. According to the noise impact assessment, the limit values pursuant to the environmental permit are mainly not exceeded, and the noise is not estimated to cause detrimental health impacts. Vibration impacts mainly occur due to traffic in the immediate vicinity of the transport routes, and they are not estimated to have detrimental health impacts. Releases into the air (nitrogen oxide, sulphur dioxide and particulate emissions) remain as they are, and they will mainly consist of releases from the reserve boilers, emergency diesel generators and traffic. Impacts on air quality will be minor and, as a result, the detrimental health impacts will be minor. No harmful health impacts with regard to groundwater will result from the operation, since there are no classified groundwater areas, water catchments or private domestic wells in the immediate vicinity of the site area.

The radioactive substances observed in the vicinity of the Olkiluoto nuclear power plant mainly originate from nature or are carried over from elsewhere; only a minor amount originates from the nuclear power plant. In the continued operation case, the radioactive releases from normal operation are estimated to have a very low impact on the radiation burden of the surrounding environment, as is currently the case (see chapter 6.16.2.1). In Finland, the radiation dose caused by nuclear power plants to the residents of the surrounding areas has been below one per cent of the dose limit of 0.1 mSv per year set by the Government *(STUK 2024b)*.

Continuing the operation of the power plant is not estimated to change the currently occurring detrimental health impacts, but the duration of the impacts will continue for 10 to 20 years following the expiration of the current operating licences.

6.17.3.2. Power uprating

In the power uprating case, the impacts on health will be very minor and similar to those described in the continued operation case (chapter 6.17.3.1). The additional construction required by the power uprating may cause short-term dust releases into the air during the shaping of the top soil layers. As a rule, particle releases originating from the soil are larger than fine particles (diameter above 2.5 µm) and exposure to them mainly occurs near the source of the release. Construction work may generate noise during earthmoving, the erection of buildings and equipment installation, but the noise releases will end once the construction stage is complete. Since the change in traffic volumes is low, noise originating from traffic will also not change when compared to the current situation. Construction work is not estimated to cause detrimental health impacts on the residents of nearby areas.

6.17.3.3. Significance of the impacts

The sensitivity of the impacted area is estimated to be low, as there is a precautionary action zone stretching to a distance of 5 km around the nuclear power plant site area, where no sensitive entities may be located. During the service life extension (VE1) and power uprating (VE2), noise, vibration, exhaust gas releases and dust will be generated similarly to the current operation of the plant units. The activities taking place in the power plant area are not estimated to cause detrimental health impacts on the residents of nearby areas. The exhaust gas emissions and dust resulting from road traffic are restricted to areas near the road network, where exposure to conventional health hazards is low. The radioactive releases from normal operation are estimated to have a very low impact on the radiation burden of the surrounding environment, as is currently the case. The service life extension or power uprating are not estimated to have an impact on the current operation of the plant and the impacts on health that result from it (Table 62).

Table 62. Significance of the impacts: People's health.

Alternative	Sensitivity of the affected aspect	Magnitude of change	Significance of the impact
VE1	Minor	No change	No impact
VE2	Minor	No change	No impact

6.17.4. Mitigation of harmful impacts

As regards detrimental impacts on health, prevention and mitigation are mainly based on reducing exposure. Suitable means for preventing and mitigating detrimental impacts have been discussed in connection with the impact assessments concerning them. In addition to reducing exposure, attention should be paid to any possible negative experiences of health impacts within the population of the nearby areas, even if the guideline values are not exceeded. Negative experiences may be mitigated with open and timely communication regarding the events in the area, and by answering any possible questions from the residents of nearby areas.

6.17.5. Uncertainty factors

The uncertainty factors in the assessment of health impacts are mainly related to the uncertainty factors described in the impact assessment section. Further uncertainty in the assessment of health impacts arises from the differences between individuals.

6.18. Incidents and accidents

6.18.1. Classification of operational occurrences and accidents and requirements concerning them

6.18.1.1. Classification according to the Nuclear Energy Decree

The Nuclear Energy Decree (161/1988) and the Government Decree on Ionizing Radiation (1034/2018) set the limit values for radiation doses for the normal operation, operational occurrences and accident conditions in nuclear facilities as well as for decommissioning. The dose rates for radiation workers, the general population and employees comparable to it, the constraints on the annual dose of an individual of the population that is caused by the normal operation and decommissioning of various nuclear facilities, and the annual dose constraints for operational occurrences and accidents are presented in the enclosed table (Table 63). The limit value for releases from a severe reactor accident has been defined in the Nuclear Energy Decree (161/1988 Section 22 d) in a manner where the release must not result in the need for extensive civil protection measures or long-term usage limitations on large land or water areas. In order to limit long-term impacts, the constraint value for a cesium-137 release to the outdoor air is 100 terabecquerels (TBq).

Table 63. Constraints on the annual radiation dose for an individual of the population and an employee (Nuclear Energy Decree 161/1988, Sections 22 b and 22 d, and a Government Decree on Ionizing Radiation 1034/2018, Sections 13 and 14).

Radiation dose	Description
0.01 mSv	Nuclear waste cleared from regulatory control
0.01 mSv	Decommissioning of a nuclear facility pursuant to plan
0.01 mSv	Normal operation of a nuclear waste facility
0.1 mSv	Final disposal facility for nuclear waste following closure
0.1 mSv	Normal operation of a nuclear power plant (DBC 1) or operational occurrence at a nuclear facility (DBC 2)
1 mSv	Effective annual dose limit for the general population and a comparable employee
1 mSv	Class 1 postulated accident (DBC 3)
5 mSv	Class 2 postulated accident (DBC 4)
20 mSv	Design extension condition (DEC)
20 mSv	Effective annual dose limit for a radiation worker

Under the Nuclear Energy Decree (161/1988), the operational occurrences and accidents at a nuclear power plant have been classified into anticipated operational occurrences, postulated accidents, design extension conditions and severe accidents. Operational occurrences and accidents have been considered in the design of the nuclear facility, the systems and structures implementing safety functions and in the facility's procedures and the operation of the organisation.

The acceptance criteria for radiation doses per event classes and the release limit for a severe reactor accident have been described above. Other acceptance criteria are set forth in STUK's YVL Guides; these include, for example, the failure assumptions that should be used to prepare for the event in the design and the safety class for which the systems should be designed. The Guides also provide limits for physical parameters, such as pressure and temperature. The meeting of the acceptance criteria must be demonstrated by means of analyses.

The classification of operational occurrences and accidents was originally designed for nuclear facilities equipped with nuclear reactors, but it has later been expanded to also apply to other nuclear facilities. Because of this, the classification and descriptions show a strong bias towards nuclear reactors.

Anticipated operational occurrence

Anticipated operational occurrences are events that may be assumed to appear once or more per one hundred years of operation.

Postulated accident

Postulated accidents are events which are used in the design and dimensioning of the main safety systems. During these events, the safety systems must stop the heat-generating chain reaction occurring in the nuclear fuel, prevent damage to the nuclear fuel and limit the amount of radioactivity released into the environment. A class 1 postulated accident is assumed to appear fewer than once per one hundred years of reactor operation. A class 2 postulated accident is assumed to appear fewer than once per one thousand years of reactor operation.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Design extension condition

Design extension condition covers situations where the initiating event for an operational occurrence or accident involves a commoncause failure occurring in the safety systems (Class A), a complex combination of defects occurs during the event (Class B) or the initiating event is a rare external event (Class C). The power plant is expected to survive such a situation without severe fuel damage.

Severe accident

In a severe accident, a significant part of the fuel inside the reactor or the spent fuel placed in storage loses its original structure. As a result, a significant amount of the radioactive substances contained in the fuel are released into the containment or the spent fuel storage building.

6.18.1.2. International Nuclear Event Scale, INES

The International Nuclear and Radiological Event Scale (INES) is a scale used to classify various events, describing the severity of emissions of radioactive material and of radiation exposure. The scale is also used for events that do not have emissions or radiation exposure as a consequence, but where the arrangements did not work as planned.

The INES scale has been developed in order to visualise the safety significance of events at nuclear facilities and to support communication regarding the events. The INES level is determined according to the publication by the International Atomic Energy Agency (IAEA 2008) on the basis of the degradation of safety or the radiation impacts targeting the environment, the power plant area or personnel. When determining the class, all of the consequences of the event or accident are examined separately. If the INES level can be determined on the basis of more than one consequential impact, the most severe consequential impact determines the final INES level. In the case of an operational occurrence or accident, the licensee proposes an INES level for STUK's approval.

Events at nuclear facilities that are significant in terms of nuclear safety and radiation safety are classified by using the INES scale's eight levels in accordance with the figure (Figure 75) INES level 0 is for exceptional events with a low safety significance. INES levels 1 to 3 are for events degrading safety, where civil protection measures are not necessary. INES levels 4 to 7 are for accidents involving emergency preparedness activities and civil protection measures.

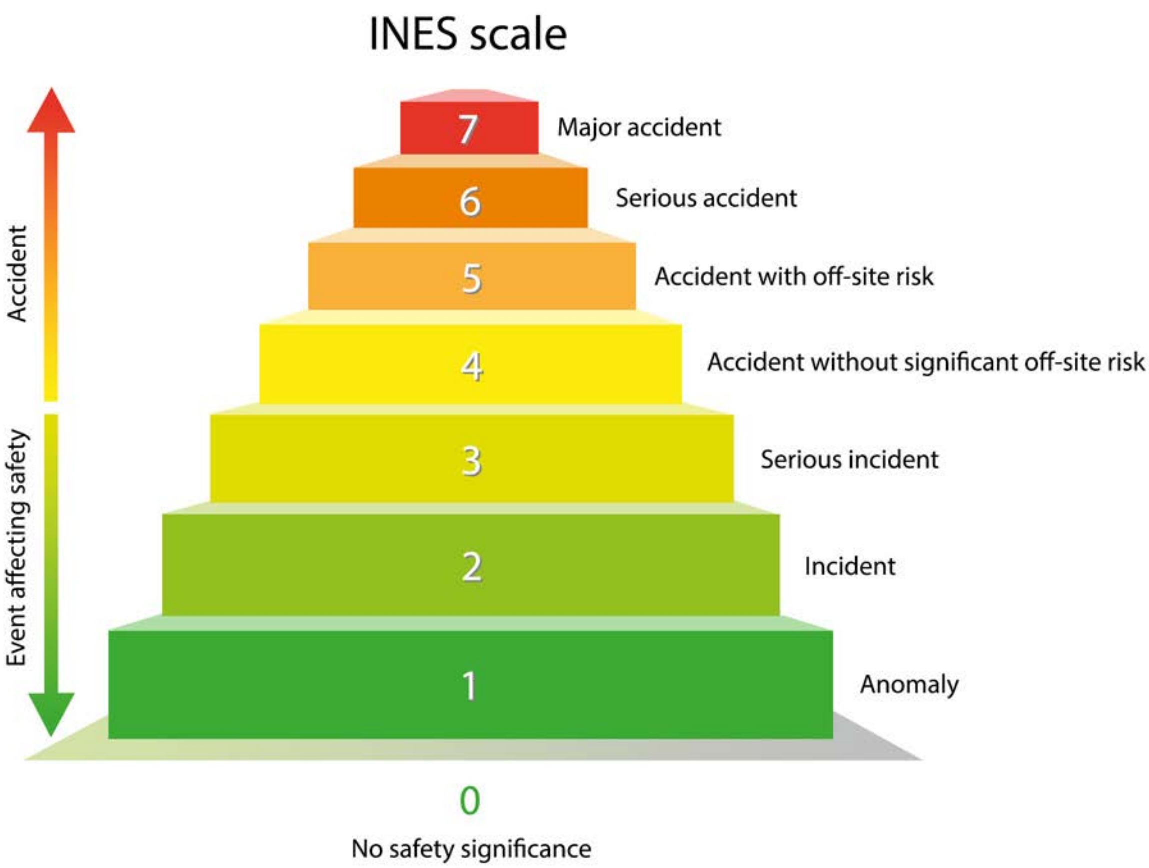


Figure 75. INES scale and categorisation of events. (STUK 2024d)

The events pursuant to the categorisation used in Finland are divided into INES levels in a manner where anticipated operational occurrences are in levels 0 to 3, postulated accidents and design extension conditions are in levels 3 or 4 and severe accidents are in levels 5 to 7. The events occurring at Finnish nuclear power plants have been categorised as INES level 0, 1 or 2. *(STUK 2024c)*. The number of INES events at Olkiluoto nuclear power plant since 2013 is shown in the enclosed figure (Figure 76).

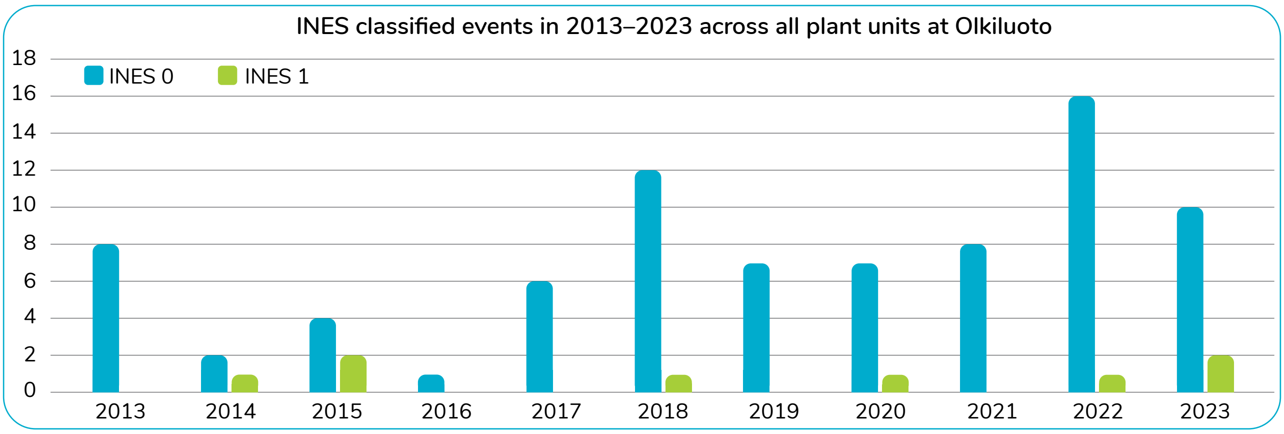


Figure 76. The number of INES classified events in categories INES 0 and INES 1 across all power plant units at Olkiluoto in 2013–2023.

The enclosed table (Table 64) epresents a description of the INES levels and lists examples of the events. Events that took place prior to 2004 are described in detail in chapter 6 of the "Säteily- ja ydinturvallisuus" (Radiation and nuclear safety) book series *(STUK 2004)*.

Table 64. Description of INES levels and examples of eventsa.

INES-classification	Explanation	Description
INES 0	An exceptional event, which, nevertheless, has such a low safety significance that it cannot be placed on the actual scale.	INES level 0 contains events with such a low safety significance that they cannot be placed on the actual scale. For example, the level includes a rapid reactor shut-down (scram). In the events at this level, all systems operate as planned. At the Olkiluoto power plant, INES 0 events have included various human errors and individual component defects. Examples include delays in testing, periodic inspections and preventive maintenance, deviations from allowed time limits for repairs, deviations from required system states and operator errors.
INES 1	Anomaly	Events at INES level 1 do not jeopardise safety, but the plant status or operation materially differs from normal conditions. The reasons for the deviation may include equipment failure, operator error or shortcomings in practices, for example. At the Olkiluoto power plant, INES 1 level events have been related to some equipment not being available in the case of a need due to equipment failures or shortcomings in processes.
INES 2	Incident	An INES level 2 event involves a significant shortcoming in factors affecting safety, but safety is, nevertheless, secured in spite of a potential additional defect. The level also contains events during which an employee's dose rate is exceeded or a substantial amount of radioactivity is released into areas of the power plant which have not been designed for its ingress. There have been 3 INES level 2 events at Olkiluoto power plant; their descriptions are presented below. More detailed descriptions are presented in chapter 6.6 of the "Säteily- ja ydinturvallisuus" book series *(STUK 2004)*. In 1985, a common-cause failure of the blow-off valves in the reactor's overpressure protection system was discovered. The failures were due to debris collected in these pilot valves that prevented the magnetic pistons from moving. A nickel coating that was unsuitable for the operating conditions and a graphite-based lubricant affected the sticking. In 1989, restricted operation of the scram system was observed at OL1 that resulted from the presence of a steel powder in the primary circuit. Problems occurred with extracting 15 control rods during the start-up that followed a reactor scram. In the inspections of the control rod drives and analyses performed later, the cause was determined to be a steel powder that matched the blasting sand used for cleaning metal surfaces in terms of composition. The actual origin of the power was not determined with certainty. During the clean-up operation that followed the event, a total of three litres of the powder were recovered. In 1991, Olkiluoto 2 lost its connection to the external electrical grids as a result of a fire in the electrical system measurement transformer and a resulting short-circuit in the 6 kV electrical busbar. The fire was put out in approximately one hour but, as a consequence of the equipment disturbances resulting from it, connections with external 400 kV and 110 kV grids were lost for approximately 7.5 hours. During this time, the power supply to systems important for safety was arranged using four diesel generators.

INES-classification	Explanation	Description
INES 3	Serious incident	In an INES level 3 event, the releases of radioactive substances into the environment exceed the limits approved by the authorities for normal operation and cause a radiation dose of less than 1 mSv to the most exposed person living in the immediate vicinity of the power plant. Protection measures are not necessary outside of the power plant. The event may also be a case where significantly exceeding an employee's radiation dose limit leads to health impacts or a severe spreading of radioactivity inside the plant. This level also comprises events where an individual additional defect in a safety system could lead to an accident, or a required safety system would be incapable of preventing an accident as a consequence of an operational occurrence. Examples of INES level 3 events are presented below. A fire broke out at the Vandellos nuclear power plant in Spain in 1989. Several systems that verify safety were damaged in the fire, based on which the event is categorised as level 3. At Paks nuclear power plant in Hungary, the cleaning of fuel assemblies took place during the annual outage by means of a separate, bespoke cleaning system located at the bottom of a deep pool of water. As a result of a design flaw in the equipment, the cooling circulation was disturbed and a batch of 30 fuel assemblies that was being cleaned was able to overheat, leading to damage. As a result of the damage, radioactive noble gases and very low amounts of iodine were released into the reactor hall. Releases into the environment and radiation doses to the personnel were minor, however.
INES 4	Accident without significant off-site risk	In an INES level 4 accident, a radiation dose in the magnitude of more than 1 mSv is incurred by the most exposed individual living in the vicinity. During the accident, fuel damage is due to the partial breakage or melting of the reactor core. Civil protection measures are generally not required outside of the power plant, with the exception of local monitoring of foodstuffs. This level is also used for events where one or more power plant employees receive a radiation dose that is likely to lead to rapid death. The following paragraph presents examples of INES level 4 events. At the Windscale (currently Sellafield) reprocessing plant in the United Kingdom, radioactive substances were released into the plant's premises in 1973 as a result of a heat-generating chemical reaction that occurred in a process container. Based on the impacts inside the plant, the accident was assigned level 4. At the Saint Laurent gas-cooled nuclear power plant in France, a metal plate that became dislodged from the reactor structures blocked the cooling flow to two fuel assemblies in 1980. This resulted in severe fuel damage, but no releases of radioactive substances into the environment occurred. Based on the impacts inside the plant, the accident was classified as level 4. In Buenos Aires, Argentina, a sudden power surge (criticality accident) occurred in the RA-2 research reactor in 1983. The accident caused the death of an operator who was working 3–4 metres away. At the Tokaimura nuclear fuel factory in Japan, a criticality accident occurred in a uranium bucket in 1999 that exposed three employees to significant levels of radiation. Two of them later died due to the radiation exposure. Based on the radiation dose, both accidents belong in level 4.
INES 5	Accident with off-site risk	In an INES level 5 accident, a minor portion of the radioactive substances contained in a nuclear power plant is released into the environment. The release would cause the partial initiation of protection measures. The level also includes accidents where a nuclear facility is severely damaged without substantial amounts of radioactive substances being released into the environment. The accident that occurred at the Three Mile Island power plant in the United States in 1979 is categorised as INES level 5. During the accident, the plant unit's reactor core melted but radioactive releases into the environment remained minor.

INES-classification	Explanation	Description
INES 6	Serious accident	In an INES level 6 accident, a large amount of radioactive substances is released into the environment. Such a release is likely to lead to large-scale environmental protection measures in order to avoid severe detrimental health impacts in the nearby areas and to reduce the radiation doses incurred by the population at locations further away. In 1957, at the reprocessing plant known as Chelyabinsk-65 near the town of Kyshtym in the Soviet Union (currently Russia), an explosion of a container of high-level liquid waste occurred that resulted in a release of radioactive substances. Countermeasures, such as the evacuation of the local population, were taken in order to limit the detrimental health impacts. Based on the environmental impacts, the accident was classified as level 6.
INES 7	Major accident	In an INES level 7 accident, a substantial portion of the radioactive substances in a nuclear power plant or other nuclear facility is released into the environment. Typically, the very large release in the accident will contain both short-lived and long-lived fission products. Such a release may cause immediate, direct detrimental impacts, delayed impacts and long-term environmental impacts across large areas. Extensive civil protection measures are launched in order to avoid severe detrimental health impacts. The events in INES level 7 are presented below. The largest earthquake in the history of Japan on 11 March 2021 and the resulting tsunami severely damaged the Fukushima Daiichi nuclear power plant, located on the east coast of Japan, as a result of which the reactor cores on three plant units melted. Radioactive substances were released into the air and sea from the plant. Based on its environmental impacts, the accident is classified as level 7. The reactor of Chernobyl nuclear power plant in the Soviet Union (currently Ukraine) was destroyed in an explosion in 1986. The complete disintegration of the reactor caused a major release of radioactive substances, and dozens of people who participated in the accident's management died from the radiation doses they received. Based on the environmental impacts, the accident was classified as level 7.

6.18.2. Safety in operations

There are functions at the OL1 and OL2 plant units and the spent fuel interim storage (KPA storage) that aim to reliably secure nuclear safety. The purpose of these functions is to control the chain reaction and the reactivity of the fuel, to ensure the cooling and integrity of fuel and to contain the radioactive substances inside the plant. At the OL1 and OL2 plant units and the KPA storage, the level of safety is determined by their technical operating principles and solutions together with the expertise of the organisation that operates them and an attitude that emphasises safety.

6.18.2.1. Safety functions and safety principles

The basic principle for nuclear safety is that radioactive substances must not spread into the environment. In order to prevent any releases, safety is ensured multiple times over. The OL1 and OL2 plant units are equipped with multiple safety systems that operate under diverse principles and can quickly detect and control any operational occurrences. A multilayer defence-in-depth safety thinking is the foundation. All functions that are significant in terms of safety are verified by means of several parallel systems and equipment, and high-quality requirements and sufficient safety margins apply to the design of all equipment and functions.

The starting point for the safety thinking is that user errors or even several equipment failures are not enough to cause a severe accident. The systems for the most important safety functions must be able to carry out their functions even if an individual component in any system were to fail to operate and, additionally, any component affecting the safety function were to be out of operation simultaneously due to repairs or maintenance.

In order to minimise the danger caused by the radioactivity in the fuel, a complex of several nested protection zones is formed. The first release barrier for radioactivity is the fuel pellet itself, which is made of uranium dioxide and retains the fission products. The second release barrier is the metal pipe used as the cladding for the fuel rods, and the third is the reactor pressure vessel. The fourth barrier is the gas-tight containment surrounding the reactor and the outermost release barrier is the massive reactor building.

6.18.2.2. Systems implementing safety functions

In preparation for a single failure, the safety systems at the OL1 and OL2 plant units are divided into four parallel subsystems (A, B, C and D). These systems are located in physically separated rooms, shelves and cabinets. This same principle also applies to the power supply and regulation systems. The areas containing equipment from different subsystems receive ventilation and cooling from separate air conditioning systems.

The reactor core has two separate emergency cooling systems – the auxiliary feed water system and core spray system. The auxiliary feed water system is a high-pressure emergency cooling system. Its capacity is sufficient to keep the reactor core submerged during a pipe break accident involving any pipe connected to the bottom of the reactor pressure vessel.

The core spray system operates at low pressure. Its capacity is sufficient for keeping the reactor core submerged during a large pipe break above the reactor core.

Both systems and their related auxiliary systems are divided into four independent subsystems. The capacity of two of these will be sufficient in a loss of coolant scenario. This arrangement also allows for the easy testing and repair of equipment in the subsystems without the need to limit the operation of the plant units.

Among other things, each subsystem has separate pumps and valves, and their power supply comes from corresponding separate emergency diesel generators. The auxiliary feed water system receives water from bespoke storage pools. A separate pool is in place for each subsystem.

The core spray system obtains water from the containment's condensation pool. The water in this pool is cooled by means of the containment vessel spray system, which, in turn, is cooled with sea water via the component cooling circuit. The heat retention capacity in the condensation pool will be sufficient for residual heat removal for several hours after the ramp-down of the reactor with no containment-external cooling.

In addition to these, a steam-powered high-pressure make-up water system has been constructed that can be used during a total loss of AC power to the plant. This system is powered by the reactor steam and requires no external energy. The system has been designed to operate at a capacity that will be sufficient for cooling the reactor core until the pressure in the reactor pressure vessel has dropped to a level where a low-pressure make-up water supply can be started.

6.18.2.3. Emergency preparedness

Olkiluoto prepares for emergency preparedness situations through emergency preparedness arrangements; this means advance preparation for accidents or events that degrade safety in the nuclear power plant or in the site area. At Olkiluoto, the implementation of emergency preparedness arrangements is the responsibility of an emergency preparedness organisation appointed from within TVO's personnel in accordance with the emergency preparedness plan. The personnel are trained annually for duties pursuant to the emergency preparedness plan.

Outside of TVO's area of responsibility, rescue services are primarily managed by the Satakunta Rescue Services, supported by the Southwest Finland Regional State Administrative Agency and other collaborating authorities. Emergency preparedness and rescue operations always involve STUK as a specialist authority.

Emergency preparedness situations are classified according to their severity and manageability. The Emergency Preparedness Manager defined in the emergency preparedness plan, i.e. the shift supervisor on duty in the main control room of the affected plant unit, initiates activities during an emergency preparedness event.

In an alert, the aim is to secure the safety of the nuclear power plant when safety has been degraded or is at a risk of such or when the situation is unclear. An alert and the reasons leading to it are quickly reported to STUK and the emergency centre in the area, which will then notify the rescue authorities.

In a site area emergency, the safety of the nuclear power plant has been substantially degraded. In a site area emergency, TVO's emergency preparedness organisation, STUK and the regional emergency centre, which will then alert the rescue authorities, must be immediately alerted.

In a general emergency, there is a risk of releases of radioactive substances that require protection measures in the vicinity of the power plant. In a general emergency, TVO's emergency preparedness organisation, STUK and the regional emergency centre, which will then alert the rescue authorities, must be immediately alerted.

6.18.2.4. Security arrangements

Security arrangements are an important part of radiation safety; however, they are usually treated as their own area due to their different nature. Security arrangements refer to advance preparations against the threat of illegal activity targeting a nuclear facility or its operation, such as sabotage or the unauthorised removal of nuclear material. Security arrangements protect the normal disturbance-free operation of the plant, the plant's systems and the personnel working at the plant. Cyber security is an important part of the security arrangements.

Olkiluoto power plant has a separate security organisation. The plans and procedures concerning security arrangements have been drawn up in cooperation with the appropriate police authorities and aligned with the rescue, emergency preparedness and abnormal incident plans drawn up by the authorities. The security arrangements and the plans and procedures concerning them are constantly maintained and developed, and activities are regularly rehearsed with the authorities during internal exercises and as part of emergency preparedness exercises. The security arrangements have been designed in accordance with the principles of defence-in-depth, based on nested security arrangement zones.

6.18.2.5. Assessment of safety and continuous improvement

The safety of a nuclear power plant and the technical solutions in its safety systems must be assessed and justified analytically and, if necessary, experimentally in accordance with STUK's regulation Y/1/2018. The meeting of the set acceptance criteria is verified by means of operational occurrence and accident analyses. Other analytical methods include, for example, the failure modes and effects analyses, strength analyses and the Probabilistic Risk Assessment (PRA). PRA is widely used to determine the risk level of plant units and to support decision-making aimed at managing safety-related risks, for example, when assessing the possibilities and needs of taking measures to improve safety.

The periodic safety assessment is an extensive assessment performed at periodic intervals that assesses the licensee's operations and the technology of the plant. The content requirements for a periodic safety assessment are set forth in STUK's YVL Guide A.1, "Regulatory oversight of safety in the use of nuclear energy", as well as in the International Atomic Energy Agency's (IAEA) document SSG-25, "Periodic Safety Review for Nuclear Power Plants" (IAEA 2013), which explains in more detail the goals, methods and content of the assessment.

The YVL Guides and their requirements only apply in full to new nuclear facilities. For existing nuclear facilities such as the plant units at Olkiluoto, STUK makes an enforcement decision concerning how and to what extent the requirements of the Guide will apply. Based on these enforcement decisions, the OL1 and OL2 plant units meet the safety requirements pursuant to the Nuclear Energy Act and the national authority requirements as they are applied in accordance with Section 7 a of the Nuclear Energy Act. STUK will submit a safety assessment to the Ministry of Economic Affairs and Employment as part of the potential application for new operating licences. The safety assessment is based on the periodic safety assessment submitted by the applicant, the other submitted documents and STUK's own view.

In addition to the national authority requirements, the operation of the Olkiluoto nuclear power plant also takes into account the international principles and guidelines, such as guidelines and recommendations from the International Atomic Energy Agency (IAEA) and recommendations from the World Association of Nuclear Operators (WANO). IAEA and WANO perform regular reviews at Olkiluoto nuclear power plant, and they also gather and distribute operating experience from other plants. Operating experience from other plants and the results of reviews performed at the plant are used in order to develop and improve safety and operations. Additionally, Olkiluoto power plant engages in active information exchange with individual power plants in order to improve the safety and operation of the plant.

During the operation of the OL1 and OL2 plant units, numerous projects have been implemented to improve safety, and the power plant is significantly safer now than when it first started, even though it already corresponded to the level of requirements at the time. Probability-based risk analysis (PRA) has been used to systematically identify risk factors for the plant units. In order to reduce the risk factors, numerous modifications have been implemented at the plant units and the management of various operational occurrences and accidents has been improved almost throughout the entire service life. Following the Fukushima accident, numerous modifications that improve nuclear safety were implemented at the plant units in order to prepare for unlikely natural phenomena and disturbances in the power supply. Of these, modifications significant for nuclear safety included the construction of new systems that can be used to pump water into the reactor in case of a total loss of AC power, improving the operational reliability of the auxiliary feed water system by adding sea water-independent cooling to the system and the addition of alternative cooling to the spent fuel pools. Furthermore, several modifications related to improving resistance to earthquakes have been completed at the plant unit, and ageing systems and equipment have been modernised.

TVO is not aware of any changes related to legislation, international obligations or operation that would have a material impact on the licensee's prerequisites for continuing operation safely and in compliance with the requirements.

6.18.3. Severe reactor accident

A severe reactor accident refers to a situation where a substantial portion of the fuel in the reactor is damaged. A severe reactor accident might occur if the reactor's safety systems were to not function in the case of an accident. Severe reactor accident mitigation systems have been installed at the OL1 and OL2 plant unit; together with the accident management procedures, they ensure the integrity of the containment and prevent its breakage.

The original safety systems of the OL1 and OL2 plant units were dimensioned on the basis of what were known as design basis accidents, corresponding to the current DBC4 event category. Among others, these included a longitudinal guillotine break on the feed water or main steam lines. Such a pipe leak also acted as the dimensioning criterion of the containment. Events leading to fuel melting were only considered later. Modifications have been performed at the plants in various projects over the years in order to prepare for severe accidents. Severe accident management is based on the plant's structural characteristics and the systems and procedures designed for severe accidents. The latest modification preventing severe accidents was the construction of high-pressure and low-pressure reactor make-up water systems at the OL1 and OL2 plant units.

In an accident at a nuclear power plant, radioactive substances that are hazardous to health may be released into the environment. This chapter examines a severe reactor accident where the volume of radioactive substances released into the environment is substantial. A severe reactor accident refers to an accident where a significant portion of the fuel inside the reactor loses its original structure. Milder cases are discussed in chapter 6.18.4.1. A severe reactor accident at a nuclear power plant is a very unlikely, extreme event, and its occurrence would require several defects in the plant's systems as well as problems with controlling the plant. Preparations have been made in the design and operation of the plant for various incidents and accidents, including a severe reactor accident, in order to keep their consequences as low as possibleä.

6.18.3.1. Initial data and assessment methods

The assessment of a severe reactor accident is based on the assumption that an amount of radioactive substances equivalent to the limit value for a severe accident pursuant to Section 22 b of the Nuclear Energy Decree (161/1988) is released into the environment. The release contains 100 terabecquerelis (TBq) of the cesium-137 (Cs-137) nuclide as well as other radionuclides with a ratio that follows how they are expected to be released in proportion to cesium-137 in the case of an accident. Based on the amount of radioactivity released, the examined imaginary severe reactor accident would be classified as an INES level 6 accident on the International Nuclear Event Scale. The impacts of the release spreading have been examined to a distance of 1,000 km from the OL1 and OL2 plant units.

The modelling results are compared to the civil protection action limits concerning evacuation and sheltering indoors presented in STUK's emergency preparedness guideline VAL 1 *(STUK 2024h)*. Furthermore, the impacts of the radioactive fallout and radiation doses caused by the imaginary severe reactor accident have been assessed. The after-care of the accident and its social and socioeconomical impacts have been discussed on a general level.

Release and dose constraints

According to the Nuclear Energy Decree (161/1988, Section 22 b), the release of radioactive material as a result of a severe accident at a nuclear power plant may not necessitate large-scale protective measures for the population or any long-term restrictions on the use of extensive areas of land and water. In order to limit long-term impacts, the constraint value for a Cs-137 release to the outdoor air is 100 TBq. The possibility of the constraint value being exceeded must be very low.

The possibility of a release that requires protective measures for the population at an early stage of the accident must also be very low. Magnitudes and guideline levels for the constraint values for civil protection measures are provided in Guide VAL 1 *(STUK 2024h)*. The enclosed table (Table 65) presents, in a concise manner, the dose criteria for sheltering indoors and evacuation, the areas and action levels related to strong gamma and beta emitters in the fallout that are related to Guides VAL 1 *(STUK 2024h)* and YVL C.3 *(STUK 2019b)*. The precautionary action zone of 5 km and emergency planning zone of 20 km mentioned in the table (Table 65) are presented for the Olkiluoto power plant in the figure (Table 62).

The release and its dispersion into the atmosphere

The radiation doses and fallout caused by a severe reactor accident were modelled by using, as a starting point, the severe reactor accidents performed for the OL1 and OL2 plant units at an uprated power level. Of the scenarios analysed, the case where the damaging of the reactor core occurs the fastest was chosen; in this accident case, releases into the atmosphere were also the highest.

The Cs-137 concentration in the release term of the modelled accident scenario remained clearly below the limit of 100 TBq pursuant to Section 22 of the Nuclear Energy Decree 161/1988, so it had to be scaled up in order to achieve the desired Cs-137 release of 100 TBq. The scaling factor applied is 734.5. The other nuclides in the release term for the accident scenario were scaled up in the same proportion, with the exception of noble gases, of which most (99.5%) are released through the release term of the original accident scenario. The scaled nuclide-specific concentrations were reviewed and it was ensured that the scaled concentration does not exceed the inventory in the core.

In the presently discussed severe reactor accident, the plant unit is generating electricity to the national grid at full power. The scenario being analysed assumes a guillotine break in the feed water line (Loss Of Coolant Accident, LOCA), a total loss of AC power and a leak of 5 square centimetres (cm^2) to the intermediate level of the containment. The development of the accident and the environmental release caused by it has been calculated for 72 hours since the start of the accident. As a consequence of the LOCA, pressure in the primary system will drop quickly. As a consequence of the loss of feed water and the boiling caused by the residual heat in the fuel, the top part of the fuel will be exposed in this accident scenario after approximately 6 minutes have passed since the start of the accident. The core will be completely exposed after approximately 17 minutes. As a result of the heating of the fuel, the core will heat up and the cladding will start to melt after approximately 19 minutes, at which time fission products will begin to be released into the primary system and containment. The melting of the fuel and its shifting to the bottom of the reactor pressure vessel will begin after approximately 42 minutes, and the pressure vessel will burst approximately 53 minutes after the accident. Following the bursting of the reactor pressure vessel, the molten core will fall into the flooded lower drywell, the flooding of which started approximately 34 minutes after the start of the accident. The filtered ventilation of the containment will begin after approximately 6.5 hours have passed since the start of the accident. The filters in the system can retain 99.9% of aerosols, 99% of elemental iodine and 80% of organic iodine. Noble gases will not be retained. Furthermore, the iodine released into the containment is assumed to divide into 95% aerosols, 4.85% elemental iodine and 0.15% organic iodine.

Table 65. Civil protection measures, dose criteria, area limitations and action levels related to the fallout.

Action	Dose criterion (VAL 1)	The maximum distance from the power plant which the action can extend to (YVL C.3)	Guideline action level (VAL 1)
Sheltering indoors	> 10 mSv over two days	Emergency planning zone for the power plant (20 km)	Fallout from the beta and gamma emitters exceeds 10,000,000 Bq/m^2
Evacuation	> 20 mSv over the first week for unprotected person	Precautionary action zone for the power plant (5 km)	Fallout from the beta and gamma emitters exceeds 10,000,000 Bq/m^2 for more than 2 days

Dispersion calculation

In line with general and established practice, the modelling of radiation doses and fallout is performed to a distance of 1,000 km from the point of release. The modelling was performed by using the Tuulet software developed by Fortum Power and Heat Oy, which STUK has approved for use in calculating the radiation doses of residents in the vicinity. The modelling is based on the software version Tuulet 2.0.0, which has been modified for the purpose of the environmental impact assessment to allow for assessing emissions to a distance of 1,000 km from the Olkiluoto power plant. In terms of external doses, the results from the modified software version have been compared to the HYSPLIT software published by the United States' National Oceanic and Atmospheric Administration (NOAA 2020). Comparisons show that the external radiation doses modelled by the Tuulet software are in the same order of magnitude with the HYSPLIT model.

The Tuulet software takes into account the impact of the power plant buildings on winds and, thereby, the impact of the initial altitude of the release on its dispersion. The vertical dispersion of the release plume has taken into account the reflection from the ground surface and the atmospheric inversion layers whose altitude depends on the stability of the atmosphere.

In the Tuulet software, the dispersion of the release plume has been described by means of a Gaussian trail model that considers the decay of radioactive substances and their settling to the ground surface as either dry or wet fallout. In order to allow for the statistical processing of results, the modelling used three years of weather data from the Olkiluoto weather mast. The weather data has been chosen in a manner that makes it representative of the climate in the areas near the power plant. The calculation of the effective whole-body radiation dose considered direct gamma radiation from the release plume, gamma and beta radiation from the fallout and the lake water and the internal dose caused by radioactive substances carried into the body via food. The emergence and drift of daughter nuclides was not modelled separately, but their dose impact has been taken into account in the dose coefficients for the parent nuclides and the average gamma energy levels.

The Tuulet software models the enrichment and drift of radioactive substances in the biosphere. The settling of nuclides directly on the surfaces of plants and their passage from the soil to the plant's internal parts by means of root uptake have been considered. Activity may also be washed off the surfaces of plants. Whether radioactivity ends up in the plants will depend on whether the release occurs in the summer, during the growth season, or outside of it. Harvest season will affect the passage of radioactivity from pasture grass and feed into cows. From cows, radioactivity will transfer to humans through eating beef and drinking milk. Radioactivity may also be transferred into wild game from forest meadows, for example, and finally into humans when they eat game. In the winter, the release will initially settle on the ice and snow, which means that radioactivity will end up in the food chain with a delay once the snow has melted. Radioactivity that settles on lakes will initially be mixed with the water volume of the lake and then end up in lake-dwelling fish and the humans who consume them. The formation of the radiation dose accumulated through nutrition over one year can be divided into the consumption periods for fresh and stored nutrition.

No civil protection measurements are assumed when modelling the radiation doses, that is, the reducing impacts of sheltering indoors or changing the consumption of nutrition are not considered. The fallouts and radiation doses are presented with a 5% probability of being exceeded. This means that there is a 95% probability that the fallout or radiation dose will be lower than the presented result.

Age groups and integration times for radiation doses

According to the International Commission on Radiological Protection (ICRP), different age groups should be considered when modelling radiation doses, since they have different consumption habits for nutrition. In accordance with the ICRP's recommendations *(ICRP 2006)*, this modelling processes 1-year-olds, 10-year-olds and adults as the age groups. Of these age groups, the so-called representative individual for radiation doses in the vicinity of the Olkiluoto power plant is an adult. The radiation dose accumulated during a person's entire life is estimated by using a 70-year exposure time (integration time) for 1-year-olds, a 60-year exposure time for 10-year-olds and a 50-year exposure time for adults. In each age group, the typical amount of nutrition consumed is taken into account, based on the Finnish consumption habits. When estimating the radiation dose for children, the person's growth and the resulting changes in living habits and nutrition are taken into account.

When modelling the potential civil protection measures caused by a severe reactor accident, both sheltering indoors and evacuation should be considered. According to Guide VAL 1 *(STUK 2024h)*, sheltering indoors should be examined with regard to the radiation dose incurred during two days, and the radiation dose incurred during the first week should be examined for evacuation. The radiation dose resulting from a severe reactor accident can also be examined during the first year and the person's entire life.

6.18.3.2. Results from the modelling

The accident modelling has been performed for extending the service life of the OL1 and OL2 plant units at an uprated power level. Similar modelling results also apply to extending the service life at the current power level, but they may be milder.

Radiation doses and fallout

The radiation doses caused by a severe reactor accident are presented in the enclosed table (Table 66). Radiation doses have been estimated for a 1-year-old, 10-year-old and an adult at a distance of 1 to 1,000 km from the OL1 and OL2 plant units. For the purpose of assessing civil protection measures, radiation doses have been presented with exposure times of two and seven days. In addition to this, radiation doses have been estimated by using exposure times of one year and the entire lifetime.

According to the modelling (Table 66), the radiation exposure resulting from a severe reactor accident to an adult individual living at a distance of 20 km from the point of release has been estimated to be approximately 6.5 mSv over an exposure time of one year. Outside of the emergency planning zone for the Olkiluoto nuclear power plant, which extends to a radius of 20 km from the plant, the radiation dose caused by one year of exposure is slightly higher than the average annual radiation dose incurred by a Finn. The average annual radiation dose for a Finn has been estimated to be 5.9 mSv *(STUK 2020a & 2024b)*.

Table 66. The radiation doses caused by a severe reactor accident to a 1-year-old, 10-year-old and an adult at a distance of 1 to 1,000 km from the point of release over 2 days, 7 days, 1 year and the expected lifetime.

	Dose estimate for 1-year-old [mSv]				Dose estimate for 10-year-old [mSv]				Dose estimate for adult [mSv]			
Distance (km)	**2 d**	**7 d**	**1 a**	**70 a**	**2 d**	**7 d**	**1 a**	**60 a**	**2 d**	**7 d**	**1 a**	**50 a**
1	17.1	18.9	50.3	76.0	17.2	18.8	42.6	88.8	16.8	18.3	37.1	92.5
5	9.5	10.5	33.0	36.4	9.6	10.7	20.5	27.4	9.0	9.7	15.2	25.6
10	6.3	6.9	25.0	27.9	6.3	6.9	14.9	20.5	5.8	6.2	11.1	18.1
15	4.5	5.0	17.6	19.8	4.6	4.9	10.9	15.2	4.2	4.6	8.2	13.2
20	3.7	4.0	13.3	14.8	3.7	4.0	8.3	12.0	3.5	3.7	6.5	10.3
50	1.5	1.7	5.0	5.6	1.5	1.7	3.4	4.5	1.4	1.6	2.7	4.1
100	0.8	0.8	2.3	2.6	0.8	0.8	1.6	2.2	0.7	0.8	1.3	2.0
300	0.2	0.2	0.6	0.6	0.2	0.2	0.4	0.5	0.2	0.2	0.3	0.4
500	0.02	0.03	0.2	0.2	0.02	0.03	0.1	0.2	0.02	0.02	0.07	0.1
700	0.01	0.02	0.1	0.1	0.02	0.02	0.07	0.1	0.01	0.01	0.04	0.08
1,000	0.009	0.01	0.07	0.08	0.009	0.01	0.04	0.06	0.006	0.007	0.03	0.05

The radiation doses for the 1-year-old and 10-year-old are typically higher than those of adults in the areas near the OL1 and OL2 plant units due to different nutrition habits that emphasise milk in comparison to adults, for example. Even though the life-long exposure time for a 1year-old and 10-year-old is longer than that of an adult, this does not automatically mean a higher lifetime radiation dose, as the radiation dose will mostly accumulate during the moments following the accident.

Estimates concerning the fallout resulting from a severe reactor accident are presented in the enclosed table (Table 67) for those cesium (Cs), iodine (I) and tellurium (Te) nuclides which, according to the radiation dose analysis, cause the highest dose through fallout over an exposure period of one year. For iodine isotopes I-131 and I-132, fallouts have been presented for the three states of iodine (aerosol, organic and element), as they have different settling rates from air to ground. The table also considers the long-lived strontium-90 (Sr) nuclide.

Table 67. The fallouts for nuclides causing the highest radiation doses through fallout [kBq/m²] at different distances from the OL1 and OL2 plant units during a severe reactor accident.

Fallout [kBq/m²]										
Distance (km)	**Cs-134**	**Cs-137**	**I-131 (aerosol)**	**I-131 (organic)**	**I-131 (element)**	**I-132 (aerosol)**	**I-132 (organic)**	**I-132 (element)**	**Te-132**	**Sr-90**
1	116.5	83.8	5,866	0.13	403	7,006	0.15	483	7,995	7.7
5	27.7	19.9	1,393	0.09	274	1,664	0.10	327	1,899	1.8
10	13.9	10.0	698	0.05	162	834	0.06	194	951	0.9
15	9.1	6.5	456	0.04	109	544	0.04	131	621	0.6
20	6.5	4.7	327	0.03	83	390	0.03	99	446	0.4
50	2.3	1.7	117	0.01	30	140	0.01	35	159	0.2
100	1.1	0.8	56	0.006	13	67	0.007	15	77	0.07
300	0.3	0.2	12.5	0.002	2.4	14.9	0.002	2.9	17.0	0.02
500	0.1	0.1	5.7	0.001	1.0	6.9	0.001	1.2	7.8	0.008
700	0.07	0.05	3.5	0.0008	0.5	4.2	0.001	0.6	4.7	0.005
1,000	0.04	0.03	2.1	0.0006	0.2	2.5	0.0007	0.3	2.9	0.003

Impacts of radiation doses

The health impacts of radiation are described on a general level in chapter 6.17.

Based on the modelling, the highest radiation dose at a distance of one kilometre, considering all age groups, will be approximately 17 mSv during the first 24 hours and approximately 19 mSv during the first week. Radiation doses of this magnitude will not cause direct radiation impacts on humans or developmental disorders in foetuses.

When comparing the results from the modelled radiation dose estimates (Table 66) to the dose criteria in the enclosed table (Table 65), the dose criterion for sheltering indoors is exceeded in an area within 5 km from the power plant. The dose criterion for evacuation is not exceeded. In other words, at a distance of more than 5 km from the power plant, the dose criteria for sheltering indoors or evacuation are not exceeded.

When examining the radiation dose at the outer edge of the precautionary action zone for the Olkiluoto nuclear power plant, that is, at a distance of 5 km from the OL1 and OL2 plant units, the estimated lifetime radiation doses from a severe reactor accident are approximately 36 mSv for a 1-year-old (exposure time of 70 years), approximately 27 mSv for a 10-year-old (exposure time of 60 years) and approximately 26 mSv for an adult (exposure time of 50 years). At a distance of 20 km from the OL1 and OL2 plant units, the radiation doses will be in the region of 4 mSv during the first days, regardless of the age group. The highest estimated lifetime radiation doses at a distance of 20 km will be approximately 15 mSv.

When the results of the modelling are compared to the average annual radiation dose for a Finn, which is approximately 5.9 millisieverts per year (mSv/a) *(STUK 2020a)*, it can be stated that a Finn will receive an average radiation dose of approximately 295 mSv from other sources over 50 years. In addition to this, a person living in a block of flats in a place where they are heavily exposed to radon through household water or indoor air may receive a maximum radiation dose of more than 1,500 mSv over 50 years *(STUK 2020a)*.

When examining the results of the modelling, it should be considered that the authorities would very rapidly initiate civil protection measures such as sheltering indoors in case of a severe reactor accident, which the dose estimates presented here do not take into account. Therefore, the results presented are also conservative in this respect. Civil protection measures taken at an early stage allow for clearly reducing the highest radiation doses received during the early stages of an accident, which are caused by radioactivity carried into the body through inhalation and the direct external radiation caused by the release plume travelling with the air flow and the fallout on the ground.

Impacts of radioactive fallout

Fallout refers to the settling of airborne radioactive particles originating from the accident from the release plume into the ground or water through gravity (dry fallout) and rain (wet fallout). The fallout may remain on the surface and cause a radiation dose through direct radiation, or it may be carried deeper into the soil and transfer entirely or in part into plants, fungi and animals through complex mechanisms. Radioactivity may also be carried into humans through nutrition. It is also possible that the fallout on the ground becomes airborne again due to the impacts of wind, for example. In water systems, some of the fallout mixes with water and some settles at the bottom, from where it may also be mixed again as a result of currents.

When examining the impacts of fallout, special attention should be paid to the long-lived Cs-137 nuclide (half-life approximately 30 years) and the shorter-lived Cs-134 nuclide (half-life approximately two years). Fallout analyses also commonly look at shorter-lived iodine isotopes (the half-life of I-131, for example, is approximately eight days) in various elements and the Sr-90 nuclide (half-life approximately 29 years). Additionally, nuclide Te-132 (half-life of approximately three days) and the short-lived I-132 (half-life of approximately 2.3 h), which is a radioactive decay product of the Te-132 nuclide, have been included in the analysis. Noble gases are not discussed here, as they do not cause fallout.

When comparing the results from the modelled fallout estimates (Table 67) to the action levels in the enclosed table (Table 65), the dose criteria for both sheltering indoors and evacuation are exceeded in an area within 5 km from the power plant. In other words, at a distance of more than 5 km from the OL1 and OL2 plant units, the dose criteria for sheltering indoors or evacuation are not exceeded. The enclosed table (Table 67) shows us that the surface activity will be quickly reduced as a function of distance and, at a distance of 5 km, the total activity of the nuclides in the table that cause most of the dose is approximately 5,600 kBq/m^2.

When examined in accordance with the criteria in STUK's Guide VAL 1 *(STUK 2024h)*, the distance up to less than one kilometre from the power plant is very heavily contaminated according to the modelling, that is, the area contains a lot of radioactivity on all surfaces. At the outer limit of the power plant's emergency planning zone (distance of 20 km from the plant), the area is heavily contaminated. The area at a distance of 50 km is contaminated and, from 300 km onwards, the area is slightly contaminated or nearly clean.

Of the examined nuclides, iodine isotopes have the largest impact immediately following the accident. In humans, iodine tends to collect in the thyroid gland, but its impacts may be mitigated with the timely digestion of iodine tablets, which allows for stable iodine to be stored in the thyroid gland in place of radioactive iodine. Of the nuclides with long half-lives, Cs-134 and, in particular, Cs-137 and Sr-90 will cause radiation doses for years through fallout. In the human body, cesium collects in the muscles and strontium collects in the skeleton. The biological half-life is usually significantly shorter than the physical half-life; this means that Cs-137 collecting in the human body, for example, will exit the body more quickly than could be assumed on the basis of physical decay alone.

Radioactive fallout may cause either short-term (e.g. iodines) or long-term (e.g. cesiums and strontiums) limitations on the use of land or water areas as well as restrictions on the use of foodstuffs. Comparing (Table 67) the fallout estimates and Guide VAL 1 *(STUK 2024h)* indicates that the modelled severe reactor accident would cause, among other things, the cleaning of the built-up environment, limitations on the recreational use of areas in their natural state and the organising of measurements and clean-up within a radius of less than 20 km from the OL1 and OL2 plant units. Furthermore, the use of constructed recreational facilities would need to be limited up to a distance of 100 km. Authorities would also set limitations on the use of products used for nutrition, such as berries, fungi, fish, game and milk products on the basis of their activity concentrations *(STUK 2024h)*.

Social and socioeconomic impacts

The impacts of a severe reactor accident on society are multi-faceted and long-lasting. The impacts on society and it functions depend, among other things, on the place of residence (urban environment compared to the countryside) and the civil protection measures ordered by the authority (evacuation of the population and applicable limit values related to dose rate and fallout, for example). As countermeasures, the management of the accident's repercussions, long-term healthcare, mental and psychological well-being and supporting society in various other ways should also be managed.

As a result of the accident, contaminated areas such as areas used for food production may need to be decommissioned for a long time, even indefinitely. Inhabited urban environments are significantly easier to clean than farmlands or forests, for example. This may lead to land values dropping by substantially more in some areas than others, even though the level of contamination is the same.

The consequences of a severe reactor accident target both constructed infrastructure and nature, but it will also have psychological impacts on people. Widespread pollution of the environment as a result of a severe reactor accident may lead to losses of jobs and, thereby, a loss of income for residents, chronic anxiety and various fears of environmental radiation – whether founded or unfounded. Furthermore, the widespread evacuation of the population may lead to significant problems in psychological well-being, even if the direct impacts of radiation could be avoided entirely with timely evaluation. The people exposed to radiation during the accident may also be discriminated against.

The social and socioeconomic impacts of the Chernobyl accident have been extensively studied. As a result of the accident, approximately 116,00 residents were evacuated soon afterwards and a total of 330,000 residents have been evacuated over the years. Even though the resettlement of the population did reduce the radiation dose incurred by them, many have considered it to be a traumatic experience even after the material forms of compensation (such as a new dwelling). *(Chernobyl Forum 2005)*

For example, the social and socioeconomic impacts of the accident included widespread land use restrictions on previously cultivatable land areas as well as consumers avoiding products being grown in areas classified as safe. This has, in part, affected the overall economy in the areas where the largest fallout caused by the Chernobyl accident was experienced. *(Chernobyl Forum 2005)*

The population structure has also undergone major changes, since the age distribution of the population in the areas most affected by the accident is abnormally biased towards the elderly. This is due to migration, for example, where the younger population has taken the initiative to move further away. In addition to an abnormal age distribution, this has also had psychological impacts. In the areas in question, the mortality rate is higher than the birth rate, and it is difficult to attract professional labour in various industries. This has had an impact on various fields, such as social services. The people living in the areas most contaminated by the accident have a more negative outlook on their state of health than people living in other areas. A sense of self-victimisation and a culture of increasingly relying on government handouts have also been on the rise. *(Chernobyl Forum 2005)*

According to a study concerning the Fukushima accident *(Hasegawa et al. 2016)*, the accident has caused psychological problems, such as post-traumatic stress reactions, chronic anxiety and sense of guilt, an undefinable sense of loss, feelings related to families or communities being broken apart and a sense of shame. In particular, increased mortality rates were observed among elderly people who were evacuated and require treatment; they have been estimated to be due to constant changes in terms of nutrition, hygiene and medical and other types of care that resulted in several evacuations. In addition to this, the Fukushima accident caused lifestyle-related changes, since many of the evacuees changed their eating habits, the amount of exercise and the use of tobacco products and alcohol. The changes have been estimated to cause an increase in lifestyle-related diseases such as obesity. *(Hasegawa ym. 2016)*

Comparisons with the Fukushima accident

The Fukushima accident is the latest severe reactor accident, and it has been documented well from the beginning. For example, the fallout and radiation doses have been surveyed across a wide area up to the present time. The Fukushima accident resulted in the melting of the reactor core at three plant units and, as a consequence, a significant release of radioactive substances and subsequent civil protection measures. The Fukushima accident is classified as INES 7 on the International Nuclear Event Scale. Based on the activity released, the classification of an imaginary severe reactor accident at the OL1 and OL2 plant units is INES 6 *(IAEA 2008)*.

In 2014, the United Nations' Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) published an extensive report on the nuclear power plant accident in Fukushima. It presents estimates, based on the information available at the time, regarding release volumes, the dispersion of the releases, the surface fallout in the environment and radiation doses *(UNSCEAR 2014)*. More information has since been obtained, which has been considered in the reports on the further analysis of the accident *(UNSCEAR 2022a)*.

The enclosed table (Table 68) presents a comparison of data regarding the Fukushima accident and the modelled severe reactor accident at the OL1 and OL2 plant units. Based on the table, the release from the Fukushima accident was approximately 14–68 times larger in terms of the I-131 nuclide and approximately 60–200 times larger in terms of the Cs-137 nuclide when compared to the severe reactor accident example from the OL1 and OL2 plant units. Most of the releases that drifted towards the continent from the Fukushima accident travelled northwest of the power plant. In this direction, the highest surface activity of I-131 was approximately 150 times higher when compared to the modelling results from the OL1 and OL2 plant units, and the lowest surface activity was approximately 30 times higher. For nuclide Cs-137, the highest measured surface activity was approximately 1,100 times higher and the lowest was in the same order of magnitude as the modelling results. The differences in the magnitude of the fallout are due to differences in the source term and the fact that, in the accident modelling for the OL1 and OL2 plant units, the fallout describes the average surface activity of a wider area, whereas in the vicinity of the Fukushima power plant, fallout was limited to a smaller area in higher concentrations.

Despite the differences in the fallout's surface activity, the radiation doses calculated for the residents of the nearby areas are of the same order of magnitude in the accident modelling for the OL1 and OL2 plant units as the estimated doses calculated on the basis of the releases from the Fukushima accident, sometimes even very close. This shows that the radiation doses in the vicinity of the plant that are caused by a severe reactor accident have been estimated conservatively. On the other hand, it also shows the orders of magnitude that the radiation doses will be in if no civil protection activities are implemented in the vicinity.

Table 68. Comparisons between the Fukushima accident and a modelled severe reactor accident at the OL1 and OL2 plant units.

	Fukushima nuclear power plant accident		Olkiluoto power plant – modelled severe reactor accident	
Release into the air [TBq]				
I-131	100,000–500,000 [d)]		7,370	
Cs-137	6,000–20,000 [d)]		100	
Fallout inside an area approximately 100 km from the power plant [kBq/m^2]				
I-131, min	4,400 (67.1 km) [a)]		146 (50 km) [c)]	
I-131, max	64,000 (24.0 km) [a) ja b)]		409 (20 km) [c)]	
Cs-137, min	1.3 (94.5 km) [a)]		0.8 (100 km) [b)]	
Cs-137, max	5,700 (24.0 km) [a) ja b)]		5 (20 km) [b)]	
Radiation dose [mSv]	**1-year exposure [d)]**	**Lifetime exposure [d)]**	**1-year exposure [e)]**	**Lifetime exposure [e)]**
1-year-old	0.1–5.3	0.3–19.0	2.3–13.3	2.6–14.8
10-year-old	0.1–4.5	0.2–17.0	1.6–8.3	2.2–12.0
Adult	0.1–3.8	0.2–15.0	1.3–6.5	2.0–10.3

a: Fallout in the direction of the release trail (northwest of the OL1 and OL2 plant unit) at distances of 20 km to 100 km from the OL1 and OL2 plant units. The surface activity has been estimated on the basis of the averaged measurement results presented in the source *(UNSCEAR 2022b)*, taking into account the decay between the time of the accident (12 Mar 2011) and the scaled sampling time (14 Jun 2011, interval 94 d), which has a significant effect on the volumes of the I-131 nuclide due to its short half-life (8.0252 d). Therefore, the figures depict the situation on the days immediately following the accident.

b: In the town of Namie on days following the accident *(UNSCEAR 2022b)*.

c: The sector selected for examination was the sector in the most common direction of dispersion, that is, the sector in the direction of 0–30°.

d: The radiation doses reported for the Fukushima accident correspond to the range of variation estimated for the dose in the Fukushima prefecture in the reference as regards areas where an evacuation of the population was not undertaken. In the beginning, the area of evacuation extended to a distance of 20 km from the power plant, and the area was later extended especially in the northwest direction. *(UNSCEAR 2022a)*

e: For the sake of comparison, the case of the imaginary severe reactor accident at the OL1 and OL2 plant unit presents the range of variation for the radiation doses at distances of 20 to 100 km from the plant unit.

In the case of an actual accident, protection measures would be implemented to the extent instructed by the authorities. In the Fukushima accident, comprehensive protection measures were taken in order to protect the population. In addition, a significant part of the release drifted east, to the sea, and the entire release did not cause fallout on land areas. This means that the fallout on the ground, as measured from the areas around Fukushima, does not correspond to the total amount of activity that was released into the atmosphere during the accident. Therefore, comparisons between the severe reactor accident example at the OL1 and OL2 plant units and the Fukushima accident are not completely straightforward.

6.18.3.3. Mitigation of impacts

The radiation dose impacts of a release caused by a severe reactor accident may be mitigated by means of various protection actions, such as digesting iodine tablets and sheltering indoors, evacuating the personnel before the release reaches a specific area or by performing the evacuation of the population at a later stage, if so required by the radiation situation. It should be noted from the mitigation of impacts point of view that, even though an evacuation may, in a best case scenario, completely avoid a radiation dose, this is a stressful protection measure from the individual's perspective that may, by itself, cause various health concerns for the evacuee or even result in their death *(Hasegawa et al. 2016)*. In terms of the implementation of the evacuation, the key factor is the correct timing, which, in turn, requires an estimate of the time of the radioactive release and the weather conditions, among other things *(STUK 2024h)*.

If the population can be evacuated before the release reaches the area, the radiation dose caused by the accident may even be avoided entirely. In some cases, such as when the population cannot, for some reason, be evacuated on time before the release plume reaches the area, sheltering indoors is a good way to reduce the radiation exposure caused by the radioactive plume.

Sheltering indoors is an action for the early stages of a radiation hazard scenario that allows for avoiding the highest radiation doses at the early stages of the event. The time limit for such is approximately two days, since, during that time, radioactive substances will begin to enter indoors in spite of any protective measures. Two days is also considered a feasible duration in terms of food supply. The efficiency of sheltering indoors depends, among other things, on the materials used in the building and the location within the building of the room used as a shelter. STUK has estimated that, even at a minimum, properly sheltering indoors will lower the radiation dose to 1/3 of what the dose would be without sheltering indoors. Sheltering indoors is at its most efficient when the building's ventilation has been turned off and the room being used for sheltering is the civil shelter in a block of flats, for example. In this case, the radiation dose is estimated to be as low as 1/500 of the dose that would be received with no sheltering. *(STUK 2024h)*

The impacts of the fallout may be mitigated in many different ways, depending on what the area is like. For example, asphalt roads in urban environments can be washed, which allows for significant parts of the fallout to be removed with the water, and land areas can be formed by removing the top soil with the most fallout and transporting it to controlled storage. In the case of fallout, the primary clean-up activities will target living environments where people spend a large part of their time (such as housing) or where the population density is highest (urban areas).

STUK's Guide VAL 1 *(STUK 2024h)* provides guidelines for the civil protection measures required during the early and late stages of a radiation hazard. The guide reviews the contents and bases of the protection measures and presents various dose criteria and guideline action values which necessitate protection actions when exceeded. In case of a radiation hazard, the Radiation and Nuclear Safety Authority will assess the safety significance of the situation pursuant to Section 46 of the Rescue Act (379/2011) and provide recommendations concerning protection activities to the authorities deciding on them. In case of a radiation hazard, the licensee will work in close cooperation with STUK in order to ensure the safety of the power plant and its surroundings in the best possible manner. Appendix 4 to Guide VAL 1 summarises the key responsibilities for protection actions during a radiation hazard *(STUK 2024h)*. Instructions for the actions of the authorities in case of a radiation hazard are provided in the Ministry of the Interior's procedure for scenarios involving radiation *(Ministry of the Interior 2016)*. The figure (Figure 77) presents the focus areas for protection actions during various stages of the radiation hazard scenario.

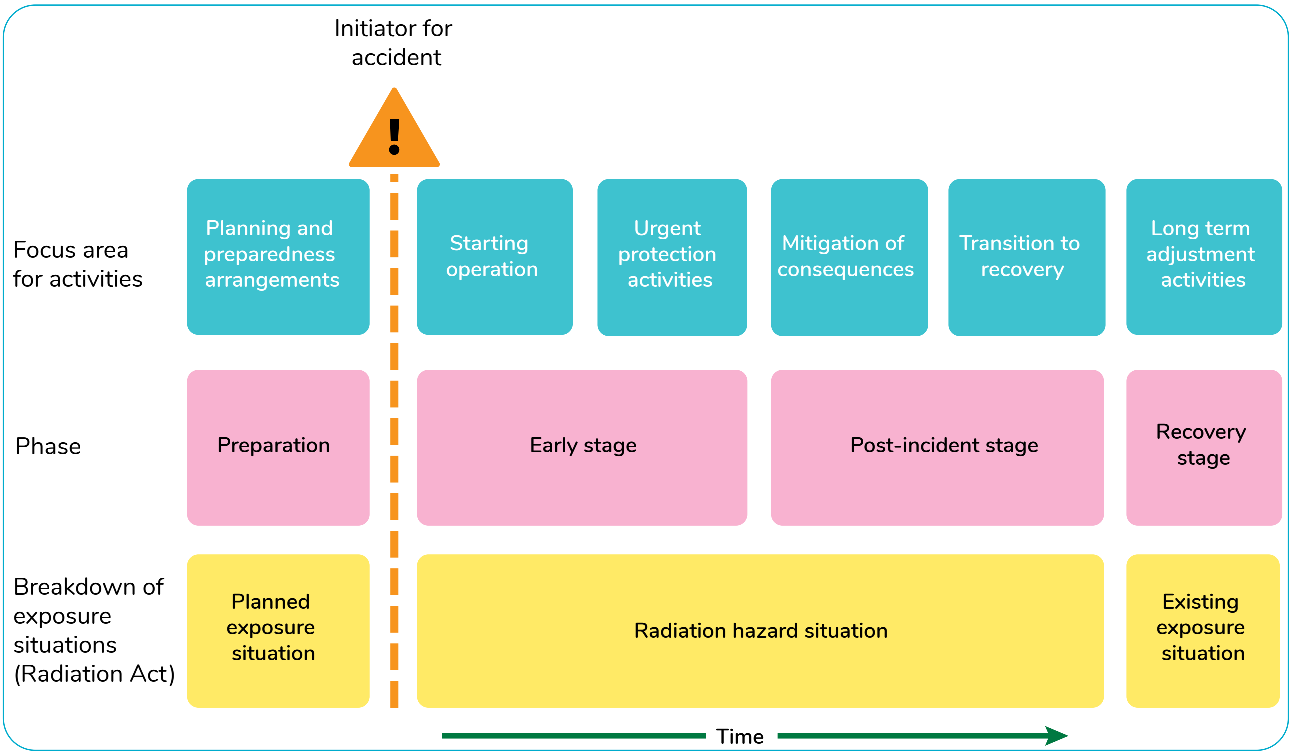


Figure 77. Development and stages of radiation hazard (STUK 2024h).

An important foundation for protection activities is advance preparation for a possible accident, which allows for quickly starting the planned actions when an accident takes place.

During the early stage of an accident, the focus of protection actions is on starting the activities and carrying out urgent protection. In the early stage , the protection actions especially focus on people and production, with the goal being to both protect people and to simplify and mitigate the actions required in the later stage. Urgent protection actions concerning the population and those working in the danger zone include, for example, sheltering indoors or limiting movement outside, digesting iodine tablets, restricting the area and imposing access limitations, evacuating the population and protecting the individuals working in the danger area. In addition to this, actions are initiated in order to protect foodstuffs, initial feed production and household water, raw materials for foodstuffs, completed products and production facilities. If necessary, limitations are also enacted on the trade of foodstuffs and goods. *(STUK 2024h)*

During the latter stages of an accident, the emphasis of protection activities is on mitigating the consequences and transitioning to recovery. In the latter stage , protection actions target the living environment and restoring the functions of society in addition to protecting people and production. As regards the population and those working in the contaminated area, protection actions are similar to those in the early stage of the accident. Additional actions include measuring and cleaning people, the removal of radioactive substances and reducing their passage. Other possible actions include regional land use restrictions as well as usage restrictions on foodstuffs, production thereof and water supply. *(STUK 2024h)*

The final stage of the protection activities is the recovery stage , during which the emphasis is on long-term adaptation *(STUK 2024h)*.

6.18.4. Other incidents and accidents

Incidents, accidents and their environmental impacts have been examined on the basis of authority requirements set for nuclear facilities and the analyses made. In order to identify incidents and accidents, the safety and risk analyses prepared for the Olkiluoto nuclear power plant have been examined, among other things.

The incidents and accidents being discussed are related to internal and external events at the power plant where the safety functions of the reactor or the spent fuel storages do not need to be started, or where they operate as planned. In other words, the situation will not directly cause an operational occurrence or accident pursuant to the Nuclear Energy Decree (161/1988). Incidents and accidents may affect functions for normal operation as well as safety functions, thereby degrading the safety level of the plant. The situation may worsen if the actions related to managing operational occurrences or accidents fail or the systems required for implementing them are inoperable. In an extreme case, the situation may – as the consequence of numerous defects and errors – escalate to a severe reactor accident, the consequences and impacts of which are discussed in chapter 6.18.3. THowever, the likelihood of such a situation is very small.

The next chapters look at other possible operational occurrences and describe the impacts and preparations related to them. The impact assessment has also examined conventional incidents and accidents which do not, as a rule, have material impacts on the plant's level of safety. These situations do not cause radioactive releases, and they are related to the transport, unloading and loading, storage and use of oils and other chemicals, for example. The causes of accidents may include equipment failures or human errors, for example.

6.18.4.1. Other situations causing releases of radioactive substances

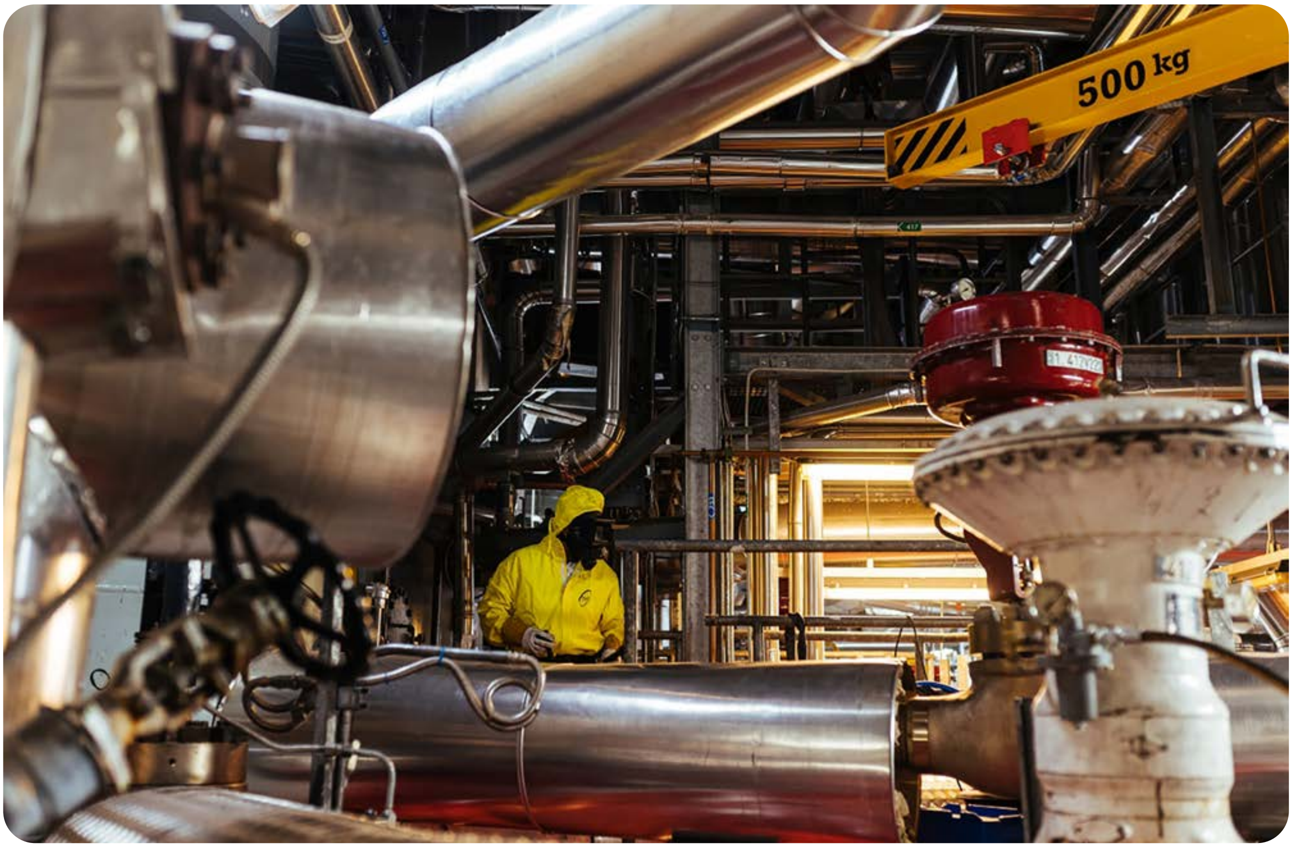
In terms of radiation doses, the worst case at the OL1 and OL2 plant units is a severe reactor accident as discussed in chapter 6.18.3. Other incidents and accidents, where a low amount of radioactive substances may spread into the environment, have been considered in the plant's safety analyses to be possible during the handling of nuclear fuel or radioactive waste, for example, or if a leak occurs in a system containing radioactive substances. Situations causing minor radioactive releases may occur in all stages of the plant's life cycle. For example, fires may cause a radioactive release, but they may also cause a degradation of the level of safety by e.g. damaging a part of the safety systems.

Radioactive substances exist in the systems of the OL1 and OL2 plant units during normal operation. Leaks from the systems will only result in minor radioactive releases. Such an event will cause a radiation dose of clearly below 0.1 mSv to a resident of the vicinity of the power plant (at a distance of 1 km from the power plant) over a one-year exposure period. This radiation dose equals approximately 1% of the average annual radiation dose of 5.9 mSv incurred by Finns. A release from a system containing radioactive substances may occur as a consequence of some of the events presented herein and an earthquake.

Handling and storage of spent fuel

The same safety functions as for the reactor are applied to the safety of the fuel pools in the reactor building and the KPA storage. If the cooling of the pools at the KPA storage is interrupted, residual heat removal from the fuel will not be jeopardised in the short term due to the very low residual heat power and the large volume of water in the pools. In order to remove residual heat in the long term, the operability of the cooling systems used normally must be restored, alternative cooling methods such as the pool water clean-up system must be used or make-up water must be supplied into the pools to compensate for any possible boiling. The supply of make-up water may take place by using the plant's active systems or through connection points created for a fire engine, for example. The power supply for systems at the plant unit is backed by emergency diesel generators, and the make-up water supply for the fuel pool inside the reactor building has also been secured by means of diesel generators. The radioactive substances in the reactor building's pools can be efficiently isolated inside the reactor building even in a scenario where the pools are boiling. In case of boiling, a small amount of radioactivity from the pool water at the KPA storage pools may be released into the environment.

Situations causing minor radioactive releases may occur during the operation of the KPA storage, similarly to the operation of the plant unit. However, there are only a few systems, and, thus, the probability of such an event is lower than at the power plant units.



Transfers of spent nuclear fuel

The safety requirements of the IAEA *(IAEA 2018)* or the Act on the Transport of Dangerous Goods (719/1994) do not apply to transfers of spent fuel between the reactor buildings, the spent fuel storage facilities and the encapsulation plant, since the transfers occur in the power plant area. However, the essential parts of the requirements have been considered. For ex-ample, the radiation dose rate on the surface of the transfer cask corresponds to the requirements set for transports outside of the power plant area. Several transfers are made each year during operation by using a bespoke transfer cask. Disturbances or accidents during the transfers are not estimated to cause radioactive releases, since the cask is transported at a low elevation and even the falling of the cask will not cause it to break. Therefore, the incident would not result in radiation doses to the personnel.

During the operation of the power plant, relatively small amounts of radioactive waste are handled, trans-ferred and stored at a time, which means that only minor radioactive releases are estimated to be generated in the case of incidents or accidents. The choice of handling methods and packaging for radioactive waste as well as logistics arrangements allow for preventing the occurrence of incidents and accidents as well as for mitigating their impacts.

6.18.4.2. Fires, explosions, oil and chemical spills

A fire may cause an initiating event in a manner where a component that is used normally is not operable due to the fire, or where a function may start spuriously. Fire prevention at a nuclear facility is based on the principle of defence-in-depth, with the aim being to:

- prevent fires;
- detect and extinguish fires quickly;
- stop fires from developing and spreading;
- limit the effects of the fire such that the safety functions can be implemented reliably in spite of the effects of the fire.

The effects of fires are limited by applying the principles of redundancy and separation, which means that only part of the necessary equipment can be damaged in a fire. The parallel subsystems of the safety systems are extensively separated into different rooms, or equipment and cables separated sufficiently far apart from each other have been fire-proofed, if necessary. According to the design basis, the buildings and parts thereof have been divided into dedicated fire compartments that prevent the fire from spreading.

The causes of fires, explosions and oil and chemical spills may include equipment failures, human errors or earthquakes, for example. In some cases, these situations may also lead to radioactive substances spreading into the environment. These situations have been prepared for in the power plant's design, guidelines and administrative procedures. The impacts of individual events are limited to a small area and the releases of radioactive substances are minor. The main task for TVO's plant fire brigade is the prevention of all accidents, and accidents are prepared for by the plant fire brigade and the emergency preparedness organisation.

The enclosed table (Table 69) briefly describes such incidents, their potential impacts and preparation for them.

Table 69. Examples of incidents related to fires and explosions and oil and chemical spills, their potential impacts and preparation for them.

Incident	Impact	Preparation
Fires and explosions	» Personal injuries and property damage » Damage to structures » In the case of a large fire, the spreading of flue gases into the environment » In the case of a large fire, the run-off of fire-fighting water into the environment » Minor spreading of radioactive substances into the environment is possible	» Structural fire protection (separation and placement of systems to be protected and fire compartmentation) » Minimisation of fire loads and appropriate storage » Instructing plant operators to manage the situation » Appropriate handling of combustible gases generated in the process systems » Overpressure protection for pressurised containers » Application of ATEX regulations for equipment and conditions » Fire detector system » Fire extinguishing systems » First response firefighting equipment » A dedicated plant fire brigade on continuous stand-by. The plant fire brigade trains regularly » Personnel training and qualification requirements » Fire and rescue plan and collaboration with the authorities » Filtered ventilation system.

Incident	Impact	Preparation
Light fuel oil transport accident or leak	Oil spill into the soil or a water system	» Transport takes place in accordance with the regulations concerning the transport of dangerous goods (VAK) » Transport takes place within the site area, along guided and paved transport routes. Speed limits and winter maintenance. » The fuel unloading areas are concreted, and their rainwater and meltwater are processed in an oil separator before being routed into the sea. » All storage tanks have level measurements and overfill protectors, and the unloading is supervised by the operator of the tanker truck and the operating personnel of the power plant. » The fuel oil storage tanks are located inside protective basins that have a volume at least 1.1 times that of the largest storage tank. The storage tanks and day tanks are located in facilities which have oil separators in their sewer systems. » The storage tanks and day tanks are monitored daily in order to detect any possible leaks. The condition of the tanks is also subject to regular inspections. » The oil separators also have oil detectors. The condition and functionality of the oil separators and detectors is checked regularly, and a record is kept of the inspections. » Spill prevention materials, such as sewer sealing mats and adsorbents, are available in the site area in order to prepare for leaks. » The security personnel will monitor for the presence of oil in the surrounding water area, at the mouths of sewage pipes and discharge ditches. » An oil spill prevention action plan has been drawn up in preparation for oil spills. » The plant fire brigade, which is on continuous stand-by, is responsible for oil spill prevention. The plant fire brigade regularly rehearses oil spill prevention.
Oil spill in the yard area	Oil spill into the soil or water system	» To counteract spills from machinery, adsorbents are available on board the machinery and in the site area. » Personnel training and qualification requirements » Oil spills occurring at the main transformers are collected in the oil containment pit below the transformers, which has enough volume to fit the entire oil inventory of each transformer. » The reserve main transformer is located inside an oil containment pool that can collect small oil leaks. » An oil spill prevention action plan has been drawn up in preparation for oil spills. » The plant fire brigade, which is on continuous stand-by, is responsible for oil spill prevention. The plant fire brigade regularly rehearses oil spill prevention activities.
Chemical transport accident or chemical spill	» Personal injuries (e.g. corrosive chemical splashes) » Release of chemicals into soil and water system	» Transport takes place in accordance with the regulations concerning the transport of dangerous goods (VAK). » Transfers of chemicals inside the power plant area adhere to the safety instructions and regulations concerning them. » Transport takes place within the site area, along guided and paved transport routes. Speed limits and winter maintenance. » Chemicals are located inside protective basins that have a volume at least equal to that of the largest storage tank. » Chemical spills occurring indoors are routed into the leak collection system. » Personnel training and qualification requirements » A chemical spill prevention action plan has been drawn up in preparation for chemical spills. » The plant fire brigade, which is on continuous stand-by, is responsible for chemical spill prevention. The plant fire brigade regularly rehearses chemical spill prevention activities.

6.18.4.3. Preparation for external hazards and climate change

The design of the OL1 and OL2 plant units includes the preparation for various external hazards, such as wind loads, flooding, lightning, the impacts of snow and ice and high and low air and sea water temperatures. Preparation has also been developed further over the years. Earthquakes were not part of the original design basis for the plant units, but earthquake resistance has later been assessed and improved through various plant modifications. Preparation against various external hazardsand the safety significance of external hazardshas been discussed in a report prepared in 2011. The safety functions have been improved even after the preparation of the report. With the latest safety improvements, the plant units can now survive, among other things, a total loss of the main heat sink, that is, the possibility of using seawater.

According to the nuclear safety Guides published by STUK, the starting point for various external hazardsis the preparation for phenomena whose probability of occurring at the plant site over the course of a year is higher than once per one hundred thousand years. Phenomena rarer than this are also considered as so-called design extension conditions (class DEC C), and the plant is required to survive them without severe fuel damage. The risk significance of various events and phenomena, including external threats, is estimated by means of probabilistic risk analysis (PRA). Based on the analysis results, the significance of earthquakes and other external threats in terms of the plant units' core damage frequency (the probability of an accident leading to severe fuel damage occurring over the course of one year) is fairly low, amounting to a total of approx. 6% of the plant unit's total core damage frequency.

Climate change will affect the strength of external events and the probability at which powerful phenomena occur. As a consequence of climate change, the average temperatures of air near the ground surface and sea water will increase in the future, among other things. Furthermore, heat waves in the air and sea water will become more common and rainfall is also likely to increase. The binding of heat and carbon dioxide into the seas will change the stratification conditions and pH values of sea water. Increased rainfall, for its part, will dilute the salinity of sea water through direct precipitation as well as run-off. Changes in these physical environmental variables form complex feedback loops, which makes estimating the magnitude of the changes problematic and prone to errors. Based on research, however, the trends are clear. *(Bolle et al. 2015)*.

The magnitude of climate change will mostly depend on humanity's actual greenhouse gas emissions. This is why climate change is assessed by means of different emissions scenarios that make assumptions regarding the development of greenhouse gas emissions in the future. Furthermore, the impact of climate change will vary significantly in terms of both areas and seasons. In Finland, for example, climate models suggest that the air temperature and total rainfall will increase the most during the winter season *(Ilmasto-opas 2023)*

From the point of view of the Olkiluoto power plant, the impacts of climate change that are related to sea water, in particular, may be significant in terms of the safety of the plant units as well as their availability. Sea level is a key factor in terms of safety since, in a worst case scenario, sea water may flood the power plant's buildings and damage the equipment inside that is important for safety. A low level, for its part, may prevent residual heat removal into the sea water that acts as the main heat sink. As a consequence of their safety significance, the various phenomena affecting sea water level variations have been researched comprehensively, while considering the latest research data related to climate change scenarios. The latest report that was prepared in 2023 assessed the probabilities of extreme sea water levels being exceeded in the area of the Olkiluoto nuclear power plant up to the year 2100 *(Finnish Meteorological Institute 2023)*. The assessment used three different emissions scenarios from the Intergovernmental Panel on Climate Change (IPCC): low carbon dioxide emissions (RCP2.6), average carbon dioxide emissions (RCP4.5) and large carbon dioxide emissions (RCP8.5). At least in the near future, the global increase in sea water level attributable to climate change will remain lower than the land upheaval following the ice age in the Olkiluoto area (currently, the rate of land upheaval is approximately 7 mm per year). However, the direction may change before the middle of the century, depending on the magnitude of the climate change impacts. Nevertheless, under even the most negative emissions scenario, a sea water level rise will not form a significant risk to the safety of the Olkiluoto plant units during their potential service life.

A possible increase in the sea water temperature does not cause a particular threat to the safety of the plant units at Olkiluoto since, if necessary, the plant units will be ramped down in good time before the sea water temperature reaches a level that could have harmful impacts on the availability of safety functions. However, a higher sea water temperature will reduce the efficiency of the plant units and may, in a worst case, cause a need for power reductions or other limitations on operation. The warming of sea water may also lead to the proliferation of various invasive alien species, which may affect the operability of sea water systems. However, the situation is constantly monitored and various actions are initiated, if necessary. The plant units can also survive even a total loss of the operability of sea water systems without fuel damage.

Some external events may lead to a temporary ramp-down of the power plant, at which time commercial electricity production is stopped and the power plant is operated to a shutdown state; if necessary, any work is stopped. Examples of such events include an oil spill in the sea area, high air or sea water temperature and a high or low sea water level. The ramp-down of the power plant is done in order to guarantee that the state of the power plant is as safe as possible, should the situation worsen for some reason. During disturbances in the electrical grid, the electricity generated by the plant cannot be transmitted to the national grid. As a result, the power plant remains on house load operation, or it is ramped down and the diesel generators in the power plant area are used to generate the electricity required in the area.

Research related to climate change is constantly monitored and modifications are made when necessary on the basis of the estimated impacts. Over the years, plant modifications have been carried out to improve preparation against seismic events, frazil ice in sea water, external flooding, heavy rainfall, freezing of rooms, invasive alien species as well as various electrical disturbances and loss of outside power scenarios.

Intentional, illegal human activities are prepared for by means of security arrangements and by adhering to the principle of separation. The enclosed table (Table 70) briefly describes examples of preparation against external hazards and climate change.

Table 70. Some examples of preparation for external hazards and climate change.

Incident	Impact	Preparation
Oil accident in the sea area	» Ramp-down of the power plant	» The oil spill control plan contains a separate procedure for controlling an oil spill in the sea area » The plant fire brigade, which is on continuous stand-by, is responsible for oil spill prevention » The plant fire brigade regularly rehearses oil spill prevention in the sea area » When the accident is large and takes place in the immediate vicinity of the power plant, commercial electricity production will be interrupted, and the power plant will be operated to a shutdown state.
Oil accident in the sea area	» Insufficient cooling capacity » Change in sea water strati-fication and pH value » Limitation of the operating power of nuclear power plant units » Ramp-down of the power plant	» Continuous monitoring of seawater temperature » Plant status control according to the temperature limits and requirements set forth in the Technical Specifications
Rise of sea water level	» Flooding in the plant area » Ramp-down of the power plant	» Continuous monitoring of sea water level » Analysis of flooding risks and assessment of climate change impacts » Improvement of flood resistance by means of plant modifi-cations.
Storms and other extreme weather phenomena	» Disturbances in the national grid	» Possibility of house load operation for the power plant » Protection of safety systems against disturbances related to overvoltage » Emergency diesel generators » Olkiluoto gas turbine plant » Steam-operated emergency feed water pump.
Clogging of the cooling water intake channel	» Limitation of the operating power of nuclear power plant units » Ramp-down of the power plant	» Switching the water intake of the safety systems to the discharge side of the sea water channels » Residual heat removal into the condensation pool and, if necessary, into the atmosphere » Air-cooled diesel generators.

6.19. Transboundary impacts

6.19.1. Severe reactor accident

In order to assess transboundary impacts, a modelling has been performed concerning the spread of a radioactive release caused by a severe reactor accident, the resulting fallout and population radiation doses at distances up to 1,000 km from the OL1 and OL2 plant units. The modelling examined the highly unlikely scenario of a severe reactor accident that would release into the environment 100 TBq of the Caesium-137 (Cs-137) nuclide – corresponding to the limit specified in Section 22b of the Nuclear Energy Decree 161/1988 – as well as other radionuclides from the reactor inventory in proportion. Based on the amount of radioactivity released, this would be classified as an INES 6 class accident.

Figure 78. Indicative distances from the OL1 and OL2 plant units, up to 1,000 km.

The modelling methods and the impacts of the modelled imaginary severe reactor accident have been described in detail in chapter 6.18.3. The results of accident analyses prepared for the OL1 and OL2 plant units were used as the starting point for the modelling. The modelling uses assumptions for ensuring that the assessed fallout and radiation doses are conservative. The modelling does not consider, for example, civil protection measures and limitations on consuming foods that would allow the radiation doses to be reduced in the short and long term.

The figure (Figure 78) visualises the distances to other countries up to 1,000 km from the OL1 and OL2 plant units. The radiation dose resulting from the radioactive release caused by a severe reactor accident is calculated for each elementary cell in the pictured grid, even outside Finland's borders. The distances provided are from the centre of the elementary cell of the OL1 and OL2 plant units.

Based on the results of the modelling, a severe reactor accident will not have immediate health impacts for people living close to the power plant or outside the Finnish borders. At 5 kilometres from the power plant, the modelled severe reactor accident would result in a radiation dose of 9.0–9.6 mSv over the course of two days, depending on the age group. Based on the dose criteria set by Finnish legislation and authority requirements (Table 65) the dose criteria for sheltering indoors and evacuation are only exceeded within the power plant's precautionary action zone, and the civil protection measures only extend up to 5 km from the power plant. Therefore, the need for civil protection measures does not extend outside the Finnish borders.

The table (Table 71) presents country-specific radiation doses resulting from a radioactive release caused by a severe reactor accident up to 1,000 km from the OL1 and OL2 plant units. The annual doses from natural background radiation in Europe amount to approximately 1.5–6.2 mSv/a, and the average is 3.2 mSv/a *(European Commission 2019)*. Compared to this, the radiation doses resulting from a release caused by a severe reactor accident will remain statistically insignificant outside Finland's borders. The table (Table 71) presents, on a coarse level, the order of magnitude of the radiation doses in various countries according to the calculation points used in the modelling and presented in a figure (Figure 78) For an adult, the estimated life-time radiation doses are 0.43 mSv at most and ≤0.02 mSv at the minimum. The life-time radiation doses estimated for children are slightly higher but in the same order of magnitude.

As regards other nations within the examined area of 1,000 km, the radiation dose estimates are shown in the enclosed table (Table 71). The radiation doses at distances of more than 1,000 km have not been examined in more detail in terms of calculations; however, on the basis of the modelling results and an expert assessment, the doses are estimated to be no higher than 0.02–0.03 mSv for children and adults in places such as north-eastern Germany, Central Poland and the parts of Russia on the European side.

Table 71. Orders of magnitude for the country-specific radiation doses estimated for children and adults for a severe reactor accident. The range of variation in the radiation doses corresponds to the approximate distance of the nation's areas from the OL1 and OL2 plant units.

Country	The approximate distance of the nation's areas from the OL1 and OL2 plant units (min, max) [km] [a]	Range of variation for the lifetime dose of a 1-year-old individual [mSv]	Range of variation for the lifetime dose of a 10-year-old individual [mSv]	Range of variation for the lifetime dose of an adult [mSv]
Sweden	200, 800	0.03–0.60	0.03–0.49	0.03–0.43
Estonia	300, 500	0.08–0.29	0.07–0.24	0.06–0.22
Latvia	400, 700	0.05–0.19	0.05–0.17	0.04–0.15
Russia	400, 1,000	0.03–0.17	0.02–0.13	0.02–0.10
Norway	500, 1,000	0.02–0.11	0.02–0.08	0.02–0.07
Lithuania	550, 800	0.06–0.10	0.04–0.08	0.04–0.07
Belarus	700, 1,000	0.03–0.06	0.03–0.05	0.02–0.04
Denmark	750, 1,000	0.02–0.03	0.02–0.03	0.02–0.03
Poland	750, 1,000	0.02–0.06	0.02–0.04	0.02–0.04
Germany	900, 1,000	0.02	0.02	0.02

[a] The maximum distance reported here represents the maximum distance of the calculation area from the OL1 and OL2 plant units. The most distant areas of the various countries may be located more than 1,000 km away from the power plant.

The largest radiation doses outside of the Finnish borders are focused on Sweden and Estonia, whose borders are a minimum of approximately 200–300 km from the Olkiluoto nuclear power plant. As the distance increases, the radiation doses will be reduced. The Swedish coast is approximately 200 km from the OL1 and OL2 plant units. Based on a conservative estimate, the lifetime dose within the area of Sweden will be at most 0.60 mSv for children and 0.43 mSv for adults (the doses have been presented for the calculation point of 300 km in sector 1). In northern Sweden, approximately 800 km away in sector 1, lifetime doses will be in the region of 0.07–0.1 mSv depending on age group, whereas in southern Sweden, approximately 800 km away in sector 8, the lifetime radiation doses will be in the region of 0.03 mSv for both children and adults. The difference in doses between the various directions is related to the prevailing weather conditions, since the most common directions of dispersion at Olkiluoto are to the north and northeast of the plant units. Estonia is located approximately 300 km away from the OL1 and OL2 plant units, in the southeast and south-southeast directions. Based on a conservative estimate, the lifetime dose within the area of Estonia will be at most 0.24–0.29 mSv for children, depending on their age, and 0.22 mSv for adults (the doses have been presented for the calculation point of 300 km in sector 6). In Estonia, the radiation doses are the smallest on the southeast parts of the country where the doses will be 0.06–0.08 mSv, depending on age.

6.19.2. Other impacts

In addition to the impacts of a severe reactor accident, the service life extension or power uprating are not estimated to have other transboundary impacts.

6.20. Joint impacts

The possible joint impacts of the OL1 and OL2 plant units' functions with the OL3 plant unit and the other functions and projects in the nearby area are presented in the following sections.

6.20.1. Teollisuuden Voima Oyj: OL3 plant unit

In addition to the OL1 and OL2 plant units, the Olkiluoto site area houses the OL3 plant unit, for which an operating licence was granted in 2019. The commercial operation of the OL3 plant unit started in May 2023, and its current operating licence pursuant to the Nuclear Energy Act is in force until the end of 2038. The OL3 plant unit has a planned service life of 60 years. This means that the operation of the OL1, OL2 and OL3 plant units will result in some joint impacts in the case of service life extension (VE1) and power uprating (VE2). The possible joint impacts with the OL3 plant unit have been considered in the impact assessments.

The cooling water modelling, which was prepared for assessing the impacts on the surface water, modelled the future scenarios with also the OL3 plant unit being in operation and continuing its operations in the present manner (chapter 6.8, appendix 5). While the OL3 plant unit has its own cooling water intake channel, the cooling water from all the plant units is discharged in the same location in the Iso Kaalonperä bay (Bild 6). The table (Tabell 32) indicates that the OL3 plant unit accounts for approximately 40% and the OL1 and OL2 plant units account for approximately 60% of the cooling water consumption and the thermal load on the sea area. Therefore, it can be estimated that approximately 40% of the impacts on the sea area are caused by the thermal load from the cooling water for the OL3 plant unit. According to the results of the cooling water modelling, in the long term, climate change will have a more significant effect on the warming of the sea area than the thermal load from the cooling water. Furthermore, the assessment of the surface water impacts considers the nutrient load on the sea area. The thermal load from the cooling water for the OL1, OL2 and OL3 plant units will only have minor, local joint impacts on the eutrophication of the sea area. However, combined with climate change and the nutrient load on the sea area, the thermal load may extend the growing season of primary producers, thereby impacting the sea area's level of eutrophication.

The results of the surface water impact assessment are described in more detail in chapter 6.8, and their joint impacts have also been considered in the assessment of the impacts on fish and fishery (chapter 6.9) and on flora, fauna and conservation areas (chapter 6.10).

With regard to service water, household wastewater and process wastewater, the assessment of surface water impacts uses the combined volumes from the OL1, OL2 and OL3 plant (Tabell 6). Correspondingly, the quantities of conventional waste, noise and vibration levels and traffic volumes and the assessment of their impacts are based on the combined figures from the OL1, OL2 and OL3 plant units (Tabell 6). The joint impacts are described for each impact in chapters 6.3, 6.4 and 6.15.

Other impact assessments have also considered the OL3 plant unit in the site area. The OL3 plant unit as well as its structures and functions have also been considered in the description of the current status of land use and zoning (chapter 6.1) and the landscape (chapter 6.2) The assessment considers the zone designations and limitations on land use as well as the power plant complex made up of the different plant units being visible in the landscape. For air quality impacts (chapter 6.5), it is expected that the OL3 plant unit will not significantly change the air quality in the area because the OL3 plant unit does not generate significant conventional air emissions. In terms of the impacts on soil, bedrock and groundwater (chapter 6.7), OL3 will not increase the impacts in the area because construction has been completed at OL3. All the plant units in the area share the VLJ repository and KPA storage, which have already been excavated.

The emergency diesel generators and reserve boilers as well as fuel consumption from traffic related to the OL1 and OL2 plant units result in minor greenhouse gas emissions and, similarly, these are also generated as part of the operations of the OL3 plant unit (chapter 6.6). Overall, the emissions generated from fuel consumption are very minor when compared with the climate benefits from electricity production using nuclear power. The OL3 plant unit generates a total of 12 TWh of emissions-free power for electricity consumers annually, while the OL1 and OL2 plant units generate approximately a total of 14 TWh/a (approximately 7 TWh/a per plant unit). According to an indicative estimate, the OL1, OL2 and OL3 plant units currently create a combined climate benefit of approximately 1,700,000 t CO_{2e} per year.

The assessment of the impacts on energy markets (chapter 6.13) has only examined the impact of the OL1 and OL2 plant units on the Finnish energy market. OL3 strengthens this positive impact, as OL3's electricity production covers approximately 14% of the need for electricity in Finland. For example, the electricity generated annually by the plant unit is enough to heat 5.2 million apartments or power 3.6 million electric cars. With regular electricity production at OL3, Finland's self-sufficiency in clean electricity grows – the share of carbon neutral electricity production will rise from 89% to approximately 94% *(Finnish Energy 2024)*. Furthermore, the production at OL3 reduces the need to import electricity to Finland by approximately 60%.

In the assessment of regional economic impacts (chapter 6.12), the impacts of the OL1 and OL2 plant units are presented separately from the production at the OL3 plant unit. The operations at the OL3 plant unit strengthen the identified direct and multiplicative effects at all the different regional levels. Furthermore, the operations at the OL3 plant unit may result in new multiplicative effects, if operational scale benefits are gained as production stabilises. This may be reflected in lower total purchase costs or maintenance costs, which increases the added value from the operations.

In the assessment of impacts on people's living conditions and comfort (chapter 6.11), one significant difference when compared to the previous years' impacts is that construction at the OL3 plant unit has been completed and the plant unit was commissioned in 2023. The impacts from the construction period on nearby areas (particularly noise and traffic), with a possible effect on living comfort, have ended.

The assessment of releases of radioactive substances (chapter 6.16) uses the data on the Olkiluoto environment concerning the releases of radioactive substances to air and water in 2013–2022, published by STUK. The OL3 plant unit, which was commissioned in 2023, is not yet included in the results, and the joint impacts cannot be assessed yet in relation to OL3. Furthermore, the releases of radioactive substances for OL3 remain very low compared to the release limits set for them. The radiation dose caused by the OL1, OL2 and OL3 plant units to the residents of the surrounding areas is considerably below the dose limit of 0.1 mSv per year set by the Government. According to section 13 of the Government Decree on Ionizing Radiation, the effective dose of a radiation worker must not exceed 20 mSv per year. TVO's own targets regarding individual annual doses are keeping the dose obtained by all Olkiluoto employees from their work below 10 mSv per year and keeping doses caused by internal contamination below 0.5 mSv. During the normal operation of the OL1, OL2 and OL3 plant units, radiation doses incurred by the personnel are considerably below these dose limits.

All plant units in the area share the KPA storage and VLJ repository, which are dimensioned for the spent nuclear fuel and low and intermediate-level waste generated as a result of the operation of the OL1, OL2 and OL3 plant units. Waste and the impacts from handling it are described in chapter 6.15.

Furthermore, an HMAJ repository for near-surface final disposal, shared by the OL1, OL2 and OL3 plant units, has been planned in the power plant area. The environmental impacts of the HMAJ repository have been assessed and described in a separate EIA report *(Teollisuuden Voima 2021)*. The construction of the HMAJ repository will possibly begin in 2025. This would mean that the repository is implemented while the existing operating licences for the OL1 and OL2 plant units are valid and, therefore, no joint impacts occur during its construction with the functions related to the service life extension (VE1) or power uprating (VE2). Once the HMAJ reposiraktory is in operation, it will reduce the amount of waste ending up in the VLJ repository. This can be considered to have a significant positive overall effect on the plant units' waste management in the long term.

6.20.2. Posiva Oy: Encapsulation plant and disposal facility for spent nuclear fuel

Posiva's encapsulation plant and disposal facility are being constructed in the Olkiluoto power plant area. The impact assessment considers the joint impacts with Posiva's current functions in the Olkiluoto area for aspects such as noise, vibration and traffic as well as air and dust emissions from traffic.

Posiva is responsible for assessing the environmental impacts for the encapsulation and final disposal activities. An updated report on the environmental impacts of the plant complex was presented in connection with the operating licence application *(Posiva 2021a)*.

If Posiva starts the final disposal activities during the 2020s as per the current plan, capacity in the KPA storage will be sufficient even in the service life extension case. If the start of final disposal activities at Posiva were to be substantially delayed for some reason, the storage capacity at the KPA storage will need to be increased. For example, the increase in storage capacity may be implemented by expanding the current KPA storage and constructing new pools as an extension of the current pools. The different impacts of the possible expansion of the KPA storage have been assessed in chapter 6 of this EIA report.

6.20.3. Other possible projects

At the moment, no planned or ongoing new projects have been identified in or near the power plant area that could have joint impacts with the service life extension and power uprating of the OL1 and OL2 plant units.

Several offshore wind power projects are being planned for the further sea areas off Olkiluoto. The Vågskär offshore wind power project is being planned in the Finnish Exclusive Economic Zone, approximately 95 km southwest from Olkiluoto. The landing point for one of the cable route alternatives for this offshore wind power project has been planned on the north side of Olkiluoto. The project is currently in the EIA procedure stage and, therefore, the final decision on the offshore power cable alternatives has not yet been made. *(Ramboll 2023)*. Any assessment of the additional capacity need for the power lines located in the Olkiluoto area is the responsibility of their owner, Fingrid Oyj.

In the future, the plant units' continued operation may involve the possible utilisation of thermal energy, for example, but there is currently insufficient information about this, and such an assessment is not included in this EIA procedure. However, the power plant's various energy production opportunities, such as the utilisation of thermal energy generated in the processes, may become relevant in the future.

6.21. End of current activities

If the operation of the OL1 and OL2 plant units is not continued, the decommissioning of the power plant will take place following the expiration of the current operating licences, from 2038 onwards. If the operation of the power plant units is continued, decommissioning will take place after the expiration of the new operating licences, from either 2048 or 2058. According to the current decommissioning plan, however, the actual dismantling and related waste management would mainly take place in the 2080s.

As regards the OL1 and OL2 plant units, the decommissioning plan is based on delayed dismantling. In this case, the actual dismantling activities for the plant units will only begin after several decades, following monitored storage. This ensures that the collective radiation dose for the workers will be low and the amount of waste placed in final disposal will be reduced. At the same time, the dismantling work for the three plant units may be scheduled to take place during consecutive years. This will allow for utilising the experience, equipment and personnel from the dismantling of the first units while dismantling the third unit.

The decommissioning of nuclear power plants is subject to licence and regulated according to the Nuclear Energy Act and Decree and STUK's regulations and guides. According to the current EIA Act (252/2017), the dismantling or decommissioning of a nuclear power plant requires an EIA procedure. A separate environmental impact assessment will be drawn up for the decommissioning of the OL1 and OL2 plant units, according to the legislation in force, once decommissioning becomes relevant.

The following sections describe, on a general level, possible impacts of the termination of operations at the OL1 and OL2 plant units and their decommissioning.

Community structure, land use and zoning

After decommissioning, the current impacts on land use from the operations will end. Depending on the further utilisation of the area, the entire area or part of it could be used for industrial operations, for example. The further utilisation of the area may require plan amendments. The annulment of a precautionary action zone presented in the plans would remove some of the limitations in the land use planning for the surroundings.

Landscape and cultural environment

Decommissioning will also have positive impacts on the landscape. Their magnitude will depend on the area's further utilisation principles. If all of the buildings and structures in the power plant area are demolished, this will result in higher positive impacts on the power plant area and the surrounding areas when compared to an alternative in which some of the buildings remain in the area. The magnitude of positive impacts is reduced by the long time span of the demolition operations, as they will be carried out in stages and the changes in the landscape will occur over the course of several decades. The demolition of the power plant buildings can also be seen as a negative aspect because the power plant is part of the regional landscape and built environment.

Traffic

The highest increase in the traffic volumes during decommissioning will be seen in the demolition stages. During demolition, the traffic volumes may momentarily reach levels that are comparable to those of the power plant's current annual outages. The growth in the traffic volumes is not estimated to have a significant impact on the flow or safety of traffic, considering the current capacity of the roads.

Noise and vibration

If buildings in the area are demolished, any crushing of concrete in the outdoor areas will generate noise that may be heard in the surroundings of the power plant area. Furthermore, machinery and transports may occasionally generate noise that exceeds the power plant's current noise level. The volume of noise reaching the surrounding areas can be reduced by choosing a suitable location for the crushing of concrete and implementing noise barriers, if necessary. During decommissioning, heavy transports may temporarily slightly increase the human perceivable vibration near roads caused by traffic

Air quality

In the decommissioning stage, air quality impacts may primarily be caused by emissions from traffic and machinery. If buildings are demolished, the crushing of concrete and any other demolition activities and earthworks may result in temporary local effects (such as dust).

Climate

The decommissioning of the OL1 and OL2 plant units would result in a corresponding need to increase the other electricity production capacity. If the substitutive electricity production form is wind power, for example, then the greenhouse gas emissions from the electricity production would remain unchanged, considering the emissions from production activities and the specific emissions for the life cycle of the electricity generation form in question. The amount of greenhouse gas emissions generated during decommissioning is very minor.

Soil, bedrock and groundwater

The impacts on soil, bedrock and groundwater are very minor. They depend on whether the buildings in the area are demolished and whether it is necessary to modify the surface layers or excavate additional underground facilities

Surface water

As a result of the decommissioning of the OL1 and OL2 plant units, the impacts of the thermal load from cooling water on the sea area will be reduced significantly. The sea water surface temperatures in the Iso Kaalonperä bay will decrease, the stratification conditions will degrade and the growing season of primary producers will shorten. Positive impacts may be visible over a longer period e.g. as a declining trend in primary production, reduction in aquatic vegetation (quantity of annual filamentous algae) and improved condition of the benthic fauna. As a result, oxygen concentration in the hypolimnion is also expected to increase in the summer, which improves the condition of the local benthic fauna communities. As the thermal load from cooling water decreases, the probability of invasive species becoming more abundant will also be reduced. Furthermore, once the operation of the OL3 plant unit ends, the impact of the thermal load from cooling water on the sea ecosystem will end completely and the Olkiluoto sea area will be gradually restored to the prevailing condition of the surrounding coastal area, inner archipelago and outer archipelago. Once the thermal load ends, the winter ice conditions will become normalised which may contribute to the formation of an ice cover in the sea area near Olkiluoto. On the other hand, it is predicted that there will be fewer icy winters and they will be shorter due to the climate change. The KPA storage cooling will continue to be in operation for several decades after the decommissioning of the plant units. The impacts from the KPA storage cooling water are very low and local, and they have practically no effect on the condition of the sea area.

Fish stocks and fishery

As a result of decommissioning, the impact on the marine ecosystem and fish stocks caused by the thermal load from cooling water will decrease significantly following the decommissioning of the OL1 and OL2 plant units and end completely once the operation of the OL3 plant unit ends. The fish stocks will be gradually restored to the same condition as in the other surrounding coastal areas. At the same time, the probability of invasive species becoming more abundant will also be reduced. Additionally, the opportunities for fishery in the winter will be restored to an improved level as the ice conditions are normalised. However, even in this alternative, it is expected that there will be fewer icy winters because of the climate change. Fish and fingerlings will no longer be carried into the cooling water intake channels, which may slightly contribute to strengthening the local fish stocks.

Flora, fauna and conservation areas

The thermal load of the sea area will decrease following the decommissioning of the OL1 and OL2 plant units and end once the operation of the OL3 plant unit ends. At this time, the open area in the winter will be reduced, which may have a minor harmful impact on the number of birds wintering in the area. However, this is not considered to have any significant impact on the populations of these bird species. Decommissioning will not have any impacts on nature reserves. If decommissioning is carried out such that buildings and other infrastructure remain in the area, the amount of flora will not increase significantly. If decommissioning involves the demolition of all the buildings and landscaping the area, the area covered by vegetation will grow as a result of the landscaping of the power plant area, which will locally increase biodiversity.

People's living conditions, comfort and health

The decommissioning of the OL1 and OL2 plant units will result in a clear, observable change to the activities that take place in the power plant area. It will take several decades to complete all of the different stages of decommissioning. The change will take place over a long period, and it may evoke uncertainty about the future, as well as related worries and expectations, in the residents. The intermittent noise caused by the activities during decommissioning may impact, in particular, the living comfort of the residents of holiday homes located near the power plant as well as the recreational use of the water areas and shores. The increase in traffic during the most active demolition stage may temporarily impact the flow of traffic. The decommissioning of the plant units and the ending of electricity production may lead to changes in the local identity and result in worries of the change impacting the vitality of the region.

Regional economy

After production ends at the OL1 and OL2 plant units, the significant impacts on the regional economy from production will end. However, decommissioning will create regional economic impacts for TVO as well as many other actors and industries. During decommissioning, impacts on the Rauma region will occur as a result of bringing the operation to a state of controlled storage. It is estimated that, in the initial stage, it will have an employment impact of more than 200 person years annually at TVO and its subcontractors in Finland because of the technical and administrative requirements involved. According to estimates, it will take several years to bring the operation to a state of controlled storage. The next stage, controlled storage, is estimated to have an employment impact of approximately 50–100 person years annually at TVO and its subcontractors in Finland because of the technical and administrative requirements involved. This stage is expected to continue for several decades. Activities related to decommissioning and bringing the operation to a state of controlled storage will also result in financial impacts and additional multiplicative effects locally and elsewhere in Finland. These have not been assessed.

The following figure visualises the presented employment impacts of bringing the operation to a state of controlled storage and implementing the controlled storage for each of the assessed alternatives (Figure 79). In the figure, the period from 2010 to 2021 is based on the actual volumes reported by Statistics Finland; at this time, the impact on employment of extending the operation of the OL1 and OL2 plant units was assumed to be the same as during the latest year for which statistics for regional accounting are available, i.e. 2021. The presented employment impacts from the service life extension and power uprating are based on modelling results, and they describe the total impact of TVO's own activities and multiplicative effects.

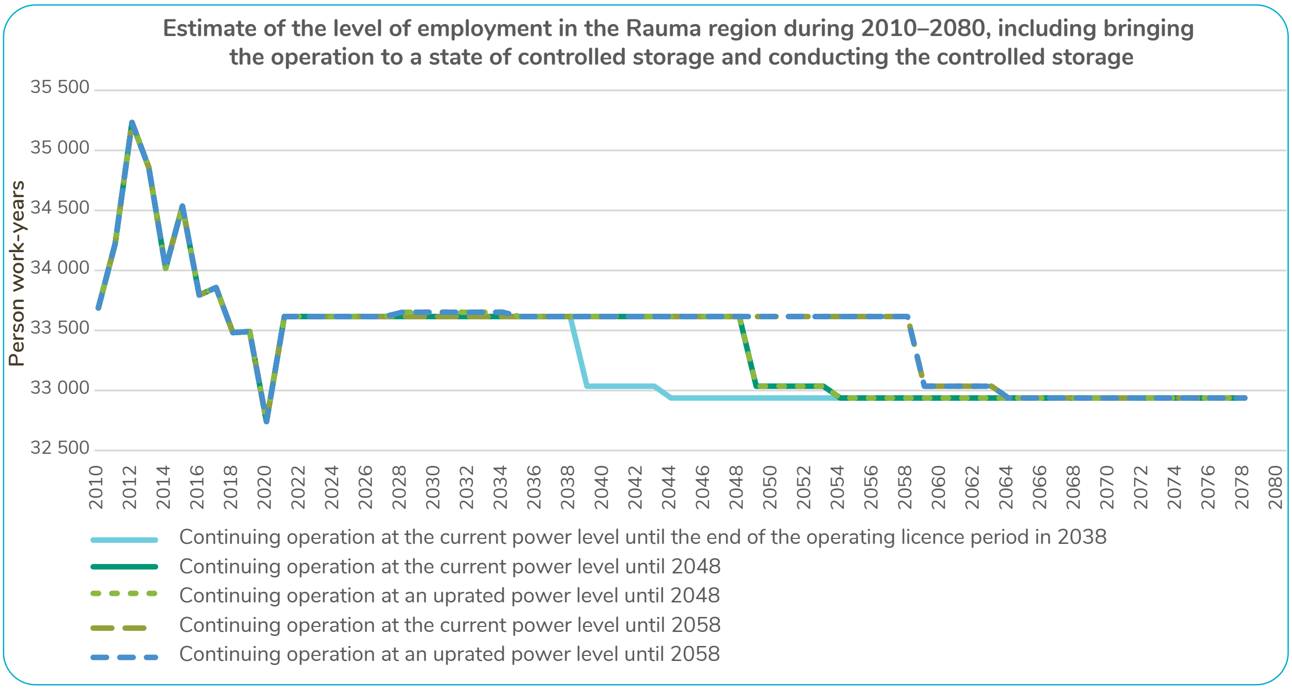


Figure 79. Estimate of the volume of employment in the Rauma region during the various stages of the operation and decommissioning of the OL1 and OL2 plant units, considering the direct employment impacts on TVO and its subcontractors.

Energy markets

The decommissioning of the OL1 and OL2 plant units would mean that it would be necessary to obtain other carbon-free electricity in order to reach Finland's carbon neutrality objective. Among other things, this would result in the construction of new electricity production capacity in Finland as well as increased imports of electricity. Furthermore, it would reduce the opportunities for electricity exports from Finland. The magnitude of the need for additional electricity depends on the time of decommissioning and the remaining electricity production capacity in Finland at that time.

Use of natural resources

Once the operation of the OL1 and OL2 plant units ends, new nuclear fuel will no longer be purchased. However, the proportion of the purchased volume has been so low in comparison with the global production volume that, in practice, it has no impact on the global uranium reserves.

Waste and its handling

The interim storage and handling of spent nuclear fuel in the power plant area do not result in any radiation or release impacts on the environment that would deviate from normal operation, and the statutory limits for personnel are not exceeded. In normal conditions, transfers of spent nuclear fuel cause very low radiation exposure to humans and the environment. It is practically impossible to differentiate between this additional exposure and the exposure caused by environmental background radiation. The collective radiation dose resulting from the decommissioning of the OL1 and OL2 plant units is estimated to be approximately 2.5 manSv. The annual collective radiation dose is in the same order of magnitude when compared with the current operation of the plant. The radiation dose of any individual employee does not exceed the power plant's targeted dose limit, which is set below the statutory limit. According to the long-term safety case, the existing sections of the VLJ repository meet the requirements for long-term safety, and the planned expansion can be implemented such that the long-term safety requirements are met. When conventional waste is processed and stored appropriately at the power plant area, it will not have environmental impacts. Indirect environmental impacts are caused by the transports of conventional waste as well as the processes used by parties tasked with their further processing.

Releases of radioactive substances and radiation

During the decommissioning of the OL1 and OL2 plant units, the radiation doses incurred by the personnel are expected to still remain significantly below the set dose limits. The methods employed in decommissioning are chosen in a manner that ensures staying below the release limits, which results in a very low radiation impact. Decommissioning is expected to have the highest impacts during the most active demolition stage. However, the effects will decrease towards the end of the decommissioning and eventually stop once the last plant components that have been made independent have been decommissioned and the VLJ repository has been closed.

People's health

The radioactive releases from normal operation are estimated to have a very low impact on the radiation burden of the surrounding environment, as is currently the case, and no direct harmful impacts to health will occur. The demolition methods to be used in decommissioning will be chosen in a manner that ensures staying below the release limits for radioactive substances validated by the authorities, in which case no harmful impacts to health will occur.

7. Summary and the comparison of alternatives

This EIA procedure determined the current state of the environment and assessed the impacts of the project in accordance with the EIA legislation. On the basis of the performed assessments, the project alternatives can be found to be feasible in terms of the environment. The further planning of the project can consider the means for preventing and mitigating any harmful impacts that have been presented in connection with the impact assessment.

The following table (Table 72) compares two alternatives, in which the operation of the OL1 and OL2 plant units is continued either at their current power level (VE1) or at an uprated power level (VE2). The examination considers the significance of each impact on the basis of the sensitivity of the affected aspect and the magnitude of the change. The descriptions of each impact are presented in more detail in chapter 6. The table presents the assessment results for the impacts from normal operations. Incidents and accidents are described in chapter 6.18.

Table 72. Summary of the significance of the impacts. The shade of colour indicates the nature and degree of significance of each impact (white: no impact, green: positive, violet: negative).

the magnitude of the change

negative					positive			
very large	large	mode-rate	minor	no change	minor	mode-rate	large	very large

Impact	Continuing operation at the current power level (VE1)	Continuing operation at an uprated power level (VE2)
Community structure, land use and zoning	Minor negative	Minor negative
Landscape and cultural environment	Minor negative	Minor negative
Traffic	Minor negative	Minor negative
Noise and vibration	No impact	No impact
Air quality	No impact	No impact
Climate	Moderate positive	Large positive
Soil, bedrock and groundwater	Minor negative	Minor negative
Surface water	Minor negative	Minor negative
Fish stocks and fishery	Minor negative	Minor negative
Flora, fauna and conservation areas: land	No impact	Minor negative
Flora, fauna and conservation areas: sea area	Minor negative	Minor negative
People's living conditions and comfort	Minor negative	Minor negative

Impact	Continuing operation at the current power level (VE1)	Continuing operation at an uprated power level (VE2)
Regional economy: local level	Large positive	Large positive
Regional economy: regional level	Minor positive	Minor positive
Regional economy: national level	Minor positive	Minor positive
Energy market	Large positive	Large positive
Use of natural resources: power plant area	No impact	No impact
Use of natural resources: procurement of nuclear fuel	Minor negative	Minor negative
Waste and its handling	Minor negative	Minor negative
Releases of radioactive substances and radiation	Minor negative	Minor negative
People's health	No impact	No impact
Construction	No impact	No impact

The OL1 and OL2 plant units have been in operation since 1978 and 1980, respectively. The environment in the Olkiluoto area has been monitored for decades, and comprehensive research data is available on the area. The impacts of the plant units are known well. The largest environmental impact has been the discharge of warm cooling water into the sea area, which will increase the surface temperature of the seawater by a few degrees in Iso Kaalonperä bay when compared to the rest of the sea area. The cooling water discharge area remains unfrozen throughout the winter. Currently, cooling water is warmed by approximately 10°C in the process. When the operation is continued at the present power level (VE1), the temperature of the water being discharged will remain the same; when the operation is continued at an uprated power level (VE2), the temperature will increase by approximately 1°C.

If the operation of the OL1 and OL2 plant units is continued at the present power level or an uprated power level, the environmental impacts of both alternatives will be similar, and the impacts are not substantially different from the impacts of the current operation of the plant units. The largest change will be the extension of the operating time, that is, the current operation will continue for a longer time, until either 2048 or 2058, instead of electricity production at the plant units ceasing when the current operating licences expire in late 2038. In this case, both the positive and negative impacts of the current operation will continue with the additional years of operation. Extending the service life at the current power level (VE1) will take place following the existing operating licences, during 2038–2048 or 2038–2058. Extending the service life at an uprated power level (VE2) could be implemented at the earliest in 2028, in which case the operation would continue until 2048 or 2058.

The impacts of continued operation and power uprating

In terms of both continued operation and power uprating, the most significant positive impacts target the climate, the energy market and the regional economy.

Both alternatives support Finland's goal of being carbon neutral by 2035. The production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects. The electricity production of the nuclear power plant does not produce significant greenhouse gas emissions, and the emission-free electricity produced by the OL1 and OL2 plant units can replace other forms of electricity production that use fossil fuels. According to the estimate, at the level of Finland the cumulative emission reduction potential in alternative VE1 would be approximately 1,100,000 t CO_{2e}, and in the case of VE2 approximately 1,600,000 t CO_{2e} if the plant units were to operate until 2058. For the power uprating alone, the emission reduction potential in Finland is approximately 500,000 t CO_{2e}. The total significance of the impacts on climate have been estimated to be a moderate positive in the case of VE1 and a large positive in the case of VE2. Greenhouse gas emissions during the life cycle of electricity produced by nuclear power are at the same level as with electricity produced by wind power.

If the operation of the plant units is continued at the current power level or an uprated power level, both alternatives will have a large positive impact on Finland's electricity market. In the future, as electricity consumption grows, extending the operation of the plant units will support the security of supply of Finland's energy system and reduce the need to import electricity. The emissions-free electricity generated by the plant units will also enable electricity exports, which can replace fossil-based electricity production.

In both alternatives, the significance of regional economic impacts at the local level in the Rauma region has been estimated to be a "large positive" , since the additional years of the plant units' operation will accumulate substantial financial gains through the multiplicative impacts of the value chain and consumption. The total impacts in the region will amount to more than €3,380 million in turnover, €1,520 million in added value and more than 7,080 person years in labour demand. In both alternatives, the significance of the regional economic impacts at the regional level in Satakunta and at the Finnish national level has been estimated to be a minor positive, when considering the size of the area being examined.

Most of the other impacts have been estimated to be at most a minor negative. Even though the impacts will remain similar to the current operation, the assessment takes into account the continuation of current impacts for a longer time when compared to a situation where electricity production at the plant units were to cease in 2038.

The most significant surface water impact from continued operation and power uprating results from the thermal load of the cooling water which targets the sea area. The impacts from the thermal load are local and mainly limited to Iso Kaalonperä bay. The magnitude of the impacts or the size of the affected area do not significantly differ from current operation, and they do not differ from each other in the continued operation and power uprating case. In the long term, the thermal load may contribute to the local eutrophication of the sea area due to the joint impacts of nutrient loads carried over by the river water and climate change. In both cases, the significance of the impacts targeting surface waters was estimated to be a minor negative, when considering the extended operation of the plant units and the additional impact brought about by climate change. Climate change will strengthen the impacts of the thermal load in the long term, which means that operating the plant units at the current or an uprated power level until 2048 will cause less load on the sea environment than a situation where operation is continued until 2058. In the nearby sea area, water quality and the state of the marine environment are mostly impacted by the long-term development of the nutrient loads in the river water and the general development of the state of the Bothnian Sea.

In the continued operation and power uprating case, the impacts of cooling water from the plant units on the Olkiluoto sea area and, thereby, on fish stocks and fishery will remain as they are. The continuation of the warming effect of the cooling water will maintain a situation that favours species of fish that are adapted to warm water, such as cyprinids. Water that is warmer than the rest of the sea area may also cause the invasive alien species round goby to become more abundant in the area. Fishing opportunities in the winter will remain at the present level; however, due to climate change, the thickness of the ice cover may be reduced and the time of ice cover may be reduced. The significance of the impact of continued operation and power uprating is a minor negative in terms of fish stocks and fishery.

In the continued operation and power uprating case, cooling waters will continue to make the Olkiluoto sea area a favourable wintering ground for aquatic birds. In the long term, the combined eutrophication impact of the cooling waters' thermal load, climate change and nutrients carried by rivers may degrade the status of the underwater habitats located in the affected area. Overall, continued operation and power uprating were assessed to have a minor negative impact on the nature of the sea area. Impacts on terrestrial habitats will remain as they are.

The extended service life will continue to define land use and the landscape in both the power plant area and its surrounding areas in the coming decades as well. In both alternatives, the impacts on land use and zoning are similar to those of current operations. The continuation of operations and the power uprating are in line with the zoning in the area and do not require any zoning changes. On the other hand, the restrictions caused by the operation of the nuclear power plant are taken into account in the zoning of the affected area. The magnitude of the impact was estimated to be a minor negative, because the extension of the service life of the plant units will limit land use in both the site area and its surrounding areas in the coming decades as well. The impacts on the landscape, its valuable areas and locations and the archaeological cultural heritage are similar to those of the current activities. When considering the continuation of the current landscape impact within the area due to additional years of operation, the impacts were, overall, estimated to be, at most, a minor negative, since the plant units will continue to impact the otherwise minute and wooded landscape visible from the sea, even over the coming decades.

In both alternatives, the impacts on traffic will remain as they are but continue with additional years of operation. Traffic safety on the roads leading into the site area will remain at the present level. However, especially during the annual outages, when traffic volumes are at their highest, the traffic flow may be temporarily degraded, which is also similar to current activities. The significance of the impacts has been estimated to be a minor negative.

The continued operation of the plant units at their current power level or an uprated power level will not have an additional impact on the soil and bedrock or on the quality, quantity or surface level of the groundwater, but the current effects will continue during the additional years of operation. The capacity of the facilities excavated earlier is also estimated to be sufficient for the final disposal of low and intermediate-level waste generated during the service life extension of the power plant and the power uprating. Taking into account the extended operating time of the plant units and possible additional construction, the effects on the soil, bedrock and groundwater are estimated to be a minor negative at most.

The impacts on people's living conditions and comfort and the detrimental impacts experienced by people will mainly remain as they are. In both alternatives, potential concerns among people regarding safety risks will continue to exist. In the power uprating case, the discharge of warm cooling water combined with the changes brought about by climate change may affect the recreational value of the water systems in the nearby sea area in the long term. Taking into account the extended operating time of the plant units, the significance of the impacts is assessed to be a minor negative.

The continued operation of the plant units and the power uprating do not change the power plant area's current limitations on the utilisation of natural resources. In both alternatives, the use of natural uranium in nuclear fuel will continue. Natural uranium is classified as a non-renewable natural resource that is practically only used by the nuclear power and defence industries. When compared to the current global uranium reserves, the amount of uranium procured during the operation of the plant units is very low, on the basis of which the significance of the impacts has been estimated to be, at most, a minor negative with the additional years of operation.

In both alternatives, with the additional years of operation, the volume of spent nuclear fuel as well as very low, low and intermediate-level waste being processed will increase and the radiation exposure caused to the processing personnel by the waste management activities will continue. However, the increase in total waste volumes will not significantly increase the radiation doses of the personnel when compared to current operations. The limit value set by the Government for the annual dose incurred by an individual of the population as a result of the entire normal operation of the nuclear power plant, including the various stages of waste management for the spent nuclear fuel and the very low, low and intermediate-level waste, is 0.1 mSv. During normal operation, the impacts caused by waste management activities are very minor and the statutory limits will not be exceeded. The significance of the impacts has been estimated to be a minor negative.

The radiation dose caused by the Olkiluoto nuclear power plant to the residents of the surrounding areas has been clearly below one per cent of the dose limit of 0.1 mSv per year set by the Government. In both the service life extension and power uprating case, the releases of radioactive substances into the environment caused by normal operation are estimated to remain low and to continue to fall below the release limits set for them in the future. The impact of the releases on the radiation exposure of the residents in the surrounding areas and the radiation-induced load on the surrounding nature will remain at the present level, and the significance of the impacts is estimated to be, at most, a minor negative when considering the additional years of operation.

The activities taking place in the power plant area are not estimated to cause detrimental health effects on the residents of nearby areas. The exhaust gas emissions and dust resulting from road traffic are restricted to areas near the road network, where exposure to conventional health hazards is low. The alternatives do not cause air quality limit values or guideline values to be exceeded, and the alternatives are not estimated to have an impact on current air quality in the area. In both alternatives, the noise from the plant units and traffic as well as the vibration caused by traffic will remain at the present level, which is considered to be very low. Noise and vibration are not estimated to cause significant impacts during the additional years of operation

Impacts during construction

The modification work required by the service life extension of the plant units will be implemented mainly inside the plant units. In the power uprating case, a new diesel-powered make-up water system and a new battery energy storage system would be built outside the plant units to improve the safety of the plant units. It is also possible that the capacity of the KPA storage will be expanded in both alternatives. The construction work taking place outside of the plant units is estimated to take approximately 2–3 years. During construction, short-term noise and vibration may occur due to earthmoving, the erection of buildings and equipment installation that mainly affects the nearby areas of the construction site. Furthermore, excavation of bedrock in relation to the KPA storage expansion may cause temporary increased noise. Traffic volumes will not increase significantly and will not, therefore, increase the resulting impacts on nearby roads. In terms of landscape, the additional construction will only affect the landscape image within the area, where the change will not be significant. The new structures will be located in areas already shaped by human activity, and they will not affect the natural environment in the area. If the KPA storage is expanded, the bedrock in its area will be excavated, and the surface layers and structures will be partly removed. The possible need for increasing storage capacity has been considered in the plans for the area

Impacts of the ending of current activities

With the end of the commercial operation of the plant units, the major positive impacts of extending the power plant's operation on climate, the energy market and the regional economy will end. During the decommissioning of the plant units, some compensatory regional economic impacts will be generated for other actors and in other sectors, but they will be smaller than the impacts of commercial operation.

With the end of operation, the impacts of cooling water discharge from the OL1 and OL2 plant units will also end. Then, the sea area will be slowly restored to the prevailing condition of the surrounding coastal area.

8. Follow-up and monitoring of impacts

The project owner has various follow-up and monitoring programmes in place for environmental impacts. The prerequisites for the programmes originate from the environmental legislation as well as the regulations and guidelines issued on the basis of the Nuclear Energy Act. Chapter 6 concentrates on regular follow-ups and monitoring.

8.1. Monitoring of releases of radioactive substances and of radiation

During the potential service life extension and power uprating of the power plant, the operation of the power plant will be similar to the present time, which is why follow-up and monitoring are anticipated to continue in a very similar manner. In the following chapters, the monitoring of radiation and radioactive emissions at the Olkiluoto nuclear power plant is briefly described for the cases of both continued operation and power uprating.

8.1.1. Emission measurements

Precise measurements for the releases of radioactive substances are used to ensure that the power plant's combined releases into the air or water do not exceed the release limits confirmed by the Radiation and Nuclear Safety Authority and that the radiation doses to the environment fall below the limits set in the Nuclear Energy Decree (12 Feb 1988/161, Section 22b). The results are reported periodically to the Radiation and Nuclear Safety Authority. The emissions of the nuclear power plant are monitored per power plant unit and emission route with continuous measuring devices and sampling. Releases into the air occur in a controlled way from the off-gas stacks. Releases into the water occur periodically through the discharge tunnel of each plant unit. Samples are taken from the pumping tank before starting the discharge. The water discharged into the sea is mixed with the cooling water flow in the discharge channel.

8.1.2. Environmental radiation monitoring

The surroundings of the Olkiluoto power plant are monitored by TVO in accordance with the environmental radiation monitoring programme. The monitoring programme started in 1977. The baseline studies were done in the early 1970s before the construction of the power plant started. The monitoring programme approved by the authority implements the obligations set for the licensee in guideline YVL C.7 to investigate the radiation exposure of the population and the radioactive substances present in the environment and their origins. The current environmental radiation monitoring programme began to be implemented from the beginning of 2023. Environmental radiation monitoring is based on sampling and identifying the radionuclides in the samples and determining their concentrations. The environmental radiation monitoring programme covers using fixed instruments to measure the radiation level in the environment, gathering samples of soil, air, household water, sea water, landfill drain water, groundwater, plants, etc., and performing whole body counts on the residents of the surrounding areas *(Kalliomaa & Sojakka 2022)*. The number of sampling points, their locations and the sample types to be analysed have been determined, taking into account the areas affected by possible emissions from the OL1, OL2, OL3 plant units, the KPA storage, the VLJ repository, the Posiva final disposal facility and the HMAJ near-surface final disposal facility, as well as any previous measurement results.

The aim of environmental radiation monitoring is to ensure that the radiation exposure to the population caused by the nuclear power plant is kept as low as reasonably achievable, and that the limit values set forth in the regulations are not exceeded. The aim is to use the measurement results to determine the critical radionuclides, their spread routes and the doses incurred by the critical population. When choosing the measurement and sampling locations, the aim is to fulfil the general principles of environmental monitoring presented in the YVL Guide in force at any given time.

The Olkiluoto environmental radiation monitoring programme focuses on measurements of external radiation; activity transportation routes leading to humans; and indicator organisms highly enriching of radioactive substances, such as fern, reindeer lichen and spruce tips. The fixed nearby and remote measurement and sampling locations for the Olkiluoto power plant's environmental radiation monitoring programme are shown in (Figure 80), together with the observation locations in the sea area.

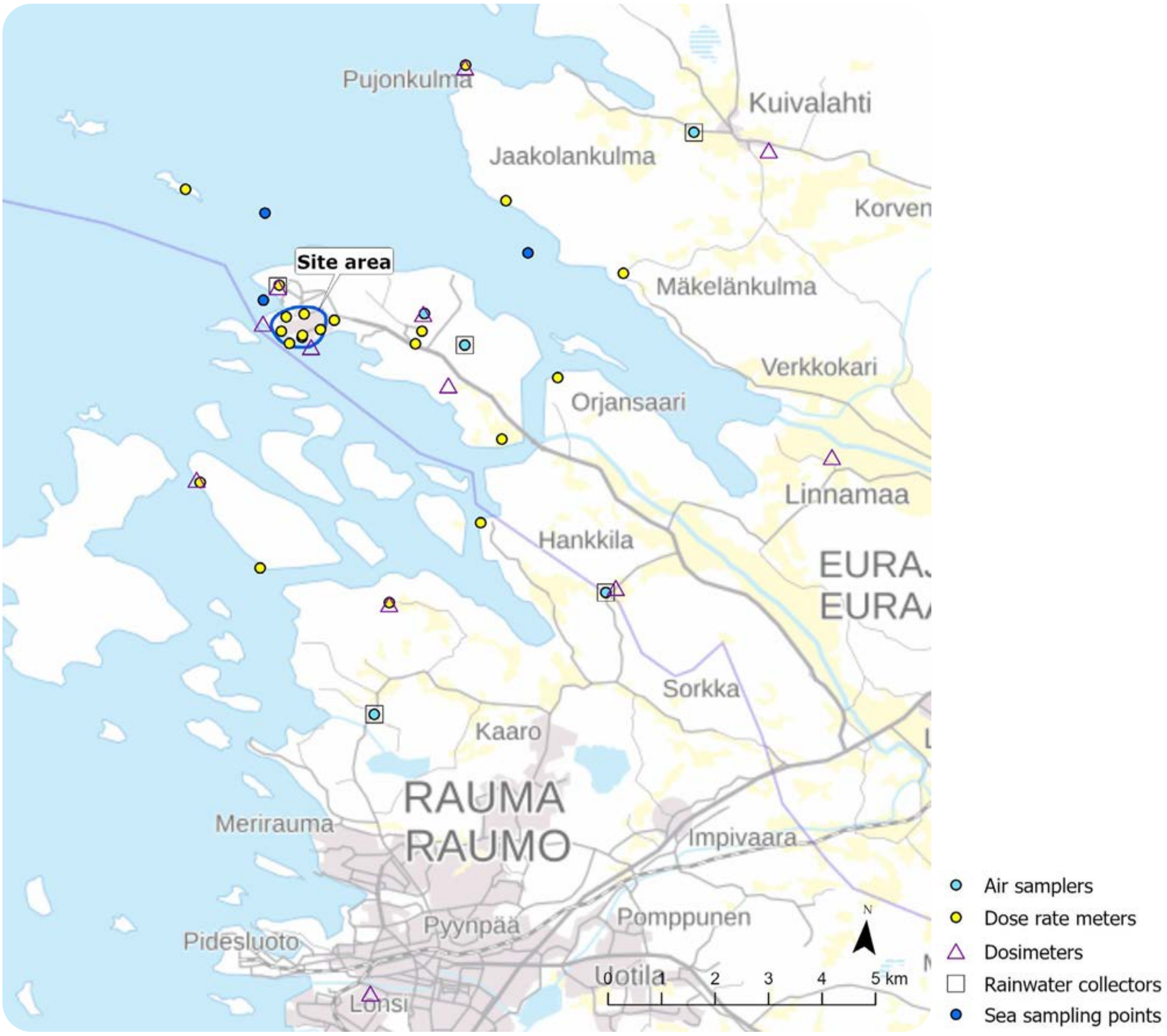


Figure 80. The fixed nearby and remote measurement and sampling points for the Olkiluoto power plant's environmental radiation monitoring programme and the observation locations in the sea area.

External radiation is measured continuously, which gives realtime access to information on changes in the radiation situation in the environment. 7 continuously operating dose rate meters have been placed in the TVO site area. When choosing the location of the meters, the prevailing dispersion directions of radiation have been taken into account. In addition, the intention has been to cover the entire 360° dispersion sector with these seven meters. Ten continuously operating meters of a similar type are located outside the site area at a distance of approximately 5 km. In order to form a uniformly comprehensive network, the meters are placed on land. On the side of the sea areas, the meters are placed while taking into account the population of the archipelago. The devices are also connected to the national radiation monitoring network, mainly for possible accident situations.

In addition to continuous external radiation measurement, 11 TLD stations have been evenly placed around Olkiluoto and the nearby areas. Four of the stations are located on the island of Olkiluoto in the immediate vicinity of the plant, measuring doses in the surrounding area. The stations also serve the emergency preparedness organisation in possible accident situations. Four of the stations are located in population centres and four in the area populated in summer. One dosimeter has been placed in the nearest city centre, Rauma. The main dispersion directions have been taken into account as far as possible.

In addition to the licensee, STUK also conducts sampling within the scope of environmental radiation monitoring in and around the Olkiluoto area. Among other things, the authority carrying out its own independent monitoring within the framework of the environmental radiation monitoring programme takes samples in connection with the annual outage of the plants and regularly collects samples from the land and sea environment. Sample types related to food chains, such as milk, agricultural products, household water, fish, game and other foodstuffs, have primary emphasis in the selection and sampling of the samples to be taken . *(STUK 2024e & 2024g)*

The monitoring and analysis methods used in environmental radiation monitoring detect naturally occurring radioactive substances, monitor changes in concentrations and detect possible radioactive emissions. The detection sensitivity of methods based on the detection of radioactive radiation is high. Even quite low nuclide concentrations far from the emission site can be detected with modern measuring devices and, based on the results, the location of the emission source can be estimated and found. The continuation of operation or power uprating will not change the operation of the power plant in any essential way from the viewpoint of environmental radiation monitoring.

8.1.3. Meteorological measurements

Meteorological measurements are used to assess the dispersion of radioactive substances released into the air during the normal operation of the plant unit and potential accidents. Meteorological information is obtained from the weather observation system of the Olkiluoto power plant. The observations of the weather observation system can be read in real time at the power plant, the Finnish Meteorological Institute and the Radiation and Nuclear Safety Authority. The quantities measured include the wind speed and direction; air pressure; relative humidity; durations and amounts of rain; and temperature.

8.1.4. Radiation dose estimates

During the operation of the nuclear power plant, meteorological measurements and releases are used to estimate the radiation exposure caused to the population of the surrounding areas each year. The results are reported to the Radiation and Nuclear Safety Authority. In the event of a possible accident, the radiation doses to people in the environment are estimated in real time, based on meteorological measurements and emissions data. The estimates serve rescue operations and are compared to the results given by the dose rate meters. The radiation dose calculation programmes used for the estimates are described in the emergency preparedness instructions of the Olkiluoto power plant, which have been approved by the Radiation and Nuclear Safety Authority.

8.2. Monitoring of cooling water and wastewater

The amount and quality of the cooling water and wastewater being routed into the sea from the power plant are monitored in a manner approved by the Centre for Economic Development, Transport and the Environment. The cooling water flow and intake and discharge temperatures are monitored with continuous measurements, and the results are recorded in the process system as hourly and daily averages. The annual quantity of heat discharged into the water body from the plant units is calculated, based on the electrical and thermal power levels of the plant units.

For the KPA storage there is no separate, continuous temperature monitoring of the discharge area; the temperature impact of the cooling water is, instead, monitored in conjunction with the seawater temperature monitoring.

The monitoring of the amount of domestic wastewater is based on measurements of the sewerage wastewater. The concentrations and releases of radioactive substances in the process wastewater emanating from the monitoring area are determined by means of samples taken from the pump tanks before routing into the discharge channel, and from compilation samples taken during the pumping-out.

8.3. Impact monitoring

Water monitoring follows the effects of cooling water and wastewater discharges on the state of the sea area. The monitoring covers physical phenomena in the sea area; water quality monitoring; and monitoring of the biological state of the water body.

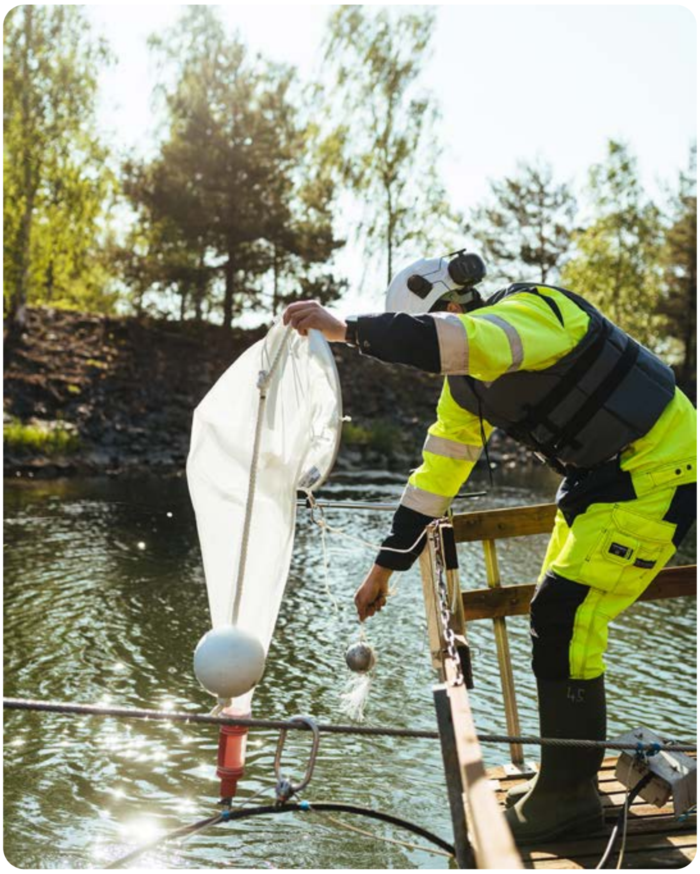
Physico-chemical and biological investigations are carried out by an accredited research laboratory whose sampling personnel are certified. Determinations are made by using approved standard analysis methods. The monitoring of physical phenomena includes, among other things, monitoring the temperature of the sea area with continuous gauges and in accordance with the monitoring plan, eight times a year from different sampling depths; as well as monitoring the ice situation. In the monitoring of water quality, variables that describe the state of the water body are widely monitored, including the pH, oxygen content, buffer capacity, electrical conductivity and salinity, colour, turbidity, visibility depth and concentrations of nutrients and solid matter. Among other things, the biological condition of the sea area is monitored with determinations of the basic production and species distribution of phytoplankton; studies investigating the species distribution and abundance of aquatic vegetation; and studies of benthic fauna.

Ice observations are made every 1–3 weeks in the winter months, depending on the ice situation. Ice observation maps are prepared on the area, in which the edge of solid ice; slush and packed ice zones; and ice breaking and drifting are marked. The newspaper published in the area publishes customary warnings about the ice area being weakened by the cooling water. Warning signs about weak ice are placed along the roads leading to the area.

8.4. Fisheries monitoring

The effects of the discharge of cooling water and wastewater on fish stocks, fishing and catches in the sea area surrounding Olkiluoto are monitored in accordance with a fisheries monitoring programme. Among other things, the fisheries monitoring programme includes net test fishing; age and growth determinations of fish; fishing inquiries for professional, amateur and recreational fishers; as well as reports based on detailed fishing records kept by fishers. The fisheries monitoring is carried out in a manner approved by the regional fisheries authority, i.e. the fisheries unit of the local Centre for Economic Development, Transport and the Environment.

Using separate reports, TVO has also monitored the quantity and quality of fish that end up in the power plant with the cooling water and of juveniles less than 1 centimetre (cm) in length which are part of the fish stocks.



8.5. Monitoring of flue gas emissions

The emissions (carbon dioxide, particles, sulphur dioxide and nitrogen oxides) of the power plant's emergency diesel generators and the emergency boiler plant are calculated on the basis of light fuel oil consumption, fuel quality data and emission factors. The emissions are reported to the environmental authorities annually. The emergency diesel generators and the emergency boiler plant are for the production of the power plant's back-up power and heat, so their operation is limited to periodic test runs and is, therefore, very rare.

Monitoring of carbon dioxide emissions under the Emissions Trading Act is carried out in accordance with the approved emission permit. The emission report certified by an external party that is required for the emission permit is submitted annually to the Energy Authority.

8.6. Noise monitoring

Noise measurements pursuant to the provisions of the environmental permit will continue within the surroundings of the power plant. These will be used to ensure that the noise caused by the power plant follows the regulatory guidelines. The measurements are made in accordance with the Ministry of *the Environment guideline 1/1995*, "Ympäristömelun mittaaminen" (Environmental noise measurement), during the plant's normal production situation. The measurement results are submitted to the environmental authorities.

The sound power level (L_{wA}) of fixed sound sources that significantly affect the noise level of the environment is measured by an external expert whenever a device is replaced.

8.7. Waste accounting

The generation, amounts, types and disposal and processing locations of radioactive and conventional waste are monitored at the power plant. The radioactive waste accounting shows the activity contained in individual waste packages as well as the storage and final disposal locations and the amounts and types of waste. The conventional waste accounting shows the types of waste, the amounts, the recipient of the waste and the method of processing.

A summary report on radioactive waste is prepared annually and submitted to the Radiation and Nuclear Safety Authority. The annual summary report on conventional waste is submitted to the Centre for Economic Development, Transport and the Environment.

8.8. Monitoring of impacts on people

Impacts on people can be monitored by methods such as organising discussion events; conducting resident surveys or interviews; and collecting information through electronic feedback channels.

The TVO Group publishes up-to-date information regarding its operations on its website and on social media. In addition, the TVO Group publishes the printed magazine Uutisia Olkiluodosta (News from Olkiluoto), distributed in the neighbouring municipalities. The TVO Group maintains cooperation with key stakeholders in the region. Through an open exchange of information, TVO receives information about the impacts of its operations and the means by which these can be mitigated or prevented.

9. The project’s licence and permit process and the project’s relation to plans and programmes

Once the environmental impact assessment procedure has concluded, the project progresses to the various licence and permit stages. The coordinating authority’s reasoned conclusion on the EIA report will be appended to the various licence and permit applications when the applications are submitted. The following provides a general description of the permits, licences and decisions the different project alternatives may require. It also outlines the project’s relation to various plans and programmes pertaining to the use of natural resources and environmental protection.

9.1. Decisions and licences according to the Nuclear Energy Act

9.1.1. Operating licence

Operating licence for the nuclear power plant

The OL1 and OL2 plant units have operating licences pursuant to the Nuclear Energy Act that are in force until the end of 2038. In order to extend the service life of the OL1 and OL2 plant units, new operating licences must be sought. In the scenario involving a power uprating, the aim is to combine the periodic safety assessment and applying for the new operating licences for the plant units. The operating licences are issued by the Government.

The licence to operate a nuclear facility may be issued provided that the prerequisites listed in Section 20 of the Nuclear Energy Act are met. These prerequisites include the following:

- The nuclear facility and its operation meet the safety requirements laid down in the Nuclear Energy Act, and appropriate account has been taken of the safety of workers and the population.
- The methods available to the applicant for arranging nuclear waste management, including the disposal of nuclear waste and the decommissioning of the facility, 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

The nuclear facility and its operation shall meet the principles set forth in Sections 5 to 7 of the Nuclear Energy Act. Operation of the nuclear facility shall not be started on the basis of the licence granted for it until the Radiation and Nuclear Safety Authority has ascertained that the nuclear facility meets the safety requirements set, that the security and emergency arrangements are sufficient, that the control necessary to prevent the proliferation of nuclear weapons has been arranged appropriately, and that the nuclear facility operator has arranged, in the manner provided, indemnification regarding liability in the event of nuclear damage. Furthermore, it is required that the Ministry of Economic Affairs and Employment has ascertained that provision for the costs of nuclear waste management has been arranged in accordance with the provisions of the Act.

Other operating licences

The operating licence for the disposal repository for low and intermediate-level waste (VLJ repository) is in force until the end of 2051. TVO will seek a new operating licence for the VLJ repository in good time before the expiration of the operating licence in order to enable the operation of the VLJ repository beyond the decommissioning of the power plant units.

The operating licences for the OL1 and OL2 plant units comprise the operation of the interim storage facilities for nuclear waste (KAJ, MAJ, KPA). If the service lives of the OL1 and OL2 plant units are extended, the operation of these interim storage facilities is also extended under the same operating licence. If the operation of the OL1 and OL2 plant units ends in 2038, a dedicated operating licence will be sought for the interim storage facilities or it will be combined with the operating licence for the OL3 plant unit.

Posiva Oy is responsible for the final disposal of spent nuclear fuel generated at the power plants of its owners, TVO at Olkiluoto and Fortum Power and Heat Oy (Fortum) in Loviisa. In December 2021, Posiva submitted to the Government an operating licence application for a spent nuclear fuel encapsulation plant and disposal facility. Posiva applied for an operating licence for the final disposal of the spent nuclear fuel of the five nuclear power plants units in Olkiluoto and Loviisa, for a total of 6,500 tU. The final disposal of spent nuclear fuel is to start at Olkiluoto in the mid-2020s. Posiva will license the capacity of its disposal facility to match the needs of its owners' nuclear power plants.

9.1.2. Decommissioning licence

If the operation of the OL1 and OL2 plant units is not continued, the decommissioning of the plant units will take place following the expiration of the current operating licences. If the operation of the plant units is continued, decommissioning will take place after the expiration of the new operating licences. A separate environmental impact assessment will be drawn up for the decommissioning, according to the legislation in force, once it is relevant.

After terminating the operation of a nuclear facility, the holder of the operating licence is under an obligation to undertake measures to decommission the nuclear facility in accordance with the plan for and the requirements set on decommissioning referred to in Section 7 g of the Nuclear Energy Act as well as apply for a licence for the decommissioning of the nuclear facility. The licence shall be applied for well in advance so that the authorities have adequate time to assess the application before the termination of the operating licence of the nuclear facility.

9.1.3. Other licences in accordance with the Nuclear Energy Act

A permit to operate has been sought from the Radiation and Nuclear Safety Authority in spring 2024 for the near-surface final disposal of very low-level nuclear waste that is being planned for the area of the Olkiluoto nuclear power plant, in a manner where operation would begin in the 2020s.

In addition to the operating licence, a decommissioning licence and permit to operate, the service life extension and power uprating may also require other licences and permits pursuant to the Nuclear Energy Act. Section 21 of the Nuclear Energy Act provides the prerequisites for granting a licence for other use of nuclear energy, such as the possession, manufacturing, production, transfer, handling, use, storage, transport and import of nuclear substances and nuclear waste, for example, as well as final disposal on a smaller scale than extensive final disposal (permit to operate). In accordance with Section 16 subsection 2 of the Nuclear Energy Act, STUK grants a permit for the aforementioned operations on the basis of an application.

A licence can be granted for other use of nuclear energy when so required by the operation if the prerequisites set in Section 21 of the Nuclear Energy Act are met. These prerequisites include the following:

- The use of nuclear energy meets the safety requirements laid down in the Nuclear Energy Act, and appropriate account has been taken of the safety of the workers and the population, and environmental protection;
- The applicant has possession of the site needed for the use of nuclear energy;
- Nuclear waste management has been arranged appropriately, and provision for the cost of nuclear waste management has been made in accordance with the provisions of the Nuclear Energy Act;
- The applicant's arrangements for the implementation of control by the Radiation and Nuclear Safety Authority as referred to in the Nuclear Energy Act are sufficient;
- The applicant has sufficient expertise available, and the operating organisation and competence of the operating staff 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;
- The authorisations required under the Council Directive on the supervision and control of shipments of radioactive waste and spent nuclear fuel *(2006/117/Euratom)* have been obtained from foreign states, and the said provisions can also be observed in other respects;
- The use of nuclear energy otherwise meets the principles laid down in Sections 5–7 of the Nuclear Energy Act and does not conflict with the obligations under the Euratom Treaty.

The use of nuclear energy may not be initiated on the basis of a granted licence until the Radiation and Nuclear Safety Authority has ascertained, when required by the operations, that the use of nuclear energy is in accordance with the safety requirements set, that the security and emergency arrangements are sufficient, that the control necessary to prevent the proliferation of nuclear weapons has been arranged appropriately, and that indemnification regarding liability in the event of nuclear damage in connection with the operations has been arranged in compliance with the relevant provisions.

9.2. Licences in accordance with the Radiation Act

Radiation practices other than the use of nuclear energy at Olkiluoto nuclear power plant require a safety licence pursuant to the Radiation Act.

At the moment, TVO, as an operator, has three different safety licences concerning the use of unsealed sources, X-ray equipment and sealed sources within industry and research. Unsealed sources used for the performance of radiochemical analyses, for instance, are handled in Olkiluoto power plant's laboratory. X-ray equipment is used in materials inspections. Sealed sources are used in the power plant units to check the calibrations of measuring instruments and operational tests, among other things. TVO also uses fluoroscopes. In addition to TVO, Posiva is the operator in one separate safety licence.

All of the safety licences for radiation practices are in force until further notice. The safety licences are documents that must be kept up-to-date in terms of any amendments, such as the addition of radiation sources or their removal from use. The supervisory authority is STUK.

In the continued operation and power uprating case, the radiation practice in industry and research will be continued to an extent deemed to be necessary. The safety licence is updated as necessary.

9.3. Licences required for the transport of radioactive substances

Transports of radioactive substances and waste are subject to the Act on the Transport of Dangerous Goods *(541/2023)*, the Radiation Act *(859/2018)* and, in terms of nuclear materials and waste, the Nuclear Energy Act *(990/1987)*, and the regulations issued pursuant to the above.

The transport of nuclear fuel requires a transport licence pursuant to the Nuclear Energy Act; the prerequisites for such a licence include a transport plan, safety plan and, in some cases, an emergency preparedness plan. For transport permit matters, the licensing authority is STUK. In the scenario where the service life of the nuclear power plant is extended and its power is uprated, the OL1 and OL2 nuclear power plant units will continue to require fresh fuel and, in terms of this, the licence process will remain the same as it currently is.

The spent nuclear fuel from the Olkiluoto nuclear power plant units is transported in Olkiluoto to Posiva's encapsulation plant as internal transfers within the power plant area, by using a transfer cask. STUK's approval must be sought for the transfers of spent nuclear fuel. STUK inspects and approves the transfer plan, the structure of the transfer cask, the security arrangements and the preparedness for accidents

9.4. Other permits

9.4.1. Zoning

The valid local detailed plan makes it possible to carry out modification work in the power plant area, construct additional structures and/or buildings. In the service life extension and thermal power uprating case, information about the restrictions pertaining to the area's further use can be included in the land use registers, if necessary.

9.4.2. Permits under the Land Use and Building Act

In accordance with the Land Use and Building Act *(132/1999)*, the construction of buildings related to the required modification work, the necessary infrastructure and facilities requires a building permit. In Eurajoki, the municipality's environmental board is responsible for the duties and decision-making of the building inspection authorities.

In areas covered by a local detailed plan, a building permit is granted under the following conditions:

- the building project is in keeping with the valid local detailed plan;
- construction meets the requirements laid down in the Act and other requirements prescribed in or under the Act;
- the building is appropriate for the location concerned;
- a serviceable access road to the building site exists or can be arranged;
- water supply and wastewater management can be organised satisfactorily and without causing environmental harm; and
- the building will not be located or constructed in a way that causes unwarranted harm to neighbours or hinders appropriate building on a neighbouring property.

Separate action permits may be required for smaller structures, such as containers or temporary warehouses if they are not included in the building permit application.

The new Building Act *(751/2023)* enters into force on 1 January 2025.

9.4.3. Environmental permit

The operation of a nuclear power plant requires an environmental permit in accordance with the Environmental Protection Act (527/2014) (annex 1 Activities subject to a permit, Table 2 Other installations, section 3 Energy production, b) nuclear power plant). Olkiluoto nuclear power plant has environmental and water permits granted by the Regional State Administrative Agency of Southern Finland on 16 Dec 2016 *(decision nos. 315/2016/1 and 316/2016/1)*. The permits became legally valid via decisions granted by the Vaasa Administrative Court on 16 August 2018 *(decision nos. 18/0157/2 and 18/0159/2)*. The permits apply to the operation of the power plant, cooling water intake, emissions of the power plant and monitoring. Furthermore, a decision concerning polyp prevention has been issued on 26 Aug 2021 *(247/2021)* and a decision on the establishment of the near-surface final disposal facility for very low-level waste has been issued on 10 Oct 2023 *(264/2023)* in relation to the operation of the nuclear power plant.

A permit is required for any change in an activity that increases emissions or their impact, or for any other substantial change in an activity requiring an environmental permit. However, a permit is not required if the change does not increase the environmental impact or risks and if the change in the activity does not require the permit to be re-evaluated. *(Section 29 of the Environmental Protection Act)*. Olkiluoto power plant has an environmental permit that is valid until further notice, and the service life extension does not require updating the environmental permit. With regard to the power uprating, it has been agreed that the environmental permit will be updated. According to the current assessment, the impacts of the operations of Olkiluoto nuclear power plant will also remain much the same in the case of these alternatives and no essential changes would be sought to the permit regulations. The operator must also inform the environmental protection authority without delay of the termination of the activity. If necessary, the authority will issue a new environmental permit with the related permit regulations regarding the actions, monitoring requirements and other obligations required for terminating the activities

The issue of an environmental permit requires that the operations, considering the permit provisions to be set and the location of the activity, do not alone or together with other functions:

- Cause health detriments;
- Otherwise significantly:
  - » cause detriment to nature and its functioning;
  - » prevent or materially hinder the use of natural resources;
  - » cause a loss of general amenity of the environment or of special cultural values;
  - » reduce the suitability of the environment for general recreational use;
  - » cause damage or harm to property or impairment of its use;
  - » constitute a comparable violation of a public or private interest
- Result in a violation of the prohibition to contaminate soil or groundwater;
- Cause the deterioration of special natural conditions, present a risk to the water supply or affect other potential uses important to the public interest within the area impacted by the activity;
- Create an unreasonable burden referred to in the Adjoining Properties Act

Permit provisions that prevent and limit emissions are set for the operations in the permit by considering the nature of the operations and local environmental conditions.

9.4.4. Permits and documents in accordance with the Chemicals Act

Facilities engaged in extensive industrial handling and storage of chemicals require a permit granted by the Finnish Safety and Chemicals Agency (Tukes). The extent of the industrial handling and storage of chemicals is determined based on the quantity and dangers of the chemicals stored in the facility. The permit sets conditions for the activities, and a commissioning inspection is conducted at the facility after the permit is granted. Olkiluoto power plant has a valid permit for the extensive industrial handling and storage of chemicals, and the power plant is an institution subject to a safety assessment regulated by Tukes. The basis for this is hydrazine used at the OL3 plant unit, which is classified as toxic and hazardous to the environment.

The Act on the Safe Handling of Dangerous Chemicals and Explosives *(390/2005, the "Act on Chemical Safety")* excludes radioactive substances and products containing radioactive substances from its area of application. Therefore, changes in the handling, storage and quantities of radioactive materials do not, as a rule, result in changes to the chemicals permit.

However, changes in the operation may, in accordance with the Act on Chemical Safety, invoke an obligation to apply in writing for a permit for a production facility change if the planned change is an expansion comparable to the establishment of a production facility or another essential change. Changes categorised as essential include a significant increase in the quantity of hazardous chemicals, a significant change in the hazardous chemicals being handled or stored, or in their properties or state, a significant change in the manufacturing or handling method, or another change that may significantly affect the accident risk. The notification of the change in the operation submitted to Tukes should include the essential information on the change and a report on the safety impact of the change. The institutions subject to a safety assessment should also update the essential parts of the safety report.

9.4.5. Other permits and plans

A restriction on movement has been put in place around the power plant area by virtue of the Police Act. Furthermore, the Government Decree on areas restricted for aviation (*VNa 930/2014*) has defined the surroundings of the power plant area as a no-fly zone. The no-fly zone covers the power plant's surroundings within a 4 km radius and at an altitude of up to 2,000 m.

The other permits related to the operation of the power plant are mainly various technical permits that are intended to, among other things, ensure industrial safety and prevent material damage.

9.5. Project's relation to plans and programmes pertaining to the use of natural resources and environmental protection

The table (Table 73) describes the project's relation to the most important plans and programmes pertaining to the use of natural resources and environmental protection. These include both international commitments and national target programmes, which, while not being directly binding upon the undertaking, may concern the undertaking through various permits and licences, for example.

Table 73. Project's relation to plans and programmes pertaining to the use of natural resources and environmental protection.

Name of programme/plan	Contents	Relation to project
Paris Agreement	A new legally binding international treaty on climate change was adopted at COP 21 in Paris, on 12 December 2015. The Paris Agreement entered into force on 4 November 2016 and became binding on Finland on 14 November 2016. The Paris Agreement aims to limit global warming to well below two degrees Celsius, compared to pre-industrial times, and to pursue measures which would limit the warming to 1.5 degrees Celsius. The objective is to achieve the peak of global greenhouse gas emissions as soon as possible and to reduce emissions quickly after that in such a way that human-derived greenhouse gas emissions and sinks are in balance by the second half of this century. In addition to the objectives of emission reduction, the agreement sets the long-term target of adapting to climate change and the target of adjusting financing flows toward low-carbon and climate-resilient development. The global stocktakes held at five-year intervals review the parties' joint progress in relation to the agreement's goals	Electricity produced by nuclear power is carbon neutral for users. Greenhouse gas emissions during the life cycle of electricity produced by nuclear power (12 g CO_{2e}/kWh) are at the same level as with electricity produced by wind power (11 g CO_{2e}/kWh). The continued operation and power uprating of the OL1 and OL2 plant units support the emission reduction target in line with the Paris Agreement as well as the goals of the EU and Finland's National Energy and Climate Strategy. Furthermore, nuclear energy supports the security of supply of Finland's electricity production.
European Union's Climate and Energy Package 2021	In 2021, the European Commission published an extensive package of legislative proposals aimed at changing the EU's climate, energy, land use, transport and tax policies in order to reduce net greenhouse gas emissions by at least 55% by 2030 compared to the levels in 1990. For example, the Renewable Energy Directive is being updated in its entirety, and the target for the share of renewable energy has been set at 40%, instead of the previous 32%.	
Carbon Neutral Finland 2035 – National Climate and Energy Strategy	The National Climate and Energy Strategy outlines measures by which Finland will meet the EU's climate commitments for 2030 and achieve the targets set in the Climate Act for reducing greenhouse gas emissions by 60% by 2030 and being carbon neutral by 2035. The goal of the National Climate and Energy Strategy is to reduce greenhouse gas emissions by means of using and increasing the use of renewable energy, using hydrogen and electric fuels, and promoting energy efficiency. Improving energy delivery reliability and security of supply is also a key starting point of the strategy.	

Name of programme/plan	Contents	Relation to project
New Climate Act and climate policy planning system	The Climate Act *(423/2022)* sets out the national targets related to climate change. According to the Act, Finland aims to be carbon neutral by 2035. A target to strengthen carbon sinks is also included in the Act. The Act specifies three emission reduction targets: the aim is to achieve greenhouse gas emission reductions of 60% by 2030, 80% by 2040 and 90% but aiming for 95% by 2050 when compared to the levels in 1990. The Act also sets out a planning system for climate policy that consists of the Long-term Climate Policy Plan, National Climate Change Adaptation Plan, Medium-term Climate Plan and Climate Plan for the Land Use Sector.	The use of nuclear power in energy production supports Finland's goal of being carbon neutral by 2035, which is included in the Climate Act. The production of electricity and heat in Finland needs to become nearly emissions-free during the 2030s, taking into account the security of supply aspects.
National Air Pollution Control Programme 2030	The National Air Pollution Control Programme 2030, approved by the Government in March 2019, is a key instrument in the implementation of EU obligations and the objectives of national air pollution control. The programme includes the measures needed to implement the emission reduction obligations set by the EU's NEC Directive *(2016/2284)* and other actions needed to improve air quality.	The production of nuclear power does not generate emissions restricted by the NEC Directive. Continuing the operation of the nuclear power plant supports the achievement of Finland's goals, given that energy production based on incineration processes would be replaced by nuclear power.
Water Framework Directive, water resources management plans and programmes of measures	The EU's Water Framework Directive *(2000/60/EC)* was adopted in 2000. The Directive aims to define the framework for the protection of inland surface waters, estuaries, coastal waters and groundwaters. According to the Water Framework Directive, EU Member States must identify the river basins within their territories and assign them to individual river basin districts. A river basin management plan must be prepared for each river basin district. Each plan includes a programme of measures, the objective of which is to achieve good ecological and chemical status for water bodies. On the national level, the EU's Water Framework Directive is implemented with the Act on the Organisation of River Basin Management and the Marine Strategy *(1299/2004)*, the Government Decree on Water Resources Management Regions *(1303/2004)*, the Government Decree on Water Resources Management *(1040/2006)*, the Government Decree on the Organisation of the Development and Implementation of the Marine Strategy *(980/2011)* and the Government Decree on Substances Dangerous and Harmful to the Aquatic Environment *(1022/2006)*. The water resources management plans and the programmes of measures complementing them provide information on the status of the waters and the factors impacting them, as well as on the measures needed to achieve and maintain a good status of waters. The valid plans and programmes of measures cover the years 2022–2027.	The water resources management plan for the Kokemäenjoki–Archipelago Sea-Bothnian Sea river basin district covers all or almost all areas of Central Ostrobothnia, Ostrobothnia, South Ostrobothnia, Pirkanmaa, Satakunta, Southwest Finland and Kanta-Häme as well as part of an area consisting of the western parts of Central Finland. The power plant's most significant impact is the thermal load carried to the waterways, the effects of which can be seen in the sea area near Olkiluoto. The operation of the power plant started in 1978, so the marine ecosystem has had time to adapt to the impacts of the operation. The ecological status of the water bodies in the area of impact of the thermal load is good. In the programme of measures to the water resources management plan for the Kokemäenjoki–Archipelago Sea-Bothnian Sea river basin district, no measures have been proposed separately for the Olkiluoto sea area. Eutrophication has been observed in the Bothnian Sea, and reducing scattered loads, in particular, is one of the most important objectives included in the programme of measures for the entire river basin district. The thermal load from the cooling waters does not have a significant eutrophication effect, but, together with the sea area's nutrient load, it can contribute to the eutrophication of the sea area. The development of the state of the water bodies is affected by the realisation of climate change scenarios and scattered-load measures.

Name of programme/plan	Contents	Relation to project
Marine Strategy Directive and Finland's Marine Strategy	The Marine Strategy Framework Directive *(2008/56/EY)* is a directive on the framework for a marine environmental policy creating a framework and objectives for the preservation of the marine environment and its protection from the noxious activity of humans and for the prevention of noxious activity by humans. Finland's Marine Strategy implements the EU's marine policy and the relevant directive on the national level. The planning of the Marine Strategy is divided into three parts and progresses in six-year cycles. Finland's Marine Strategy has involved an assessment of the sea's present state and the setting of the objectives needed for the attainment of a good status as well as indicators for monitoring the status. The Marine Strategy covers Finland's territorial waters and exclusive economic zone. The Marine Strategy's programme of measures includes suggested measures that would improve the status of the sea. The valid programme of measures covers the years 2022–2027.	The thermal load from the cooling water could have an impact on the status of the sea area through eutrophication, radioactivity, energy conduction, hydrographic changes, invasive species, and changes in biodiversity. In the Marine Strategy, industrial wastewaters are listed as pressures on the qualitative descriptors of a good status, but, in the case of the cooling waters, the impacts are deemed to be local enough not to have an impact on the status of the sea area as a whole.
Maritime spatial plan	The European Union's Directive establishing a framework for maritime spatial planning obliges the Member States to draw up national maritime spatial plans, the main purpose of which is to balance the interests of different forms of utilisation in marine areas, promote sustainable economic growth and protect marine ecosystems under increasing human pressure. The plans emphasise the synergy benefits of different operators and aim to preserve the good status of the marine environment, prevent conflicts and strengthen ecological diversity. The planning also takes into account long-term cultural heritage and the development of tourism, as well as the possible environmental impacts associated with them. The goal is to create a clear vision for each marine area until 2030, which takes into account the targets set for the area's development, such as the growth of the technology industry, the vitality of the fisheries and aquaculture sectors, the development of renewable forms of energy, and the impacts of special areas on the marine environment.	Maritime spatial planning identifies special and unusual activities connected to the sea. The Olkiluoto nuclear power plant and its surroundings are classified as a special area in the maritime spatial plan. The designation indicates significant special areas connected to the sea. When developing the areas, the restrictions set by special activities on other activities are taken into account and the possibilities for multiuse of the areas are explored. According to the maritime spatial plan, the water areas near Olkiluoto belong to important coastal net fishing areas and to the outer coastal waters of the outer archipelago, in the area of which there are significant habitat types and areas important for birds. The planning and development consider the protection needs of underwater marine nature and archipelago nature, areas significant in terms of biodiversity, fish spawning and nursery areas, areas suitable for offshore wind power, seafaring areas, further rearing areas for fish farming and fishing areas.

Name of programme/plan	Contents	Relation to project
Convention on the Protection of the Marine Environment of the Baltic Sea and the Action Plan	The general convention concerning the conservation of the marine environment in the Baltic Sea region (1974, 1992), also known as the Helsinki Convention, obligates the signatories to reduce loads from all pollution sources, protect the marine environment and preserve biodiversity. The convention's key principles are the use of the best available technology from the perspective of environmental protection, applying the practices best in terms of the environment and compliance with the precautionary principle and the 'polluter pays' principle. The Helsinki Commission (HELCOM) is an intergovernmental organisation established by the signatories to the Helsinki Convention. The commission monitors and promotes the application of the Helsinki Convention and gives recommendations to the governments of the signatories. HELCOM's Secretariat approved the Baltic Sea Action Plan (BSAP) in 2007. The action plan's objective is the good ecological status of the Baltic Sea. The action plan covers the worst environmental problems of the Baltic Sea and actions related to eutrophication, harmful and dangerous substances, biodiversity and nature protection. The action plan was updated in 2021 because the objective of a good status was not attained. In the new action plan, the aim is to achieve a good status of the Baltic Sea by 2030.	The action plan lists eutrophication and invasive species as key pressures affecting the status of the Baltic Sea. The action plan recommends management targets in order to minimise nutrient loads originating from human activity and prevent the spread of invasive species. The eutrophication effects of the project are minor and local; they are not considered to have an impact on the eutrophication of the sea area as a whole. The thermal load from the cooling waters may contribute to the spread of invasive species, but invasive species are observed through regular monitoring and their occurrences are removed in accordance with the environmental permit.
Natura 2000 network	The European Union aims to stop the loss of biodiversity in its area. The Natura 2000 network is one of the most important means by which to attain this goal. The network safeguards the environments of the habitat types and species defined in the Habitats Directive. These areas pursuant to the Habitats Directive are called Sites of Community Importance (SCI). The Habitats Directive applies to wild fauna, flora and habitat types. It aims to i) attain and maintain a favourable level of conservation in terms of some species and habitat types, ii) preserve species in their natural environments so that their natural range does not shrink, and iii) preserve a sufficient number of a species' habitats to ensure its survival in the future, too. The network also includes Special Protection Areas (SPA) pursuant to the Birds Directive. The Birds Directive applies to Europe's wild birds. The Directive's general objective is to maintain certain bird populations on a level that meets ecological, scientific and educational requirements.	The Natura 2000 network site closest to the power plant area is the Rauma archipelago, which is located, at its nearest, approximately 1.2 km to the south-east. As a conclusion of the screening drawn up for the Natura area, it was stated that the possibility of significant deterioration targeting the protected habitat types and species can be excluded in terms of both continued operation and power uprating. However, it is recommended to continue the monitoring of the natural conditions in the long term.

Name of programme/plan	Contents	Relation to project
National land use goals	National land use goals are part of the land use planning system pursuant to the Land Use and Building Act. Among other things, the task of land use goals is to help to achieve the goals of the Land Use and Building Act and of land use planning, the most important of which are a good living environment and sustainable development. According to the Land Use and Building Act, the goals must be taken into account and their implementation must be advanced in provincial planning, municipal zoning and the operation of government authorities. The national land use goals concern the following entities: functional communities and sustainable mobility, an effective transport system, a healthy and safe living environment, a viable natural and cultural environment as well as natural resources and energy supply that is capable of renewing itself. The goals of renewable energy supply are based on Finland's climate and energy policy, as a result of which it is necessary to make provisions in land use for e.g. a significant increase in carbon neutral energy production.	The use of nuclear power in electricity production contributes to curbing climate change, as electricity produced by nuclear power is carbon neutral for users. The project makes use of the existing community structure, built environment and road network. The emissions caused by the operation of the power plant and their environmental impacts are observed and monitored to ensure that the living environment remains healthy and safe.
National programme for spent nuclear fuel and radioactive waste management	The national programme for the management of spent nuclear fuel and other radioactive waste was published in 2022. The national programme for spent nuclear fuel and radioactive waste management is a comprehensive plan aimed at ensuring that all spent fuel and radioactive waste generated in Finland is managed safely and in a way that all waste management measures from the generation of waste to its final disposal are carried out without undue delay. The national programme ensures the implementation of the national policy for spent nuclear fuel and radioactive waste. The policy can be seen as a strategy for the management of spent nuclear fuel and radioactive waste generated in Finland. The policy consists of several principles included in the Nuclear Energy Act and the Radiation Act. The principles are, therefore, mandatory on the undertakings and authorities. The national programme applies to all spent nuclear fuel and radioactive waste generated in Finland. One of the objectives of the national programme is to develop a safe and cost-effective final disposal solution for all spent nuclear fuel and radioactive waste generated in Finland. Among other things, the attainment of this objective requires the licence and permit conditions of the facilities and disposal repositories intended for the treatment and handling of the radioactive waste generated at existing nuclear facilities to also allow the handling and final disposal of radioactive waste generated outside of their own operations.	The management of spent nuclear fuel and radioactive waste will be implemented in accordance with the national programme in the event of both the continued operation and power uprating of the power plant.

Name of programme/plan	Contents	Relation to project
National Waste Plan	The National Waste Plan to 2027 sets the objectives for waste management and for preventing the generation of waste as well as the measures needed to achieve the objectives. It was adopted by the Government in 2022. The National Waste Plan was updated during 2021. At the same time, the plan's validity was extended to 2027. The updated Waste Plan implemented the following entry in the Government Programme: "Create a vision for the waste sector that supports the objectives of recycling and the circular economy and extends to the 2030s. The aim is to increase the recycling rate at least to the level of the EU's targets for recycling." The renewed Waste Framework Directive and the Single-Use Plastics Directive also require new content to be incorporated into the Waste Plan. The principle in the waste management of conventional waste is what is referred to as prioritisation: 1) minimising waste 2) the reuse of waste 3) recycling as material 4) recovery as energy 5) landfill.	The nuclear power plant generates conventional waste in a manner similar to any other industrial activity. Waste containing radioactivity can be cleared from regulatory control if the activity of the waste batch falls below the limit values set by authorities. The further treatment of waste cleared from regulatory control can be identical with that of conventional industrial waste. In both the continued operation and power uprating case, attention will be paid to the minimisation of conventional waste, the appropriate handling of the waste and on final disposal in accordance with the principles of waste management and the Waste Act.

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Appendix

Appendix 1: Terms and abbreviations

Appendix 2: Experts involved in the preparation of the EIA report

Appendix 3: Statement of the coordinating authority concerning the environmental impact assessment programme

Appendix 4: The consideration given to the coordinating authority's statement on the EIA programme when drawing up the assessment report

Appendix 5: Cooling-water modelling report

Appendix 6: Natura screening

Appendix 1. Terms and abbreviations

Terms and abbreviations used and their explanations..

Abbreviation	Explanation
ALARA	As Low As Reasonably Achievable optimisation principle, according to which individual and col-lective radiation doses are kept as low as possible by practical measures.
ASME	American Society of Mechanical Engineering
Bar	A unit of pressure often used to indicate liquid and gas pressure.
BAT	Best Available Technology
Becquerel (Bq)	The measurement unit of radioactivity, refers to the decay of one atom per second. The radioactive substance concentrations are specified as Becquerels per unit of weight or volume (Bq/kg or Bq/l). Multiple units of becquerel include the kilobecquerel (kBq), which is a thousand becquerels, and the megabecquerel (MBq), which is a million becquerels.
BWR	Boiling Water Reactor
Circalittoral	A zone of the sea where there is not enough light for photosynthesis, but benthic fauna is present.
CO_{2e}	Carbon dioxide equivalent; describes the combined climate-warming impact of different green-house gas emissions.
Decontamination	Isolation of radioactive materials.
Desibel (dB)	A unit of the sound pressure level, having a logarithmic scale. An increase of 10 dB in-creases noise by tenfold.
ELY centre	Centre for Economic Development, Transport and the Environment
EU	European Union
FINIBA areas	Nationally important bird areas in Finland
Fissile	Able to undergo nuclear fission. Split with thermal neutrons. A substance suitable for fission.
Fission	A nuclear reaction in which the core of one large atomic nucleus, such as uranium or plutonium, splits into two or more smaller nuclei, releasing a large amount of energy. During fission, free neutrons and radiation are usually also released. This released energy is used in nuclear reactors for electricity production.
Gram (g)	A gram is a unit of mass. Multiple units of the gram include the microgram (µg), which is one mil-lionth of a gram, and the ton (t), which equals one million grams.
HELCOM	An intergovernmental organisation whose members include all the countries of the Baltic Sea region. Its main task is to protect the environment of the Baltic Sea and promote the ecologically sustainable development of the region. HELCOM coordinates and imple-ments the international convention on the protection of the Baltic Sea. Also known as the Helsinki Commission.
Person year (py)	A unit used to measure the work input of employees in an organisation during the year. It corre-sponds to one person's full-time working time over one year.
HINKU munici-pality	The HINKU municipalities are committed to aiming for an 80% reduction in emissions from the 2007 level by 2030. In order to achieve this goal, the municipalities are devel-oping various meas-ures, such as improving energy efficiency, increasing the use of re-newable energy and sustaina-ble transport.
HMAJ	Very low-level waste (average activity level ≤100 kBq/kg).
IAEA	International Atomic Energy Agency

Abbreviation	Explanation
IBA areas	Internationally important bird areas.
ICRP	International Commission on Radiological Protection
INES	The International Nuclear and Radiological Event scale is a scale used to classify various events, describing the severity of emissions of radioactive material and of radiation exposure. The scale is also used for events that do not have emissions or radiation exposure as a consequence, but where the arrangements did not work as planned..
IPCC	The goal of the Intergovernmental Panel on Climate Change is to analyse scientifically produced information on climate change for national and international decision-making. The most important results of the IPCC's assessments are published as reports.
Joule (J)	Unit of energy, work and heat. Used to describe different energies, such as mechanical work, heat, electrical energy and chemical energy. A multiple unit of the joule is kJ, which equals 1,000 J.
KAJ	Intermediate-level waste (typical activity 1–10,000 MBq/kg).
KAJ storage	Storage for intermediate-level waste
International hearing	A hearing procedure in accordance with the Espoo Convention on the assessment of the trans-boundary environmental impacts, in which different countries can participate.
Chrolophyll A	Chlorophyll A is a quantity that describes the amount of chlorophyll. It is used to describe the amount of phytoplankton and to assess the general eutrophication state of a water body.
KPA storage	Storage for spent fuel
Cubic metre (m^3)	Unit of volume. A litre (l) is an additional unit of a cubic metre. One cubic metre equals 1,000 litres.
Site area	A limited site area located inside the power plant area that houses OL1, OL2 and OL3 and the related functions (HMAJ interim storage, MAJ, KAJ and KPA storage facilities).
LO1	Nuclear power plant unit Loviisa 1
LO2	Nuclear power plant unit Loviisa 2
LO3	Nuclear power plant project Loviisa 3
LOCA	An accident due to the loss of coolant, to which the protection systems and operating methods are designed to respond (Loss Of Coolant Accident)
LULUCF sector	The sector consists of six land use categories: forest land, cultivated land, grassland, wetlands, built-up areas and other land. These cover the entire land area and inland waters of Finland. The abbreviation LULUCF comes from the words "Land Use, Land-Use Change and Forestry".
L_{WA}	Refers to the assessment of long-term exposure to noise and its possible impacts on health. For example, the L_{WA} value can be a measure that describes the average noise exposure of people in a certain area or location in the long term.
MAJ	Low-level waste (typical activity 1 MBq/kg at most).
MAJ storage	Storage for low-level waste
Metre (m)	Unit of length. Multiple units of the metre include the kilometre (km), which is equal to 1,000 metres, and the millimetre (mm), which is equal to 0.001 metres.
MRL	Land Use and Building Act
MWe	The megawatt electrical is a unit used to describe the capacity of electricity production or the production capacity of power plants.
NaClO	Sodium hypochlorite
Square metre (m^2)	Unit of surface area. Multiple units of the square metre include the square kilometre (km^2) and the hectare (ha).
NOAA	The National Oceanic and Atmospheric Administration of the United States
NO_x	The nitrogen oxides, i.e. nitrogen monoxide (NO) and nitrogen dioxide (NO_2).

Abbreviation	Explanation
NWC plant	Normal Water Chemistry
OL1	Nuclear power plant unit Olkiluoto 1
OL2	Nuclear power plant unit Olkiluoto 2
OL3	Nuclear power plant unit Olkiluoto 3
OL4	Nuclear power plant unit Olkiluoto 4
pH	Describes the acidity or alkalinity of a solution. The pH scale is logarithmic and generally ranges from 0 to 14, where 7 is neutral, values below 7 are acidic and values above 7 are alkaline.
Posiva	Posiva Oy, a company whose task is to take care of the final disposal of its owners' spent nuclear fuel.
PRA	Probabilistic Risk Assessment is widely used to determine the risk level of plant units and to support decision-making aimed at managing safety-related risks, for example when assessing the possibilities and needs of taking measures to improve safety.
Fishing day	The number of days when the fishing nets or fykes are active in the water area. For ex-ample, if a fisherman fishes for two days with 5 nets, the result is 10 fishing days.
Radioactive	A radioactive substance contains atomic nuclei which can become other nuclei as a result of conversion or decay. In connection with the decay process, ionising radiation (e.g. alpha, beta and gamma radiation) is usually generated. See "Radioactivity".
Radioactivity	Radioactive substances will spontaneously decay into lighter elements or isotopes of the same element that have lower binding energy. The process releases ionising radiation that is either electromagnetic radiation or particle radiation.
SAC area	Special Area of Conservation
Second (s)	Basic unit of time. Multiple units of a second are the minute (min) and hour (h). A minute consists of 60 seconds and an hour of 3,600 seconds.
Siemens (S)	The unit of conductance. One siemens corresponds to an electric current of one ampere (A) passing between two points in a conductor between which there is an electric voltage of one volt (V) and the resistance of the conductor is one ohm (Ω).
Sievert (Sv)	The unit of radioactive dose that represents the health effect of radiation on the human body. Fractions of it include a millisievert (mSv), which is a thousandth of a sievert, and a microsievert (μSv), which is a millionth of a sievert.
SO_2	Sulphur dioxide
SPA	Special Protection Area designated under the EU Directive on the Conservation of Wild Birds
STUK	The Radiation and Nuclear Safety Authority is the authority supervising safety in Finland, a research institution and an expert organisation.
Syke	Finnish Environment Institute
Radiation	Radiation is either an electromagnetic wave motion or particle radiation.
Radiation dose	Radiation dose is a variable that describes the harmful effects of human radiation expo-sure. The unit for the radiation dose is the sievert (Sv).
Conventional waste	A nuclear power plant, as any other industrial facility, generates conventional waste, such as paper waste, plastic waste and biodegradable waste As well as wood waste and scrap metal.
TEM	Ministry of Economic Affairs and Employment. Acts as the coordinating authority (liaison authority) in the environmental impact assessment procedure.
THL	Finnish Institute for Health and Welfare
TLD	Thermoluminescent dosimeter, a so-called passive radiation dose meter
Tonnes of uranium (tU)	The unit tU is used when indicating quantities of nuclear fuel.

Abbreviation	Explanation
Tukes	Safety and Chemicals Agency Tukes
TVO	Teollisuuden Voima Oyj
UNSCEAR	UN Scientific Committee on the Effects of Atomic Radiation
UF_6	Uranium hexafluoride
UO_2	Uranium oxide
U_3O_8	Triuranium octoxide
uranium-235	An isotope of uranium that has 92 protons and 143 neutrons in its atomic nucleus.
VE0	The operation of the OL1 and OL2 plant units will continue until the expiration of the valid operat-ing licences in 2038.
VE1	The OL1 and OL2 plant units operate at their current power level until 2048 or 2058.
VE2	The OL1 and OL2 plant units operate at an uprated power level until 2048 or 2058.
Power plant area	Generally speaking, the Olkiluoto power plant area refers to the area which houses TVO's plant units and Posiva Oy's encapsulation plant and disposal facility for spent nuclear fuel.
Operating waste	Very low, low and intermediate-level waste generated in nuclear facilities, such as nu-clear power plants. Operating waste is generated in the handling of radioactive liquids and gases, and in main-tenance and repair work carried out in the radiation controlled area, for example.
VLJ repository	Operating waste repository
day (d)	Unit of time corresponding to 24 hours.
year (y)	Unit of time corresponding to 12 months or approximately 365 days.
WANO	World Association of Nuclear Operators
Watt (W)	A unit used to measure work or energy. Multiple units of the watt include the kilowatt (kW) and megawatt (MW). One kilowatt equals 1,000 watts, and one megawatt equals one million watts.
Watt hour (Wh)	A unit of measurement of energy that is often used to measure electricity. It gives an idea of how much energy has been used or generated in a certain time. Multiple units of the watt hour include kWh, TWh and GWh. The multiple unit kWh equals 1,000 Wh; GWh equals 1,000,000,000 watt hours; and TWh equals 1,000,000,000,000 watt hours.
Nuclear material	Special fissionable materials and source materials, such as uranium, thorium and pluto-nium, which are suitable for producing nuclear energy.
Nuclear waste	General term for radioactive waste generated during the operation of a nuclear facility. Nuclear waste is low-level or intermediate-level waste or high-level spent nuclear fuel.
Nuclear facility	A nuclear facility refers to plants used to generate nuclear energy, including research reactors, facilities carrying out extensive final disposal of nuclear waste, as well as facilities used for the extensive manufacture, production, use, handling or storage of nuclear material and nuclear waste.
Nuclear fuel	Uranium (or plutonium) intended for use in the reactors of nuclear power plants. Nuclear fuel is not combustible in the sense of material being oxidised (such as when burning coal or wood); it generates heat as uranium nuclei split in a chain reaction. The "com-bustion products" are isotopes of lighter elements generated in the chain reactions. Most of them are radioactive.
Nuclear power plant	A nuclear power plant refers to a nuclear facility, equipped with a nuclear reactor, used to generate electricity or heat, or a plant complex formed by power plant units and other associated nuclear facilities in the same location. A nuclear power plant comprises one or more nuclear power plant units.
Nuclear power plant unit/power plant unit/plant unit	Olkiluoto nuclear power plant consists of three nuclear power plant units, Olkiluoto 1 (OL1), Olki-luoto 2 (OL2) and Olkiluoto 3 (OL3).

Abbreviation	Explanation
Coordinating authority	The coordinating authority for this EIA procedure is the Ministry of Economic Affairs and Employ-ment (MEAE).
YKR	Community structure monitoring documentation, community structure monitoring sys-tem
YVA	Environmental impact assessment
YVL Guides	Nuclear Safety guides, authority guides published by the Radiation and Nuclear Safety Authority which describe the detailed safety requirements concerning the use of nuclear energy.

Appendix 2. Experts involved in the preparation of the EIA report

The environmental impact assessment report has been prepared by Ramboll Finland Oy to-gether with Teollisuuden Voima Oyj, which is responsible for the project. In addition, experts of Fortum Power and Heat Oy participated in the preparation of the report. The experts who participated in the EIA working group are described in the following table. The qualifications of the experts are also indicated.

Area	Ramboll Finland Oy	Teollisuuden Voima Oyj
Project Leader	Antti Lepola	
Project Manager	Anna-Katri Räihä	
Project coordinator	Annika Grönvall	
Community structure, land use and zoning	Niko Mäkinen	
Landscape and cultural environment	Silja Raappana	
Traffic	Suvi Pielismaa-Saarela and Leena Manelius	
Noise and vibration	Timo Korkee	
Air quality	Mikko Happo and Anna-Katri Räihä	
Climate	Anna-Katri Räihä and Annika Grönvall	
Soil, bedrock and groundwater	Ida Tapiola	
Surface water	Saara Mäkelin, Arto Inkala (cooling-water modelling)	
Fish stocks and fishery	Launo Pulli, Saara Mäkelin and Milla Sigg	
Flora, fauna and conservation areas	Ella von Weissenberg (also Natura screening), Juuli Paananen, Taika Lehtimäki, Milla Sigg and Saara Mäkelin	
People's living conditions and comfort	Maria Puustinen and Eeva-Riitta Jänönen	
Regional economy	Samuel Rintamäki	
Energy markets	Anna-Katri Räihä	Rasmus Somerkoski
Use of natural resources	Anna-Katri Räihä	Maria Laakso
Waste and its handling	Anni Mannonen, Annika Grönvall, Anna-Katri Räihä	Ulla-Maija Piiparinen, Merja Levy, Samu Myllymaa
Releases of radioactive substances and radiation exposure		Ulla-Maija Piiparinen, Jaana Kalliomaa
People's health	Mikko Happo and Annika Grönvall	
Incidents, accidents and transbound-ary impacts		Juha-Pekka Jurvanen (Fortum), Ulla-Maija Piiparinen
Location data and maps	Kirsi Tyrmi	
Layout	Aija Nuoramo	

The experts of Ramboll Finland Oy and their qualifications:

Antti Lepola, M.Sc. (forestry)

Mr Lepola has more than 30 years of experience in environmental research and engineering. His core areas of expertise include environmental impact assessment (EIA) and applications for water permits, environmental permits and chemical permits as well as the analyses related to these. Mr Lepola has solid experience in environmental consulting related to energy pro-duction and the environmental impacts of industry. Mr Lepola has participated in nearly 100 EIA procedures and has acted as project manager in more than 30 EIA procedures.

Anna-Katri Räihä (M.Sc., environmental economy), sub-consultant

Ms Räihä has 15 years of experience in environmental consulting and project leadership relat-ed to environmental projects in various industrial fields. Her core competences include envi-ronmental impact assessments, international hearings for EIAs, environmental legislation and greenhouse gas emission calculations. Ms Räihä has acted as project manager and project coordinator for several large-scale EIA procedures and as an environmental expert in numer-ous impact assessments for EIA procedures (e.g. air quality, greenhouse gas emissions and impacts on climate, impacts on traffic, impacts of the use of natural resources). Her special expertise in EIA also covers the various areas of communications and stakeholder dialogue.

Annika Grönvall (M.Sc. (Tech.), environmental engineering)

Ms Grönvall has studied and worked in renewable energy systems for 4 years. At Ramboll, Ms Grönvall works as an environmental consultant in the Impact Assessment unit. Ms Grönvall works as an EIA coordinator and as an expert on climate impacts. In addition, she has worked in fields such as waste management and nuclear power over her career.

Niko Mäkinen (MA, geography)

Mr Mäkinen has four years of experience in area and land use planning at the local and master plan levels and in impact assessments and other expert duties related to land use planning. Mr Mäkinen has solid knowledge of the legislation concerning land use and construction. Mr Mäkinen has mainly participated in EIA procedures as regards impact assessments for societal structure and land use, but also as regards landscapes and the cultural environment. His spe-cial expertise also covers action area solutions and exceptions, especially in shore areas.

Silja Raappana (landscape architect)

Ms Raappana has more than seven years of experience as a designer and expert in projects of various scopes as part of diverse working groups. Ms Raappana has carried out several land-scape analyses and acquainted herself with cultural-historical sites.

Suvi Pielismaa-Saarela (M.Sc. (Tech.), environmental technology; logistics expert)

Ms Pielismaa-Saarela has almost two years of experience covering a wide range of transport system planning projects in the role of junior designer. Her tasks include development plans for transport networks and systems; environmental impact assessments; promotion of cy-cling and sustainable development; and geolocation expertise. In addition, she works as an interaction expert in a wide range of tramway, road, street and traffic projects.

Leena Manelius (M.Sc. (Tech.), construction engineering)

Ms Manelius has more than 10 years of experience in expert duties in projects related to road traffic and land use. Her special areas of expertise include, among other things, assessments of traffic impacts and improving opportunities for pedestrian traffic and bicycling. Ms Manelius also acts as the representative for sustainable development in the traffic unit.

Timo Korkee (B.Sc., engineering)

Mr Korkee acts as a noise expert at Ramboll and as the Project Manager for noise projects in the Air Quality group. Mr Korkee has more than 20 years of working experience in various noise analyses and noise prevention projects. His special expertise covers noise analyses and noise prevention for industry, the energy sector, ports, terminals, the rock material industry, sport shooting and motorsports. With more than 20 years of experience, he is an expert in modelling the dispersion of noise and has accreditation (SFS-EN /IEC 17025:2017, T302) for noise measurements. Each year, Mr Korkee works as a noise impacts expert in various pro-jects related to EIAs and environmental permits and as a project manager for noise analysis projects.

Mikko Happo (Ph.D., environmental health); docent (toxicology of combustion emissions)

Mr Happo's job description includes expert tasks related to air quality as well as development tasks in air quality and health services. In addition, his duties include expert services related to the environmental and health sector and its reporting concerning air quality, emissions into the air, or other environmental and health impacts.

Ida Tapiola (MA, soil geology)

Ms Tapiola has more than five years of experience in expert and project coordinator duties, especially as regards groundwater and the follow-up of environmental impacts. She has spe-cial experience in the assessment of impacts to soil, bedrock and groundwater, EIA projects within industry and in environmental licensing.

Saara Mäkelin (Ph.D., aquatic sciences)

Ms Mäkelin has broad expertise in analyses related to surface water quality and the marine environment. Trained as a marine biologist, Ms Mäkelin has a good overall picture of the struc-ture and operation of water ecosystems and the water system impacts of environmental changes. At Ramboll, Ns Mäkelin has participated in environmental impact assessments (EIA), permit and zoning projects, nature surveys, Natura assessments and other surveys targeting the aquatic environment or aquatic life as an expert on water bodies

Arto Inkala (Dr. Eng., Applied mathematics), sub-consultant

Mr Inkala has more than 20 years of experience in the mathematical modelling of water sys-tems and the development of water system models. Modelled applications created by Mr Inkala have been utilised in dozens of EIA procedures and environmental permit applications.

Launo Pulli (MA, aquatic sciences)

Mr Pulli works as an environmental designer and project manager, especially in projects relat-ed to surface waters and fish stocks. He has experience in implementing versatile impact as-sessments, fish stock and water quality studies and environmental analyses throughout Finland since 2018.

Milla Sigg (MA, environmental science)

Ms Sigg has focused her studies on marine biology, and benthic fauna are her special area of expertise. She works at Ramboll as an expert on water bodies and project coordinator in EIA projects. She has previous work experience from surveys of harmful and dangerous sub-stances in maritime transport and from marine research.

Ella von Weissenberg (Ph.D., aquatic sciences)

A marine biologist by training, Ms von Weissenberg has examined the impacts of temperature on plankton communities in the Baltic Sea in her dissertation. At Ramboll, Ms von Weissenberg has been involved in various nature analyses (e.g. flora and habitat types, bats, moor frog, flying squirrel, birdlife, benthic fauna); Natura assessments; and the assessment of impacts on nature in several different EIA projects.

Taika Lehtimäki (MA, biology)

In her studies, Ms Lehtimäki has focused on water ecology and nature conservation. She works at Ramboll as a project coordinator in EIA projects and an expert in surface water im-pact assessments. She has previous experience from projects related to environmental moni-toring and macrophyte and benthic fauna surveys, among other things.

Juuli Paananen (MA, ecology and evolutionary biology)

Ms Paananen works in the Impact Assessment unit as an expert in the Ecology group. In 2017, she graduated with a master's degree from the University of Helsinki, majoring in ecol-ogy and evolutionary biology. Ms Paananen has many years of work experience from the field of geolocation in the IT sector. She works at Ramboll in environmental impact assessments, as a nature project manager and as a geolocation expert

Maria Puustinen (M.Soc.Sc., social policy)

Ms Puustinen works as a senior expert in social impact assessments and as a project manager in EIA projects. She has 13 years of experience from projects promoting people's well-being, including 4 years as a project manager.

Eeva-Riitta Jänönen (MA, geography)

Ms Jänönen has six years of experience in project coordinator and expert tasks in various EIA projects (including industry, waste management, wind power). She specialises in the assess-ment of impacts targeting living conditions and comfort. She also has experience in interac-tion, such as arranging workshops and meetings for discussion as well as resident surveys

Samuel Rintamäki (M.Sc. (Tech.), industrial engineering)

Mr Rintamäki has about three years of experience in the assessment of impacts on regional economy and business life. He has completed dozens of assessments for projects of various types, such as the energy industry, the manufacturing industry and large infrastructure pro-jects; he has also participated in several projects related to the development of regional busi-ness life and the industrial environment.

Anni Mannonen (M.Sc. (Tech.), environmental engineering)

Ms Mannonen has worked for more than six years in various projects in an expert role and as project manager, especially as regards waste management and circular economy. She has experience in working with handling radioactive waste and the final disposal of nuclear fuel, for example. Ms Mannonen has also been involved in several EIA projects performing the as-sessment of climate impacts.

Kirsi Tyrmi

Ms Tyrmi has worked as a technical assistant for more than 20 years. She has participated in the preparation of map images for various EIA programmes and reports. In addition to the geographical location software, she has used various interface data and map services in her work.

Aija Nuoramo (Media Designer)

Ms Nuoramo works as a versatile graphic designer in the company's various sectors. She has years of experience of preparing various graphic presentations, publications and visualisations. As a Media Designer, she has the requisite skills for multi-channel publishing in both print me-dia and on the web. In addition, she has experience from working as a project secretary and as a person responsible for project bank document management.

The experts of Teollisuuden Voima Oyj and their qualifications:

Petri Holma (B.Sc. (engineering), process technology): Engineering

Jaana Kalliomaa (B.Sc. (engineering), radiological protection): Radiation protection

Ville Kulmala (MA, community communications): Communications

Maria Laakso (M.Sc. (Tech.), engineering physics): Fuel procurement

Eero Lehtonen (M.Sc. (Tech.), mechanical engineering): Engineering

Merja Levy (B.Sc. (engineering), environmental technology): Environmental considerations

Samu Myllymaa (MA, biotechnoology and cellular/molecular biology): Licensing, nuclear waste

Dino Nerwey (M.Sc. (Tech.), material technology): Ageing management

Ulla-Maija Piiparinen (M.Sc. (Tech.), electrical engineering): Radiation safety, accident situations, nuclear waste

Venla Ryyppö (M.Sc. (Tech.), material technology): Licensing

Rasmus Somerkoski (M.Sc. (Tech.), electricity networks and energy markets): Energy markets

Ilkka Tammela (MA, aquatic sciences): Fisheries

Mikko Tammela (M.Sc. (Tech.), engineering physics and mathematics): Nuclear fuel

Antti Tarkiainen (Dr. Eng., engineering physics and mathematics): Nuclear safety

Matti Vaaheranta (M.Sc. (Tech.), electrical and automation technology): Ageing management

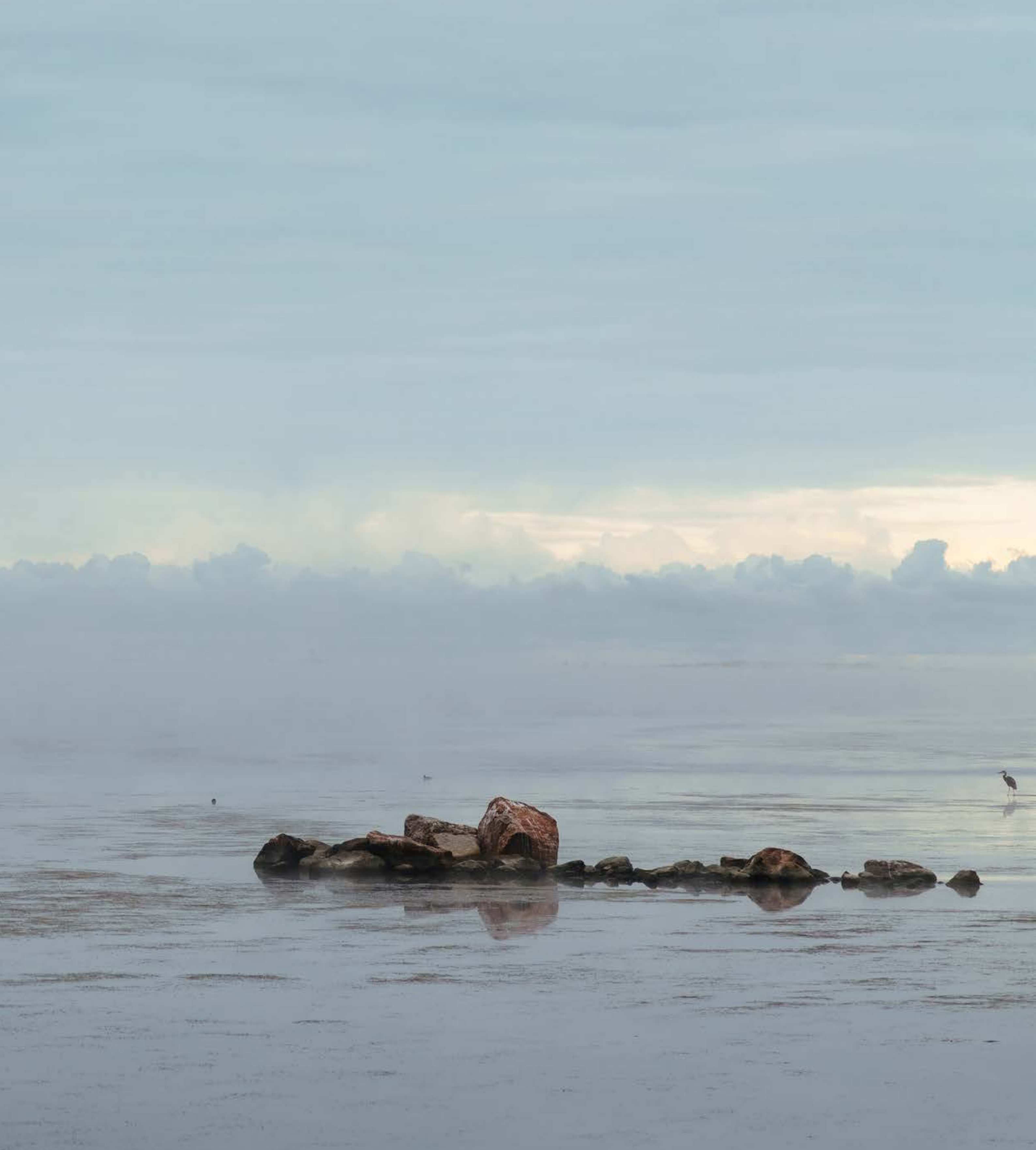
Experts of Fortum Power and Heat Oy:

Juha-Pekka Jurvanen (MA, meteorology): Accident modelling

Satu Ojala (MA, limnology): Aspects of the power plant related to water bodies

Reko Rantamäki (Dr. Eng., physics): Cooling-water modelling

Appendix 3. Statement of the coordinating authority concerning the environmental impact assessment programme



Työ- ja elinkeinoministeriö
Arbets- och näringsministeriet

According to distribution

Statement
25 April 2024 VN/1026/2024

TRANSLATION

THE COMPETENT AUTHORITY'S STATEMENT ON THE ENVIRONMENTAL IMPACT ASSESSMENT PROGRAMME FOR THE EXTENSION OF THE SERVICE LIFE OF THE OLKILUOTO 1 AND OLKILUOTO 2 PLANT UNITS AND FOR THE UPRATING OF THEIR THERMAL POWER

On 5 January 2024, Teollisuuden Voima Oyj (hereinafter TVO) submitted to the Ministry of Economic Affairs and Employment an environmental impact assessment programme (hereinafter the EIA programme) referred to in the Act on the Environmental Impact Assessment Procedure (252/2017, hereinafter also the EIA Act) concerning the Olkiluoto 1 and Olkiluoto 2 (OL1 and OL2) nuclear power plant units located in the Eurajoki Olkiluoto power plant area.

1 Project details

1.1 Developer

The developer of the project is Teollisuuden Voima Oyj.

1.2 Competent authority

The competent authority for the environmental impact assessment procedure of the project is the Ministry of Economic Affairs and Employment in accordance with section 10(1) of the EIA Act.

1.3 The developer's description of the project and its options

In the environmental impact assessment procedure, the implementation options reviewed are continuing the operation of the Olkiluoto 1 and Olkiluoto 2 plant units in the Olkiluoto power plant area at the current power level until 2048 (VE1a) or 2058 (VE1b) and continuing the operation at an uprated power level until 2048 (VE2a) or 2058 (VE2b). In addition, the continued use of the plant units at the current power level until the expiration of the current operating licence until 2038 (VE0) is examined.

The starting point for the uprating assessed in the EIA procedure is a 10% increase in the thermal power of the reactor to 2,750 MW, which corresponds to an increase in the nominal electrical output of the plant units from the current 890 MW to 970 MW. The annual increase in electricity production in the OL1 and OL2 plant units would total approximately 1,200,000 MWh.

The plant units were commissioned in 1978 (OL1) and 1980 (OL2). The initial planned service life of the plant units was 40 years. The service life of the plant units has previously been extended to 60 years. The extension of operation until 2048 or 2058 currently examined is equivalent to an extension of the service life to 70 or 80 years.

If the operation of the Olkiluoto 1 and Olkiluoto 2 plant units is not continued (VE0), the plant units will be decommissioned after the expiry of the valid operating licence. If the operation of the plant units continues, decommissioning will take place after expiry of the new operating licence. A separate environmental impact assessment procedure will be prepared for the decommissioning of the plant units in accordance with the legislation in force when decommissioning becomes topical.

1.4 Connections to other projects

In addition to the OL1 and OL2 plant units, the Olkiluoto site area houses the OL3 plant unit, for which the Government granted an operating licence in 2019. The commercial operation of the plant unit started in April 2023. OL3 has a planned service life of 60 years. Its current operating licence pursuant to the Nuclear Energy Act is in force until the end of 2038. The power plant area also houses the interim storage facility for spent nuclear fuel (KPA) and the storage facilities for very low-level waste (HMAJ), low-level waste (MAJ) and intermediate-level waste (KAJ) as well as the operating waste repository (VLJ repository) for the final disposal of low-level and intermediate-level waste. The operating licence under the Nuclear Energy Act of the VLJ repository is valid until the end of 2051.

According to the assessment programme, TVO has also been planning the establishment of a separate near-surface final disposal facility for very low-level waste (HMAJ) in its power plant area. The environmental permit for the near-surface final disposal facility was obtained in October 2023. The assesment programme points out that building the HMAJ disposal repository also requires a building permit from the municipality and a permit to operate from the Radiation and Nuclear Safety Authority.

Posiva Oy's encapsulation plant and disposal facility for spent nuclear fuel is located in the Olkiluoto power plant area and has its own separate plant area. Posiva is responsible for the research and technical implementation of the final disposal of spent nuclear fuel produced in Finland by TVO and Fortum Power and Heat Oy. In November 2015, the Government granted Posiva a construction licence in accordance with the Nuclear Energy Act for the construction of an encapsulation and final disposal facility in Olkiluoto.

1.5 Plans and permits required by the project

The assesment programme describes the permits and decisions that may be required by different project options. In addition, the assesment programme describes the project's relationship with various plans and programmes concerning the use of natural resources and environmental protection.

The current operating licence for the Olkiluoto 1 and Olkiluoto 2 plant units under the Nuclear Energy Act (990/1987) is valid until 2038. A new licence must be applied for in all project options. According to the assesment programme, in the case of options VE2a and VE2b, this will be done by the end of 2028 and with options VE1a and VE1b no later than before 2038 when the current licence expires. The assessment programme states that, under the terms of the current operating licence, TVO must carry out a periodic safety assessment of the OL1 and OL2 plant units and submit it to the Radiation and Nuclear Safety Authority for approval by the end of 2028.

The operating licence of the VLJ repository is valid until the end of 2051. According to the assesment programme, TVO will apply for a new operating licence for the VLJ repository well in advance of the expiry of the operating licence, which will enable the use of the VLJ repository even after the decommissioning of the power plant units.

The assesment programme highlights that the operating licence for the plant units includes the use of intermediate nuclear waste storage facilities (KAJ, MAJ, KPA) and, if the service life is extended for OL1 and OL2, the use of these intermediate storage facilities will also be continued with the same operating licence. If the use of the plant units ends in 2038, a separate operating licence will be applied for the intermediate storages or it will be combined with the operating licence of the OL3 plant unit. An operating licence for the final disposal facility for very low-level nuclear waste planned for the Olkiluoto power plant area (near-surface final disposal) will be applied for so that the activities would start in the mid-2020s.

The assesment programme indicates that if the operation of the OL1 and OL2 plant units is not continued, the plant units will be decommissioned after the expiry of the valid operating licence. If the operation of the plant units continues, decommissioning will take place after the expiry of the new operating licence. According to the assesment programme, a separate environmental impact assessment procedure will be prepared for the decommissioning of the plant units in accordance with the legislation in force when decommissioning becomes topical.

Posiva’s spent fuel encapsulation and final disposal facility is also located on the island of Olkiluoto, for which Posiva applied for an operating licence at the end of 2021. The operating licence is issued by the Government. The final disposal of spent nuclear fuel is planned to begin around the mid-2020s.

The assesment programme highlights that the operation of the Olkiluoto nuclear power plants may require other permits subject to the Nuclear Energy Act in the future and they will be applied for if necessary. Section 21 of the Nuclear Energy Act lays down the conditions for granting a licence for other uses of nuclear energy, such as the possession, manufacture, production, transfer, handling, use, storage, transport and import of nuclear material and nuclear waste, and disposal of nuclear waste that is of a lesser extent than large-scale disposal of nuclear waste (operating licence). Under section 16(2) of the Nuclear Energy Act, the Radiation and Nuclear Safety Authority grants a permit for the above-mentioned activities upon application.

The programme also describes the permits required under the Radiation Act that the implementation of the project may require. According to the programme, TVO currently has three separate safety licences for the use of unsealed sources, X-ray sources and sealed sources in industry and research. The safety licences for radiation activities are all valid until further notice. According to the programme, in the case of continued use, radiation activities in industry and research will continue to an extent deemed sufficient and the safety licence will be updated as necessary.

The programme also describes the permits required for the transport of radioactive materials. The programme points out that, in the case of the extension of the lifetime of plant units, new fresh fuel is still needed by the plant units and that the licence practice will remain the same in that respect. Posiva is responsible for the transporting of spent fuel for encapsulation and final disposal to Olkiluoto in Eurajoki.

The assesment programme points out that the decommissioning of a nuclear power plant is subject to a licence, which is laid down in the Nuclear Energy Act and Decree and the regulations and instructions of the Radiation and Nuclear Safety Authority. Under the current EIA Act, the dismantling or decommissioning of a nuclear power plant requires an EIA procedure.

The assesment programme also covers permits required under the Land Use and Building Act (132/1999), the Environmental Protection Act (527/2014) and the Chemicals Act (390/2005). The programme also states that a restriction on movement has been imposed around the power plant area under section 52 of the Police Act. In addition, the environment of the power plant area has been designated as a no-fly zone by the Government Decree on Restricted Areas in Aviation (VNa 930/2014). The programme also states that the other permits related to the operation of the power plant are mainly various technical permits, the purpose of which is to ensure occupational safety and prevent material damage.

According to the programme, the valid local detailed plan enables the modification of the power plant area and the construction of additional structures and/or buildings.

According to the assesment programme, the project may have an interface with various plans and programmes concerning the use of natural resources and environmental protection, which include both international commitments and national target programmes. According to the programme, the most significant plans and programmes are identified and listed in the EIA report, and the project’s relationship with them is assessed.

1.6 Location of the project and space requirements

As described in the assesment programme, the Olkiluoto nuclear power plant area owned by TVO is located in the municipality of Eurajoki, on Olkiluoto Island. The OL1 and OL2 plant units are located in the plant area that is delimited in the western part of Olkiluoto Island. The plant area contains the OL1, OL2 and OL3 plant units as well as facilities, equipment and functions related to the plant units, which include the interim storage for spent fuel (KPA storage) and the interim storage facilities for very low, low and intermediate-level operating waste (HMAJ, MAJ and KAJ storages). According to the assesment programme, the project alternatives do not require new space reservations in the power plant area and any modifications will be implemented within the existing, constructed plant area.

1.7 Planning and implementation schedule

According to the assesment programme, a preliminary analysis for the uprating of the plant units’ thermal power was drawn up during 2022. In addition to the technical analyses regarding plant engineering and nuclear fuel, the scope of the preliminary analysis included assessments related to nuclear safety, a preliminary licensing plan and permit plan for the project and the analyses related to the management and implementation of the power uprating project. Following the preliminary analysis, a project planning stage of the power uprating project has been launched. During the project planning stage, safety analyses are drawn up, the necessary plant modifications are specified and, based on them, a plant-level plan for principles for the power uprating is drawn up, allowing for the information presented therein to be used at the project’s EIA report stage. The EIA procedure has been estimated to last until the end of 2024.

According to the assesment programme, the preliminary schedule for the power uprating project indicates that the plant modifications and operating tests required for the power uprating may be implemented in the 2020s but that they could also be implemented in the 2030s. No decision has been made on the implementation or its date. The earliest possible implementation time for the power uprating would be in 2028, assuming that all necessary permits for the implementation have been granted.

According to the assesment programme, in the alternatives where the decision is made to extend the service life but no power uprating is done, the necessary permits will be applied for by 2038.

The Ministry of Economic Affairs and Employment states that by its decision dated 29 November 2023 (VN/9813/2023) it has issued binding preliminary information following a request for preliminary information submitted by Teollisuuden Voima Oyj. In the decision, the ministry has considered that the valid operating licences issued by the Government for the Olkiluoto 1 and 2 nuclear power plant units can be used to carry out the plant modifications and test runs required by the power increase, provided that they have been assessed and approved by the Radiation and Nuclear Safety Authority. The ministry has further stated in the decision that the documents prepared in the preparation of the periodic safety assessment can be used in connection with the licence processing under the Nuclear Energy Act resulting from the power uprating of the Olkiluoto 1 and 2 nuclear power plant units.

2 Information and consultation on the assesment programme

Under section 17(1) of the Act on Environmental Impact Assessment Procedure, the competent authority must ensure that the necessary statements on the assessment programme are requested and that an opportunity to submit opinions is provided. The competent authority must request a statement on the assessment programme from the municipalities in the area affected by the project and from the other authorities likely to be concerned by the matter, including the project permit authority. Further according to subsection 2 of the section, the competent authority must announce the environmental impact assessment programme by public notice without delay. Under subsection 3 of the section, information on the notice must be published without delay in the municipalities in the area likely to be affected by the project. In addition, information on the assesment programme must also be published in at least one newspaper in general circulation in the area affected by the project.

On 23 January 2024, the Ministry of Economic Affairs and Employment has notified the assesment programme with a public notice published on the ministry’s website. The ministry has also submitted the assesment programme and the related announcement to the municipalities in the area affected by the project and asked the municipalities to keep the document on their website between 23 January 2024 and 25 March 2024.

In addition, the ministry has requested an opinion on the assesment programme from the following parties: Municipality of Eurajoki, municipality of Eura, municipality of Nakkila, city of Pori, city of Rauma, Regional State Administrative Agency for Southwestern Finland, Regional State Administrative Agency for Southern Finland, Satakunta ELY Centre, Southwest Finland ELY Centre, Regional Council of Satakunta, Helsinki–Uusimaa Regional Council, Southwestern Finland Police Department, Rescue Department of Satakunta, Ministry of Social Affairs and Health, Ministry of the Interior, Ministry of Defence, Ministry of the Environment, Ministry of Finance, Ministry of Transport and Communications, Ministry for Foreign Affairs, Ministry of Agriculture and Forestry, Radiation and Nuclear Safety Authority, VTT Technical Research Centre of Finland Ltd, Finnish Safety and Chemicals Agency (Tukes), Advisory Committee on Nuclear Safety, Finnish Heritage Agency, Geological Survey of Finland (GTK), Finnish Environment Institute , AKAVA ry, Confederation of Finnish Industries, Greenpeace, Central Union of Agricultural Producers and Forest Owners (MTK), Finnish Society for Nature and Environment, Finnish Energy, Central Organisation of Finnish Trade Unions, Federation of Finnish Enterprises, Finnish Association for Nature Conservation, Finnish Confederation of Professionals (STTK), WWF, Fingrid plc and Posiva Ltd. The request for an opinion has been sent electronically via the lausuntopalvelu.fi service. Other parties and citizens have also had the opportunity to give their statements and express their opinions on the project.

On 23 January 2024, the ministry has provided information on the assesment programme, its availability for viewing and the possibility of issuing statements and expressing opinions in the following journals: Helsingin Sanomat, Hufvudstadsbladet, Länsi-Uusimaa and Satakunnan Kansa.

In cooperation with the developer, the ministry organised a public event on the assesment programme at the Olkiluoto Visitor Centre on 6 February 2024 from 5:30 p.m. to 7:30 p.m. The event allowed remote participation. In addition to representatives of the competent authority, the developer and Ramboll Finland Oy, 4 people attended the event in person and around 20 people participated remotely.

On 15 January 2024, the Ministry of Economic Affairs and Employment has submitted a request for action to the Finnish Environment Institute to launch an international consultation. On 23 January 2024, the Finnish Environment Institute submitted a notification of the project to Sweden, Estonia, Latvia, Lithuania, Norway, Denmark, Poland and Germany. Austria has also requested the notification of the project, which has been submitted to it. In addition, on 23 January 2024, the Finnish Environment Institute informed all parties to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention). In their reply, Bulgaria and Hungary have requested a notification of the project, which has been submitted by the Finnish Environment Institute to the countries concerned.

The announcement, assesment programme and statements and opinions concerning the programme have been published on the ministry’s website at https://tem.fi/olkiluoto-ol1-ja-ol2-yva-ohjelma.

3 Statements and opinions on the assesment programme

3.1 A summary of statements and opinions

The ministry received 20 opinions from national consultations. Regional State Administrative Agency for Southern Finland, Regional State Administrative Agency for Southwestern Finland, Satakunta ELY Centre, Helsinki–Uusimaa Regional Council, Ministry for Foreign Affairs, Ministry of Transport and Communications, municipality of Eura, city of Pori, municipality of Nakkila, AKAVA ry, Confederation of Finnish Industries, Greenpeace, Central Union of Agricultural Producers and Forest Owners (MTK), Finnish Society for Nature and Environment, Finnish Energy, Finnish Association for Nature Conservation, Finnish Confederation of Professionals (STTK), WWF and Fingrid plc have not submitted a statement. The Southwestern Finland Police Department stated, referring to its statutory duties, that it does not consider it necessary to provide an actual statement on the matter. The Finnish Environment Institute stated that it will not provide a statement on the matter.

The statements largely considered the EIA programme to be comprehensive and sufficient. Under normal conditions, the environmental impacts of the project were generally considered to be minor. In their statements, the parties paid particular attention to the increase in the thermal load caused by cooling water on the sea water and the risks caused by climate change. Attention was also paid to nuclear waste management and, among other things, to the energy market.

In an international consultation under the Espoo Convention, Sweden, Estonia, Denmark, Latvia, the Land of Saxony in Germany, Austria and Bulgaria have announced that they will participate in the environmental impact assessment procedure of the project. Norway, Lithuania and Poland do not consider themselves to be affected parties and will not participate in the assesment procedure. However, Lithuania requests the assessment report for information. A total of 2 statements from organisations were received. The international consultation highlighted in particular the risk of a severe nuclear accident and its consequences.

The statements and opinions received by the ministry are available on the Ministry of Economic Affairs and Employment's website on the project.

3.2 Requested official statements

3.2.1 Geological Survey of Finland (GTK)

The Geological Survey of Finland GTK (GTK) considers that the EIA programme as a whole is comprehensive and takes due account of the impacts of the extension of service life and the power uprating.

GTK further notes that the power uprating and extension of operation (VE2a and VE2b) will also generate impact due to the fact that the spent fuel will be hotter than fuel produced at the current power level. The EIA programme states that cooling will take place after the initial cooling in the interim storage facility for spent nuclear fuel, whose space capacity is either sufficient for the required cooling or, if necessary, will be increased. The EIA programme does not comment on the cooling schedule from the perspective of final disposal. However, a possible longer cooling time would probably only affect the planned implementation schedule of the final disposal, and the timetable effects, if any, would hardly have environmental impacts. In addition, the EIA programme does not comment on the possible effects of uprating on the composition of the fuel used. From the perspective of final disposal of spent nuclear fuel, it would be advisable to know whether the options VE2a and VE2b have an impact on the cooling time of the fuel in the interim storage facility or on the composition of the spent fuel, although the EIA programme duly includes an indication that the nuclear power plant has final disposal methods and plans on which the continued operation and power uprating will have no significant impact.

3.2.2 Municipality of Eurajoki

In the view of the municipality of Eurajoki, it is very positive that the EIA programme currently under way has been drafted thoroughly and the various impacts are assessed comprehensively, taking into account different areas. In this way, the impacts of extending the service life of plants and uprating their thermal power can be assessed thoroughly and accurately in compliance with the high Finnish safety culture and the objectives of the Nuclear Energy Act. The municipality considers it particularly important that environmental impact assessments examine in particular the possibilities of preventing and mitigating the potential adverse impacts of the project, for example by means of planning and implementation, which are presented later in the EIA report.

3.2.3 Finnish Heritage Agency

The Finnish Heritage Agency notes that future measures will take place on the current plot, inside the existing walls, so they will have no direct impact on the values of the cultural environment. The Finnish Heritage Agency therefore has nothing to comment on the proposed EIA programme.

3.2.4 Ministry of Defence

The Ministry of Defence states that the proposed extension of operation from 2038 to 2058 (VE2b) can be favoured. The estimated environmental impacts of this option can be considered to be minor, particularly in view of the positive social impacts of the increase in thermal and electric power. The implementation of option 2B would significantly increase our weather-independent electricity production and strengthen our degree of self-sufficiency for a considerable period of time. At this stage, the Ministry of Defence does not see any significant increase in existing security risks in any of the options presented.

3.2.5 City of Rauma

The city of Rauma states that of the three options for implementing the EIA procedure, all have environmental impacts on the city of Rauma. The most significant environmental impact is the warming of seawater due to the conduction of cooling water, which gets prolonged with option VE1 and both prolonged and increased with option VE2. Fish mortality associated with cooling water intake and its partial impact on fish stocks in the city of Rauma can be considered a minor impact. The environmental and licensing board of the city of Rauma has not been informed of any facts on the basis of which it should be assumed that the prolonged or increased warming effect would cause harm, on the basis of which one of the proposed alternatives should be chosen instead of another alternative. As a result of the long age of the energy production plants, the environment and species have adapted to the warming effect. It can even be assumed that cessation of the warming effect would in some respects have a greater environmental impact than continuation of operations.

3.2.6 Satakunta rescue department

In the view of the rescue authorities, the alternatives would not change the nature of the rescue services' protection measures in a severe radiation accident. The assesment plan states that when examining the option of uprating power, the changed reactor inventory is taken into account in an unlikely but potentially severe reactor accident. In any case, rescue resources to protect the environment are small in large-scale radiation accidents and cooperation between actors is emphasised. The assessment of the overall ability is also carried out at the international level, and the results obtained from these should be taken into account in this context. The Radiation and Nuclear Safety Authority has the right expertise for the assessments. According to the rescue department, it should be taken into account in the assessment plan whether any preparation obligations follow from any power increase that would have an impact on the storage volumes of other chemicals, such as fuel oil. In the view of the rescue authority, any increase in chemical storage volumes would be minor and would not be likely to change the operator's obligations here.

3.2.7 Regional Council of Satakunta

The Regional Council of Satakunta states that it is advisable to examine the conditional extension of the service life of the OL1 and OL2 nuclear power plant units if the safety requirements are met in terms of material efficiency and the use of the areas.

According to the Regional Council of Satakunta, it is important to take into account the progress of climate change and the risks arising from climate change. The combined effects of the OL1 and OL2 plant units and the Olkiluoto 3 plant unit should be assessed to assess the extent of the spread of warm water and the average and highest temperature values at different distances and the permanently ice-free area or area of weak ice. In addition, the link between known projects and TVO's project and the preservation of the prerequisites for its implementation should be examined as a synergy with other energy production projects. It is also important to clearly indicate the need for electricity transmission in the alternatives examined in the EIA procedure. The change in the role of nuclear power in the electricity market as a result of the growing production of renewable energy and the connection to electricity storage and price-based use should be discussed in the evaluation procedure.

In addition, the Regional Council's statement discusses the regional land use plan situation in the region.

3.2.8 Ministry of Social Affairs and Health

The Ministry of Social Affairs and Health considers the EIA programme to be comprehensive and well prepared and notes that the programme provides a good basis for preparing the next EIA report.

The Ministry of Social Affairs and Health states that the assesment programme does not indicate whether a power uprating would be implemented in connection with annual maintenance or at some other time. Thus, the programme does not indicate whether increasing the electrical power will have an impact on electricity production in Finland. The Ministry of Social Affairs and Health considers it important that this is reflected in the EIA report prepared on the basis of the programme, as Finland lacks a significant amount of electricity production needed during peak consumption. Electricity shortages during price spikes may have negative social impacts on households due to electricity price pressures. In addition, the programme does not clearly indicate whether additional permits are needed for the organisation of nuclear waste management if the plant units' electrical power increases are implemented.

3.2.9 Radiation and Nuclear Safety Authority

The Radiation and Nuclear Safety Authority (STUK) notes that the EIA programme takes into account the emissions of radioactive substances during normal use and in possible accidents, as well as the increase in fuel use and, as a result, the increased amount of spent fuel and other active waste to be disposed of. In the view of the Radiation and Nuclear Safety Authority, the EIA programme proposed by TVO meets the EIA programme criteria laid down in section 16 of the Act on Environmental Impact Assessment Procedure in terms of radiation and nuclear safety. The EIA programme presents the necessary information on the project, its reasonable alternatives, and a description of the current state of the environment, a proposal for assessing the environmental impacts and how they are to be examined, and a plan for organising the assesment procedure.

The Radiation and Nuclear Safety Authority further notes that the radiation impacts caused to the environment and humans by different alternatives will be assessed during the EIA procedure. The Radiation and Nuclear Safety Authority will assess the fulfilment of safety requirements in detail in connection with the processing of any new licence application. According to section 2.2. of the EIA programme, due to the low radiation levels in fresh fuel, the transport packaging requires no radiation protection features. In this context, it should be pointed out that although fresh fuel radiates weakly and thus does not pose a radiation hazard to humans or the environment, the transport of fresh nuclear fuel is subject to a licence for the transport of substances classified as hazardous. Transport packaging is subject to requirements in the code for the transport of hazardous goods.

3.2.10 VTT Technical Research Centre of Finland Ltd

VTT Technical Research Centre of Finland Ltd (VTT) states that from the perspective of national and international climate objectives and the predictability of electricity production, it is a good thing that the continued operation of the OL1 and OL2 plant units and also power uprating are examined, as nuclear power is carbon-neutral and stable form of energy production. VTT considers that the EIA programme meets the requirements set for the EIA programme. In addition, VTT states that the energy market has been listed as an area to be examined in the EIA procedure, but not the Finnish energy system from the perspective of infrastructure. VTT proposes that, in addition to what is presented in the EIA programme, a separate object of examination could be impacts on the Finnish energy system, such as the main grid and the security of supply of electricity distribution.

3.2.11 Southwest Finland ELY Centre

Southwest Finland ELY Centre considers that the assesment programme is a carefully prepared entity. However, in its statement, the ELY Centre points out some detailed observations, especially concerning the impacts on waterways, the risks associated with the operation of the plant and the decommissioning of the nuclear facility. According to the statement, the production of electricity at the Olkiluoto nuclear power plant has so far not been found to have caused significant environmental damage in its normal operations.

The ELY Centre states that the assesment programme has appropriately identified the significant impact of the project on the increase in heat load caused by cooling water on sea water. According to the ELY Centre, the impact assessment has mostly been presented in the assesment programme in an adequate manner when assessing the impacts on the physicochemical water quality and ice conditions of the marine area and the possible indirect impacts on aquatic organisms and impacts on the ecological and chemical status of the marine environment in the different alternatives.

The ELY Centre considers that the assessment report should describe whether the use of cooling waters in plant units is associated with an increasing risk for invasive species in the coming years. In addition, according to the ELY Centre, more detailed research is needed for the assessment of the effects of the heat load of the Olkiluoto plant units on the state of sediment in the sea area and the regulation of internal loading. According to the statement, the assessment report must include a more extensive extract from the maritime spatial plan in the environment of the project, and the assessment of the effects of thermal loads must be based on the entire water column and also the seabed. The statement says that the modelling of the impacts of the project on water bodies caused by thermal loading will not be able to directly assess how the so-called internal load on the seabed of the affected area will change. According to the statement, the effects of cooling water abstraction should also be included in the examination of surface waters.

According to the statement, the cooling water temperature used by the project may also be affected by climate change as it heats seawater, which should be taken into account in the assessment. In the assessment report, it is still important to assess what the increase in temperature in seawater means in the marine flora and fauna and how the monitoring of changes and the prevention of harmful impacts will be implemented. The ELY Centre also considers why, for example, algae production in the research area is constantly increasing, even though there have been no significant changes in the amount of heat load.

The ELY Centre considers it important that, in addition to a severe reactor accident and its effects, the assessment report discusses and analyses reasons that may lead to a severe reactor accident at the plant, its threat or other exceptional situation. According to the statement, as a result of the impact assessment, it is necessary to present a probability analysis of the risks, on the basis of which it can be assessed whether the changes planned in the plant's implementation options (VE1 and VE2) are environmentally safe.

The ELY Centre states that integrating the decommissioning of a nuclear power plant into the current assessment procedure would not be an unreasonable addition when the nuclear power plant already has a decommissioning plan, to be updated every six years. In addition, the ELY Centre notes that the assesment programme remains unclear as to whether some by-products are formed in the plant units. According to the statement, it is difficult to get an overall picture of the "other waste" described in the assesment programme.

With regard to permits related to land use planning and the project, the ELY Centre states that the assessment report should specify the objective of the plans drawn up for the area and the national land use goals targeted for the area. As regards plans and planning processes, it is also necessary to describe any pending significant land use plans in the assessment report, such as the Satakunta regional land use plan 2050. According to the statement, it is also necessary to assess whether a change to a water permit and a permit for the final disposal of very low-level waste is needed.

3.2.12 Advisory Committee on Nuclear Safety

The Advisory Committee on Nuclear Safety notes that the EIA programme has been drawn up in such a way that the central role of nuclear safety in the operation of the nuclear power plant is well and sufficiently presented, and the advisory committee hopes this will be the case also in the EIA report in accordance with the act. The statement presents that approximately 20 EIA processes related to the use of nuclear energy have been implemented in Finland so far. The first processes in the early 1990s dealt with the power uprating of both Finnish nuclear power plants. The power uprating was already then seen as a significant safety issue and thus also as a significant change in the project referred to in the EIA Act. Over a period of approximately 30 years, the processing of nuclear safety in the EIA has continued to evolve and, for example, the processing of potential transboundary environmental impacts has become established.

The Advisory Board notes that in the EIA programme, nuclear safety issues are related to both extending the service life and power uprating, which will be key issues in STUK's statement on the application for a licence. Ageing management of the plant units becomes an important task in extending the service life. In cases of extension, the amount of spent fuel increases significantly, and the amount of other nuclear waste increases. From the perspective of nuclear safety, the most significant impacts assessed in the project are the report on waste and by-products in the Olkiluoto area, the report on emissions and radiation of radioactive substances, and the modelling of exceptional and accident situations within 1,000 km of the area.

In addition, the advisory committee notes that 100 TBq of caesium emissions have been selected for today's large nuclear power plants for transboundary environmental impacts for accident situations (based on section 22b of the YEA). This procedure has proved effective, as it illustrates the severity of these accidents and the emission limit also covers various imaginable accident chains. Similar processing is also carried out in this EIA, in which emission estimates are compared to historical accidents. A guide for dealing with severe accidents has been written within the scope of the Espoo Convention, and this Finnish practice has been taken into account in them. Any radioactive emissions and their spread are described in the handling of possible accidents. The advisory committee hopes that the above will also be presented in the report by means of examples.

3.2.13 Ministry of Agriculture and Forestry, Ministry of the Interior, Finnish Safety and Chemicals Agency Tukes, Ministry of Finance and Ministry of the Environment

The above authorities did not have any comments on the environmental impact assessment programme for the project.

3.3 Other statements requested

3.3.1 Posiva Oy

Posiva Oy states that it acts as a future final disposal and expert organisation of spent nuclear fuel for its owners Fortum Power and Heat Oy and Teollisuuden Voima Oyj. Posiva states that it has no comments to make on the EIA programme. The programme describes the different future situations sufficiently in terms of different lengths of service life extensions. Posiva has also been consulted on spent nuclear fuel in connection with the preparation of the EIA programme.

According to the statement, in the situation presented in the EIA programme, when the service life is extended by 20 years, the accumulation of spent nuclear fuel is approximately 3% more than Posiva has applied capacity for (6,500 uranium tonnes) in its licence application – in the other situations presented, the capacity will not be exceeded. In its own EIA programmes, Posiva has previously carried out impact assessments for significantly larger fuel volumes than in the project planned by TVO without a significant increase in environmental impacts. Posiva states that, if necessary, additional capacity will be applied for the final disposal of the spent fuel of its owners in accordance with the Nuclear Energy Act.

3.3.2 Central Organisation of Finnish Trade Unions SAK

The Central Union of Finnish Trade Unions SAK estimates that the project would have positive impacts on reducing greenhouse gas emissions and mitigating climate change. This is particularly true if/when nuclear power is compared to fossil-based energy. The project would also have positive impacts on the regional economy, the energy market, self-sufficiency in electricity and the functioning of the Finnish energy system.

According to the organisation, the programme is logical and contains all the essential elements, but remains superficial in some places, especially as regards the impacts of the current state of the environment to be assessed and the most significant environmental impacts. As regards the current state of soil, rock and groundwater, it would have been useful to record in the programme what kind of results have been achieved so far in groundwater research, deep drilling and underground disposal facilities. Similarly, it would have been justified to broaden the scope of the results of the bedrock surveys carried out. The probability of the presence of acid sulphate in the

Olkiluoto area is found to be very low in the current situation in the programme. However, it does not clearly state whether sulphate has already been found to have any effects on the area, e.g. eutrophication. According to the organisation, it would have been useful to open up more the impact of existing measures on groundwater. According to the statement, it is difficult to understand the proportion of occasional significant eutrophication and oxygen depletion in the water near the bottom caused by OL1 and OL2 in relation to other human-induced activities in the area, such as agriculture. Questions arise, for example, as to whether the change in sea water temperature would not also have an impact on the acceleration of eutrophication and the increase in oxygen loss.

According to the organisation, it would be justified to prepare alternative scenarios on the environmental impact of waste volumes and spent fuel and its growth in proportion to the same amount of energy produced with renewable energy.

3.3.3 Federation of Finnish Enterprises

The Federation of Finnish Enterprises states that it has no comments on the environmental impact assessment programme.

3.4 Statements provided in the international hearing

3.4.1 Bulgaria

In its reply, the Bulgarian Ministry of Environment and Water states that Bulgaria will participate in the EIA procedure for the project.

3.4.2 Austria

The Austrian Ministry of Climate, Environment, Energy, Mobility, Innovation and Technology submitted a reply accompanied by an expert opinion commissioned by the Austrian Environment Agency. The reply was also accompanied by a statement by the State of Upper Austria and the Vienna Environmental Ombudsman. The opinion of the Austrian Institute of Ecology, signed by 12 non-governmental organisations in addition to the Institute, was also annexed to the opinion.

In its opinion, the Austrian Environment Agency states that Austria will participate in the EIA procedure for the project. According to the Agency, the possibility of significant environmental impacts on Austria cannot be excluded, in particular in the event of a severe accident. In its reply, the Austrian Ministry of Climate, Environment, Energy, Mobility, Innovation and Technology hopes that Finland will later send an assessment report and information on public consultation and participation in the procedure to Austria.

According to the expert opinion, extending the service life of the plant units to more than 60 years would make these plants the first Gen II plants in Europe with such a long service life. According to the opinion, the assesment programme assesses local environmental impacts in great detail, but the assessment of transboundary impacts and the management of ageing remain less important. According to the statement, prolonging the service life of plant units increases the likelihood of a transboundary accident. The expert opinion requires the presentation of selection criteria and the criteria, technical basis, safety assessment and impact assessment for different options. There is also a need to consider alternatives such as new nuclear power plants or non-nuclear power plants.

According to the expert opinion, the cumulative effect of the power increase on structures and equipment must be carefully investigated, taking into account previous power increases at plant units. According to the expert statement, the assessment report should present an ageing management programme with measures, plans for handling increased failure of equipment as the service life increases, plant changes required by service life extension, an approach for meeting the requirements of the authorities as the service life grows longer, an action plan for carrying out the analysis of the periodic safety assessment, a report on the remaining issues and corrective measures, a concept for reaching the safety objectives of new nuclear power plants with the extension of the service life, and numerical values for the metrics available. With regard to power uprating, the report should include the power uprating concept, a detailed list of plant changes, detailed handling of safety margins, an examination of safety improvements and safety performance in relation to the safety targets set for new nuclear power plants, a list of analyses to be carried out within the framework of the periodic safety assessment, and an assessment of the impact of the power uprating on the ageing of structures, systems and equipment.

According to the expert statement, the assessment report should also present an analysis of extreme weather phenomena and the rise and flooding of sea water, taking into account the impacts of climate change, an assessment of human-induced external threats, a summary of the results of the assessment of human-induced threats, an assessment of the impacts of military measures, an assessment of the combinations of external threats taking into account several units on the site, information on safety margins, impacts of threshold phenomena (cliff-edge) and the necessary or planned safety improvements for the analysis of all external threats and a thorough analysis of events and emissions affecting several plant units.

According to the expert opinion, as a result of a severe accident, actual emissions can be significantly higher than 100 TBq. According to the statement, areas with a radius of more than 1,000 km must be taken into account in the dispersion modelling. Reference is made to the Flexrisk research project. According to the opinion, from the point of view of transboundary impacts on Austria, the assessment report should include a list of cases analysed to determine the source term, a detailed description of severe accidents and source terms, taking into account all radionuclides relevant for transboundary impacts, a detailed description of the modelling assumptions for accidents, a thorough presentation of the modelling of dispersion, a presentation of the significant assumptions and justifications for the distribution calculations, and a probability distribution of radiation impacts that covers all eventualities.

The statement by the State of Upper Austria contains observations on the length of the service life of the plant units and, among other things, on the principles on which the decision to extend the service life of the nuclear power plant should be based. According to the opinion, extending the service life of nuclear power plants and the use of older nuclear power plants increase the risks associated with the use of nuclear energy in Europe. The risks of faults and malfunctions also increase. New threat scenarios, such as terrorism and extreme natural phenomena, have also increased.

In its opinion, the Vienna Ombuds Office for Environmental Protection raises a number of detailed questions related to the reduction of the overall efficiency of the plant in the power increase alternative, analyses of the brittle fracture scenario of the reactor pressure tank, analyses of component replacements, impacts in the proximity of the core, component replacements, compliance of material with safety standards in case of several service life extensions, consideration of the Vienna safety declaration, the latest-generation security systems and environmental risks caused by terrorism and war and the consideration of these in the environmental impact assessment procedure.

3.4.3 Latvia

In its reply, the Latvian Environment Agency states that Latvia will participate in the EIA procedure for the project.

The Latvian Ministry of Health proposes that more detailed information on the transboundary effects of the project on human health be added to the Latvian-language assesment programme and summary.

3.4.4 Lithuania

In its reply, the Lithuanian Ministry of Environment states that Lithuania will not participate in the EIA procedure for the project. However, Lithuania requests the environmental impact assessment report for information.

3.4.5 Norway

In its reply, the Norwegian Environmental Authority states that Norway will not participate in the EIA procedure for the project.

3.4.6 Polish

In its reply, the Directorate-General for Environmental Protection in Poland states that Poland will not participate in the EIA procedure for the project.

3.4.7 Swedish

In its reply, the Swedish Environmental Protection Agency states that Sweden will participate in the EIA procedure for the project. A statement from the Swedish Radiation Safety Authority, the Swedish Forest Agency, Swedish Food Agency, the Swedish Board of Agriculture and the association Miljovänner för Kärnkraft is attached to the Swedish opinion.

The Swedish Radiation Safety Authority estimates that extending the service life and power uprating of the plant units may have significant environmental impacts in the Swedish territory as referred to in the Espoo Convention. According to the authority, the procedure should take into account severe accidents that exceed the planning criteria, such as the assumed accidents in the Radiation and Nuclear Safety Authority's report STUKA268. Emissions must be limited by the application of best available techniques (BAT), also in the case of continued operation.

The Swedish Forest Agency notes that only the release of radioactive substances as a result of a severe reactor accident can lead to significant transboundary effects. In the assessment of the transboundary effects of a severe reactor accident, the impacts on ecosystem services in Swedish forests must be taken into account. The Swedish Food Agency states that a detailed study, risk assessment and impact analysis should be carried out in the environmental impact assessment on how a severe accident would affect drinking water and food production – including fisheries – outside Finland's borders. For example, it should be investigated whether a severe accident can lead to exceeding threshold values for food (Euratom 2016/52) in the EU.

3.4.8 Germany

The Land of Saxony states in its reply that it will participate in the EIA procedure for the project.

The Land of Saxony states that the assessment report should focus in particular on the current state of safety-relevant components and the management of ageing. In addition, different scenarios should be considered that may lead to the release of radioactive substances and, correspondingly, to several different source terms of different sizes in order to better interpret and assess potential transboundary effects. According to the opinion, the programme does not clearly describe how the periodic safety assessment to be carried out by 2028 at the latest relates to the project and what significance it has for the planning of any necessary technical measures. According to the opinion, the assessment report should contain information on the extent to which the risks of accidents leading to the release of radioactive substances change as a result of different project alternatives and how they are handled.

3.4.9 Denmark

In its reply, the Danish environment agency states that Denmark will participate in the EIA procedure for the project.

3.4.10 Hungary

The Ministry of Economic Affairs and Employment will provide the Hungarian reply, after receiving it, to the developer for consideration in the EIA procedure.

3.4.11 Estonia

In its reply, the Estonian ministry of climate announced that Estonia will participate in the EIA procedure for the project. Estonia's response is accompanied by a statement from the Estonian rescue service.

According to Estonian rescue service, the assessment report must describe in more detail how extending the service life and increasing the power of the plant units affect neighbouring countries, including Estonia, in particular as to whether and to what extent the life and health of people is threatened. On this basis, Estonia may assess whether it would be necessary to implement a radiation preparedness plan for Estonia in the event of an accident, rescue measures caused by a radiation emergency at the level of Estonian rescue services, or, with a possible request for assistance, to support Finland with resources.

3.5 Other comments and opinions

3.5.1 Österreichisches Ökologie-Institut, Vorarlberger Plattform gegen Atomgefahr, Anti Atom Komitee, Wiener Plattform Atomkraftfrei, Mütter gegen Atomgefahr | Mothers against Nuclear Hazard, Waldviertler EnergieStammtisch, Verein Lebensraum Waldviertel, atomstopp_atomkraftfrei leben!, Plattform gegen Atomgefahren Salzburg (PLAGE) e.V./Platform Against Nuclear Dangers, Gemeinsam für Sonne und Freiheit, Begegnungszentrum für aktive Gewaltlosigkeit, Jihočeské matky, z.s., NGO Estonian Green Movement

The statement by NGOs contains observations on the examination of alternative forms of energy production, the transboundary effects of a severe nuclear accident, the consequences of the ageing of the power plant and the increasing external threats. According to the statement, the assessment report should present an alternative based on the use of renewable energy, energy efficiency and energy saving measures, as well as a long-term forecast of Finland's energy needs.

According to the statement, the assessment report must provide more information on the consequences of a severe accident. In this context, reference is made to the Flexrisk research project, which, according to the opinion, demonstrates that the breakage of the reactor pressure vessel and the early closure of the containment may result in the release of a large proportion of the radioactive storage from the plant units. According to the statement, the 1,000 km limit used in the dispersion calculation is therefore not sufficient. According to the opinion, safety standards for new nuclear power plants are not applicable to old plants. In addition, according to the statement, the risk of a severe accident increases as the nuclear power plant ages.

The statement also draws attention to external threats such as terrorism and warfare. The statement further draws attention to the risks posed by climate change, such as floods and other extreme weather events. According to the organisations, the assessment report should take into account how the above risks increase as the plant ages. In addition, the assessment report should include accident calculations with the highest source term with non-zero risk, and dispersion calculations for the whole of Europe, not just for a radius of 1,000 km.

3.5.2 Miljovänner för kärnkraft

The Miljovänner för kärnkraft organisation supports the project alternative VE2b, i.e., extending the service life of the plant units at an uprated power level until 2058. According to the organisation, the option in question, together with an environmental perspective in accordance with the Espoo Convention, is the best alternative for comprehensive consideration of the environment in electricity production in Finland and thus in the Nordic electricity market as a whole.

3.6 Comments made in the public event

In cooperation with the developer, the Ministry of Economic Affairs and Employment organised a public event on the assesment programme at the Olkiluoto Visitor Centre on 6 February 2024 from 5:30 p.m. to 7:30 p.m. The event allowed remote participation. Among other things, the event discussed the additional need for electricity transmission to the main grid, the increase in cooling water temperature and volume, the role of the Radiation and Nuclear Safety Authority, the increase in the amount of nuclear fuel used and the consideration of the impacts of climate change in the assessment.

4 Statement by the competent authority on the evaluation programme

The statement of the Ministry of Economic Affairs and Employment is based on the requirements laid down in sections 16 and 18 of the Act on Environmental Impact Assessment Procedure and section 3 of the Government Decree on Environmental Impact Assessment Procedure (277/2017, hereinafter also the EIA Decree) as well as the statements and opinions received regarding the assesment programme. The ministry considers that the assesment programme meets the content requirements laid down in section 3 of the EIA Decree. The assesment programme presents a description of the project, its purpose, planning phase, location, size, land use need and its relation to other projects. In addition, the programme contains information on the developer of the project, an assessment of the project’s planning and implementation schedule, and information on the plans and permits required for the implementation of the project. In addition, as required by the above section, the programme presents reasonable alternatives to the project that are relevant for the project and its specific characteristics and one of which is the non-implementation of the project.

The ministry considers that the assesment programme is a sufficiently extensive and detailed plan for assessing the environmental impacts of the project, provided that the issues presented in this statement are taken into account as the project progresses and in later stages of the EIA procedure. In addition, other questions, comments and points of views have been raised in the statements and opinions received by the competent authority, to which the developer should pay attention.

4.1 Environmental impacts to be assessed and their assessment

As required by section 3 of the EIA Decree, the assesment programme contains a description of the current state and development of the environment in the likely impact area of the project as well as a proposal for identified and assessed environmental impacts, including transboundary environmental impacts and combined impacts with other projects, as well as justifications for the limitation of the environmental impacts to be assessed. In addition, the programme presents information on the reports prepared and planned on environmental impacts as well as the methods used for acquiring and evaluating the material and the related assumptions.

According to the assesment programme, based on preliminary planning data, the continuation of the current type of impacts after the current licence period, either until 2048 or until 2058, has been identified as the most significant environmental impact at this stage. In the case of power uprating, some changes will take place in the operation of the plant units, the most significant of which is an increase in the thermal load of cooling water. Based on preliminary data, the temperature of the cooling water discharged into the sea area would increase by approx. 1 °C compared to the current activity. This would have a slight impact on surface waters and ichtyofauna, also taking into account climate change scenarios.

According to the assesment programme, the positive effects of the greatest significance of the continuation of the operation of plant units and uprating their thermal power would very likely be on regional economies. The energy market is also expected to experience positive effects of great significance. In addition, the project is estimated to have positive impacts on, for example, greenhouse gas emissions and climate change mitigation.

According to the assesment programme, the aim is to define the scope of the environmental impact assessment area so that significant environmental impacts cannot be expected to occur outside the area under consideration. If it is established during the assessment procedure that an environmental impact has a wider impact area than expected, the impact area will be redefined. The environmental impacts will be examined especially in the power plant area and its surroundings, but the scope will also be extended if necessary. According to the assesment programme, the areas under review have been defined to the extent where the impacts could reach, at a maximum. The assesment programme states that in reality, environmental impacts will likely take place in an area smaller than the area under review.

According to the assesment programme, the uncertainties related to the assessment and their significance are described in the assessment report. In addition, as part of the environmental impact assessment work, the possibilities of preventing or mitigating the potential adverse impacts of the project are examined, for example, by means of planning and implementation. The identified prevention and mitigation measures are presented in the EIA report. When assessing the significance of environmental impacts, both the magnitude of the change and the sensitivity of the object affected are taken into account. Based on their significance, the impacts are classified as minor, moderate, large and very large. The impacts may be either positive or negative from an environmental point of view.

Next, the ministry will make some detailed observations to which the developer must pay attention in the further work of the project.

4.1.1 Continuation of operation, power uprating and management of ageing

Continuation of the operation of the plants is linked to the two implementation options examined in the assesment procedure, namely the continuation of the operation at the current power level until 2048 (VE1a) or 2058 (VE1b) and the continuation of the operation at an uprated power level until 2048 (VE2a) or 2058 (VE2b).

The assesment programme points out that the plant units have been qualified for a service life of 60 years. Qualification of the systems for a service life of 70 or 80 years is planned to be done through a separate management programme by 2038. According to the assesment programme, the same basic principles of nuclear and radiation safety will be observed during the continuation of operation as in the current legislation. During the continuation of any use, safety improvements will also be made in accordance with a good safety culture. According to the assesment programme, the maintenance and improvement work required to continue the operation of the plant units is carried out within the plant units and there is no need for additional construction in the power plant area.

Increasing the thermal power of the plant units is related to project options VE2a and VE2b. According to the assesment programme, the maintenance and improvement work already carried out in the plant units in previous years will enable the implementation of the power uprating and its combination with a periodic safety assessment to be carried out by 2028 at the latest. According to the assesment programme, uprating the reactor thermal power can be achieved through changes and reparameterisation of existing systems without substantially changing their functionality.

The Ministry of Economic Affairs and Employment considers it important that the risk factors related to the possible extension of the service life of the plants and the impacts of the ageing of the plants are carefully assessed and that the means of preventing or mitigating the impacts are assessed. The Radiation and Nuclear Safety Authority will assess the safety of continued operation and power uprating later in connection with the processing of the licence application.

In addition, the ministry notes that the assessment report should contain a concise description of the methods used to monitor ageing and reduce the consequences of ageing. In particular, methods should be described to prevent possible risks of accidents and, consequently, high emissions resulting from ageing. The assessment report should also address the application of the BAT principle to reduce or prevent emissions. The impact of power uprating on ageing should also be addressed.

4.1.2 Surface and groundwater and ichtyofauna

The assesment programme identifies, in the case of continued operation, as the most significant environmental impacts the continuation of present-like effects and, in the case of power uprating, the increase of the thermal load of the cooling water. Based on preliminary data, the temperature of the cooling water discharged into the sea area would increase by approx. 1 °C compared to the current activity. This would have a slight impact on surface waters and ichtyofauna, also taking into account climate change scenarios.

According to the assesment programme, the impacts of the thermal load caused by the project on the physicochemical water quality and ice conditions, and possible indirect impacts on the ecological and chemical status of the marine area in different alternatives will be assessed as an expert assessment based on the current state of the marine area and the distribution modelling of heated cooling water. The assessment focuses on Olkiluoto's nearby sea area within a radius of approximately 10 km. The groundwater impact assessment examines whether the project will have an impact on the quality, quantity or surface level of groundwater. Existing research data on groundwater conditions and the quality of groundwater in the area are used as the basis for the assessment.

The Ministry of Economic Affairs and Employment notes that the impacts of cooling waters are the most significant of the environmental impacts of a nuclear power plant during normal operation. However, in the ministry's view, the assessment of impacts on water bodies should not only be restricted to cooling waters, but the impacts should be assessed for the entire operation of the plant. The significance of climate change to the environmental impacts of the project must be taken into account in modelling.

4.1.3 Risks caused by climate change and external threats

According to the assesment programme, the risks caused by climate change (e.g. rising sea level or floods) to the project will be identified during the EIA report phase with regard to possible exceptional situations and accidents related to them, and preparation for the risks will be described.

The Ministry of Economic Affairs and Employment states that climate change affects external threats to the plant, including extreme weather phenomena. The ministry considers that the assessment report should assess phenomena caused by climate change at the site and the preparedness for them. External threats to the project include not only extreme weather phenomena but also other threats. External threats and the risks arising from climate change must be taken into account when assessing the safety of the project. The Radiation and Nuclear Safety Authority will assess the safety of the project later in connection with the processing of the licence application.

4.1.4 Emissions of radioactive substances and radiation

According to the assesment programme, the radiation exposure of employees and the impacts of emissions of radioactive substances are assessed based on the actual emissions of radioactive substances in the power plant and the radiation doses received by the employees. Radioactive emissions to air and water and the calculated radiation doses caused by them to the inhabitants of the surroundings are presented and compared to the set emission limits and dose limits. According to the radiation monitoring carried out in the surroundings of the plant area, the examination area is approximately 10 km, and further the examination area for radiation dose calculations is 100 km.

The Ministry of Economic Affairs and Employment considers the proposed assessment appropriate. In addition, the ministry states that the radiation doses of employees must be examined in accordance with the ALARA principle, also taking into account the effect of the power uprating.

4.1.5 Waste and by-products

According to the assesment programme, the EIA report describes the quantity, quality and treatment of very low, low and intermediate-level waste generated in the operation of the nuclear power plant as well as conventional and hazardous waste. The related environmental impacts are assessed on the basis of, for example, the properties of waste and by-products, waste treatment methods and final disposal solutions. The processing and intermediate storage of spent nuclear fuel in the power plant area and the transport of spent nuclear fuel from the power plant to the Posiva encapsulation and final disposal plant in Olkiluoto are described. The environmental impacts of the transports and final disposal of spent nuclear fuel have been assessed in Posiva's encapsulation and final disposal facility's environmental impact assessment procedure, the main results of which are described in the EIA report. In addition, the risk and implementation method report on transports will be utilised.

According to the assesment programme, extending the service life does not affect the amount of fuel used annually, but the amount of fuel removed from the reactor annually remains at the current level (19 t/year). However, in the continuation of plant units, the total amount of spent nuclear fuel will increase according to the additional years of operation. If the operation continues from 2038 to 2048, the total amount of spent nuclear fuel will increase by about 378 t. If the operation continues until 2058, the corresponding increase is approximately 767 t. According to the current plan, the final disposal of spent fuel at Posiva is to begin in the 2020s, in which case the capacity of the interim storage for spent fuel will be sufficient to accept the spent fuel from the OL1 and OL2 plant units. If the start of final disposal activities at Posiva were to be substantially delayed for some reason, storage capacity at the KPA storage may need to be increased.

The assessment programme points out that Posiva will licence the capacity of its disposal facility to match the needs of its owner´s nuclear power plants. Posiva has previously carried out an EIA procedure for 12,000 uranium tonnes of spent nuclear fuel, which included the Olkiluoto 4 and Loviisa 3 plant units that were being planned at the time. Based on the aforementioned environmental impact assessment, the impacts on the environment will not substantially increase even if more fuel is placed in final disposal. According to the assesment programme, the extension of service life does not significantly affect the annual accumulation of very low, low and intermediate-level waste. However, the total amount of nuclear waste mentioned above will increase according to the additional years of operation. The programme estimates that the total capacity of the VLJ repository is sufficient for the final disposal of the nuclear waste in question.

In the Ministry of Economic Affairs and Employment's view, extending the service life of nuclear power plant units as well as uprating their thermal power will significantly increase the amount of spent nuclear fuel. The total amount of other nuclear waste will also increase. The ministry considers important the company's planned report on waste and by-products in the Olkiluoto area. Attention should be paid to the adequacy and timeliness of the nuclear waste management arrangements required for the extension of service life. Attention should also be paid to the potential impacts of the fuel technology changes required by the power uprating on existing nuclear waste management arrangements. If the environmental impact assessment of the implementation of nuclear waste management refers to previous environmental impact assessments, their most significant impacts must be described.

4.1.6 Exceptional and accident situations and transboundary impacts

According to the assessment programme, the EIA report examines a severe reactor accident as an imaginary accident case. The assessment is based on the assumption that an amount of radioactive substances equivalent to the limit value for a severe accident pursuant to section 22 b of the Nuclear Energy Decree (161/1988) is released into the environment (100 TBq of Cs-137 nuclides). The impacts of such a release´s dispersion in the accident will be studied over a distance of 1,000 km from the power plant. The fallout and radiation dose resulting from the release and the impacts on the environment will be described on the basis of the modelling results and existing research data. In addition, the EIA report describes identified environmental and safety risks related to the operation of the power plant and assesses the impacts of potential incidents and accidents based on authority requirements and the power plant´s safety and risk analyses, among other things.

According to the assesment programme, the preliminary estimate for the alternatives to be examined in the EIA procedure is that only the impacts of releases of radioactive substances resulting from a severe reactor accident could extend beyond the borders of Finland. The EIA report assesses possible transboundary, for example on the basis of dispersion calculations, in which the impacts of the dispersion of the accidental release are examined up to 1,000 km from the power plant. In addition, other possible risks related to incidents, accidents and transports are examined and the potential for the impacts extending beyond the borders of Finland is assessed.

The Ministry of Economic Affairs and Employment notes that Finland has set the high emission threshold value at 100 TBq caesium-137 and this value has been used as a source term describing an INES 6 category accident in Finnish environmental impact assessments. The ministry considers that it is appropriate for the developer to present a comparison between the source term used and more realistic emissions estimated for the plant under review. At the same time, the developer should also examine the plant’s safety principles that aim to prevent or reduce major emissions in the event of severe accidents.

The ministry also notes that the assessment report must also address any other exceptional situations and risks, such as fires or transport-related risk situations. Assessing the impacts of exceptional circumstances and emergencies must not be limited to the exclusion area or the emergency planning zone for rescue operations. The EIA report must contain various accident scenarios involving emissions and, with the help of illustrative examples, describe the extent of the affected zones and the impact of emissions on people and nature.

4.1.7 Energy market and security of supply

According to the assesment programme, the impacts on the energy market and availability of electricity are assessed on the basis of statistics, forecasts and reports on the electricity markets in Finland and other Nordic countries, taking into account Finland’s target of carbon neutrality by 2035. The impacts on the electricity market are examined taking into account the schedule for the various project alternatives.

The Ministry of Economic Affairs and Employment notes that it is appropriate to assess the impacts on the energy market and security of supply, but the developer is not required to carry out nationwide energy market and security of supply reviews.

4.2 Competence of the authors of the assesment programme

According to section 33 of the EIA Act, the developer must ensure that it has sufficient expertise available to prepare the environmental impact assessment programme and report. The competent authority will evaluate the expertise when reviewing the assessment programme and report. According to the detailed rationale of the act (HE 259/2016 vp, detailed rationale of section 33), the provision is flexible, as in addition to training and experience, the adequacy of expertise can be assessed by taking into account, for example, the competence in a special field demonstrated in practice by the experts used by the developer.

The environmental impact assessment programme was prepared by Ramboll Finland Oy as a consultant. The experts participating in the EIA working group are presented in appendix 2 of the assesment programme.

The Ministry of Economic Affairs and Employment notes that the assesment programme contains, as required by section 3 of the EIA Decree, sufficient information on the qualifications of the parties preparing the assesment programme. The ministry considers that the developer has sufficient expertise at its disposal in the preparation of the environmental impact assessment programme.

4.3 Plan for the EIA procedure and participation

The assesment programme includes a plan for organising the assesment procedure and the related participation and interaction. The assesment programme describes the public events organised in connection with the assesment programme and later in connection with the assessment report. A monitoring group consisting of different stakeholders is to be set up for the assesment process.

The assesment programme includes a preliminary schedule for the project and the EIA procedure. According to the assessment presented in the assesment programme, the developer will submit the assessment report to the competent authority in August 2024. The period of availability for viewing of the assessment report would be August, September and October 2024. The reasoned conclusion of the competent authority would then be issued in December 2024.

The ministry notes that, as required by section 3 of the EIA Decree, the assesment programme presents, to the extent necessary, a plan for organising the assesment procedure and the related participation as well as their connection to the planning of the project and an estimate of the date of completion of the assessment report.

5 Submission and communication of the competent authority's statement

In accordance with section 18 of the EIA Act, competent authority will give its statement on the environmental impact assessment programme and other statements and opinions to the developer. At the same time, the statement will be forwarded to the relevant authorities and published on the ministry's website at https://tem.fi/olkiluoto-ol1-ja-ol2-yva-ohjelma.

Minister of Climate and the Environment	Kai Mykkänen
Senior Specialist	Hanna-Mari Kyllönen

Distribution	Teollisuuden Voima Oyj
For information:	Authorities concerned Other commentators

Appendix 4. The consideration given to the coordinating authority's statement on the EIA programme when drawing up the assessment report

Acting as the coordinating authority, the Ministry of Economic Affairs and Employment provid-ed its statement on the EIA programme on 25 April 2024. According to the statement, the EIA programme prepared by Teollisuuden Voima Oyj covers the content requirements set in Sec-tion 3 of the EIA Decree. The coordinating authority took the view that in terms of its scope and accuracy, the assessment programme was sufficient for assessing the project's environ-mental impacts, provided that the issues presented in the coordinating authority's statement are taken into account as the project progresses and in the later stages of the EIA procedure. In addition, other questions, comments and considerations have been raised in the state-ments and opinions, and the party in charge of the project should pay particular attention to these. According to Section 4(15) of the EIA Decree, the assessment report must present an account of how the coordinating authority's statement regarding the assessment has been considered.

The accompanying table compiles together the main points which, according to the coordinat-ing authority's statement, require attention during the impact assessment or supplementa-tion while drawing up the assessment report. The right-hand column of the table describes how the statements have been taken into account in the EIA report.

Main points of the statement by the coordinating authority	Consideration in the EIA report
4.1 The environmental impacts being assessed and the assessment methods	
The ministry next presents some detailed considerations to which that the party in charge of the project should pay attention in the further work on the project	
4.1.1 Extension of service life, uprating of thermal power and ageing management of the nuclear facility	
Extending the service life of the plant units is related to both implementation options considered in the evaluation procedure, which are continuing the operation at the current power level until 2048 (VE1a) or 2058 (VE1b) and continuing the operation at an uprated power level until 2048 (VE2a) or 2058 (VE2b). The assessment programme points out that the plant units are qualified for a service life of 60 years. The plan is to qualify the systems for a service life of 70 or 80 years with the help of a separate management programme by 2038. According to the assessment programme, the current basic principles for nuclear safety and radiation will continue to be observed during the service life extension, taking into account the requirements of evolving legisla-tion. During the possible service life extension, safety improvements will also be made in line with a good level of safety culture. According to the assessment programme, the maintenance and improvement work required by the service life extension of the plant units will be implemented inside the plant units, and no additional construction will be required in the power plant area. Uprating the thermal power of the plant units is related to project alternatives VE2a and VE2b. According to the assessment programme, the maintenance and improvement work already performed at the plant units in earlier years allow for the power uprating to be implemented and combined with the periodic safety assessment that will be performed at the latest in 2028. According to the assessment programme, increasing the thermal power of the reactor may be implemented by means of modification and reparameterisation of existing systems without essentially changing their functionality.	The project alternatives are described in Chap-ters 1.3 and 3.
The Ministry of Economic Affairs and Employment considers it important that the risk factors related to the possible extension of the service life of the plant units and the effects of the aging of the plant are clarified and the means of preventing or mitigating the effects care-fully evaluated. The Radiation and Nuclear Safety Authority will assess the safety of the extension of service life and uprating of thermal power later in connection with the processing of the permit application. In addition, the Ministry states that the assessment report should closely describe the methods used to monitor aging and to reduce the consequences of aging. In particular, the methods used to prevent possible risks of accidents and, thus, large emissions resulting from aging should be described. The assessment report should also deal with the applica-tion of the BAT principle to the reduction or prevention of emissions. The impact on aging of the power uprating should also be discussed.	Service life manage-ment and maintenance in the alternatives is described in Chapters 3.2.1 and 3.3.1. The impacts related to the alternatives and the methods for mitigating them are described for each impact in Chapter 6. Possible risk factors and the preparations for them are described in Chapter 6.18. The appli-cation of the best avail-able technology (BAT) in terms of emissions is described in Chapter 3.2.1.

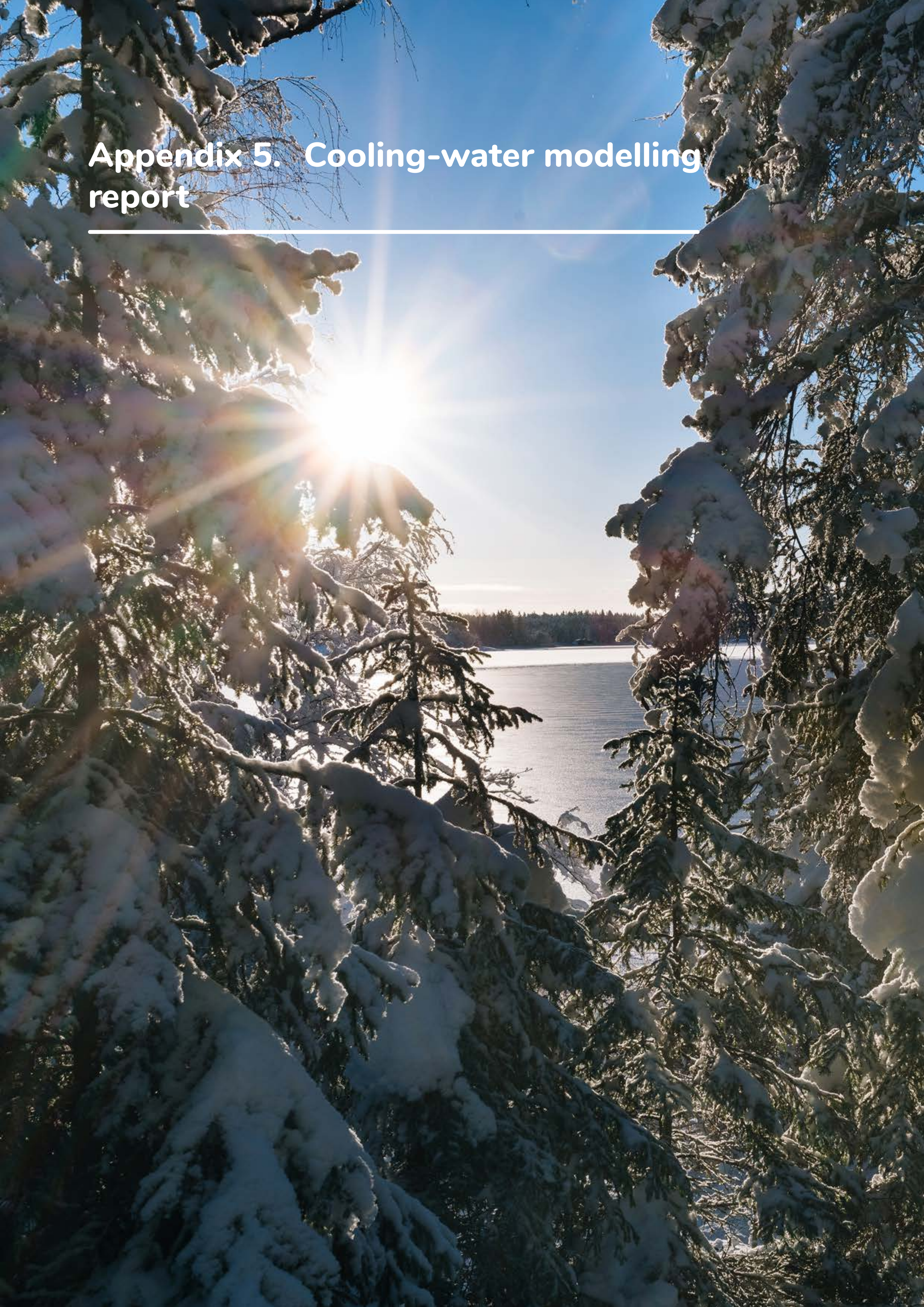
Main points of the statement by the coordinating authority	Consideration in the EIA report
4.1.2 Surface water, groundwater and fish stocks	
The assessment programme has identified the increase in the thermal load of the cooling water as the most significant environmental impact in the case of continued operation, in the case of the continuation of the current impacts and in the case of uprating the thermal power. Based on preliminary information, the temperature of the cooling water discharged into the sea area would increase by approx. 1 °C when compared to the current activities. As a consequence, the impacts on surface water and fish stocks would be increased slightly, when climate change scenarios are also considered. According to the assessment programme, the impacts of the thermal load caused by the project on the sea area's physicochemical water quality and ice situation and any possible indirect impacts on the ecological and chemical status in the different alternatives are assessed as an expert assessment, based on data on the current status of the sea area and a dispersion model for warm cooling water. The area under review in the assessment com-prises the nearby sea areas of Olkiluoto to a radius of approximately 10 km. The groundwa-ter impacts assessment examines whether the project causes impacts on the quality, vol-ume or surface level of groundwater. Existing research data on the groundwater conditions in the area and groundwater quality will be used as initial data for the assessment. The Ministry of Economic Affairs and Employment states that the effects of cooling water are the most significant of the environmental impacts during normal operation of the nuclear power plant. However, according to the Ministry's view, the assessment of the impacts on water bodies should not be limited only to cooling water; the impacts should be assessed for the operation of the entire plant. The modelling should take into account the importance of climate change to the environmental impacts caused by the project.	The impacts on surface water (including impacts of cooling water, wastewater and water intake) are assessed in Chapter 6.8. The as-sessment has taken into account the current state of the sea area (Chapter 6.8.2) and, in the cooling water modelling, the effects of climate change. The climate change scenari-os used in the modelling are described in Chapter 6.8.1. The results of the sur-face water impact as-sessment have also been used in areas such as the evaluation of the impacts on fish stocks and fishing (Chapter 6.9) and on vegetation, animals and protected areas (Chapter 6.10). The impacts on ground-water are assessed in Chapter 6.7.
4.1.3 Risks caused by climate change and internal and external threats	
According to the assessment programme, the risks to the project caused by climate change (such as sea level rise or flooding) are identified in the EIA report stage as regards any possible incidents and accidents related to them, and preparation for them is described. The Ministry of Economic Affairs and Employment notes that climate change affects the external threats to the plant, including extreme weather phenomena. The Ministry considers that the assessment report should assess the phenomena caused by climate change at the plant site and the preparation for these. External threats affecting the project include not only extreme weather phenomena, but also other threats. External threats and risks caused by climate change must be taken into account when evaluating the safety of the project. The Radiation and Nuclear Safety Authority will assess the safety of the project later in connec-tion with the processing of the permit application.	Preparations for exter-nal threats and extreme weather conditions has been discussed in Chap-ter 6.18.4.3.
4.1.4 Releases of radioactive substances and radiation	
According to the assessment programme, the radiation exposure of employees and the impacts of releases of radioactive substances will be assessed on the basis of the actual releases of radioactive substances from the power plant and the radiation doses received by the employees. The radioactive releases into the air and water system resulting from the operations and the calculated radiation doses caused to the surrounding population are presented and compared with the set emissions limits and dose limitations. The area under review is, in line with the radiation monitoring performed in the nearby areas of the power plant, an area of approximately 10 km; furthermore, in radiation dose calculation, the area is 100 km. The Ministry of Economic Affairs and Employment considers the assessment presented to be appropriate. In addition, the ministry states that the radiation doses to employees should be examined in accordance with the ALARA principle, also taking into account the impact of the power uprating.	Releases of radioactive sub-stances and radia-tion exposure (including local residents and employees) are exam-ined in Chapter 6.16. Background in-formation on the health impacts of radiation is described in Chapter 6.17. Possible incident and accident situations and their impacts have been evaluated in Chapter 6.18.

Main points of the statement by the coordinating authority	Consideration in the EIA report
4.1.5 Waste and byproducts	
According to the assessment programme, the EIA report describes the amount, nature and processing of conventional waste, hazardous waste and very low, low and intermediate-level radioactive waste generated during the operation of the nuclear power plant. The environ-mental impacts related to these are assessed based on, among other things, the character-istics of the waste and byproducts, the waste processing methods and the final disposal solutions. The handling and interim storage of spent nuclear fuel in the power plant area as well as transports of spent nuclear fuel from the power plant to Posiva's encapsulation plant and disposal facility at Olkiluoto are described. The environmental impacts of the transport and final disposal of spent nuclear fuel are assessed in the environmental impact assess-ment for the encapsulation plant and disposal facility performed by Posiva, the main results of which are described in the EIA report. The risk and implementation analysis concerning transports is also utilised. According to the assessment programme, the service life extension does not affect the volume of fuel used each year; the amount of fuel being removed from the reactor each year will remain at the current level (19 t/a). However, the total amount of spent nuclear fuel will increase according to the number of additional years of operation. If operation is continued from 2038 until 2048, the total amount of spent nuclear fuel will increase by a total of ap-proximately 378 t. If operation continues until 2058, the corresponding addition will be approximately 767 t. According to the current plan, the final disposal of spent fuel at Posiva is to begin in the 2020s, in which case the capacity of the interim storage for spent fuel (KPA) will be sufficient to accept the spent fuel from the OL1 and OL2 plant units. If the start of final disposal activities at Posiva were to be substantially delayed, storage capacity at the KPA storage may need to be increased. Assessment programme notes that Posiva will license the capacity of its disposal facility to match the needs of its owners' nuclear power plants. Posiva has previously carried out an EIA procedure for 12,000 t of spent nuclear fuel, which included the Olkiluoto 4 and Loviisa 3 plant units that were being planned at the time. Based on the aforementioned environmen-tal impact assessment, the impacts on the environment will not substantially increase even if more fuel is placed in final disposal. According to the assessment programme, extending the service life does not significantly affect the amount of very low-level, low-level or medi-um-level nuclear waste accumulated each year. However, the total amount of the aforemen-tioned forms of spent nuclear fuel will increase according to the number of additional years of operation. The programme estimates that the final disposal capacity of the company's operating waste repository is sufficient for nuclear waste disposal.	For other nuclear waste, the corresponding in-formation is presented in Chapters 3.2.7 and 3.3.7. The impact assessment (Chapter 6.15) reviewed the volume, quality and handling of the very low, low and intermediate-level, and conventional waste generated during extended operation and power uprating in the power plant area. The handling and interim storage of spent nuclear fuel in the site area are described and their environmental impacts are assessed on the basis of, among other things, the plant's ac-tion plans. Transfers of spent nuclear fuel from the power plant to Posiva's encapsulation plant and disposal facility, as well as the main principles and long-term safety of the spent nuclear fuel's final disposal concept, were reviewed at a general level based on Posiva's publications.
According to the Ministry of Economic Affairs and Employment, extending the service life of the nuclear power plant units and uprating their power will significantly increase the amount of nuclear fuel used. The total amount of other nuclear waste will also increase. The ministry considers the company's planned report on waste and byproducts in the Olkiluoto area as important. Attention must be paid to the adequacy and timeliness of the nuclear waste management arrangements required by the extension of service life. Attention must also be paid to the possible impacts on the existing nuclear waste management arrangements of the changes to fuel technology required by the power uprating. If the assessment of the environmental impacts caused by the implementation of nuclear waste management refers to earlier environmental impact assessments, their most significant impacts must be de-scribed.	

Main points of the statement by the coordinating authority	Consideration in the EIA report
4.1.6 Incidents and accidents; transboundary impacts	
According to the assessment programme, a severe reactor accident is examined in the EIA report as an imaginary accident case. The assessment is based on the assumption that an amount of radioactive substances equivalent to the limit value for a severe accident pursu-ant to Section 22 b of the Nuclear Energy Decree (161/1988) is released into the environ-ment (100 TBq of Cs-137 nuclides). The impacts of such a release's dispersion in the acci-dent will be studied over a dis-tance of 1,000 km from the power plant. The fallout and radia-tion dose resulting from the release and the impacts on the environment will be described on the basis of the modelling results and existing research data. The EIA report also de-scribes identified environmental risks and safety risks related to the operation of the power plant and assesses the impacts of potential incidents and accidents based on authority requirements and the power plant's safety and risk analyses, among other things. According to the assessment programme, as regards the alternatives examined in the EIA procedure, a preliminary estimate indicates that only the impact of releases of radioactive substances resulting from a severe reactor accident could extend be-yond the borders of Finland. In the EIA report, the possible transboundary impacts will be assessed on the basis of, among other things, a dispersion calculation where the impacts of the release's disper-sion in the accident will be studied up to a dis-tance of 1,000 km from the power plant. Fur-thermore, other potential risks related to, for example, incidents, accidents and transports are examined and the potential for the impacts extending beyond the borders of Finland is assessed. The Ministry of Economic Affairs and Employment states that in Finland the limit value for a large emission has been set at 100 TBq for the emission of cesium-137, and this value has been used as a source term to describe an INES class 6 acci-dent in Finnish environmental impact assessments. The ministry considers that it is appropriate for the party in charge of the project to present a comparison between the source term used and the more realistic estimated emission for the plant under consideration. In the same context, it is also advisa-ble for the party in charge of the project to clarify the safety principles of the plant which aim to prevent or reduce large emissions in the event of serious accidents. In addition, the Ministry states that the assessment report must also deal with possible other incident situations and risks, such as fires or transport-related risk situations. The assessment of the impacts of incidents and accidents should not be limited to the precau-tionary action zone or the emergency preparedness area. The assessment report must present various accident situations that cause emissions and use illustrative examples to describe the extent of the affected areas and the effects of the emissions on people and nature.	The imaginary situation of a serious reactor accident and its impacts are described in Chap-ter 6.18.3. Other incident and accident situations have been discussed in Chap-ter 6.18.4. In addition, the trans-boundary impacts of a serious reactor ac-cident are described in Chapter 6.19.1.
4.1.7 Energy markets and security of supply	
According to the assessment programme, the impacts on the energy markets and security of supply are assessed on the basis of statistics on the electricity markets of Finland and other Nordic countries as well as projections and reports, taking into account Finland's target of carbon neutrality by 2035. Impacts on the electricity markets and Finland's security of supply will be examined while taking into account the schedule for the various project alternatives. The Ministry of Economic Affairs and Employment states that it is appropriate to as-sess the impacts on the energy market and security of supply, but that the party in charge of the project is not required to conduct countrywide reviews of the energy market and security of supply.	The impacts on energy markets are described in Chapter 6.13.

Main points of the statement by the coordinating authority	Consideration in the EIA report
4.2 Qualifications of the parties preparing the assessment programme	
According to Section 33 of the EIA Act, the party in charge of the project must ensure that it has sufficient expertise to prepare the environmental impact assessment programme and report. The coordinating authority evaluates the expertise when inspecting the assessment programme and report. According to the preliminary work on the law (Government Proposal 259/2016, detailed grounds given for Section 33), the provision is flexible, because, in addi-tion to training and experience, the practically demonstrated expertise of the experts used by the party in charge of the project can be taken into account when assessing the adequacy of their expertise. The environmental impact assessment programme has been drawn up by Ramboll Finland Oy under a consulting arrangement. Appendix 2 to the assessment programme indicates the experts who participated in the EIA working group. The Ministry of Economic Affairs and Employment states that the assessment programme contains the necessary information required by Section 3 of the EIA Decree on the qualifica-tions of the authors of the assessment programme. The Ministry takes the view that the party in charge of the project has sufficient expertise to prepare the environmental impact assessment programme.	The authors of the EIA report and their qualifi-cations are presented in Appendix 2.
4.3 Plan on the arrangement of the EIA procedure and participation	
The assessment programme includes a plan for organising the assessment procedure and the related participation and interaction. The assessment programme describes the public events organised in connection with the assessment programme and later the assessment report. It is planned to establish a monitoring group consisting of different stakeholders for the assessment procedure. The assessment programme includes a preliminary schedule for the project and the EIA procedure. According to the estimate presented in the assessment programme, the party in charge of the project will submit the assessment report to the coordinating authority in August 2024. The assessment report would be available for public review in August, Sep-tember and October of 2024. The coordinating authority's reasoned conclusion would then be issued in December 2024. The Ministry notes that, as is required by Section 3 of the EIA Decree, the assessment pro-gramme, presents to the necessary extent a plan for organising the assessment procedure and related participation, as well as the connection of these to the project planning, and an estimate of when the assessment report will be completed.	The updated schedule of the EIA procedure is described in Chapter 4.4 and participation in the procedure in Chapter 4.5.
5 Submission of the coordinating authority's statement and informing about it	
In accordance with Section 18 of the EIA Act, the coordinating authority submits its state-ment and other statements and opinions to the party in charge of the project. At the same time, the statement is submitted for information to the relevant authorities and published on the ministry's website at https://tem.fi/olkiluoto-ol1-ja-ol2-yva-ohjelma.	

Appendix 5. Cooling-water modelling report



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EXTENDING THE SERVICE LIFE OF THE OLKILUOTO 1 AND OLKILUOTO 2 PLANT UNITS AND UPRATING THEIR THERMAL POWER

SIMULATION OF IMPACTS ON SEAWATER FLOWS, TEMPERATURES AND ICE COVER

RAMBOLL

SIMULATION OF IMPACTS ON SEAWATER FLOWS, TEMPERATURES AND ICE COVER

Date	30 Aug 2024
Author	AI Innovaatio Oy; Arto Inkala
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Description	Simulation of impacts on seawater flows, temperatures and ice cover

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CONTENTS

1. BACKGROUND AND PURPOSE OF THE REPORT

Teollisuuden Voima Oyj (TVO) is planning an extension of the operation of the Olkiluoto OL1 and OL2 plant units and a possible power uprating. For the related EIA procedure and Natura needs assessment, an assessment of the project's impacts on the state of the sea area is required. A model for the Natura assessment of the OL4 plant unit has previously been prepared on the area (Inkala & Lauri 2009). This model application could be used as a basis for the study that has now been carried out.

2. CALCULATION MODEL

Model grid

A regionally refined grid with several nested levels was used to model the coastal area off Olkiluoto. Efforts have been made to model the actual target area with sufficient accuracy in relation to the goals of the study and the available computing capacity. More coarse grids are used to define boundary values for the target area grid. The area near Olkiluoto is modelled to a precision of 40 m (size of grid level 11 x 10.4 km). The outermost level of the grid covers a section of the Baltic Sea from approximately the Hiidenmaa level to the Northern Quark (precision 5 km, size 300 x 475 km). Furthermore, there are two grid levels between the nearby areas and the outermost area, with precisions of 1 km and 200 m. Depth-wise, the grid is divided into 21 levels whose size varies from half a metre, used near the surface, to one hundred metres used in the open sea abysses. The location of the calculation grid is shown in Figures 1 and 2.

In the more coarse grids, the free depth data available on the Baltic Sea (Baltic Gis 2008) and the digital map data of the Maritime Administration from the vicinity of Olkiluoto (Merenkulkulaitos 2006) were used as depth data. The depth information on the nearest area was digitised from the 1 m depth curve data and technical drawings provided by TVO. If there are excessively few depth points, linear interpolation produces excessively shallow depths for points close to the shore. For this reason, the lowest depth used in the model grid is one metre.

The shoreline of the OL4 model application used as a basis has been updated with respect to the cooling water intake and discharge structures of the OL3 plant unit and the Kuusisenmaa embankment. New measurements have also been available from the sea areas close to the water intake and discharge locations (Teollisuuden Voima Oyj 2023).

Similarly to the OL4 model application, an arrangement of the grid different from the depth data of the cooling water discharge point had to be implemented for computational reasons. There must be enough land around the discharge point, or the temperature settings will leak into the surrounding water area. Controlling the calculated flow requires an additional earth cell below the discharge point and a directed flow, so that the calculated flow rate and the spread of the thermal emission will correspond to reality better.

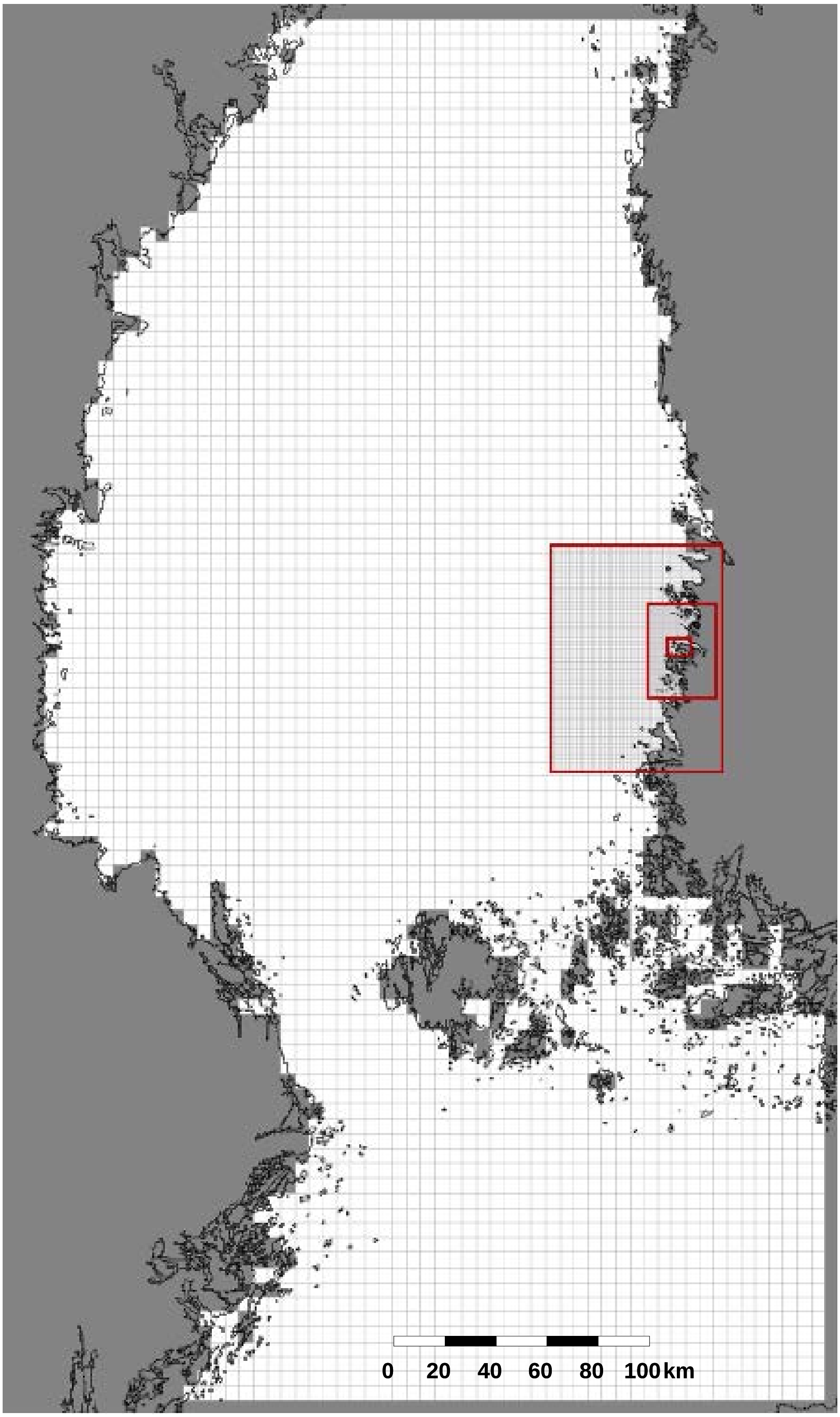

Figure 1. Entire model grid with nested sections delimited in red. The sizes of the elementary cells, from largest to smallest, are 5 km, 1 km, 200 m and 40 m.

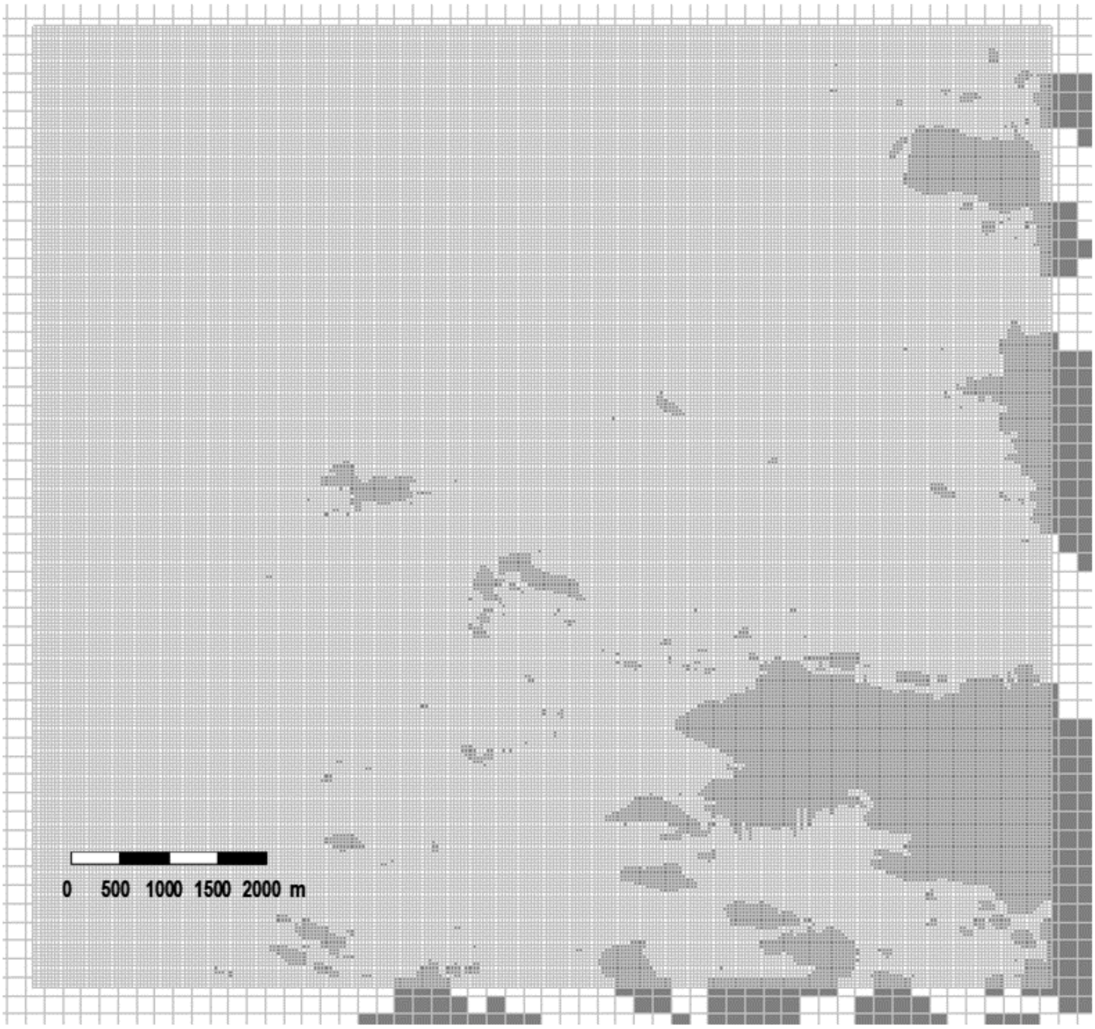

Figure 2. The vicinity of Olkiluoto; the size of the elementary cells in the more coarse grid is 200 m and in the finer one 40 m.

Calculation methods and parameters

The model calculations were done by using the 3D flow model developed by YVA Oy, which is a baroclinic model suitable for water areas based on the hydrostatic Navier-Stokes equations. A more detailed description of the model can be found in Appendix 1. In this respect, the model did not differ from the earlier OL4 model application.

The following calculation settings were used in the Olkiluoto application:

- Non-linear flow equations are used in the calculation, where the transfer of momentum is calculated with the TVD-Superbee algorithm.
- The density effect of temperature and salinity is included in the flow calculation.
- The calculation of vertical turbulence uses the k-epsilon turbulence model.
- The calculation of horizontal turbulence uses the Smagorinsky turbulence model.
- The motion of the thermal load is calculated with the TVD-Superbee algorithm.
- The vertical temperature diffusion is calculated from the momentum diffusion by using a depth-dependent correction factor.
- The temperature balance of the surface layer of water is calculated based on incoming and outgoing radiation and evaporation for each elementary cell separately.
- A dynamic ice model was used to calculate the winter period.

3. SIMULATION SCENARIOS AND INITIAL DATA

Simulation periods and scenarios

The main aim of the simulations was to achieve an understanding of the impacts of uprating the power of the OL1 and OL2 plant units and to assess extending the operation of the plant units from the end of the current operating licence period in 2038 until 2048 or 2058. As the effects are assessed over a long period of time, the effects of climate change were also assessed for the coming years. The model simulations examined the effect of climate change and power uprating on seawater flows, temperatures and ice cover. In order to estimate the yearly fluctuation, a cool and a warm summer and a cold and a mild winter were chosen as simulation periods.

The model was used to simulate the open water season in the summer period from 1 May to 1 September and the winter period from 1 December to 1 May. In order to assess the current situation, periods were chosen from the past ten years that are as warm or as cool as possible, which means that the impacts will most likely remain between these two extremes. Table 1 collects together weather information from Pori (Finnish Meteorological Institute 2023b), based on which the years 2017 and 2021 were chosen as the cool and warm summer and the years 2018 and 2020 as the corresponding winter simulation years.

Table 1. Deviations of the average temperature at the Pori measuring station for the years 2014–2023 when compared to the average temperatures of the years 1991–2020 for the periods 1 June–31 August (summer) and 1 January–31 March.

Year	Difference to average summer temperature (°C)	Difference to average winter temperature (°C)
2014	0.8	1.50
2015	-1.03	3.33
2016	-0.07	0.13
2017	-1.20	1.77
2018	1.60	-1.87
2019	0.43	1.00
2020	0.70	4.67
2021	1.93	-0.30
2022	1.23	1.80
2023	not included in the comparison	1.57

Based on Finland's eighth national report on climate change (Ministry of the Environment & Statistics Finland 2022), the climate in Finland is estimated to warm up and precipitation is expected to increase. Wind speeds are expected to remain approximately at the present level. According to the report from the Intergovernmental Panel on Climate Change (IPCC 2021), the sea level is estimated to rise by a total of 15–20 cm from 2019 until 2050, which is of the same magnitude as land upheaval in the Olkiluoto area (Poutanen 2023). Because of this, rising water levels are not considered in the climate change scenario.

From the climate change scenarios, IPCC's higher temperature increase scenario SSP5-8.5 was chosen, so that the impact of climate change would not be underestimated in the modelling. The change was estimated, compared to the situation in 2020 and the forecast of the national climate change report. Table 2 shows the estimated effects of climate change on temperatures and precipitation/flows in the different simulation periods.

Table 2. Changes using the year 2058 SSP5-8.5 climate change scenario when compared to the situation in 2020.

Year	Temperature increase, summer (°C)	Flow rate increase, summer (%)	Temperature increase, winter (°C)
2058 SSP5-8.5	2.2	5.3	2.6

The climate change scenarios were calculated by adding the estimated impact to the input data. The simulations were only done for the reference situation and the year 2058. The other points in time were obtained by linear combination from the results of these simulations. In the calculations, it was thus assumed that the power uprating has a similar-sized effect in all years and that climate change has its effect in relation to the elapsed time. Table 3 collects together the situations obtained by direct simulation or linear combination. Table 4 indicates the flow rates and temperature changes used in different situations by plant unit.

Table 3. The EIA programme had presented the following scenarios of situations simulated (s) and estimated by linear combination (l).

	Current weather conditions	2038	2048	2058
OL1, OL2 and OL3 current power level	s	l	l	s
OL1 and OL2 uprated power and OL3 current power level	l	l	l	s

Table 4. Flow rates and temperature changes used in the simulations for different plant units.

	Reference situation		Power uprating	
	flow rate (m^3/s)	ΔT (°C)	flow rate (m^3/s)	ΔT (°C)
OL1	38	9.8	38	10.9
OL2	38	9.8	38	10.9
OL3	56	10.8	56	10.8

Initial meteorological data

As meteorological data, the model uses the global ERA5 reanalysis data (C3S 2017), which contains global weather data from 1940 onwards. From the ERA5 dataset, the meteorological data closest to the Earth’s surface on wind speed, air humidity, temperature, pressure, cloudiness and radiation were extracted for the simulation period. The horizontal accuracy of the data is 0.25 degrees or approximately 31 km. In the model, an individual atmospheric forcing from the three nearest data points was interpolated into each grid square.

In the area near Olkiluoto, meteorological data for the years 2017–2021 provided by TVO and measured hourly from the Olkiluoto weather mast was also available. The weather mast’s wind data are from heights of 20 m, 60 m and 100 m. Figure 3 compares the time series of the weather mast (lat 61.24°, long 21.43°, 20 m) and the nearest ERA5 data point (lat 61.25°, long 21.5°, height 10 m) for the comparison periods used.

There are surprisingly large differences between the weather information from the ERA5 data and the weather mast. The wind direction distribution is similar only in the winter period of 2020, and the speeds indicated by the weather mast are lower by approximately 2 m/s. The temperatures include periods of several weeks when the temperature differences are several degrees. The main reason for the difference is probably that the ERA5 data point describes the average value for an area of 31 x 31 km^2 and the weather tower a data point value. The data from the weather mast are, therefore, more strongly affected by the elevation differences in the nearby islands and the surrounding area, and also by the thermal effect of the power plant. Both of the weather forcings were tried out in the model application, and it was decided to use the ERA5 data everywhere, as it had a better correspondence to the temperatures measured from the sea.

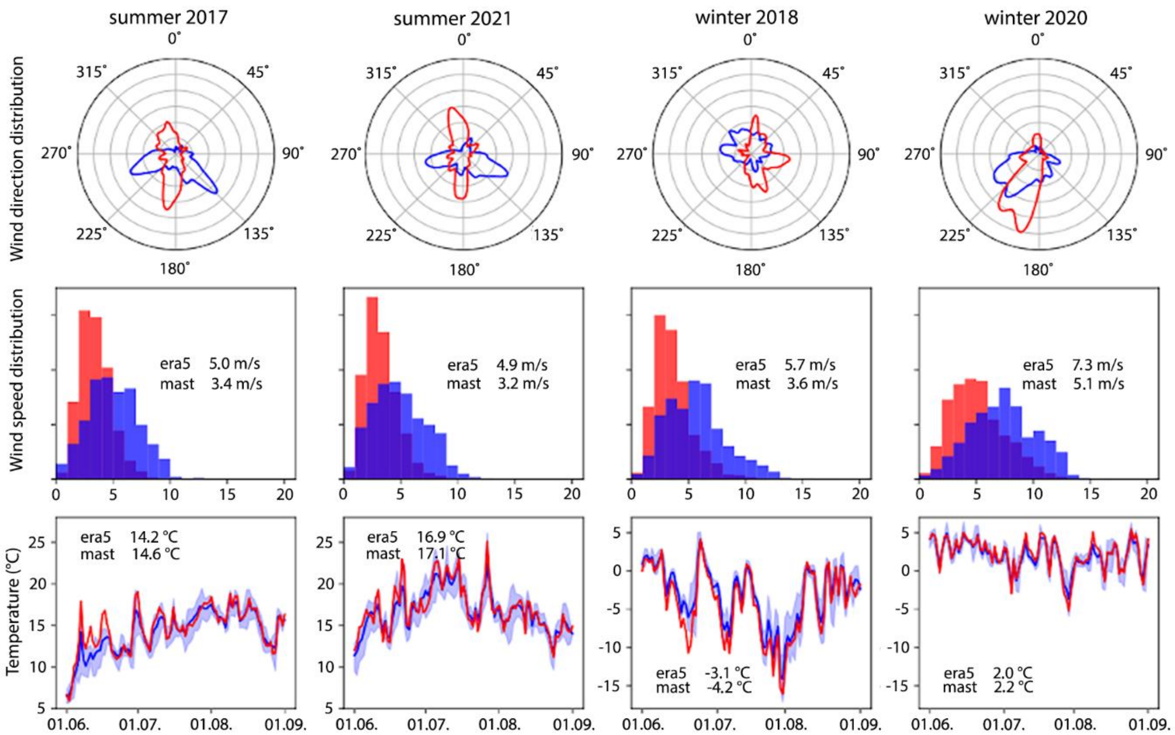

Figure 3. Wind direction and speed distributions and temperatures in the ERA5 data (blue) and at the Olkiluoto weather mast (red) during the reference periods. In addition to the daily average values, the temperatures indicate the daily range of the ERA5 data.

Initial hydrological data

The model considers the largest rivers running into the Bothnian Sea (Ångermanälven, Indalsalven, Ljungan, Ljusnan, Dalälven, Kokemäenjoki, Aurajoki and Paimionjoki) as well as the smaller Eurajoki and Lapinjoki, which are located in the densest areas of the grid. Rivers bring freshwater to the sea, so, in addition to their own flows, they also affect salinity and water density. For rivers on the Swedish side (Ångermanälven, Indalsälven, Ljungan, Ljusnan and Dalälven), average flows were used, and for rivers on the Finnish side (Kokemäenjoki, Aurajoki, Paimionjoki) daily flows to which rivers from the nearby catchment areas were combined (Finnish Environment Institute 2023). Eurajoki and Lapinjoki were included in the model according to the flow rate measurements. The rivers' flow rates in the simulation periods are shown in Figure 4.

In the cooling water intake of the Olkiluoto power plant, actual values and maintenance outages were used when the model results were compared with measurements. In the scenario simulations, a constant value of 132 m^3/s was used throughout the calculation period. The cooling water intake of the Olkiluoto power plant is, thus, the most significant flow, but the flows of Eurajoki and Lapinjoki are almost half of this during the spring floods.

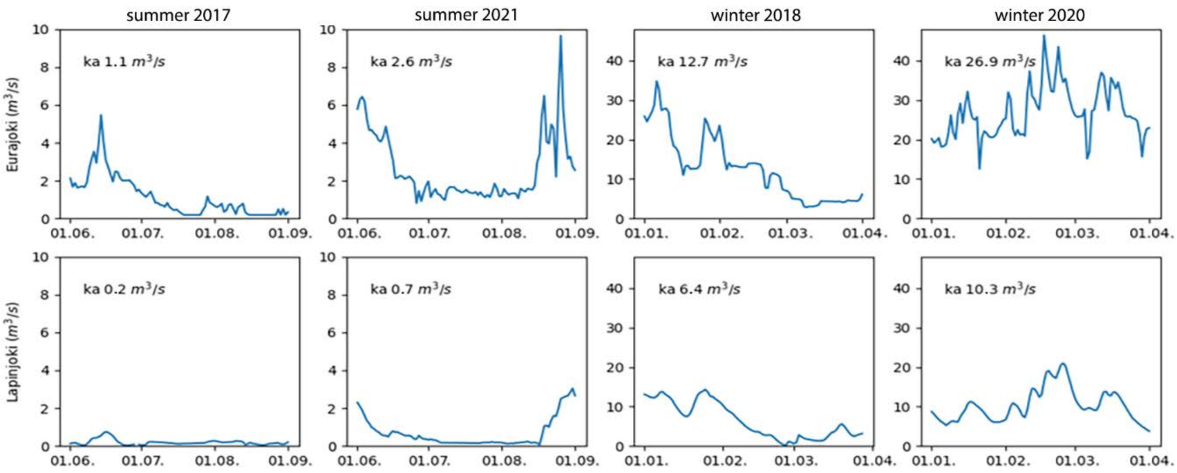

Figure 4. Flows in Eurajoki and Lapinjoki during the simulation periods.

The surface heights at the edges of the model area and the water exchange into the wider Baltic Sea were obtained from the CMEMS data presented in Figure 5. Especially during the winter periods, a clear difference can be seen between cold and mild winters. This arises from the prevalence of southerly and northerly winds during the years in question.

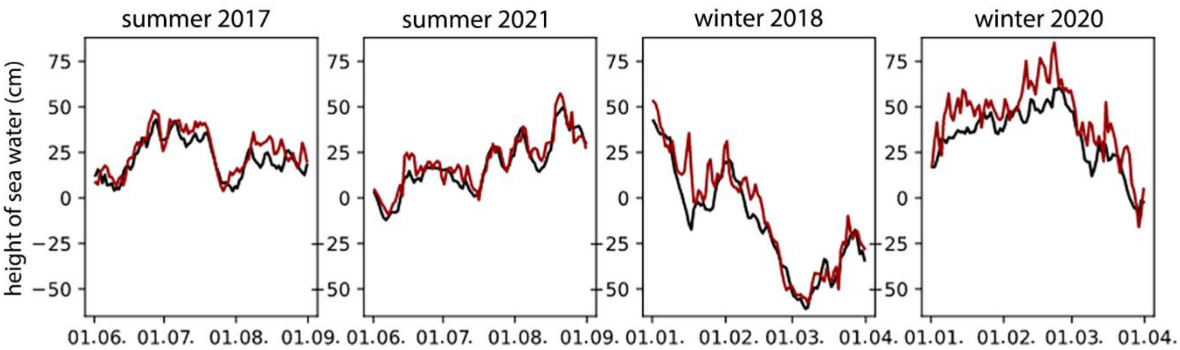

Figure 5. Sea water levels at the southern (black) and northern (red) edges of the model area.

Initial values

The model simulations were started from the beginning of May (summer periods) and from the beginning of December (winter periods), when the seawater has mixed after the spring and autumn cycle. The Baltic Sea Physics Reanalysis data of the EU's Copernicus Marine Environment Monitoring Service (CMEMS) were used as initial values for both temperature and salinity. The horizontal resolution of the data is less than 2 km and, as in the model used in the vertical direction, it is denser in the surface layers and more sparse when progressing deeper. Figure 6 shows the temperature and salt distributions of the surface and benthic water layers in the initial situations of the different simulation periods.

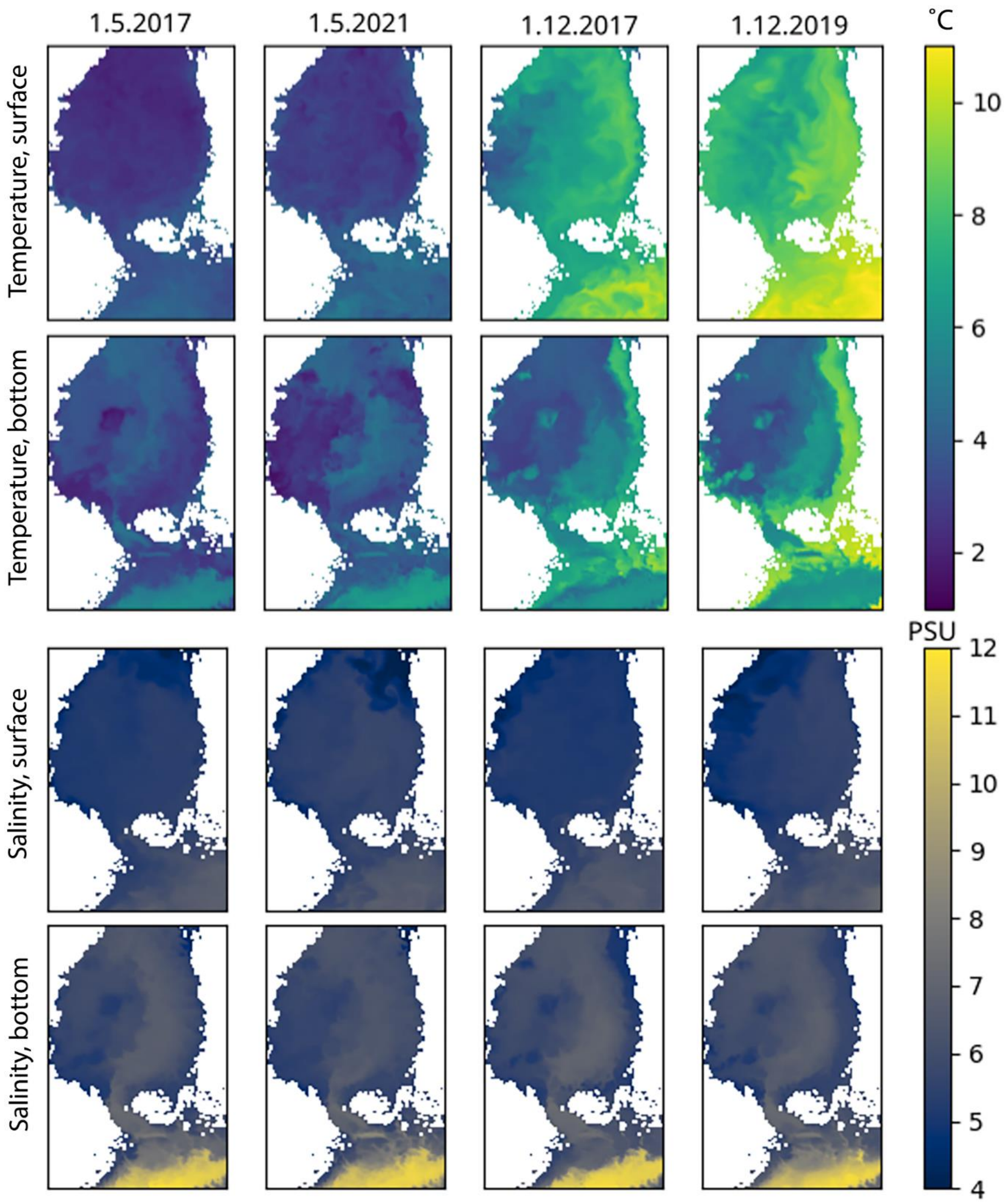

Figure 6. Data used to interpolate the initial values of temperature and salinity from the surface and benthic water layers at the beginning of different simulation situations.

At both the southern and northern edge of the model area, the variation in initial values was reduced for ten grid squares to reduce artificial flows arising from the initial values at the beginning of the calculation. Before the scenario comparisons were made, a month-long initialisation period was also calculated with the model, during which the instabilities arising from the initial situation had time to even out and the thermal distribution of the sea area off Olkiluoto had time to develop to the correct level.

4. COMPARISON OF MODEL TO MEASUREMENT RESULTS

Temperature comparison

The impacts of the nuclear power plant units on the sea area off Olkiluoto are being monitored constantly, so a lot of measurement data was available off Olkiluoto for the model comparisons. In addition to the continuously operating stationary temperature gauges (K501–K506), automatic temperature measurement is carried out in the area during the summer with partially changing measurement points and depths. Figure 7 shows the locations of the stationary temperature measurement points and of TVO's temperature loggers used in the model comparisons.

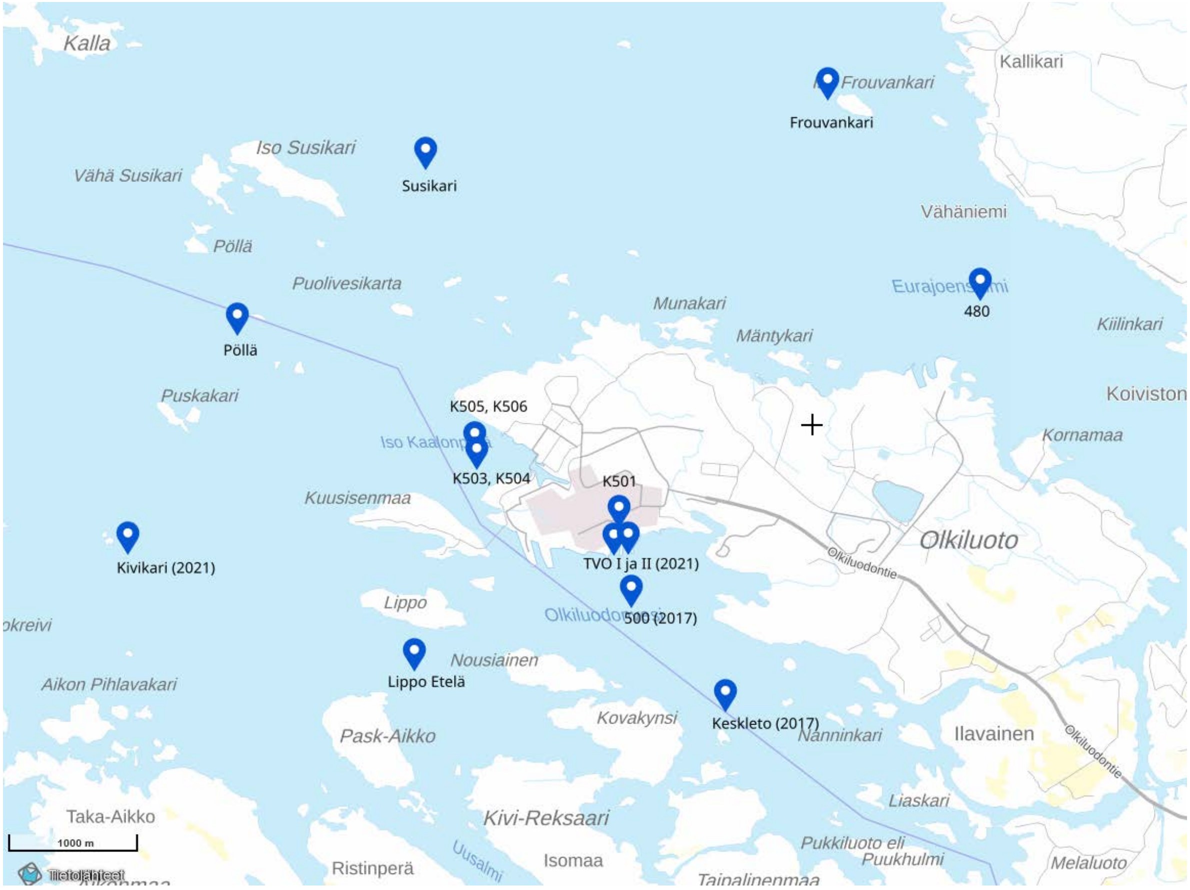

Figure 7. **Locations of measurement points. If the temperature is followed by a year, TVO's loggers have only measured it during one of the simulation summers.**

A surface temperature survey was made off Olkiluoto in 1998 (Peltonen 1998), the results of which are shown in Figure 8. The thermal load moves along the northern edge of Iso Kaalonperä bay to the open sea. This was considered to be the desired prevailing situation in the model as well, although the simulation periods were from different years.

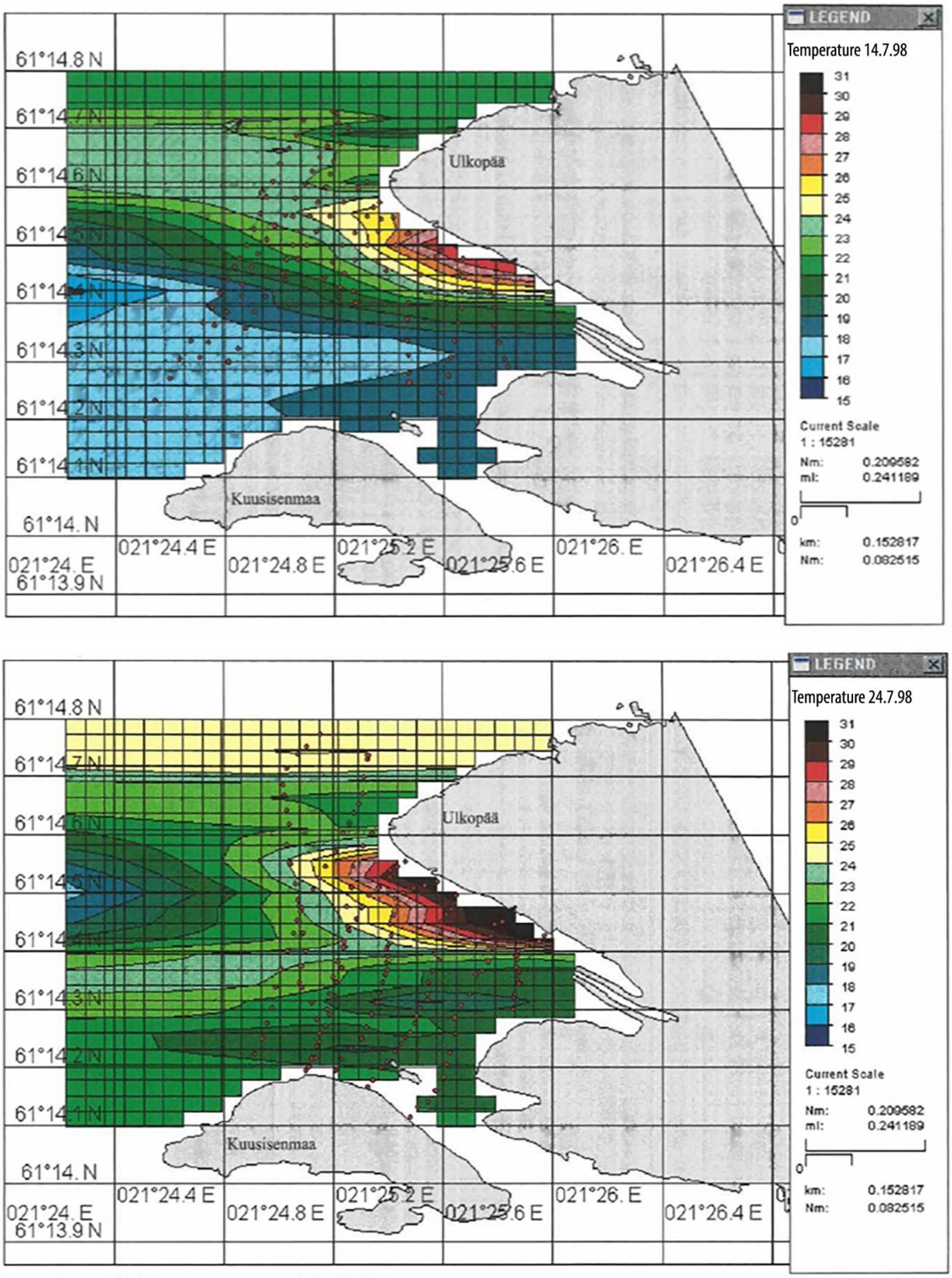

Figure 8. Surface temperatures measured in summer 1998 (Peltonen 1998).

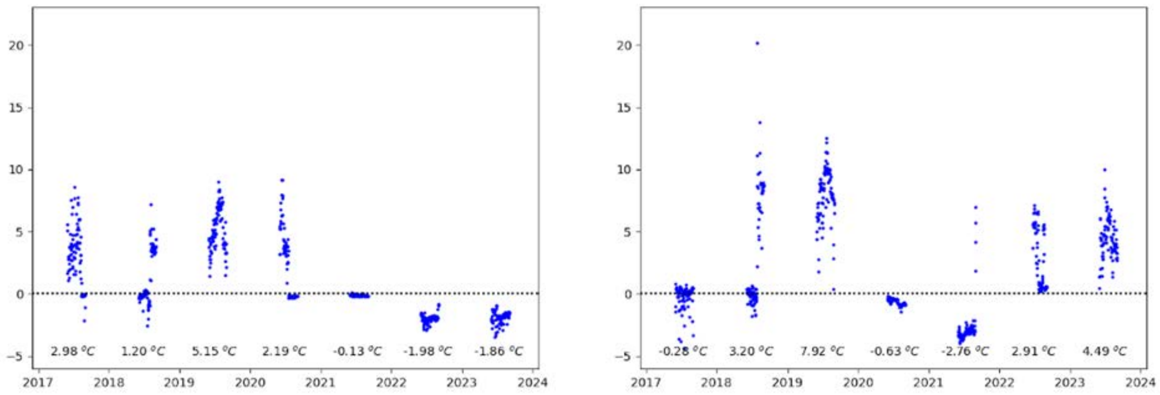

Figure 9. The temperature difference between the surface and benthic water layers at the southern point (left) K504 and K503 and the northern point (right) K506 and K505 during the summer months, 1 June–31 August, in 2017–2023. The numerical value for the year indicates the average difference.

Figure 9 shows the temperature stratification measured off the cooling water discharge location during different summers. In several years the measurements show an unstable temperature stratification, where the benthic water layer has warmer and lighter water than the surface layer. Corresponding stratification was not observed at the measurement points located further away, and it is typically normalised quickly.

Unstable temperature stratification could arise from the difference in salinity if the warmer water were more salty. A temperature difference of 10 ºC would require a salinity difference of 3 PSU to keep the water density the same. However, there is not always any kind of salinity gradient between the surface water and benthic water off Olkiluoto, and even at its largest, the salinity difference between the surface and bottom is approximately 0.3 PSU.

In suitable weather conditions, colder water could rise to the surface, but the effects of the phenomenon would be noticeable in a wider area than merely the immediate vicinity of the discharge point. The weather can also cool down suddenly, causing the surface water to cool faster than the benthic water. Since these situations never continue for a long time, they cannot explain the unstable temperature stratification lasting the whole summer. Phenomena on a smaller scale than the resolution accuracy of the model and the uneven temperature distribution of discharge water could also affect the emergence of unstable temperature stratification, but the effect could be assumed to remain similar from one year to another.

A possible explanatory factor could also be the blocking of discharge and return flows slightly differently in different years in connection with the start-up after the annual outage, in which case the warm discharge water would circulate for a longer time in slightly different routes near the bottom.

In the model simulations, there was no unstable temperature stratification in Iso Kaalonperä bay during either simulation summer, but, instead, a stable temperature stratification of approximately 4ºC. This corresponds in magnitude to the situation in those summers when the temperature stratification also developed in the physically assumed way in the measurements. Figures 10–12 show the comparisons to the measurement results.

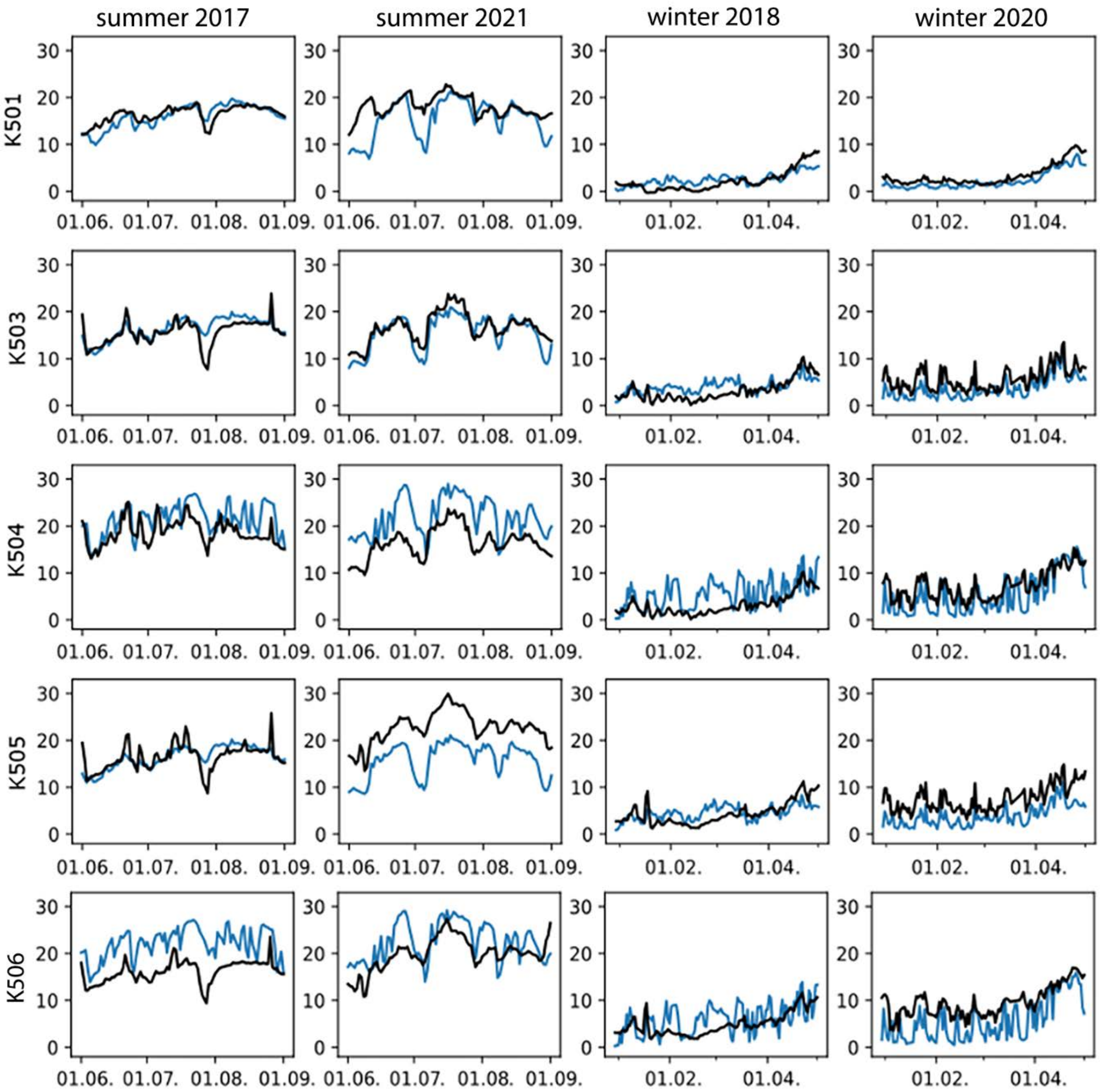

Figure 10. Measured (black) and modelled (blue) temperatures at the locations of the continuously operating temperature gauges for all simulation periods.

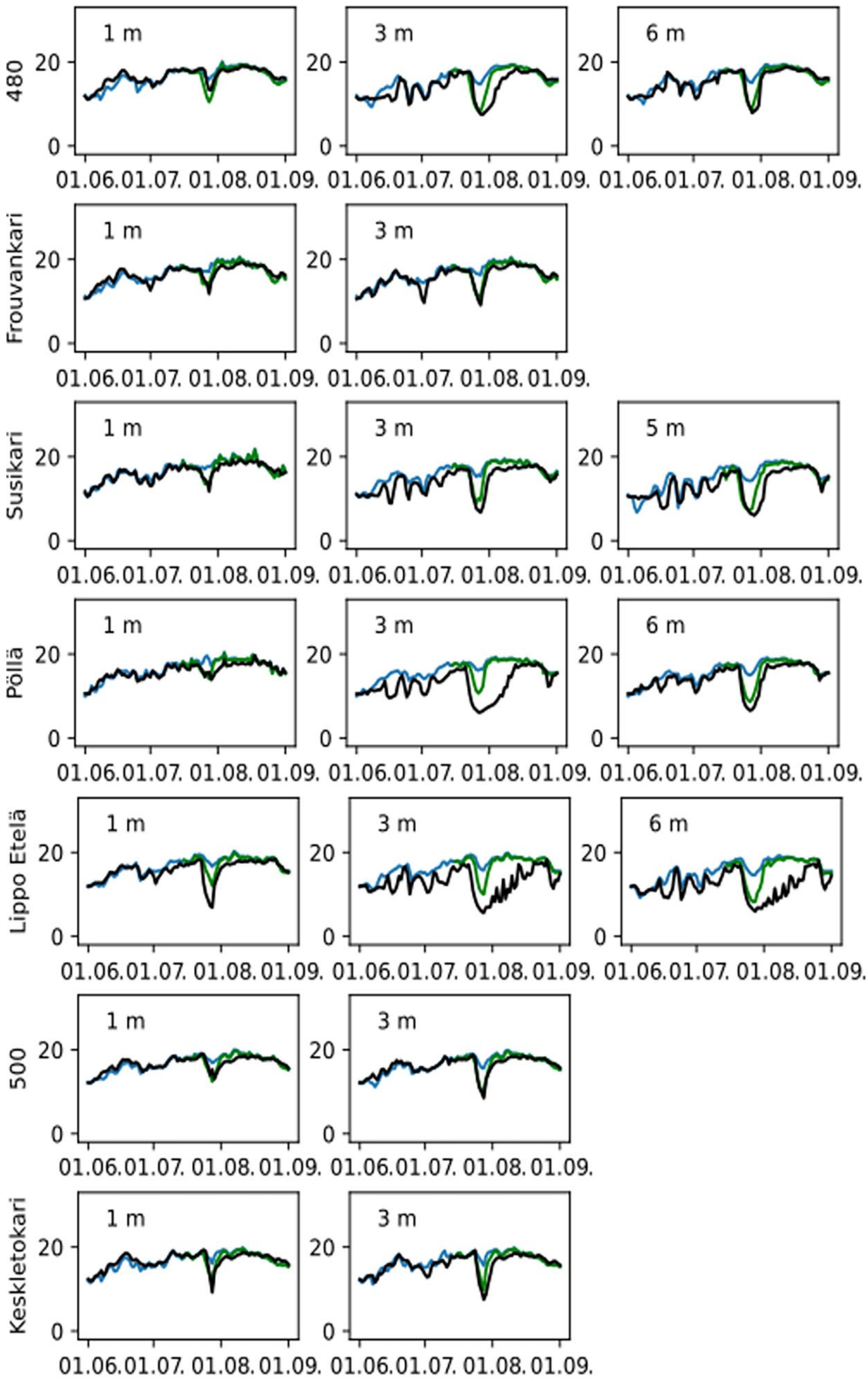

Figure 11. Temperatures measured (black), modelled (blue) and modelled after groundwater temperature correction (green) at **TVO's temperature loggers in summer 2017. The numerical value indicated in the** time-series images is the measurement depth.

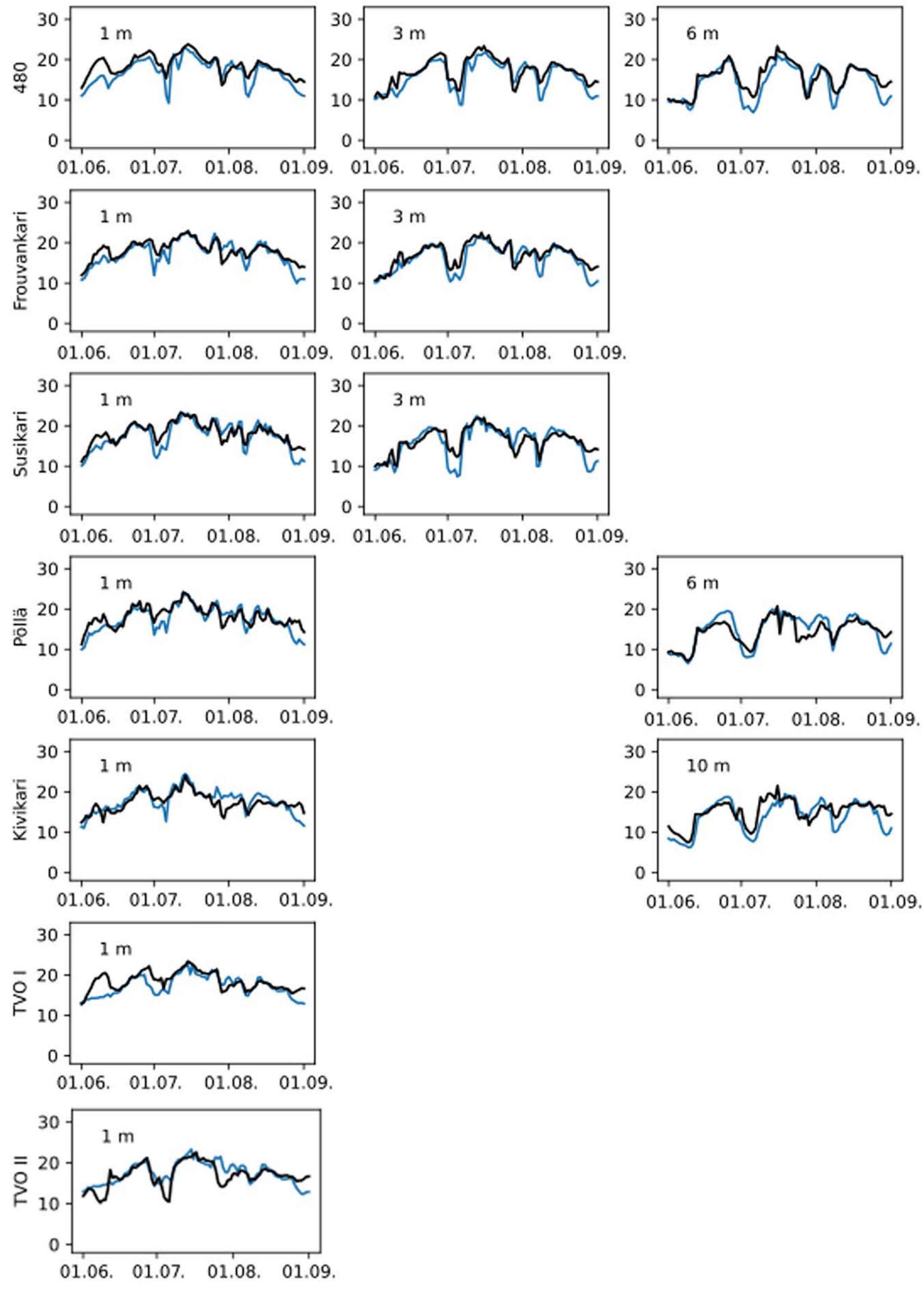

Figure 12. **Temperatures measured (black) and modelled (blue) at TVO's temperature loggers in summer** 2021. The numerical value indicated in the time-series images is the measurement depth.

Temperature measurement points K501–K506 are in the same place continuously, so they provided useful comparison data for winter periods as well. Gauge K501 is located at the cooling water intake point of the power plants, so the modelling error of the point is transferred directly to the discharge water. The four gauges in the vicinity of the discharge channel are located at a distance of approximately half a kilometre from the cooling water discharge point. On the south side are gauges K503 (bottom) and K504 (surface), and on the north side K505 (bottom) and K506 (surface). The surface gauges are at a depth of approximately half a metre, and the bottom gauges are conversely half a metre above the bottom.

In all the gauges on the discharge side, rapid temperature changes of up to ten degrees occurred both in the measurements and in the model, with similar dynamics. The largest temperature differences were at surface gauge K506, where the model simulations of summer 2017 were clearly higher than the measured ones and the simulations of winter 2020 were clearly lower. The unstable temperature stratification measured in the summer of 2021 was visible at point K505 as temperatures clearly higher than those modelled. An almost equal opposite difference was seen at surface point K504.

In summer, TVO has made independent measurements of seawater temperatures every four hours by using temperature loggers. The aim of the loggers is to find out the impacts of the thermal load on a wider scale than mandatory monitoring.

In the preliminary inspection of the measurement data, the locations of the middle and bottom measurement data from the measurement points in Kallipöllä, Kivikari and Susikari were changed. The lowest temperatures in the middle depth contradicted the assumed vertical distribution and the measurements made at the mandatory monitoring points.

At the time of the 2017 measurements, there was a strong upwelling phenomenon off Olkiluoto at the end of July. This brought cooler benthic water from the deeper water layers of the Bothnian Sea to the surface, and temperatures dropped by approximately ten degrees at many measurement locations. The model described the phenomenon as clearly weaker, because in the model, water warmer than actual is transported from the bottom of the open sea to Olkiluoto due to numerical mixing.

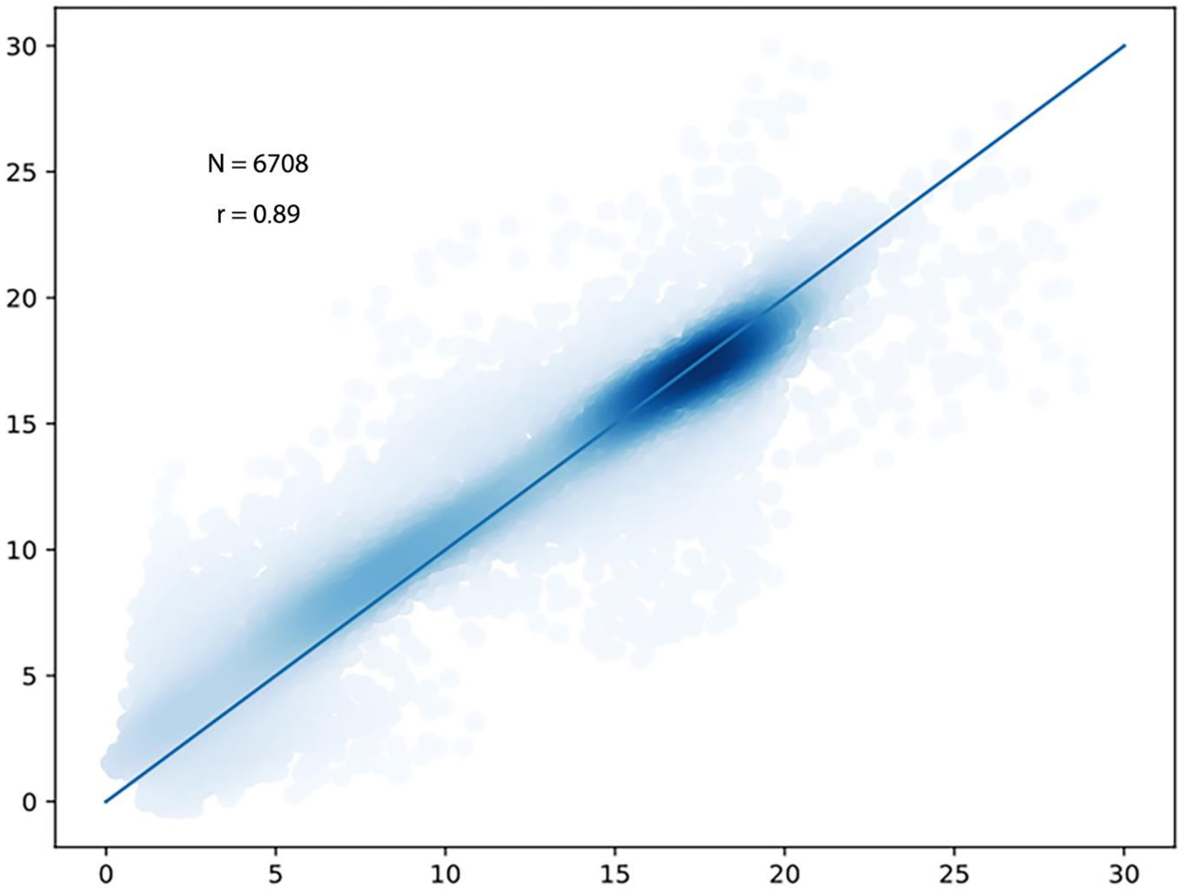

Figure 13. Compatibility of all continuous temperature measurements and temperature logger measurements with the model simulations for all simulation periods. The points with more comparison results are darker in the image. The temperatures calculated by the model are shown on the x axis and the measurements made on the y axis. A daily average value has been taken from each measurement point for comparison, ensuring that measurements made with different time resolutions are equally weighted.

Numerical mixing is a common problem in flow models. It arises from simplifications of the numerical description of the model, for example, because the concentration inside the elementary cell is the same everywhere. In the model, the largest amount of numerical mixing occurs at the boundaries of compaction areas. The mixing accumulates over long simulation periods, causing surface and groundwater temperatures to even out. The effect of this was tested by correcting temperatures to +5 ºC at a depth of more than 15 m (i.e. mainly outside the most dense model area) in the middle of the calculation on 15 July, causing the cooling of the seawater to be imaged at the same level as the measurements. In the scenario simulations a corresponding correction cannot be made, because the effect under investigation might then be partly erased.

In 2021, a clear cooling of seawater temperatures occurred at the beginning of July in the temperature loggers. The simulated change was slightly stronger in the model than in the measurements. Regarding the temporal development of the temperature, the measurements and model results corresponded well to each other.

Figure 13 combines all measurement days (a total of 6,708 comparison days) from the continuously operating temperature gauges, TVO's temperature loggers and measurement periods, resulting in a Pearson correlation of 0.89 between the measurements and model simulations. The correspondence can be considered reasonably good, taking into account the uncertainties related to local weather data and the unstable temperature stratification in Iso Kaalonperä bay, which is difficult to explain. On average, the simulated temperatures were approximately 0.3 ℃ lower than the measured ones, and the median error was approximately 1.2 ℃.

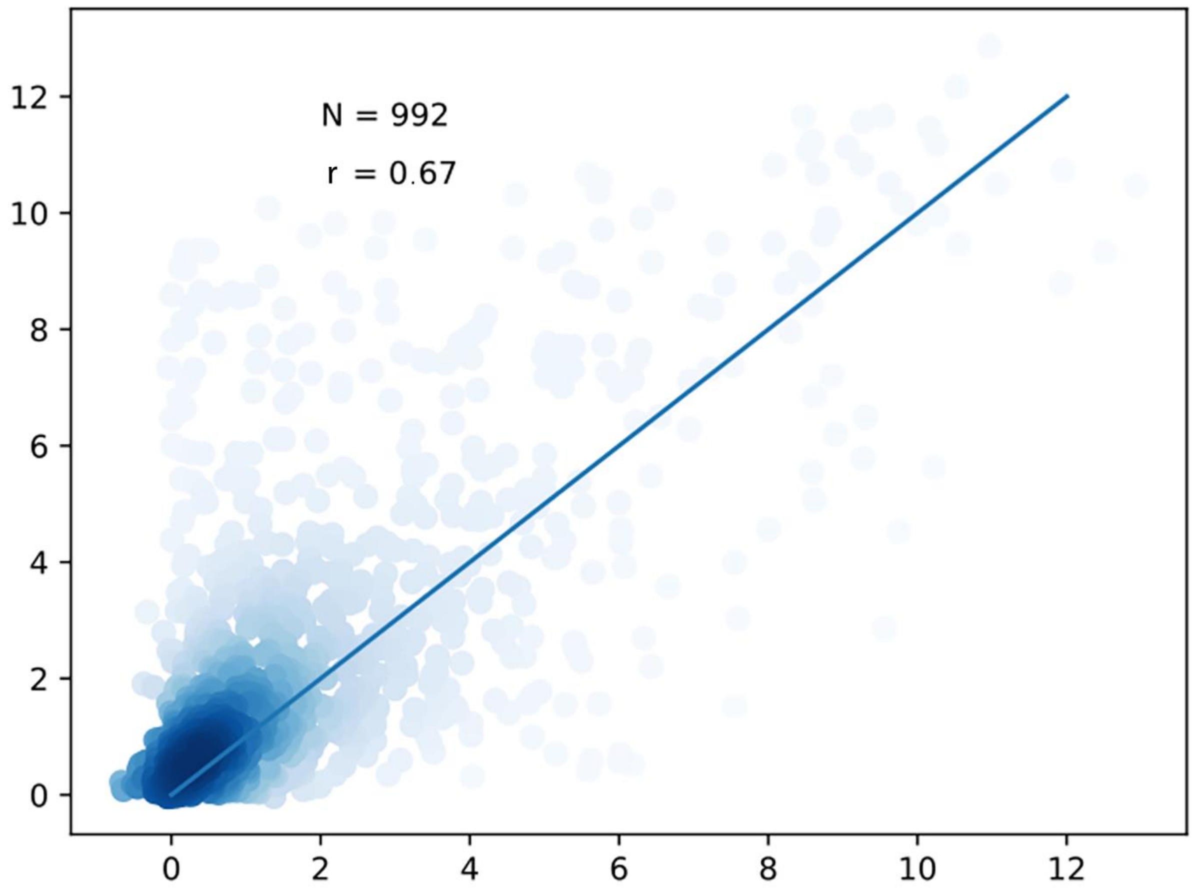

Figure 14. The temperature difference between measurements on the surface and deeper than 5 m, as measured by all TVO temperature loggers in the summers of 2017 and 2021 (y axis), and the temperature difference generated by model simulations (x axis). The points with more comparison results are darker in the image. A daily average value has been taken from each measurement point for comparison, ensuring that measurements made with different time resolutions are equally weighted.

TVO's temperature loggers were located far enough from the discharge stream to enable the naturally occurring temperature stratification to be detected. Figure 14 compares the temperature differences observed in the measurements and the model result between the surface and the deepest measurement depth. Both measurement results and model results occasionally show a strong temperature stratification of more than 10 ºC. In the main, the temperature stratification in the model is slightly less than the measured one. In particular, the upwelling in late summer 2017 does not show in the model as long-lasting enough. Excluding this period in the summer of 2017 and the entire summer of 2021, the Pearson correlation of the stratified comparison was approximately 0.8.

Ice comparison

The model simulated two winter periods with different temperatures. The mild winter of 2020 was the first in the history of the measurements when no ice formed off Olkiluoto. For this reason, only the colder winter of 2018 is included in the ice comparison.

Depending on the ice coverage, winter ice conditions on the Baltic Sea are classified as mild, moderate or severe. In the winter of 2018, the ice cover of the Baltic Sea was at its widest in a decade, and the ice surface area was 170,000 km^2 at its largest, but the winter was nevertheless classified as an average ice winter. The deepest areas of the Bothnian Sea were open all winter, and the open sea ice cover was 10–25 cm at its thickest (Finnish Meteorological Institute 2023a). The modelled ice cover, on the other hand, covered the entire sea area of the Bothnian Sea. The ice cover was some 15 cm thick at its strongest in the south and 30 cm in the north, which was slightly more than the values measured in the Bothnian Sea.

The dynamics of the interface between ice and open water is a chaotic process, especially in a situation where the ice is weak. Even a small difference in the thermal load affects whether a thin layer of ice remains in the area or whether it thaws away completely. In open water, the winds change the surface currents into completely different ones when compared to the ice cover. In addition, the movement of packed ice is affected by weather conditions far beyond the area being studied.

The ice model used does not calculate the drift of ice, so it easily creates a thin ice cover in open areas, from which the developing ice would, in reality, drift to the shores due to the influence of winds. For this reason, ice forms in the open sea area to a larger degree and earlier in the model simulations than in reality.

In spite of its shortcomings, the model was able to correctly simulate the retreat and weakening of ice in late January and again in mid-February. At its largest and strongest, the ice cover was around 10–20 cm in early March in both the measurements (Teollisuuden Voima Oyj 2019) and the model simulations. Towards the end of March a lot of pack ice was transported to the area, which the model does not calculate but which slowed down the thawing of the ice in reality. In the model, the ice thawed prematurely. The simulated ice thickness is compared to the available ice maps in Figure 15.

In addition, Figure 16 includes images from the Finnish Environment Institute's monitoring service (Finnish Environment Institute 2024) taken by the Sentinel2 MSI satellite from February to March, when the area had the largest number of cloudless days. The images show how quickly the ice situation changes in the area, as well as the typical spread of the thermal load towards the south-west similarly to the model results.

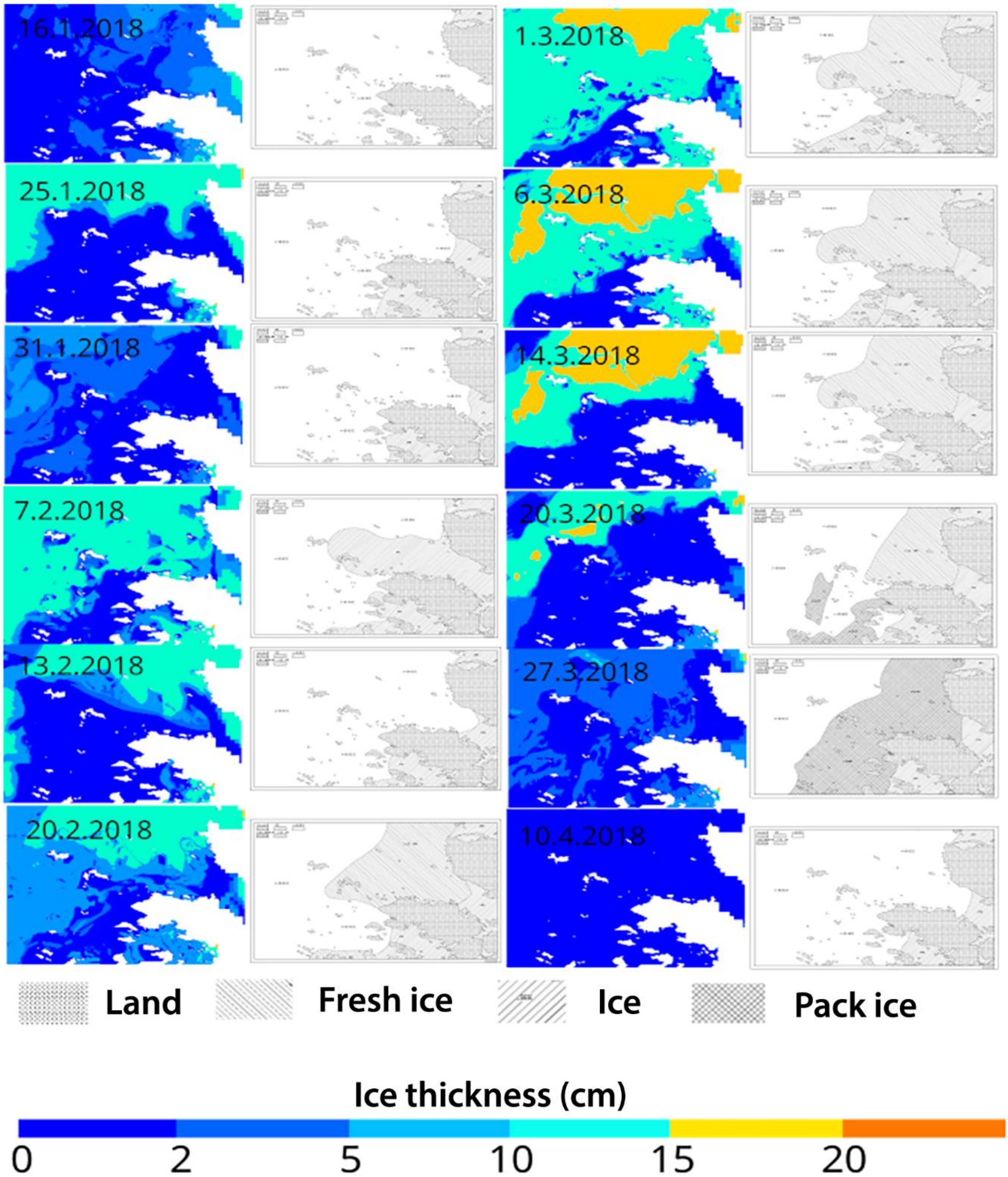

Figure 15. Comparison of simulated ice thickness to ice maps.

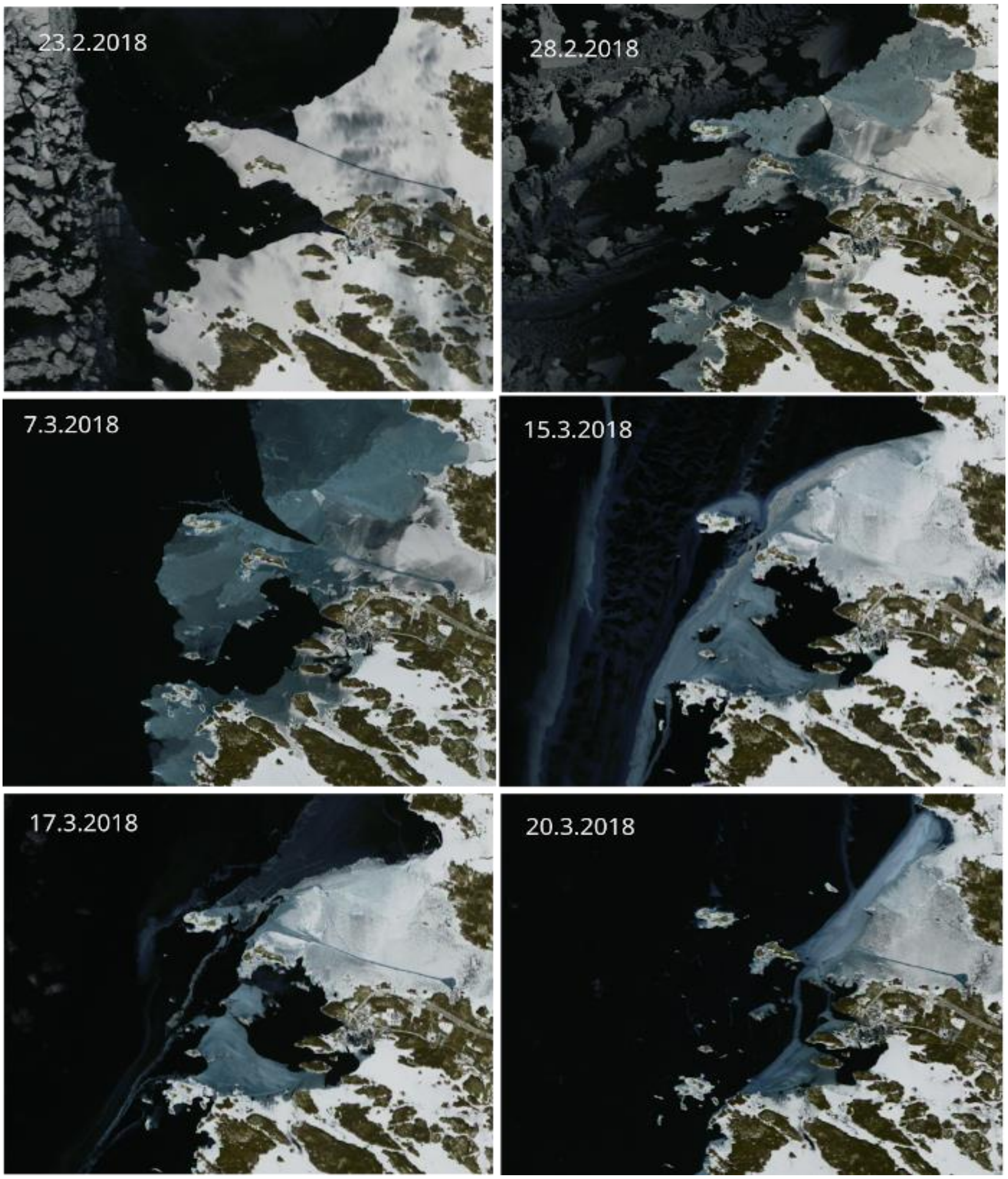

Figure 16. Example images from the Sentinel 2 MSI (10 m) satellite from a few cloudless days.

5. SCENARIOS

Impacts on seawater temperature

In the comparison of different scenarios, the base situation was an alternative where all three plant units (OL1, OL2 and OL3) are in operation at normal power for the entire calculation period and the impacts of climate change are not taken into account. Average temperatures during the reference periods are shown in Figure 17.

The model did not calculate a natural reference situation with no power plant, but from the simulations it is possible to estimate that the average surface temperatures of the seawater are increased by the current activity in the summer by some 3–4 ºC at a distance of 3–4 km and by approximately one degree at a distance of 5–8 km. Due to the prevailing currents, the thermal load spreads the most to the north and the least to the west/east. A momentary temperature rise can occur approximately twice as far away or on twice as large a scale as the average temperature rise.

The changes in seawater temperatures obtained by using different calculation periods, climate change years and power scenarios are presented in Figures 18–25. In addition, Figure 26 outlines the more momentary effects of power uprating during the summer period of 2017.

Around 2058, the surface temperatures calculated with the SSP5-8.5 climate change scenario would have risen by approximately 1–1.5 °C. In the open sea season, the rise in surface temperature is higher in cool months and lower in hot summers. During the ice cover period, the effects of climate change on the seawater temperature are minor, as the rising air temperature mainly affects the formation of the ice cover.

Due to the stratification of waterspouts, the effects of climate change are most clearly visible in the surface layer. The plant units take their discharge water from the lower layers, so even in the vicinity of the discharge site, the effects of climate change will be slightly less than in the rest of the area.

Based on the modelling results, the thermal load of the power uprating spreads quickly in the direction of the discharge channel to an area approximately 300 m wide and 1,500 m long where the water does not have time to cool down significantly (temperature rise of more than 0.5 °C). After this, the flow weakens and the heat spreads more along the currents caused by the prevailing winds, mainly to the northeast and southwest. The power uprating increases the average seawater surface temperature by approximately 0.2 °C at a distance of some 2–2.5 km and 0.1 °C at a distance of 3–4 km. The temperature increase of 0.1 °C is a typical resolution accuracy of environmental measurements, so any changes in seawater smaller than this are difficult to verify.

The thermal load caused by the power uprating can be seen in seawater temperatures mainly in the surface layer, as water that is warmer and lighter than its surroundings naturally stays on the surface until it cools to 4 °C. The motion of the thermal load in the surface layer mainly depends on the wind situation. In a stable wind situation, a temperature increase of 0.1°C may occur at approximately twice the distance when compared to the average value. Momentary temperature variation also occurs within a day, and it is greater than 0.1 ºC.

Table 5. Average sea area (km^2) where the seawater temperature increase exceeds the limit value (0.1 ºC, 0.2 ºC and 0.5 ºC) momentarily (left) and in the long term (right) due to power uprating and climate change.

	0.1 ºC	0.2 ºC	0.5 ºC
Summer 2017	22.1/12.1	8.6/3.5	0.68/0.39
Summer 2021	18.8/11.2	7.5/3.3	0.50/0.24
Winter 2018	18.4/10.7	11.2/2.2	0.82/0.11
Winter 2020	13.1/10.7	5.6/2.4	0.73/0.11

Table 5 compiles the average surface areas of the sea where the temperature increase exceeds certain limit values momentarily or in the long term. With the limit value of 0.1, the areas are approximately double when compared to the area where the same temperature increase occurs over the entire simulation period. In suitable weather conditions, the sea areas can temporarily be 2−3 times larger than the average area.

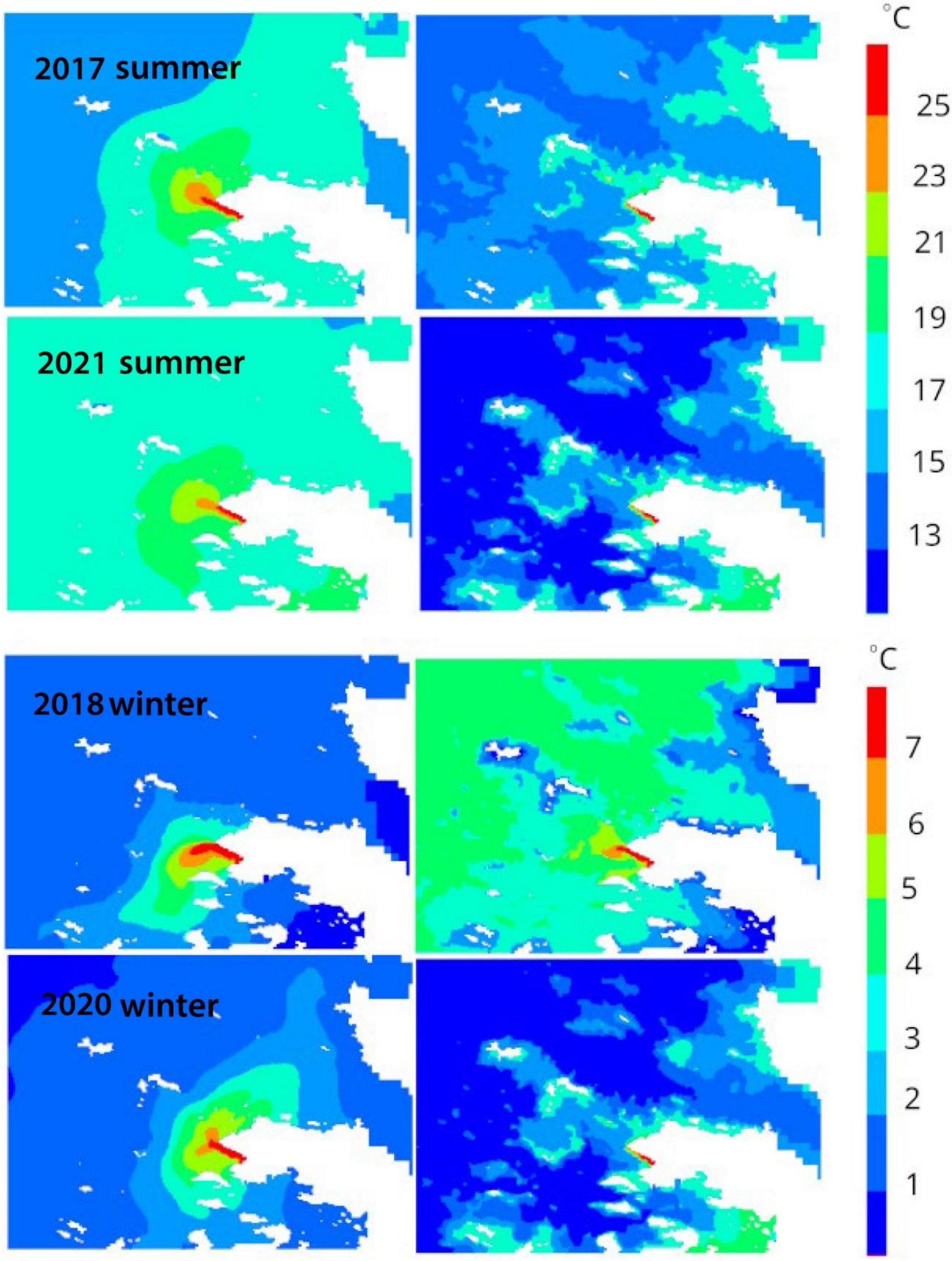

Figure 17. Average temperatures during the reference periods. In the figure, the surface layer is on the left and the benthic water layer is on the right.

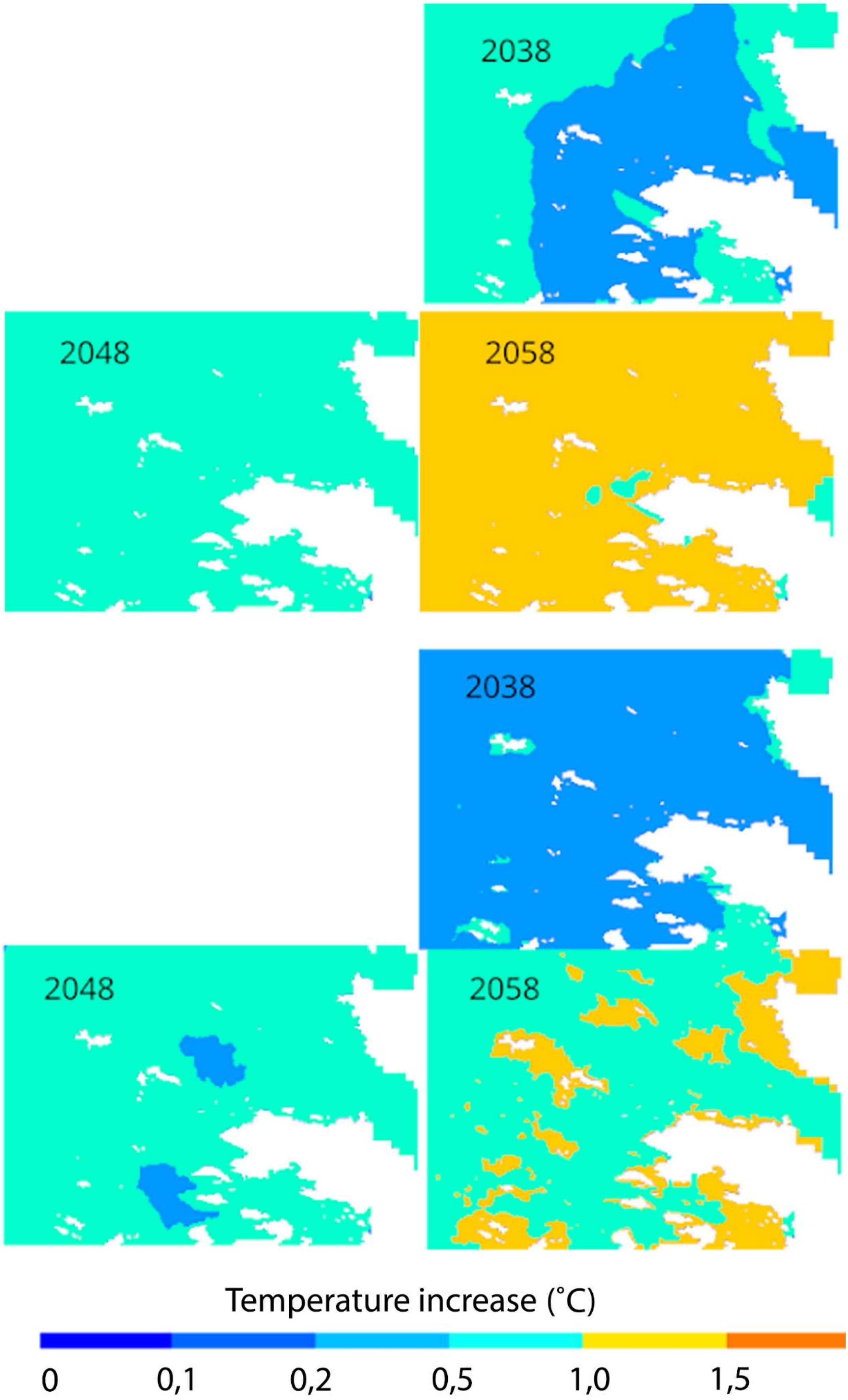

Figure 18. Effects of climate change on temperatures during the cold summer of 2017. The first 3 images are from the surface layer and the lower ones from the benthic water layer.

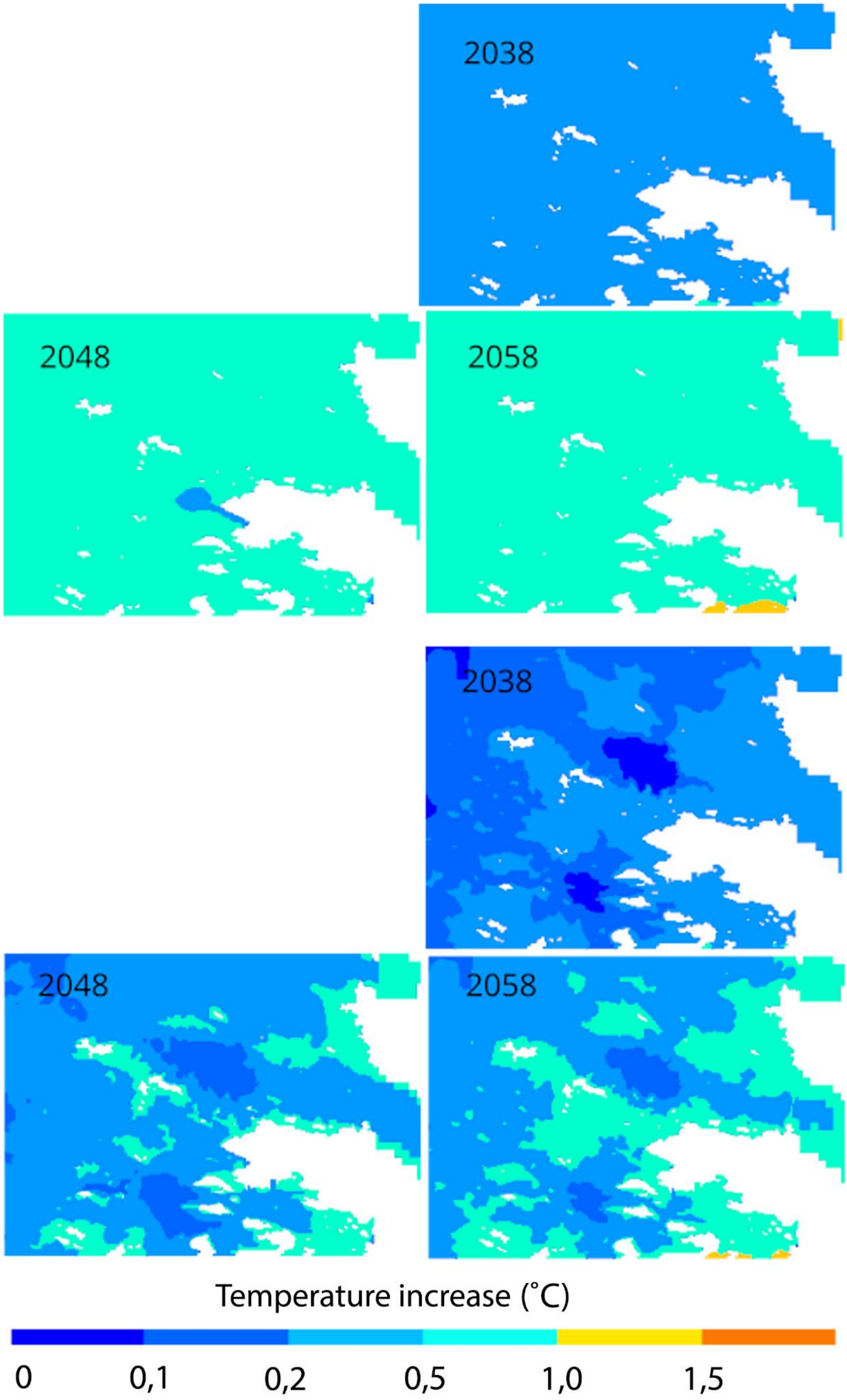

Figure 19. Effects of climate change on temperatures during the hot summer of 2021. The first 3 images are from the surface layer and the lower ones from the benthic water layer.

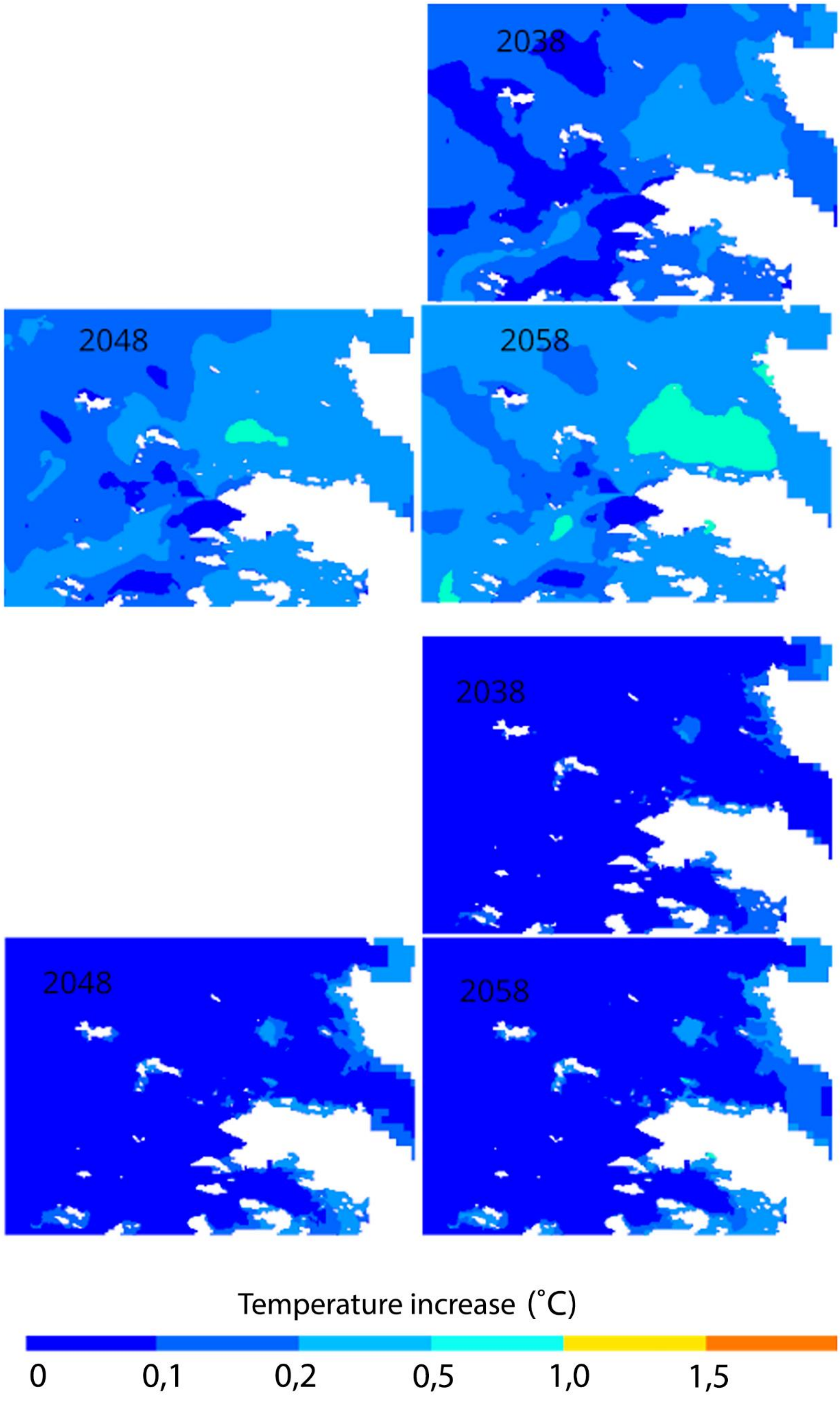

Figure 20. Effects of climate change on temperatures during the cold winter of 2018. The first 3 images are from the surface layer and the lower ones from the benthic water layer.

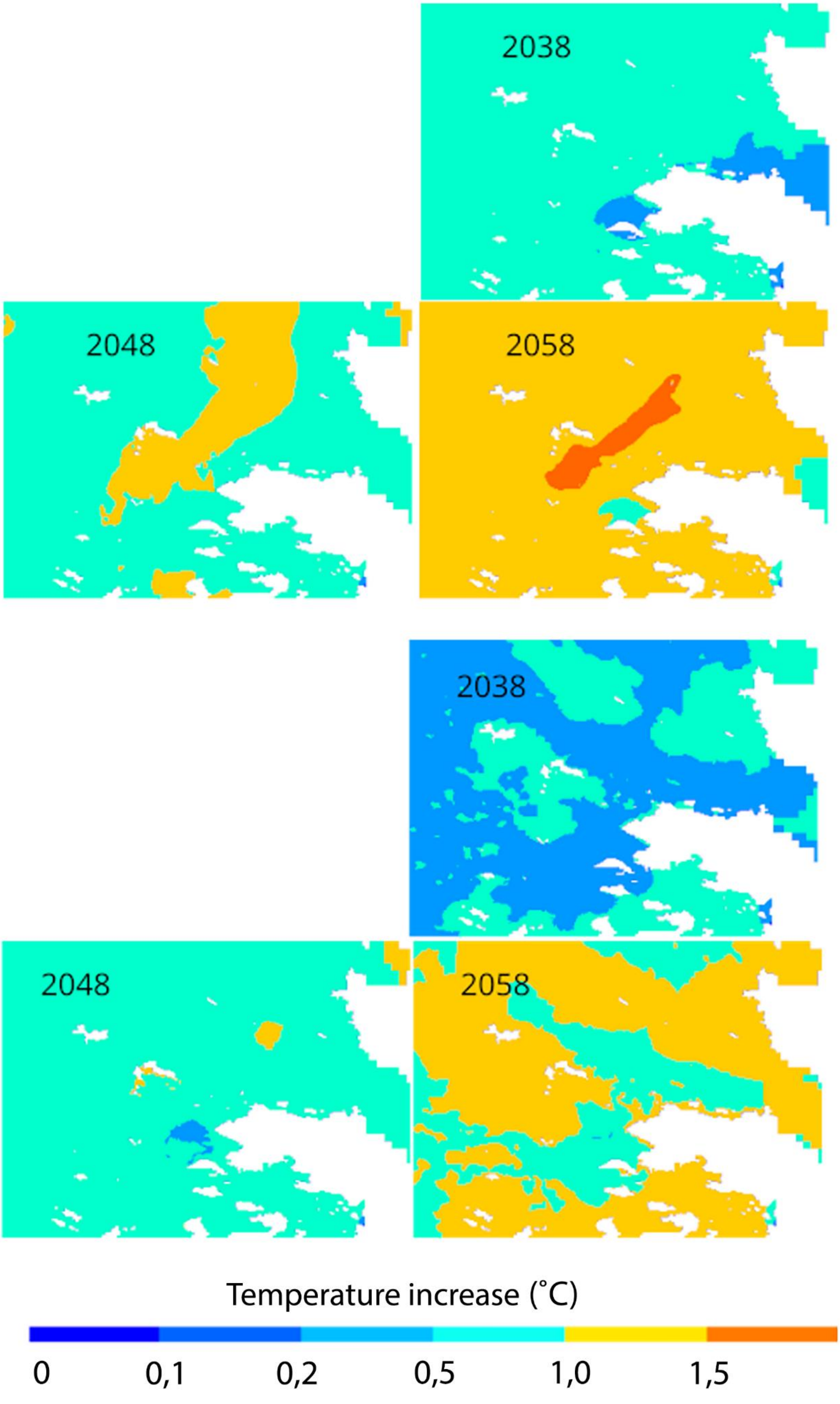

Figure 21. Effects of climate change on temperatures during the mild winter of 2020. The first 3 images are from the surface layer and the lower ones from the benthic water layer.

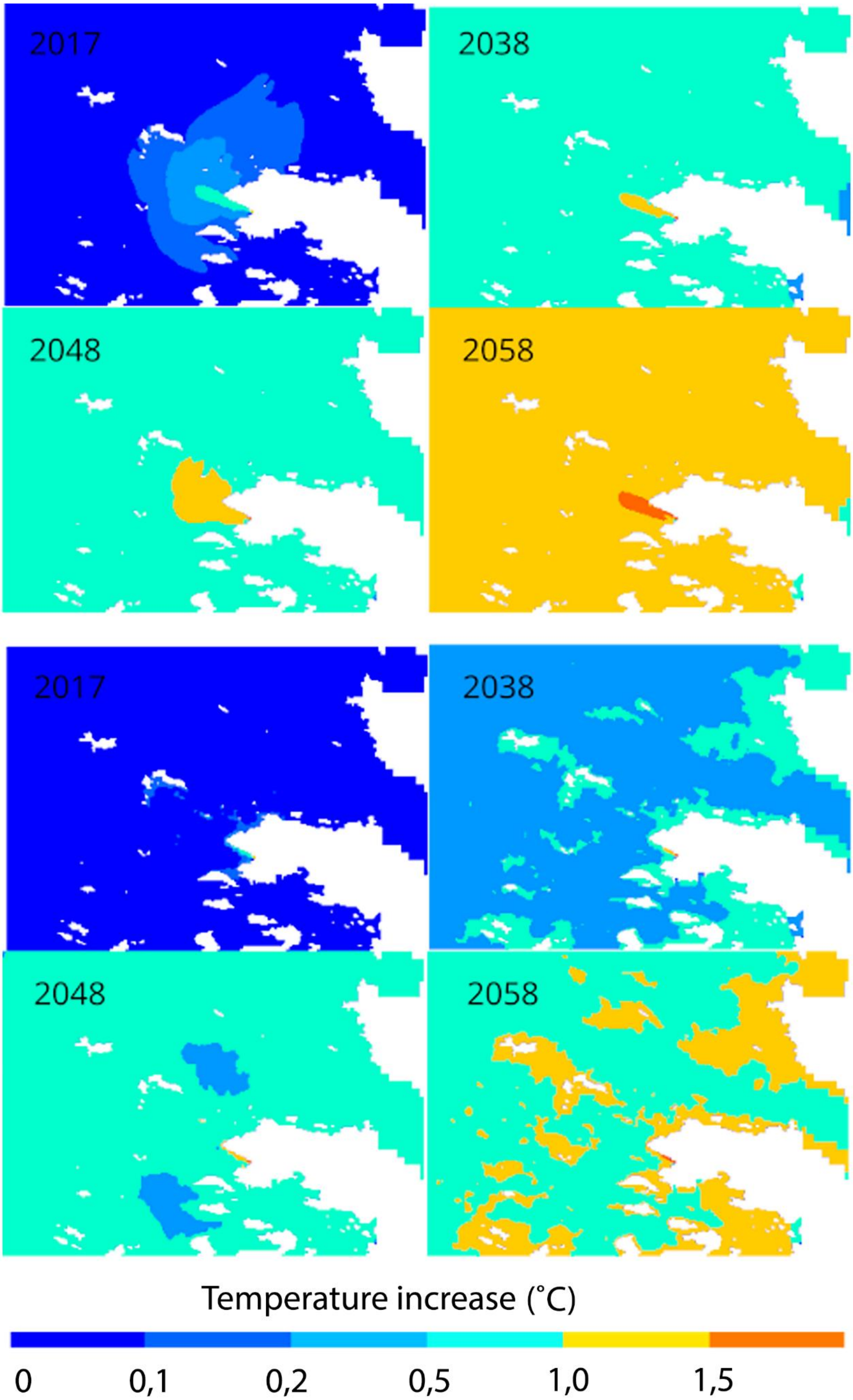

Figure 22. Effects of climate change and power uprating on temperatures during the cold summer of 2017. The first 4 images are from the surface layer and the lower ones from the benthic water layer.

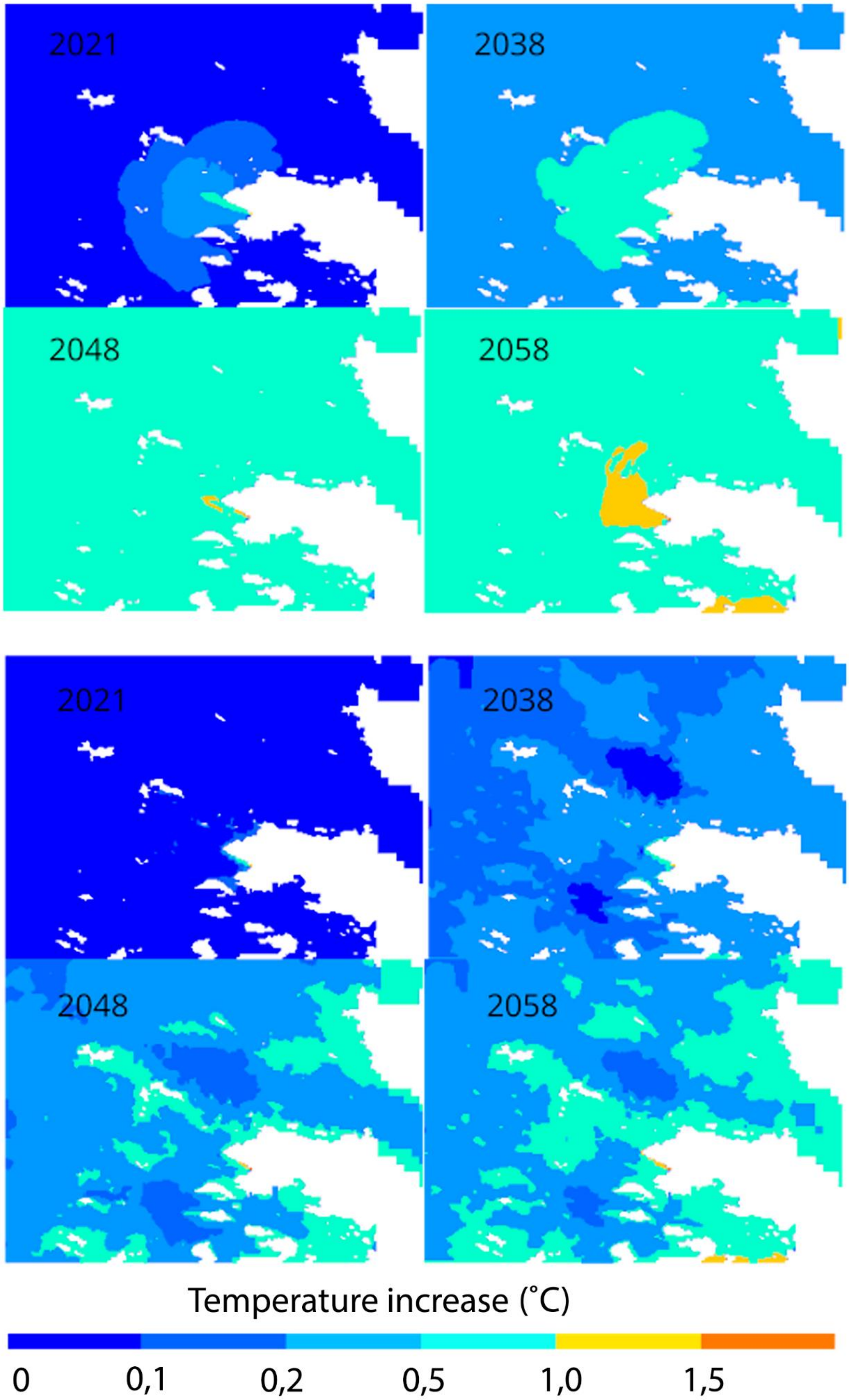

Figure 23. Effects of climate change and power uprating on temperatures during the hot summer of 2021. The first 4 images are from the surface layer and the lower ones from the benthic water layer.

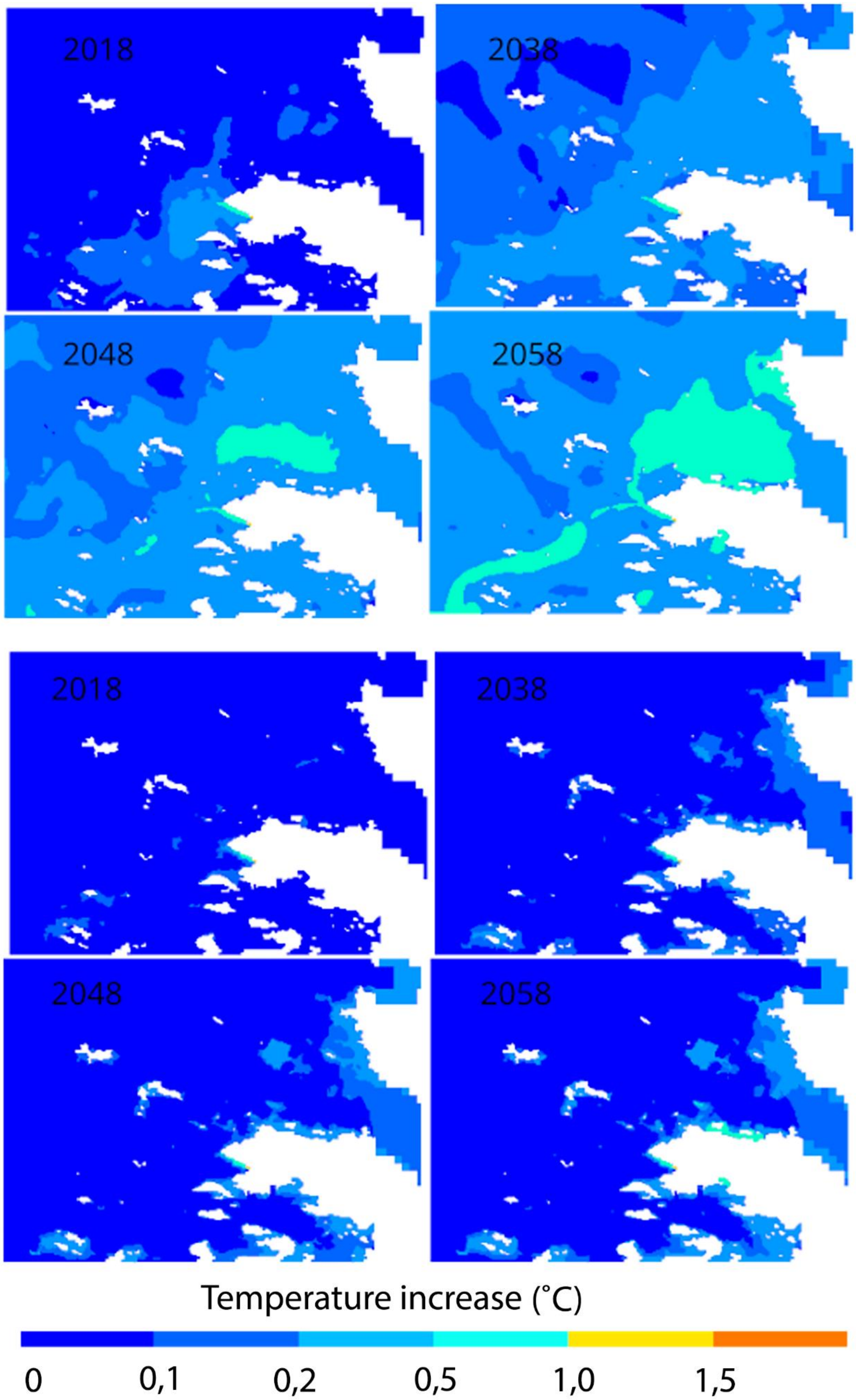

Figure 24. Effects of climate change and power uprating on temperatures during the cold winter of 2018. The first 4 images are from the surface layer and the lower ones from the benthic water layer.

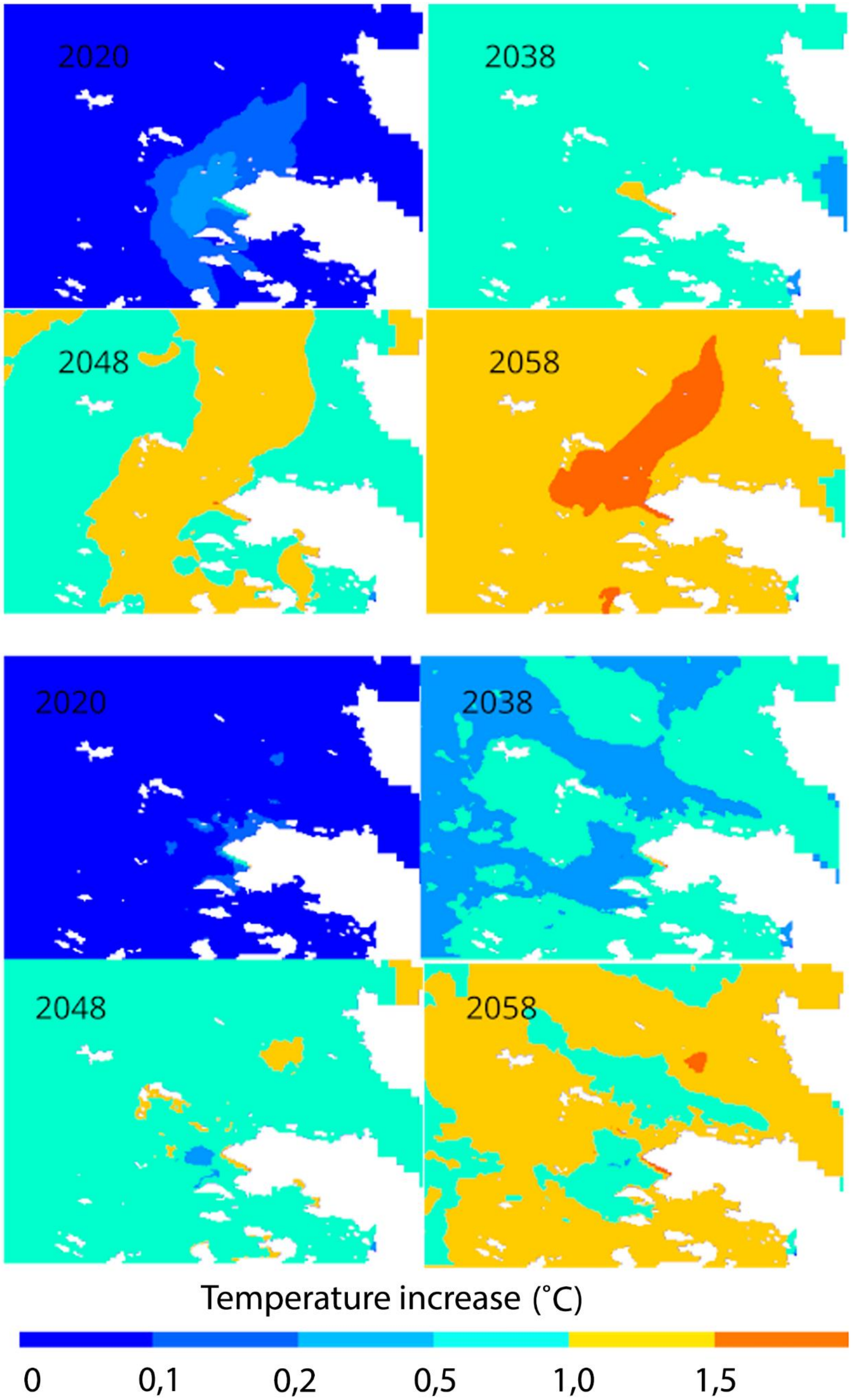

Figure 25. Effects of climate change and power uprating on temperatures during the mild winter of 2020. The first 4 images are from the surface layer and the lower ones from the benthic water layer.

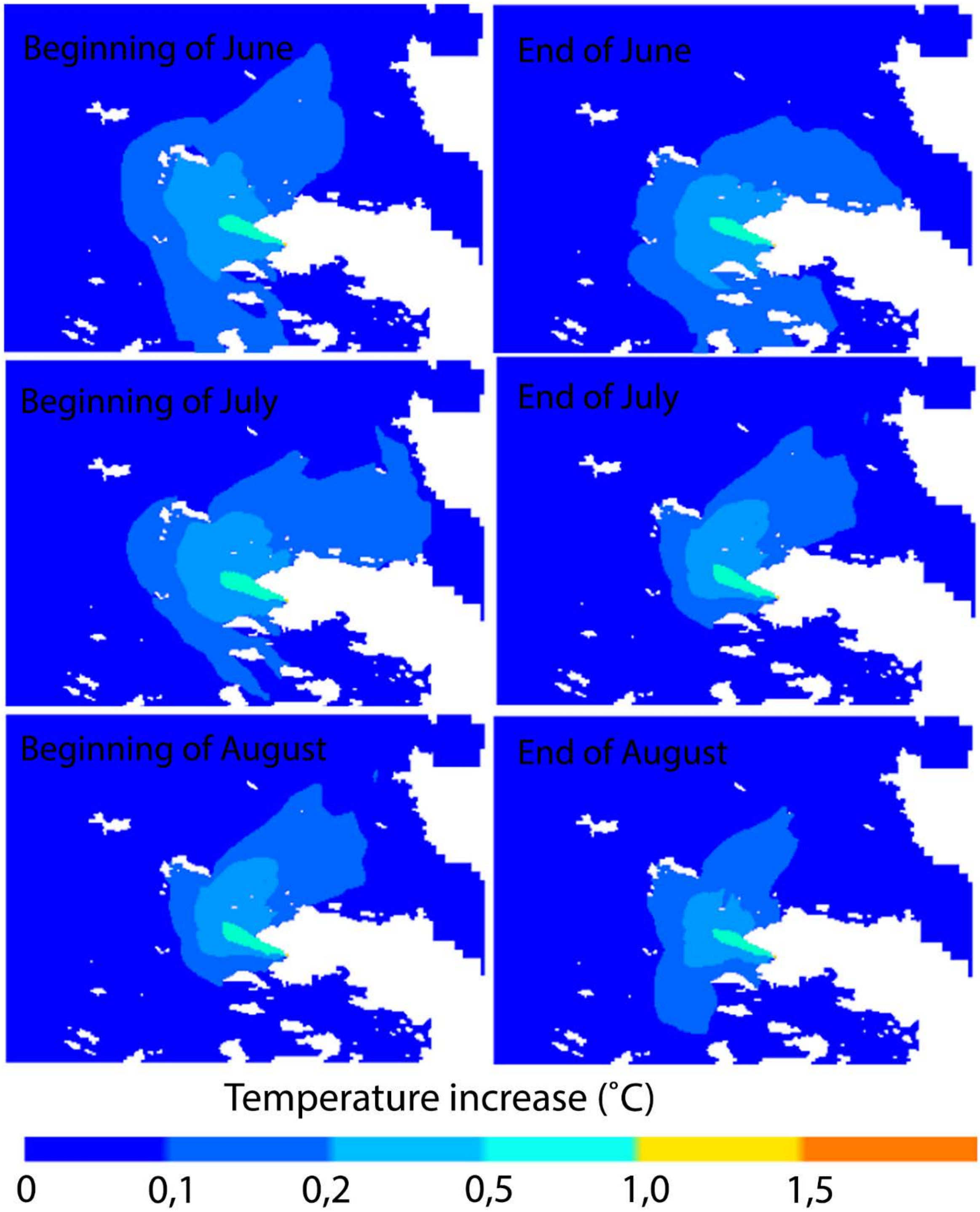

Figure 26. Variations in temperature change due to power uprating in the cool summer of 2017 in half-month periods (beginning: 1st to 15th day, end: 16th to 30th/31st day).

Effects on flows

The seawater intake and discharge volumes of the plant units remained the same in all scenarios. There are, thus, no direct changes to the currents in the sea area, but the temperature increase and density changes of the discharge water cause indirect effects on the currents there. It will take a little longer for the density differences to even out, and the flow paths to equalising the temperature will change. Figure 27 shows changes in flow rates both in momentary situations and as a two-week average in the summer and winter periods.

The same temperature change in discharged water causes a greater density change in summer than in winter. This is why the currents change more in the summer. The biggest changes occurred in the vicinity of the discharge current and were in the range of several cm/s, i.e. a few per cent of the strength of the discharge current. The location of the discharge current was affected by the wind situation, so when the location of the largest area of change is changed, the average change remains smaller. Temperature changes are concentrated in the surface layers, so the flow changes were also greater on the surface.

From a wider viewpoint, the power uprating amplifies the temperature stratification of the sea slightly in summer in the areas near Olkiluoto. It, thus, reduces the exchange of water between the surface and bottom layers. In winter, the thermal load reduces the ice cover in the sea area and enables wind-induced currents in thawed areas. However, these changes are small when compared to the yearly fluctuation.

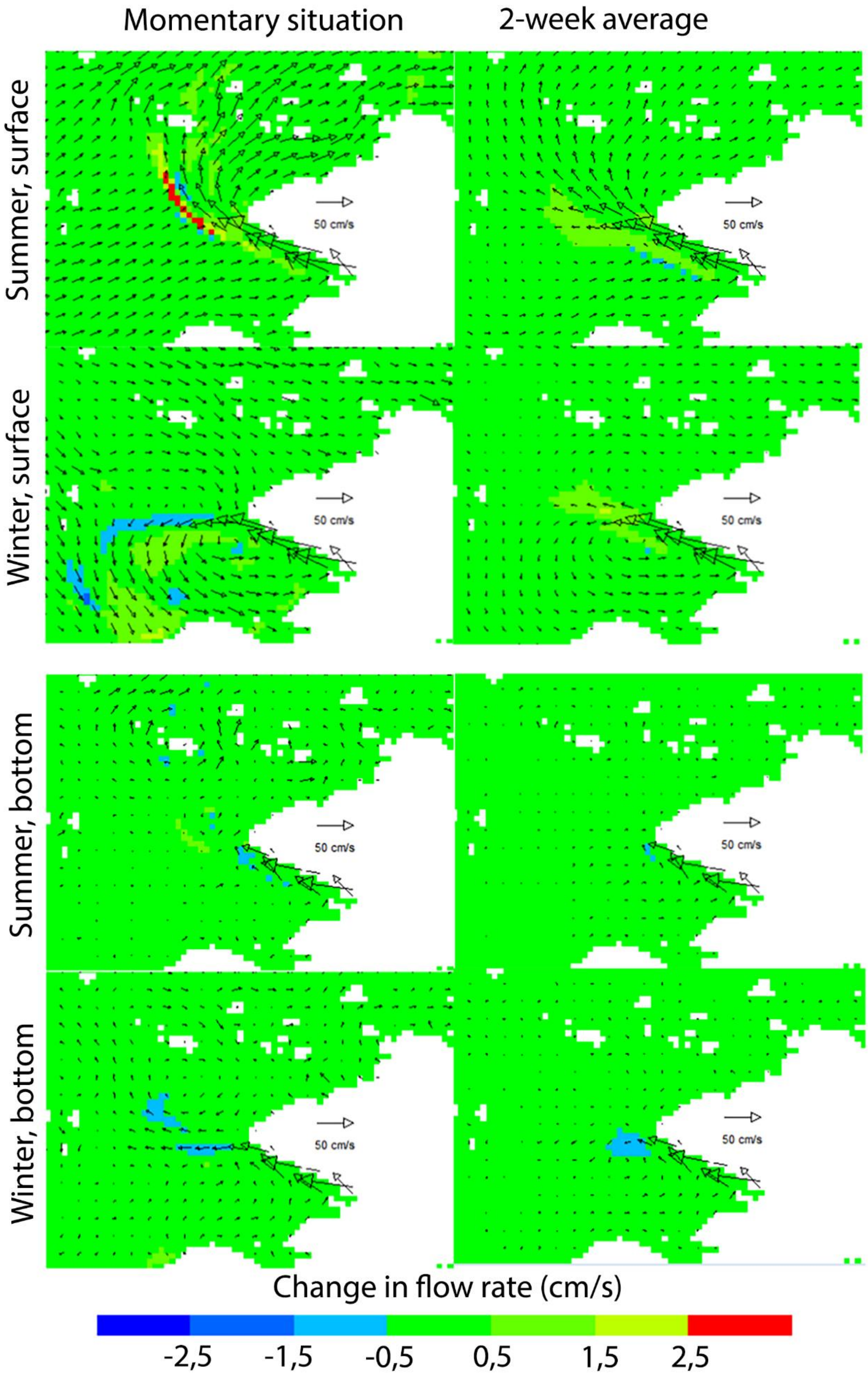

Figure 27. Changes in flow rates in momentary situations (summer 1 August 2017, winter 1 April 2020) and as 2-week averages from these points onwards in both the surface and benthic water layers. The flow arrows indicate the flow situation in the area without power uprating.

Effects on ice cover

Changes in ice days were chosen as the variable to illustrate changes in the ice cover. The results of the impacts of power uprating and climate change on the number of ice days are presented Figure 28. When evaluating the model results, it is worth remembering that in the model simulations, ice also formed off Olkiluoto in some areas where it was not observed. For this reason, the results should be interpreted more as general magnitude changes in the areas where ice was actually observed in the ice maps of Figure 15.

Unlike temperature changes, which spread evenly away from the discharge site, changes in ice days are more random. In areas with no ice, the changes in ice days are also zero. The same applies to situations where the thermal load thins the ice but it later freezes back to a similar thickness. Changes to the ice days mainly occur in situations where the ice is just forming or thawing, so the prevailing wind conditions also play a major role.

From the simulated changes to ice days, it can be concluded that the effects of the power uprating shorten the ice cover time by an average of 2 days, but larger changes may occur in some places due to random weather conditions. Climate change has a greater impact on the ice cover than the power uprating. In the situation of 2058, the ice cover period had shortened by 2−3 weeks.

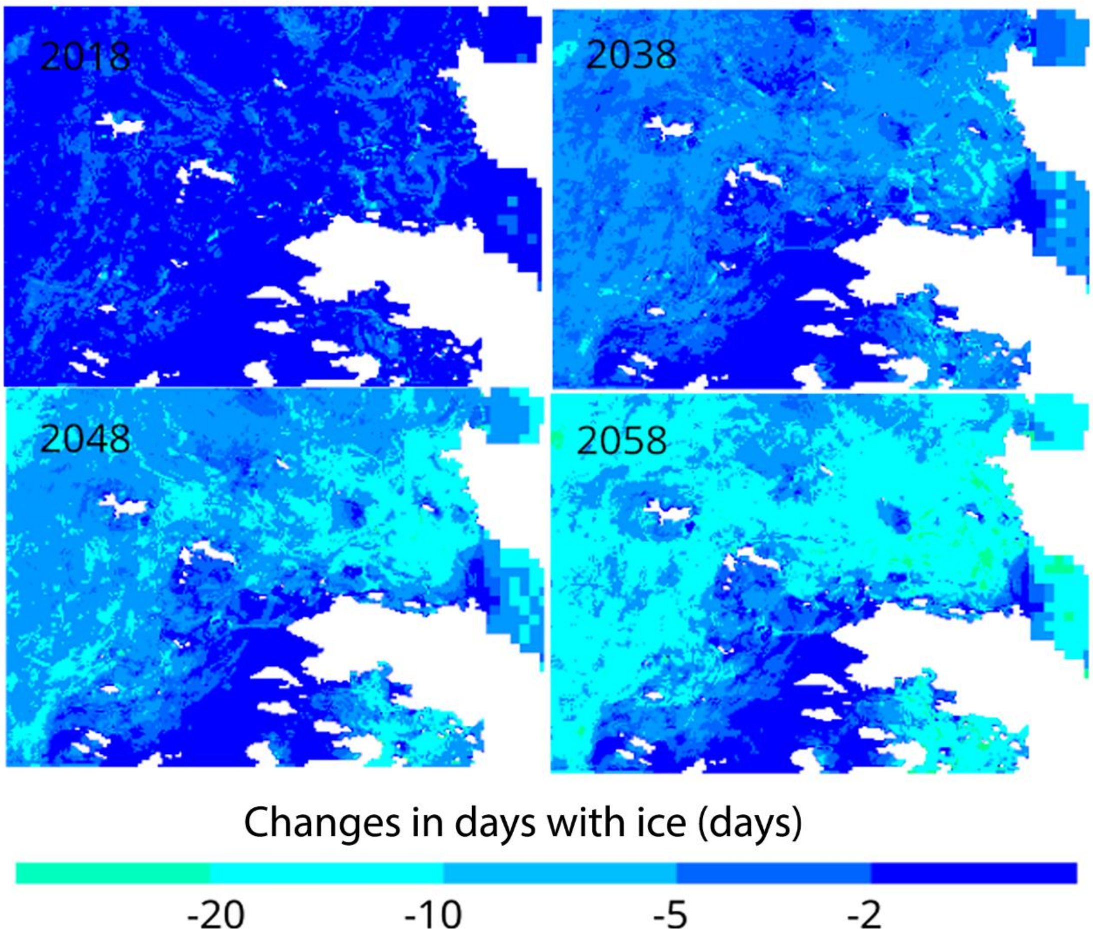

Figure 28. Changes in ice days due to power uprating and climate change.

The strength of the ice cover is crucially important for the recreational use of the sea area. Figures 29 shows an area where an ice cover of more than 10 cm is formed during the winter in different simulation situations. Both climate change and the power uprating had little effect on this area, as during a severely cold period, the ice thickens quickly and the warmer water has time to cool, thinning the weaker ice before it travels to the load-bearing area. The area of load-bearing ice will, therefore, have a rather similar extent as today, but the load-bearing ice period will be shortened in the same way as with the ice days.

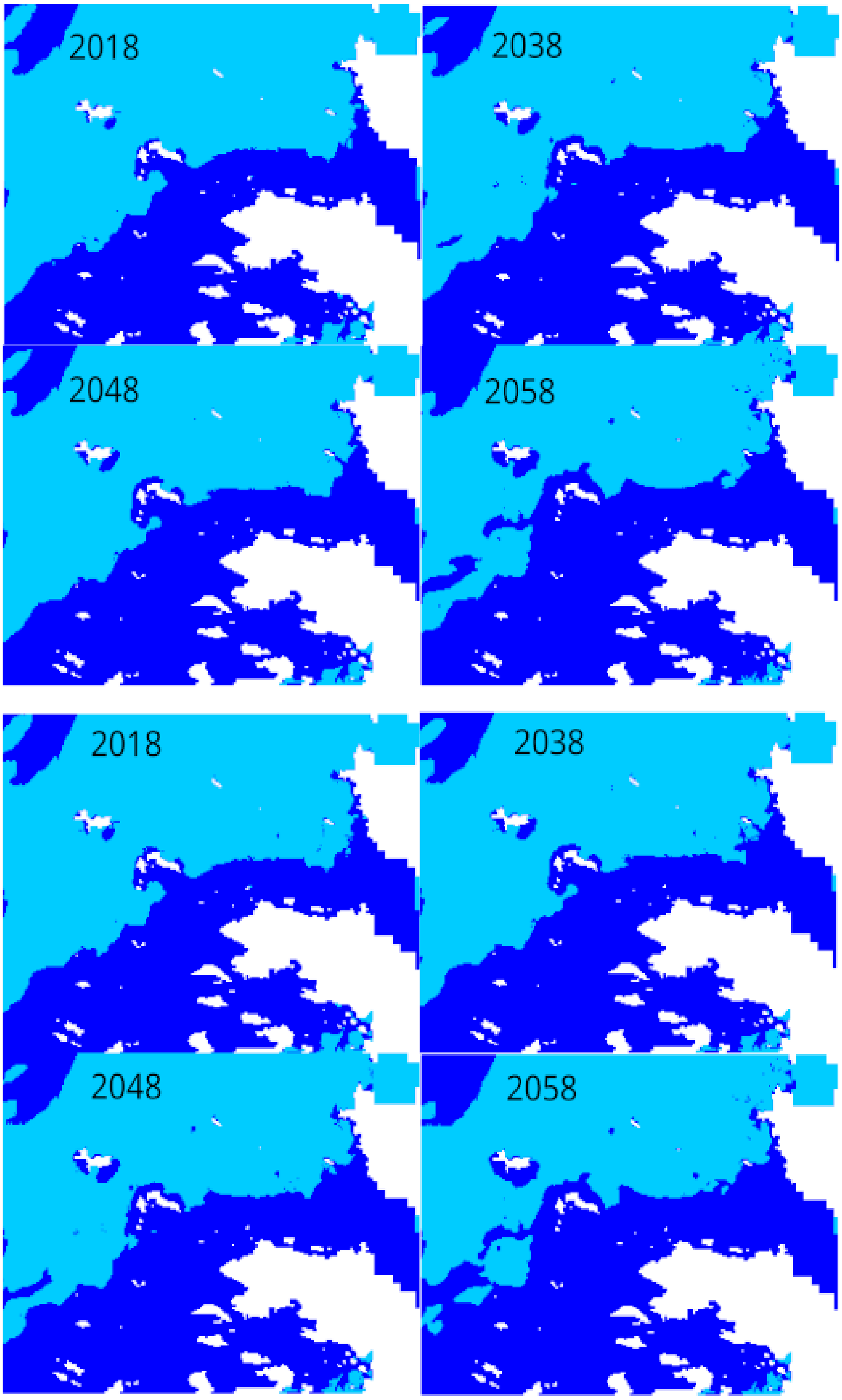

Figure 29. Areas where simulations suggest that ice of more than 10 cm in thickness will occur in the current status and as climate change progresses (first four images) and with power uprating (last four images). Light blue colour indicates an ice cover of more than 10 cm in thickness, while dark blue colour indicates ice that is less than 10 cm in thickness or an open water area.

6. RELIABILITY ASSESSMENTS

The hydrological model is a compromise between descriptions of natural processes, accuracy in differentiation and the calculation time required by the model. The model includes the most common equations used in hydrological models affecting flows, convection and mixing, and in the most accurate model area, the horizontal differentiation accuracy was 40 m. With these choices, a single calculation cycle of the model application could be simulated in approximately one week.

Processes on a scale smaller than the differentiation accuracy or the internal distribution of flows and concentrations within the elementary cell cannot be taken into account very precisely in the model. Water flowed from the mouth of the discharge channel at a rate of 132 m^3/s. The channel was narrower (approximately 30 m) than the resolution of the model, so the resolution is not sufficient to describe the flows near the discharge channel. After the discharge current spreads to the width of several grid squares (approximately 100 m), the resolution accuracy of the model is no longer a problem. This will be realised, at the latest, after the discharge current has passed the tip of Ulkopää on its way to a more open sea area.

The area covered by the most accurate resolution of the model was 10.4 x 11 km^2. The most essential impacts of the power uprating on seawater temperature occurred within this area, so the areas for calculating the most reliable area of the model application covered the most essential affected areas.

In addition to the simplifications of the model, the reliability of the model results is affected by the reliability of the input data of the simulation, the most important of which are the data on the amount and temperature of power plant discharge water (which can be considered reliable) and the meteorological data. The weather conditions of the sea area off Olkiluoto were evaluated both from the measurements of the Olkiluoto weather mast and from ERA5 data. The wind data obtained from these two sources had little correlation with each other, and the distributions of direction and speed were also clearly different in each. There were long periods when the temperature differences reached several degrees.

Inaccuracies in the local weather conditions may explain most of the differences in the measurement and model results. Inaccurate weather data is not so important for scenario comparisons, because all the situations compared results obtained with the same input data. By choosing different simulation years, it was ensured that the possible future weather would be located between these extreme periods.

The ice calculation in the model has been simplified in such a way that it does not take into account the movement of ice, so the phenomena resulting from this cannot be determined with the model. The simulated maximum winter ice thicknesses were similar to the ice observations, and the ice dynamics had the same kinds of trend as the observations. But, in general, ice is generated in the model over too large an area. The most realistic estimate of the impacts of the power uprating on the ice cover is obtained by combining the ice maps and model results with an expert assessment.

7. SUMMARY

The report assessed the effects of climate change and the continued operation and power uprating of the OL1 and OL2 plant units on the local temperatures, flows and ice cover. In the calculation, a three-dimensional calculation model refined for the entire Olkiluoto area was used, with a calculation grid with a resolution of 40 m being utilised in the area near the power plant. To calculate the boundary values, the coarsest grid of the model contained the entire Bothnian Sea with a grid resolution of 5 km.

As initial meteorological data, the model included ERA5 data with a resolution of approximately 31 km, as well as the flow rates of the largest rivers flowing into the Bothnian Sea or located near Olkiluoto and the use of seawater by the nuclear power plant. In addition to temperature, the model calculated salinity as a factor affecting water density.

The model was applied to two periods in summer and two in winter, which were chosen to be as different from each other as possible in terms of the average air temperature. In the sea area off Olkiluoto, measurements have been made in summer with several continuously operating temperature gauges and temperature loggers, to which the simulation results of the model were compared. The phenomena observed in the measurements stood out reasonably well in the simulation results, with the exception of unstable temperature stratification situations in Iso Kaalonperä bay. The correlation between measurements and model results was 0.89.

The most relevant findings related to seawater temperature in the scenario calculations were the following: Climate change will affect the seawater temperature in the sea area off Olkiluoto more than the continued operation of the OL1 and OL2 plant units or the power uprating. The effects of the power uprating are greatest in the initial part of the discharge stream: approximately 0.5 °C. They are below 0.1 °C on average at a distance of more than 4 km. The power uprating mainly affects surface water temperatures, and climate change also affects the surface layer more.

The power uprating has only a minor effect on flows near the current discharge flow. In winter, the power uprating affects the ice-covered period only for a few days, and its effect cannot be distinguished from the yearly fluctuation. Climate change will clearly affect the ice cover more than the power uprating.

In terms of the reliability of the calculation, the biggest uncertainty factors were related to local weather data, the ice model and the temperature distribution in the area near the discharge point. Two simulations containing the same uncertainty factors were compared in the scenario calculations, so the uncertainty related to their relative differences is smaller than when comparing the absolute values of one simulation period.

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Teollisuuden Voima Oyj 2023. Luotaustiedosto.

APPENDIX 1. DESCRIPTION OF FLOW WATER QUALITY CALCULATION

The numerical modelling of water flows is based on the physical laws of conservation of mass, momentum and energy. When these conservation laws are written for a very small volume of liquid, the Navier-Stokes equations of motion are obtained. Here the liquid to be modelled is assumed to be incompressible.

$$(1) \quad \frac{\partial u}{\partial t} = fv - \frac{1}{\rho_0}\frac{\partial p}{\partial x} + \frac{\partial}{\partial x}\left(v_{hor}\frac{\partial u}{\partial x}\right) + \frac{\partial}{\partial y}\left(v_{hor}\frac{\partial u}{\partial y}\right) + \frac{\partial}{\partial z}\left(v_{ver}\frac{\partial u}{\partial z}\right) - u \cdot \nabla u$$

$$(2) \quad \frac{\partial v}{\partial t} = -fu - \frac{1}{\rho_0}\frac{\partial p}{\partial y} + \frac{\partial}{\partial x}\left(v_{hor}\frac{\partial v}{\partial x}\right) + \frac{\partial}{\partial y}\left(v_{hor}\frac{\partial v}{\partial y}\right) + \frac{\partial}{\partial z}\left(v_{ver}\frac{\partial v}{\partial z}\right) - u \cdot \nabla v$$

$$(3) \quad \frac{\partial p}{\partial z} = -g\rho$$

$$(4) \quad \nabla \cdot u = 0$$

u = velocity vector, m/s
u,v = horizontal components of flow velocity, m/s
t = time, s
p = pressure, Pa
f = coriolis factor
ρ_0= average water density, kg/m^3
ρ=water density, kg/m^3
g = 9.81 m/s2
ν_{hor},ν_{ver} = horizontal and vertical eddy viscosity coefficient, m^2/s

In the above equations, equations (1) and (2) describe the change of horizontal flow in relation to time. The change in the flow in relation to time is the sum of the Coriolis effect, the effect of the surface height difference, the effect of eddy viscosity and the conservation of momentum. Equation (3) describes the effect of density differences on the vertical pressure term, and equation (4) ensures conservation of mass. A more detailed description of the equations can be found in the literature on the subject.

The Navier-Stokes equations show how a very small box of liquid behaves. In order to apply the equations to practical problems, they must be written in a form that can be solved by a computer. For this, a model grid is prepared where the equations are then solved using some numerical method.

A model grid is a description of the model area prepared for numerical calculation, where the area is divided into a number of boxes called elementary cells. The set of elementary cells should represent the model area as accurately as possible, but the size of the cells naturally determines how accurately the area can be depicted. The smaller the elementary cells are, the more precisely the area can be represented and the more cells and computing capacity will be needed. Each elementary cell represents the area it covers. The quantities to be calculated inside the elementary cell are assumed to remain constant or change in a pre-defined way.

The calculation model is usually formulated in such a way that when the values of the quantities to be calculated in the grid at time t are known, the situation at the end of time step Δt can be calculated from these values and the known boundary values by using the model equations. The result is thus the situation at moment $t+\Delta t$. The numerical calculation of water quality involves transferring the substances to be calculated from one elementary cell to another by utilising known flow rates and the calculation of the processes of the substances. These processes can include sedimentation, decomposition, oxygen depletion and so on.

The model grid is usually three-dimensional, i.e. it has elementary cells in both horizontal and vertical directions. The grid can be nested, i.e. inside a more coarse grid there is a grid whose cells are smaller than the coarse grid. In this way, the calculation can be refined in a particular area and still take into account the effect of a larger area on the refined one.

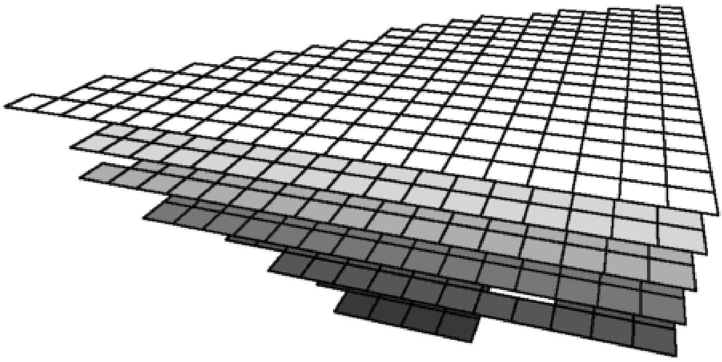

Figure: simple 3D grid, deeper levels are drawn darker

Water starts flowing when a factor forces the water to move. Factors that produce currents include wind, tides and the rivers entering the area. Currents are also affected by the state of the water mass, such as temperature stratification and differences in salinity. The modelled area also usually has edges, in which case the water levels or flow rates at the edges of the area need to be known. Currents are slowed down by friction forces, mainly friction at the bottom and on the shoreline and turbulence.

The calculation model contains a set of parameters that are used in fitting the model to the modelled area. Not all of the parameters can be estimated in advance, so they must be calibrated by using the measurement results. During calibration, the model is calculated by using several alternative parameter combinations and the alternative that best fits the measurements is selected.

Errors in calculation occur for several reasons. Firstly, the model equations have had to be simplified so that they can be solved quickly enough for the practical application of the model. Another type of error is caused by describing the model area as square elementary cells − these errors decrease when the smaller elementary cells are used. However, the largest errors are usually caused by boundary values, loads or initial situations being poorly known.

Appendix 6. Natura screening

Recipient
Teollisuuden Voima Oyj

Document type
Natura screening

Date
30 Aug 2024

Reference
1510076597

EXTENDING THE SERVICE LIFE OF THE OLKILUOTO 1 AND OLKILUOTO 2 PLANT UNITS AND UPRATING THEIR THERMAL POWER

SCREENING FOR NATURA ASSESSMENT RAUMA ARCHIPELAGO (FI0200073)

RAMBOLL

TVO – SCREENING FOR NATURA ASSESSMENT

Date	30.8.2024
Author	Ella von Weissenberg
Inspector	Elina Salo-Miilumäki, Saara Vauramo
Description	Screening for Natura assessment

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CONTENTS

1. INTRODUCTION

As part of service life management for the Olkiluoto nuclear power plant, Teollisuuden Voima Oyj (TVO) is analysing the possibility of extending the service life of the OL1 and OL2 plant units and uprating their thermal power.

The screening for the Natura assessment targets the Natura area of the Rauma archipelago (FI0200073) located in the vicinity of the Olkiluoto nuclear power plant area, which is classified as a Special Area of Conservation (SAC). The location of the project area and Natura areas is presented in the following figure (Figure 1).

The screening for the Natura assessment precedes any Natura assessment that may be carried out. Its purpose is to determine whether the possibility of significant impacts on the Natura area's conservation criteria can be excluded. The screening involves describing the project, the impacts it causes and the Natura areas located in the affected area, as well as assessing the significance and probability of the impacts.

This screening for the Natura assessment has been prepared in the manner required by Section 35 of the Nature Conservation Act 9/2023 as a habitat type and species-specific expert assessment, and it focuses on the conservation values, i.e. habitat types and species, on the basis of which the site has been included in Finland's Natura 2000 network. As a result of the screening, an estimate has been put forth as to whether the service life extension and power uprating of the Olkiluoto 1 and Olkiluoto 2 nuclear power plant units is likely to cause such significant adverse impacts on the Natura area's conservation criteria that an actual Natura assessment in accordance with Section 35 of the Nature Conservation Act should be carried out.

The screening for the Natura assessment was prepared by marine biologist (PhD) Ella von Weissenberg from Ramboll Finland Oy.

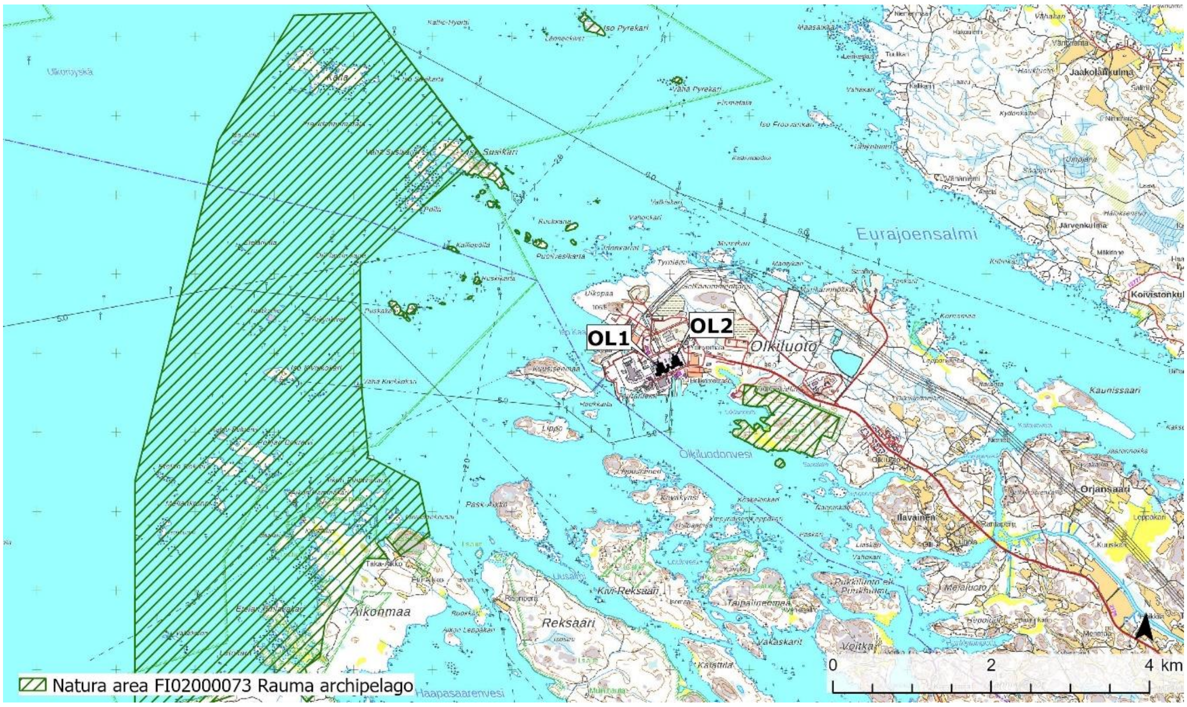


Figure 1. Location of the project area in relation to the Rauma archipelago Natura area. Background map: National Land Survey of Finland.

2. CONSERVATION OF NATURA AREAS AND ASSESSMENT CRITERIA

2.1 Legislation

The Natura network protects the habitat types, species and their habitats defined in the EU Habitats Directive (892/43/EEC) and Birds Directive (79/409/EEC) occurring at sites which the Member States have announced or proposed to form part of the Natura network. The Member States are obliged to ensure that in the preparation and decision-making of projects and plans, a so-called Natura assessment is carried out to ensure that the nature values for which a site has been included or is proposed to be included in the Natura network are not significantly deteriorated. Activities causing a significant deterioration in the conservation values are prohibited both inside the site and outside its borders. At a site included in the Natura network, conservation in line with the conservation objectives must be carried out. In Finland, conservation is carried out pursuant to the Nature Conservation Act, the Wilderness Act, the Land Extraction Act, the Act on the Protection of Rapids and the Forest Act, depending on the site. The means of implementation affects, among other things, what kind of activities are possible in each Natura area. The conservation of the Natura areas where conventional land use is most severely restricted is carried out via the Nature Conservation Act. At these sites, most measures that modify the environment are prohibited. Correspondingly, at sites where conservation is carried out via the Forest Act or the Land Extraction Act, the prohibitions are usually less severe and e.g. small-scale forestry activities and land extraction procedures in a manner that preserves the nature values of the site may be allowed. (Mäkelä & Salo 2024).

2.2 Determination of assessment obligation

Pursuant to Section 34 of the Nature Conservation Act (9/2023), an authority may not issue a permit or adopt a plan that can be estimated to cause a significant deterioration in nature values for the conservation of which the site has been included in the Natura network. Section 35 of the Act states the following regarding the Natura impact assessment of projects and plans:

"If a project or plan, either individually or in combination with other projects and plans, is likely to cause a significant deterioration in nature values of a site included in or proposed by the Government to be included in the Natura 2000 network for the conservation of which the site has been included or is intended to be included in the Natura 2000 network, the implementer of the project or the formulator of the plan shall carry out an appropriate assessment of these impacts in view of how they affect the conservation objectives of the site." (Nature Conservation Act 9/2023, Section 35).

A Natura impact assessment obligation arises if the impacts of the project a) target the nature values on the basis of which the Natura area is conserved, b) are deteriorating in nature, c) are significant in quality, and d) are probable based on advance assessment. The assessment is based primarily on the nature values on the basis of which the site has been included in the Natura network of protected areas. These include, on a site-specific basis:

- habitat types listed in Annex I to the Habitats Directive (SAC areas);
- species listed in Annex II to the Habitats Directive (SAC areas);
- species of bird listed in Annex I to the Birds Directive (SPA areas); and
- migratory species of bird referred to in Article 4(2) of the Birds Directive (SPA areas).

The starting point for the assessment is, therefore, the conservation values (habitat types and species) pursuant to the Habitats Directive in SAC areas, the species and migratory species of bird pursuant to the Birds Directive in SPA areas, and both of these in SAC/SPA areas. In addition to the impacts on individual habitat types and species, the impacts of the project on the integrity of the Natura area must be assessed.

2.3 Screening for Natura assessment

The screening for the Natura assessment precedes any Natura assessment that may be carried out. When determining the necessity of a Natura assessment for a project or plan, at least the following information should be compiled (Mäkelä & Salo 2024):

- a description of the project or plan, its activities and location in relation to the Natura area;
- a delimitation of the area affected by the activities and the direct or indirect environmental changes caused to this area;
- the general description and conservation objectives of the Natura area; and
- the impacts of the activities and joint impacts on the nature values that form the basis for the conservation of the Natura area.

A Natura assessment is required in a situation where significant impacts on protected species or habitat types cannot likely be excluded based on advance assessment. The screening does not address mitigating measures or involve carrying out a detailed impact assessment.

3. IMPLEMENTATION OF THE NATURA SCREENING AND THE DATA EMPLOYED

3.1 Data and methods

The impact assessment has been carried out regarding the Rauma archipelago Natura area's habitat types listed in Annex I and species listed in Annex II to the Habitats Directive on the basis of which the sites have been included as part of the European Natura 2000 network. The analysis has been carried out as a literature review based on the existing data. The assessment was drawn up by marine biologist Ella von Weissenberg, PhD.

The key data employed in the assessment have included:

- a data form of the Rauma archipelago FI0200073 Natura area (Metsähallitus 2024a) and a summary of the data form (Syke 2018);
- biotope patterns of the Rauma archipelago FI0200073 Natura area (extracted from the SAKTI system of Metsähallitus on 8 April 2024);
- sea seal population densities 2023 and moulting islets, Natural Resources Data service (Luke 2024);
- Velmu map service of underwater marine nature (Syke 2024); and
- the project's cooling water modelling (AI Innovaatio Oy 2024).

4. RAUMA ARCHIPELAGO NATURA AREA (FI0200073)

4.1 Location and general information

The Rauma archipelago Natura area (FI0200073) is part of the boreal zone. The total surface area of the site is 5,350 ha, of which 86% is at sea. The area is located in the Bothnian Sea.

According to the Natura data form (Metsähallitus 2018), the outer archipelagos of the Bothnian Sea and the archipelagos of the sea zone are narrow in the Rauma archipelago area. The bedrock is mica slate. The bedrock is covered by moraine of varying thickness. The dominant shore types are rocky shores and stony banks. The area features, among other things, an outer archipelago, a land upheaval coast with groves and traditional biotopes, an old fisherman's farm and primeval forest.

The extensive open sea area of the Rauma archipelago Natura area comprises small islands and islets as well as larger forested islands. The shores of the outer islands are shallow with clean water, allowing the occurrence of exceptionally extensive and healthy communities of *Fucus vesiculosus*. The outer archipelago meadows of the Natura area are representative, and the area is also a valuable archipelago and traditional landscape. The area has abundant birdlife and flora, and several nationally threatened species occur there.

The Natura data form for the Rauma archipelago (Metsähallitus 2018) does not mention any specific threat factors.

4.2 Conservation criteria and implementation

The conservation criteria of the Rauma archipelago Natura area include 15 habitat types listed in Annex I to the Habitats Directive (Table 1) and one species listed in Annex II to the Habitats Directive (Table 2).

The minimum conservation objective mentioned is preserving the site's significance as part of the Natura 2000 network. In addition, the following objectives are emphasised in conservation (Metsähallitus 2018):

- "The state of habitat types, species and their habitats prevailing at the site is preserved by securing the development according to nature's own processes.
- The state of habitat types, species and their habitats prevailing at the site is preserved through management measures.
- The quantity of a habitat type, habitat or population of a species is increased by restoration and management measures.
- The quality of a habitat type or habitat of a species or the viability of a population of a species is improved through restoration and management measures."

4.3 Habitat types listed in Annex I to the Habitats Directive

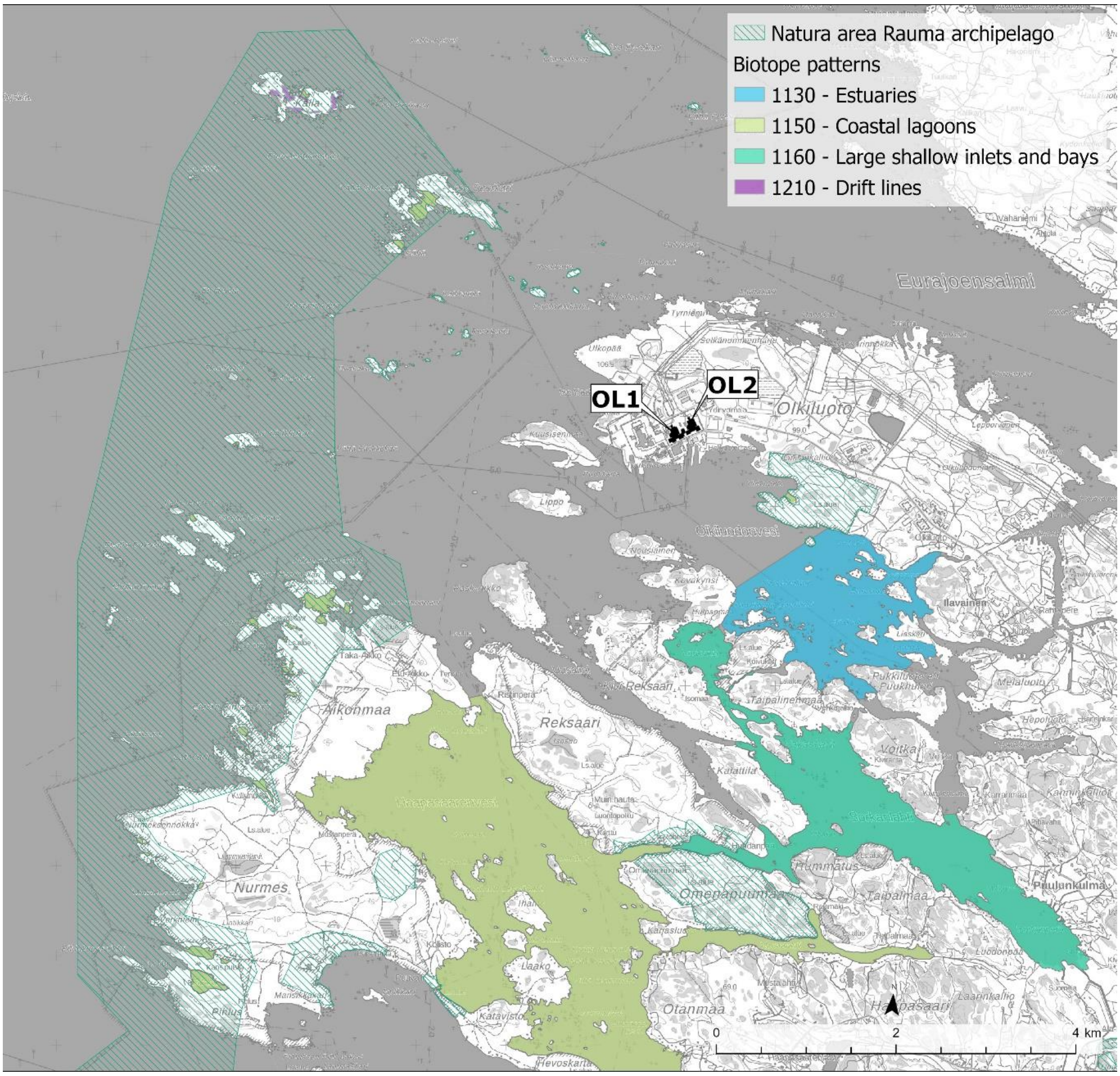


Figure 2. Patterns of habitat types subject to protection in the Rauma archipelago Natura area. The figure also shows patterns outside the Natura area, which are not included in the assessment. The biotope patterns were extracted from the SAKTI system of Metsähallitus (2024). Background map: National Land Survey of Finland.

Table 1. Habitat types listed in Annex I to the Habitats Directive, their surface area and representativeness in the Rauma archipelago Natura area. Representativeness: A = excellent, B = good, C = significant.

Code	Name	Surface area (ha)	Represent-ativeness
1150	Flads, gloe lakes and lagoon-type bays	43.3	A
1170	Reefs and the underwater parts of rocky shores featuring algal zones	187	B
1210	Annual vegetation of drift lines	8	A
1220	Perennial vegetation of stony banks	45	A
1230	Vegetated sea cliffs of the Atlantic and Baltic coasts	27	C
1620	Baltic islets and islands in outer archipelago and open sea zones	76.2	A
1630	Boreal Baltic coastal meadows	34.6	B
1640	Boreal Baltic sand beaches with perennial vegetation	0.1	B
3260	Water courses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation	0.01	C
6270	Fennoscandian lowland species-rich dry to mesic grasslands	1	B
9010	Western taiga	50	B
9030	Natural forests of primary succession stages of land upheaval coast	50	B
9050	Fennoscandian herb-rich forests with *Picea abies*	40	B
9070	Fennoscandian wooded pastures	0.59	B
91D0	Bog woodland	1.2	C

Descriptions of the protected habitat types that may be subject to changes from the project due to the identified impact mechanisms are presented below (presented in chapter 6).

1150 Coastal lagoons, i.e. flads, gloe lakes and lagoon-type bays

Airaksinen and Karttunen (2001) describe the habitat type as follows: "Coastal lagoons include lagoon-type bays, flads and gloe lakes. Lagoon-type bays are coastal areas of shallow salt water, with varying salinity and water volumes. Lagoons are wholly or partially separated from the sea by sandbanks or shingle, or sometimes also by rocks. Salinity may vary greatly depending on rainfall and evaporation, as well as through seawater flooding into the lagoon due to storms, high water in winter or the tides. Vegetation is either absent or of the classes *Ruppietea maritimae*, *Potametea*, *Zosteretea* or *Charetea*. Flads and gloes are small, shallow and clearly delimited water basins that are still connected to the sea or that have been cut off from the sea very recently. They are characterised by well-developed reedbeds and luxuriant submerged vegetation. Flads and gloes have several different morphological and botanical development stages, which represent ecologically important succession stages of land upheaval in the process whereby sea becomes land."

The coastal lagoons habitat type occurs in the Natura area in an area spanning approximately 43 ha. The representativeness of the habitat type in the Natura area is excellent. The representativeness is determined by the presence of *Charophyta* algae and the abundance of flora. Shore construction, pollution, eutrophication and dredging reduce naturalness, and the deterioration of water quality, in particular, is a major threat to coastal lagoons (syke 2023).

1170 Reefs, i.e. reefs and the underwater parts of rocky shores featuring algal zones

According to Airaksinen and Karttunen (2001), reefs are "submarine, or exposed at low tide, rocks or biogenic concretions in the sublittoral zone. They may also extend into the littoral zone where there is an uninterrupted zonation of plant and animal communities. Reefs generally have zones of benthic communities of algae and animals species as well as concretions and corallogenic concretions."

Reefs cover 187 ha of the Natura area, and the representativeness of the habitat type in the Natura area is good. The representativeness is characterised by the clear zonation of the algal vegetation and the extensive and healthy growths of *Fucus vesiculosus*. The most important known threat factor is eutrophication, which will retain its significance in the future as well due to the slow recovery of biotic communities. Furthermore, the decline in ice winters as a result of climate change threatens reefs (Syke 2023).

1210 Drift lines

Airaksinen and Karttunen (2001) describe the habitat type as follows: "Annual vegetation of drift lines refers to vegetation occupying accumulations of organic material carried by the water along the upper limit of a beach on gravel (2–64 mm) and shingle (64–256 mm) beaches, but also sandy (0.06–2.0 mm) beaches and stony banks. They are usually found on open shores and at the far ends of bays in the outer parts of the archipelago. Certain beaches accumulate more drift material than others, and drift lines also regularly form on them. The accumulations generally consist of fresh and decomposed *Fucus vesiculosus*, common reed and other organic matter, and often various kinds of waste. Distinctive, very luxuriant vegetation thrives on this highly nitrogen-rich growing medium (Borg 1967). Fresh and old material support separate plant communities. Several annual species thrive on fresh material. Large accumulations of *Fucus vesiculosus* have become rarer with the decline of the species, while accumulations of common reed have become more common."

The drift lines of the Rauma archipelago Natura area are of excellent representativeness. In the Natura area, drift lines formed by *Fucus vesiculosus* can be found in the Kalla and Susikari area, around which in places there are even large concentrations of the species (Ramboll 2009). Drift lines account for only 0.0015% of the entire Natura area.

1630 Coastal meadows

Airaksinen and Karttunen (2001) describe the habitat type as follows: "The extent of low-growing coastal meadows is affected by the nature of the shore and land use. Coastal meadows are more extensive on the low-lying shores of the Gulf of Bothnia than on the minute and ragged coastlines of the Archipelago Sea or the Gulf of Finland (Siira 1970). Coastal meadows that naturally remain low-growing mainly only include coastal meadows subject to the regular erosive effect of ice. Coastal meadows always comprise several plant communities, which occur on the shore in a zonal or mosaic pattern. Nowadays, the threat is the spread of reedbeds and bushes following the decline in the use of the meadows for grazing and due to the eutrophication of the Baltic Sea."

Coastal meadows that are mostly of significant (class C) or non-significant representativeness are found on the shores of the Kalla and Susikari islands. Two patterns are of good representativeness (class B). Coastal meadows of good representativeness are slightly more abundant in the northern part of Aikonmaa and on Aikon Pihlavakari.

4.4 Species listed in Annex II to the Habitats Directive

The Natura data form (Metsähallitus 2018) mentions one species listed in Annex II to the Habitats Directive (92/43/EEC), the grey seal (*Halichoerus grypus),* the form-specific information for which is in the table below (Table 2).

Table 2. Species listed in Annex II to the Habitats Directive occurring in the area (Natura 2000 data form, 2018)

Code	Species	Scientific name	Population size	Conservation	Isolation
1364	Grey seal	*Halichoerus grypus*	not known	B	C

5. PROJECT DESCRIPTION

5.1 General

The OL1 and OL2 plant units are identical boiling water reactors that were commissioned in 1978 (OL1) and 1980 (OL2). The current net electrical output of the OL1 and OL2 plant units is 890 megawatts (MW) per plant unit and their annual electricity production in 2023 was 14.29 terawatt hours (TWh) in total, corresponding to approximately 18% of the electricity consumption in Finland. Since the early 1990s, the capacity factors for OL1 and OL2 have been around 90%.

The original planned service life of the OL1 and OL2 plant units was 40 years, until 2018. During their years of operation, the plant units have been modernised in many ways through annual servicing, while also improving their safety. Due to significant investments, the power plant units remain in excellent operating condition, so it has been possible to extend the service life of the plant units to 60 years. The current operating licences for the OL1 and OL2 plant units are in force until 2038. The currently examined project involves analysing the possible extension of the service life of the plant units until 2048 or, alternatively, until 2058.

At the time of commissioning, the thermal power of the plant units' reactors was 2,000 MW, from which it has been uprated to the current 2,500 MW in two stages: in 1984 (to 2,160 MW) and between 1994 and 1998 (to 2,500 MW). Correspondingly, the nominal (net) electrical power of the plant units has gone up from the original 660 MW to 710 MW in 1984 and to 840 MW in 1998. As a result of the turbine plant modernisations carried out in 2005–2006 and 2010–2012 and the increase in efficiency, the current nominal value for electrical power is 890 MW. In the presently examined power uprating, the starting point is an increase of the reactor's thermal power by 10% to 2,750 MW, which corresponds to increasing the plant units' nominal electrical power output from the current 890 MW to 970 MW. The total additional electricity generated by the OL1 and OL2 plant units each year would be approximately 1,200,000 MWh, which is roughly equivalent to the annual consumption of a city the size of Jyväskylä or Kuopio.

The location of the site area in relation to the Rauma archipelago Natura area is presented in the figure above (Figure 1).

5.2 Implementation alternatives in the EIA procedure

In this EIA procedure, the implementation alternatives being examined for the project are continuing the operation of the OL1 and OL2 plant units at the current power level until 2048 or 2058 (VE1) and continuing the operation at an uprated power level until 2048 or 2058 (VE2). In the zero alternative, the operation of the plant units will continue until the expiration of the valid operating licences in 2038 (VE0). The alternatives being considered are presented in the enclosed figure (Figure 3).

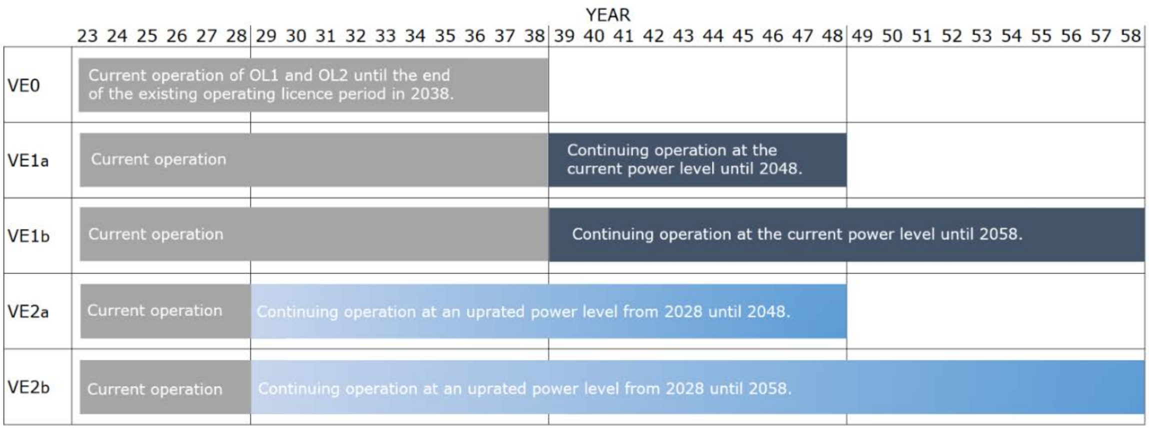


Figure 3. The alternatives examined in the EIA procedure and their preliminary, planned schedules.

New operating licences pursuant to the Nuclear Energy Act (990/1987) must be applied for in all implementation alternatives. In alternative VE1, the new operating licences will be applied for before 2038 at the latest, as this will be the year of expiration for the existing operating licences. For alternative VE2, this will be carried out during 2028.

If the operation of the OL1 and OL2 plant units is not continued (VE0), the decommissioning of the plant units will take place following the expiration of the current operating licences, from 2038 onwards. If the operation of the plant units is continued, decommissioning will take place after the expiration of the new operating licences, from either 2048 or 2058 onwards. The decommissioning of nuclear power plants is subject to licence and regulated according to the Nuclear Energy Act and Decree and STUK's regulations and guides. According to the current EIA Act (252/2017), the dismantling or decommissioning of a nuclear power plant requires an EIA procedure. A separate environmental impact assessment will be drawn up for the decommissioning of the OL1 and OL2 plant units, according to the legislation in force, once decommissioning becomes relevant.

6. IMPACT MECHANISMS AND AREA OF IMPACT

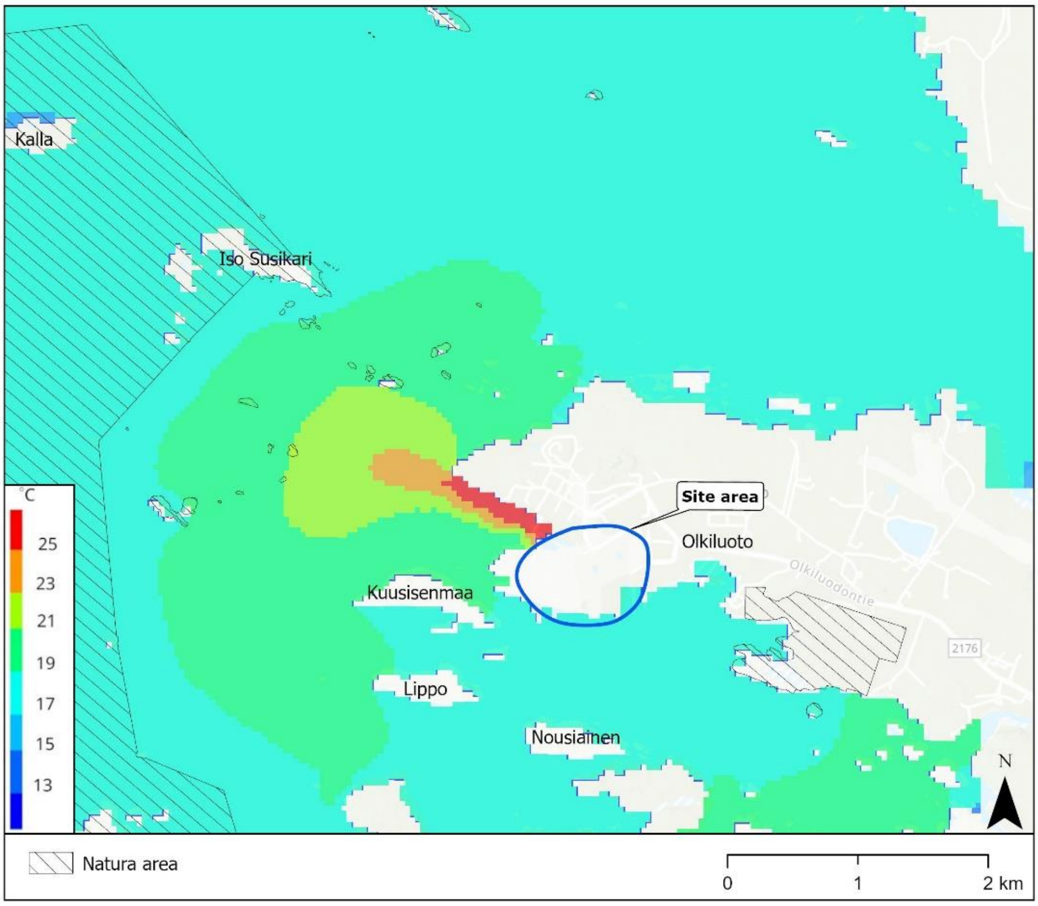
The thermal load of the cooling water routed to the sea from the nuclear power plant is the only impact mechanism identified in the project that could have impacts on the conservation criteria of the Rauma archipelago Natura area. Direct and indirect impacts would target underwater habitat types, which include coastal lagoons (1150) and reefs (1170). In addition, there may be indirect impact on drift lines (1210) and coastal meadows (1630) through changes in the ice conditions. Furthermore, possible changes in the ice conditions may affect the protected grey seal.

The impact of the project on the seawater temperature has continued since 1978, enabling the environment to adapt to this change. With continued operation, the impact of the activities on the environment will not change. With the power uprating, the temperature of the cooling water routed into the sea will increase by 1°C and the thermal load will increase by approximately 11,000 TJ/year when compared to the current operation.

Based on the results of the cooling water modelling (AI Innovaatio Oy 2024), the thermal load from the cooling water caused by the power uprating will mainly affect the surface layer of the seawater. The most significant temperature increase is observed in the immediate vicinity of the cooling water discharge tunnel, and the impact of the temperature increase extends from the discharge tunnel to an area approximately 300 metres wide and 1,500 m long, in relation to the direction of the flow, with the temperature impact decreasing as the distance increases. The area of impact of the cooling waters covers the eastern side of the Rauma archipelago, roughly from Kalla to Aikonmaa in a north-to-south direction (Figure 4). At a distance of approximately 2 km from the discharge point of the cooling waters, the power uprating increases the average seawater surface temperatures by 0.2°C and at a distance of 3–4 km by 0.1°C. In both alternatives, the duration of the impact is long-term at more than 20 years.

Table 3. Possible impact mechanisms on the habitat types of the Rauma archipelago Natura area and their causes.

Conservation criterion	Cause	Possible impact mechanisms
Coastal lagoons (1150)	Indirect and direct impacts of seawater temperature increase	Ice conditions, increased periphyton abundance, eutrophication
Reefs (1170)		
Drift lines (1210)	Changes in ice conditions, decline of *Fucus vesiculosus*	Decrease in *Fucus vesiculosus* forming drift lines and degradation of the habitat type
Coastal meadows (1630)	Change in ice conditions	Decrease in the erosive effect of ice on the shore may increase overgrowth and degrade the habitat type
Grey seal (*Halichoerus grypus)*	Change in ice conditions	Possible impact on reproduction, as the grey seal gives birth e.g. on pack ice



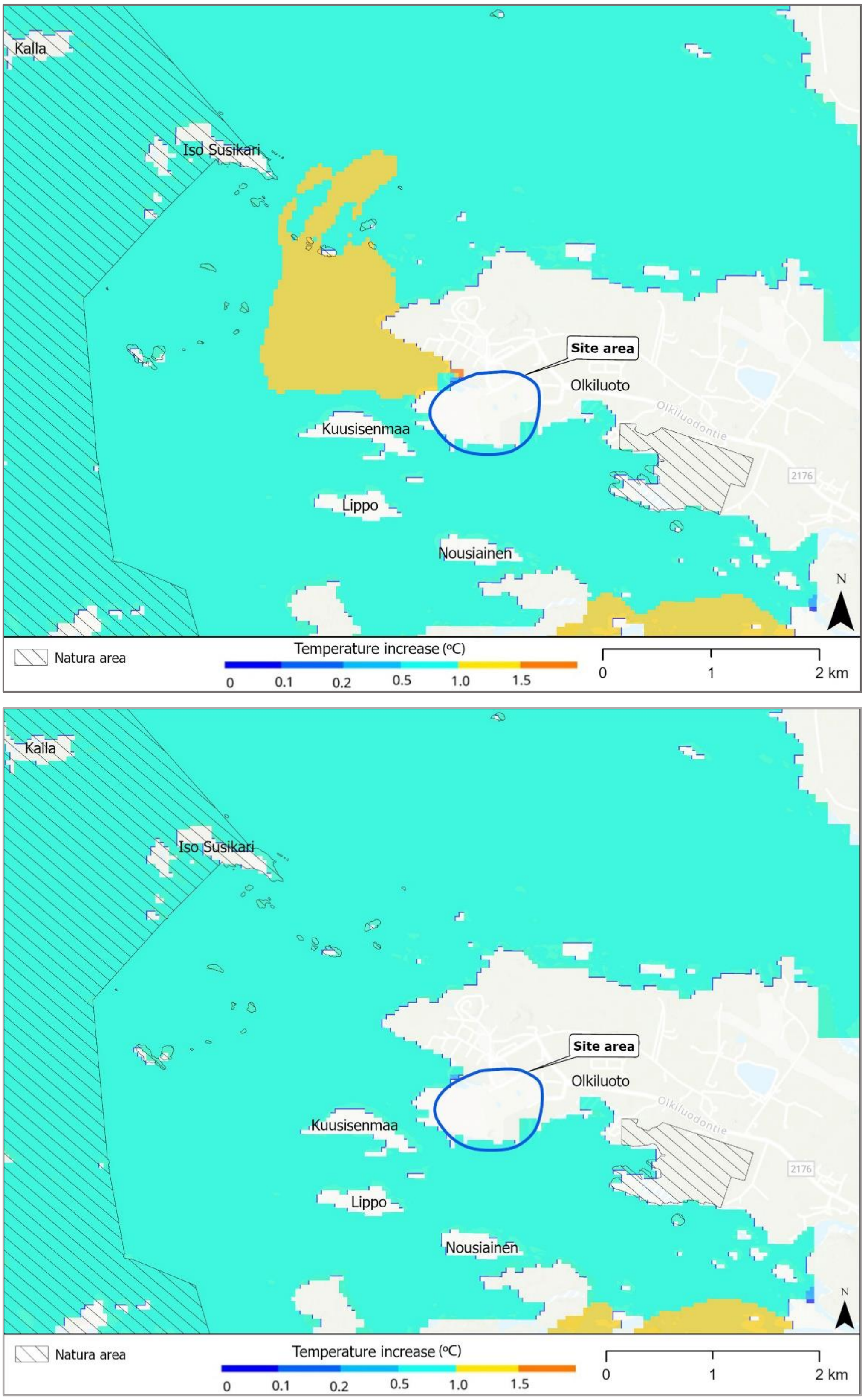


Figure 4. Impact of service life extension and power uprating in the sea area off Olkiluoto. The first figure shows the modelled surface water temperature at the current power level. The second figure shows the modelled temperature increase of surface waters in 2058 at the current power level, taking into account climate change. The third figure shows the modelled surface water temperature increase in 2058, taking into account the power uprating and climate change.

6.1 General description of the impacts

The increase in seawater temperature has several possible direct or indirect impact mechanisms on the habitat types and species in the area of impact of the cooling waters (Figure 4). The direct impacts relate to the physiological effects of temperature. There are large differences between species in what the optimal temperature for them is and what temperatures they can tolerate without it affecting growth, reproduction or survival. As the temperature rises, the level of metabolism increases and growth accelerates up to a certain point, but if tolerance is exceeded, rising temperatures can even increase mortality. The tolerance of a species to fluctuating temperatures decreases if it is subjected to several simultaneous stress effects from the environment (Sumelius & Boström 2024). In the Baltic Sea, low salinity already weakens the tolerance of most species, i.e. increases their sensitivity to environmental changes. This is because only a few species are perfectly adapted to brackish water; most of the species in the Baltic Sea have adapted to either seawater or freshwater, in which case the water is constantly either too fresh or too salty for them (Ahlvik et al. 2021). The tolerance of species to different temperatures varies, which means that a rise in temperature can affect the species composition in both plankton and fish communities.

An increase in temperature can also affect the species indirectly through biological or physico-chemical impacts. Cold water can have a higher oxygen concentration, so aquatic organisms that need a lot of oxygen often require sufficiently cool water. On the other hand, a high temperature can increase the eutrophication of the sea area or promote the growth of filamentous algae, as the growing season of phytoplankton and aquatic plants is lengthened (HELCOM 2021). Furthermore, a rise in temperature increases the stratification of the water column, which can contribute to oxygen depletion of the hypolimnion in deeper areas.

Eutrophication refers to the primary production of phytoplankton becoming stronger than usual due to, for example, a rise in temperature and an increase in nutrients. The strong growth of filamentous algae can be harmful when they take over growing area from hard benthic habitats, or when the periphyton growing on the surface of aquatic vegetation or macroalgae (e.g. *Fucus vesiculosus*) become more common and prevent them from receiving light. The increased growth of phytoplankton, especially cyanobacteria, also affects e.g. visibility depth and, thus, the amount of light received by the phytobenthos.

The rise in temperature can also affect the formation of ice in the area impacted by the cooling waters. The sea ice that forms every year plays an important role in shaping the habitat types of the Baltic Sea. These include reefs and coastal meadows, in particular. Species may also be impacted. The weakening of the ice cover may have impacts on the reproduction of the grey seal, as the species makes use of the ice for giving birth. Grey seals can also give birth on the shore, but according to research, giving birth on land increases pup mortality when compared to giving birth on the ice in the Baltic Sea (Jüssi et al. 2008). On the other hand, the weakening of the ice cover may benefit seabirds that need open water to find food.

In the surface water impact assessment, it has been found, as part of the EIA report, that the project alternatives VE1 and VE2 are not estimated to cause a significant change in the ecological state of the sea area. However, the continuation of the thermal load until 2058 and the impacts of the power uprating may contribute to the eutrophication of the sea area, in addition to which the project, together with climate change, may have a minor negative joint impact on the habitat types of the Natura area. In addition to the project, the development of eutrophication is affected by climate change projections and actions planned to curb the nutrient releases from agriculture. In this screening for Natura assessment, the assumption is that climate change can in itself slightly promote the development towards eutrophication.

6.1.1 Impact mechanisms on coastal lagoons (1150)

Coastal lagoons are typically sheltered, so the impacts of flows are quite minor. The coastal lagoons of the Rauma archipelago are located almost 3 km from the discharge point of the cooling waters. Furthermore, coastal lagoons are in most cases already quite shallow and warm up more easily in summer than more open marine habitat types, so the potential impact of the project on the temperature of coastal lagoons is likely to be small. Climate change or the temperature development of summer weather conditions are likely to have a greater impact. Correspondingly, the impacts of the project on the ice conditions are likely to be small, as shallow lagoons freeze over more easily. It is, therefore, unlikely that possible temperature-induced eutrophication could cause significant changes in coastal lagoons.

6.1.2 Impact mechanisms on reefs (1170)

Fucus vesiculosus

Fucus vesiculosus is a key species of the coastal zone of hard benthic habitats in the Baltic Sea, whose shrub-like growths form a highly diverse habitat in terms of species that provides nutrition and hiding places for invertebrates and fish. In the area of the Bothnian Sea, *Fucus vesiculosus* communities are an important part of the reefs and the underwater parts of rocky shores featuring algal zones, i.e. reefs (1170), habitat type listed in the EU Habitats Directive. The extent and health of *Fucus vesiculosus* communities are important factors affecting the representativeness of reefs (Airaksinen & Karttunen 2001).

An increase in the seawater temperature impacts *Fucus vesiculosus* in many ways. Firstly, its growth accelerates especially in spring and early summer when the temperature rises, although in an experimental study, growth was found to weaken after a critical temperature of approximately 24°C (Graiff et al. 2015b). *Fucus vesiculosus* is able to grow at a temperature of 5−26°C, but its mortality increases at temperatures above 27°C (Graiff 2015b; Liesner et al. 2015). Secondly, an increase in temperature can also affect *Fucus vesiculosus* indirectly through other species. Graiff et al. (2015a) found in their experimental study that a higher temperature in late summer increased the amount of epiphytic algae, i.e. algae growing on the surface of vegetation, on the surface of *Fucus vesiculosus*. According to the researchers, this may have been the case partly because the temperature rise decreased the number of *Amphipoda* and *Idotea balthica* that feed on epiphytes.

The deterioration of ice conditions can also impact reefs. Every year, the ice cleans the underwater parts of coastal cliffs and maintains the zonation of algae. Bare rock provides new habitats for e.g. *Fucus vesiculosus* and renews the filamentous algae zone every year. Furthermore, weak ice conditions can bring the growing season forward and, thus, increase the amount of filamentous algae, especially in shallower water.

The general eutrophication of the sea also impacts reefs and especially *Fucus vesiculosus*. The increase in temperature caused by the cooling waters of the project alone is likely to cause, at most, minor increases in the growth of phytoplankton or filamentous algae, which would impact, for example, the depth of occurrence of *Fucus vesiculosus*.

6.1.3 Impact mechanisms on drift lines (1210)

Drift lines are created when the mass of annual and perennial plants, algae or other organic material carried by the water accumulates on the shore. The lines support plant communities whose species are influenced by the composition of the accumulated vegetation, such as the species or the freshness of the material. The decline of *Fucus vesiculosus* has reduced the number of drift lines formed by the species. Thus, the impacts mentioned in the previous subchapter 6.1.2 on the *Fucus vesiculosus* communities of reefs further affect drift lines. The abundance of *Fucus vesiculosus* in drift line accumulations and the size of the drift lines are essential factors in terms of the representativeness and naturalness of the habitat type (Airaksinen & Karttunen 2001).

6.1.4 Impact mechanisms on coastal meadows (1630)

The vegetation in coastal meadows is typically low. Grazing and the annual erosive effect of sea ice maintain the low-growing nature of coastal meadows (Airaksinen & Karttunen 2001). Coastal meadows are generally threatened by overgrowth. The year-round thermal load from the cooling water caused by the Olkiluoto project can affect the ice conditions and, thereby, possibly reduce the erosive effect of ice on the meadows. This could increase overgrowth if the habitat type patterns are not subject to grazing.

6.1.5 Changes targeting species listed in the Habitats Directive

According to the Natural Resources Data service, there are no known sea seal moulting islets off Olkiluoto or in the area of impact of the cooling waters (Luke 2024). Pack ice favoured by the grey seal for giving birth does not occur in the area of the cooling waters, so impacts targeting the grey seal can be excluded.

7. ASSESSMENT OF THE SIGNIFICANCE OF THE IMPACTS

The significance of impacts has not been principally defined in the Habitats or Birds Directive. In general, a habitat type can be estimated to be deteriorating if its surface area shrinks or the structure and functionality of the ecosystem are weakened as a result of changes. Correspondingly, at the species level, impacts can be estimated to be deteriorating if the habitat of a species shrinks and the species is no longer viable in the examined area due to this or any other reason. In this context, the significance of the impacts is particularly affected by the extent of the change.

Overall, the impacts must be seen in proportion to the size of the area and the significance of the site's nature values at the regional and national level. In some cases, even a small change can be significant in nature if it targets a site that is exceptionally valuable at the regional or national level, or if the habitat type or species impacted is estimated to be more sensitive than usual to even small changes in habitat in terms of its characteristics.

The deterioration of nature values can be significant if any of the following is realised (Byron 2000):

1) The conservation status of a protected species or habitat type is not favourable following the implementation of the project.
2) The conditions at the site change as a result of the project or plan, such that the occurrence and reproduction of protected species or habitats at the site is not possible in the long term.
3) The project materially reduces the abundance of protected species.
4) The characteristics of a habitat type are degraded or partially lost due to the project.
5) Characteristics are degraded or protected species disappear from the site completely.

7.1 Significance of the impacts on habitat types listed in Annex I to the Habitats Directive

Coastal lagoons

The coastal lagoons closest to the Olkiluoto site area are located approximately 2.8 km away on Susikari. Several patterns of coastal lagoons are found from the area around Susikari and Kalla south all the way to Aikonmaa; however, they are of significant (class C) representativeness, i.e. markedly less representative than in the Natura area in general. There is one flad of excellent representativeness on the northern shore of Aikonmaa; however, it is sheltered from the direct impacts of the thermal load and located approximately 4 km away from the water discharge area of the power plant. An area of 6.85 ha of the coastal lagoons habitat type is exposed to the impact, which corresponds to approximately 16% of the coastal lagoons in the entire Natura area (Metsähallitus 2024b).

Taking into account the lower than average representativeness of the coastal lagoons habitat type patterns located in the area of impact, their small surface area in relation to the entire site and the slightness of the possible eutrophication impacts, the possibility of a significant deterioration in coastal lagoons can be excluded.

Reefs and drift lines

Kalla Island houses, in total, approximately 4 ha of the drift lines habitat type of excellent or good representativeness, which means that the drift lines are more representative than average on the scale of the entire Rauma archipelago Natura area (Metsähallitus 2024b). Drift lines are also present on Susikari, but they are smaller in terms of surface area and less representative. The drift lines located on the shores of Kalla, Vähä Susikari and Iso Susikari are ones formed by *Fucus vesiculosus*, inventories of which were taken in 2009 (Ramboll 2009). According to the 2009 underwater inventory, *Fucus vesiculosus* grows in abundance around Kalla, and its coverage is very high- in some places at over 50% (Ramboll 2009). Also based on the Velmu data, there is plenty of *Fucus vesiculosus* growing around Kalla and Susikari (Syke 2024). The *Fucus vesiculosus* reefs and drift lines around Kalla and Susikari can be considered to be particularly significant in terms of the entire Natura area and the Natura network. Were the increase in temperature found to cause a substantial decline in *Fucus vesiculosus*, the impact on the conservation criteria of the Natura area would likely be significant.

The temperature increase in the seawater surface layers in the area of the Kalla and Susikari islands is, however, relatively minor based on the hydrological modelling: the rise in temperature resulting from the continued operation of the plant units and even their power uprating will be a maximum of 1.5°C by 2058 when compared to the cool summer of 2017 when the impacts of climate change are taken into account (AI Innovaatio Oy 2024). In this case, the seawater temperature could be 17.5°C around Kalla and 19.5°C at Susikari in summer.

The modelled temperatures are unlikely to exceed the threshold at which the growth of *Fucus vesiculosus* weakens; based on an experimental study carried out in the western Baltic Sea, the growth of *Fucus vesiculosus* would slow down when the temperature exceeds approximately 24°C (Graiff et al. 2015a). Right at the discharge flow of the cooling water, where *Fucus vesiculosus* does not occur, the seawater temperature may exceed 27°C. At the discharge flow, however, the water masses are large and the mixing of the water is efficient. Nevertheless, it is unlikely for the temperature of 27°C, which significantly increases the mortality of *Fucus vesiculosus*, to be exceeded further away from the discharge point of the cooling water (Graiff et al. 2015b) (Figure 4). If the power uprating is not implemented, the impacts will be decidedly smaller than presented above. However, the share of climate change in the total increase in temperature is significantly greater than that of the project. The possibility of significant physiological effects from the project can, therefore, be excluded.

The most important zone of occurrence of *Fucus vesiculosus* in the Rauma archipelago Natura area was at a depth of 1–4 m in 2008 (Ramboll 2009). Although a slight increase in the growth of phytoplankton or periphyton due to the impact of the cooling waters may generally reduce the visibility depth and, thus, the transmission of light, it is unlikely to cause a reduction in the depth of occurrence of *Fucus vesiculosus* when the occurrence of the species is mostly concentrated in such shallow water. The possibility of significant impacts related to eutrophication can, therefore, be excluded.

Coastal meadows

Significant impacts from the project on the coastal meadows of the Natura area are not likely because, in the event of a possible deterioration in the ice situation, overgrowth occurs fairly slowly and it is possible to prevent it through compensatory measures, such as grazing. Weakening of the ice cover will occur regardless of the project due to climate change, but together with the power uprating, the overall impact will be slightly greater. According to modelling, the ice cover period will decrease by 10–20 days by 2058 when the impacts of climate change and the power uprating are included. The power uprating accounts for approximately 2 days of this if climate change is not taken into account. The variability of the ice cover can be high, and, in some years, the duration of the ice cover may be higher or lower than the modelling predicts. Part of the sea area may be free of ice in winter already at present, depending on the weather. A weaker ice cover in a single year is not likely to cause permanent deterioration of the habitat type, but ice-free winters becoming more common can impact the shore vegetation in the long term if the weak ice situation continues year after year. Coastal meadows can also be restored or maintained through grazing if the natural erosion caused by ice decreases and there is a threat of the meadows becoming overgrown.

7.2 Significance of the impacts on species listed in Annex II to the Habitats Directive

The increase in temperature caused by the cooling waters does not target areas where the pack ice typically used by the grey seal to give birth would occur. The possibility of significant impacts on the grey seal can, therefore, be excluded.

7.3 Joint impacts with other projects

The operation of the OL3 plant unit has been taken into account in the cooling water modelling, so the model includes the possible cumulative impacts of the joint impacts. No other projects related to the marine environment have been identified. There are also no fish farms in operation or new ones planned in the area impacted by the project or in its vicinity within 10 km of the site area.

8. CONCLUSIONS OF THE NATURA SCREENING

Based on the best available information, it can be excluded in advance that the project would cause significant deterioration of the Natura area FI0200073 Rauma archipelago, on its own or in combination with other projects.

Based on the Natura screening, the continued operation of the Olkiluoto 1 and Olkiluoto 2 plant units or their power uprating is not estimated to have the possibility of significant negative impacts on the conservation criteria of the Natura area. Based on the temperature modelling, the temperature rise would likely not exceed a level that would have significant direct impacts on protected habitat types or species. The increase in temperature may benefit the growth of phytoplankton (especially cyanobacteria) and indirectly also affect habitat types through slight eutrophication, but significant deterioration due to the project's impact alone are unlikely. The project's possible joint impacts with the Olkiluoto 3 plant unit can be excluded because the cumulative temperature increase it causes with the other plant units has already been taken into account in the cooling water modelling. No other projects related to the marine environment which could have an impact on the Natura area were identified in the area.

When determining the necessity of a Natura assessment, the precautionary principle must generally be followed; *"The mere possibility of significant impacts triggers a Natura assessment obligation"* (Mäkelä & Salo 2024). Therefore, in the Natura screening, efforts have been made to take into account all possible impact mechanisms at a low threshold and to consider, among other things, the joint impact brought by climate change in the long term. Significant impacts can be excluded, in which case a Natura assessment pursuant to Section 35 of the Nature Conservation Act is not deemed to be necessary.

However, it is recommended to continue the monitoring of the natural conditions as the project and climate change progress. If, during the implementation of the continued operation or the power uprating, there are larger than estimated changes in the state of the surface waters, the possibility of significant impacts must be reassessed.

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