Environmental impact assessment programme | January 2024

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

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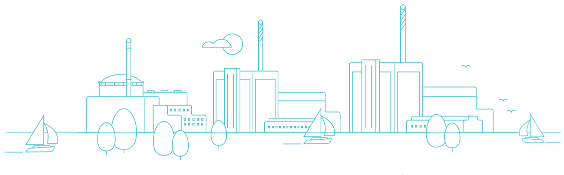
Translations Alasin Media Oy

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

The project owner for the environmental impact assessment procedure (EIA procedure) is Teollisuuden Voima Oyj (TVO). TVO produces clean energy domestically, all year round and regardless of the weather at Olkiluoto in Eurajoki using three nuclear power plant units: Olkiluoto 1 (OL1), Olkiluoto 2 (OL2) and Olkiluoto 3 (OL3). The annual production from the OL1 and OL2 plant units is on average 14.4 TWh per year, amounting to approx. 17% of all electricity consumed in Finland. After the start of regular electricity production at OL3 in April 2023, TVO now produces approximately 30% of all electricity in Finland. TVO has been generating electricity safely and reliably for more than 40 years.

The project and its background

The power plant units OL1 and OL2 are identical boiling water reactors. They were commissioned in 1978 (OL1) and 1980 (OL2). The original planned service life of the OL1 and OL2 plant units was 40 years, until 2018. Their service life was extended earlier to 60 years, which will be met in 2038.

At the time of commissioning, the thermal power of the OL1 and OL2 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 OL1 and OL2 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.

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 until 2048 or, alternatively, until 2058. Extending the service life with an uprated thermal power is also being analysed. In the thermal 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. The extensive and demanding maintenance and improvement work already performed at the plant units in earlier years allow for the power uprating to be implemented.

The alternatives examined in the EIA procedure and the schedule for the project

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 (VE1a) or 2058 (VE1b) and continuing the operation at an uprated power level until 2048 (VE2a) or 2058 (VE2b). In the zero alternative, the operation of the plant units will continue until the expiration of the current operating licence in 2038 (VE0). The alternatives being considered are presented in the enclosed figure (Figure 1).

The current operating licence for the OL1 and OL2 plant units is in force until 2038. A new operating licence must be applied for in both alternative 1 and 2. In the case of alternative 2, this will be done before 2028 and, in alternative 1, at the latest before 2038 when the current operating licence expires. According to the terms of the valid operating licence, TVO must draw up a periodic safety assessment for the OL1 and OL2 plant units and submit it to the Radiation and Nuclear Safety Authority (STUK) for approval by the end of 2028.

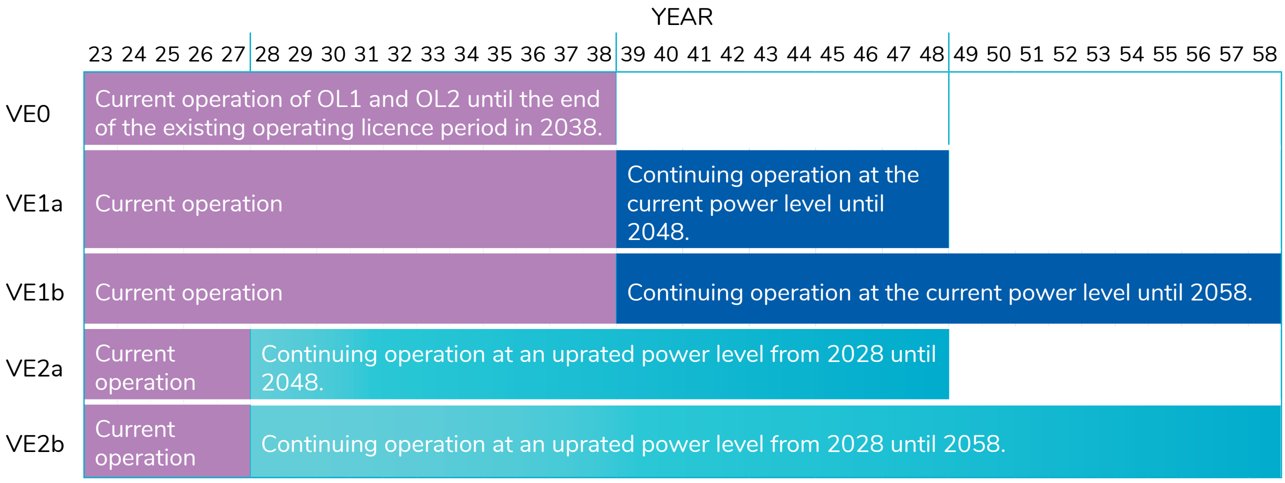


Figure 1. The alternatives examined in the EIA procedure and their preliminary, planned schedules.

Project location

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 Oy'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. The site area 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 intermediatelevel 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 site area.

Figure 2. Aerial view of the power plant area.

Key figures for the project

The table (Table 1) presents key figures for OL1 and OL2 during the current operation (VE0) and compares 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.

Explanation	VE0 Continuing current operation of OL1 and OL2 until 2038	VE1 Extension of operation until 2048/2058	VE2 Power uprating and extension of operation until 2048/2058
Plant type	Boiling water reactor		
Electrical power output	890 MW		970 MW
Thermal power output	2,500 MW		2,750 MW
Efficiency	35.6%		35.3%
Reactor operating pressure	70 bar		
Annual electricity production	approx. 7 TWh/plant unit		approx. 7.6 TWh/plant unit
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		
Cooling water temperature	Temperature increase of approx. 10 °C		Temperature increase of approx. 11 °C
Volume of service water	Approx. 272,000 m^3 of raw water for Olkiluoto, of which approximately one half is used as household water and half as process water, fire-fighting water and other uses.		
Fuel	Uranium dioxide UO_2		
Number of fuel assemblies	500 pcs		
Fuel consumption	approx. 18 t/a		
Spent nuclear fuel (per year)	approx. 19 t/a		
Spent nuclear fuel (over the plant's entire service life)	approx. 2,483 t (by 2038)	approx. 2,861 t (by 2048) approx. 3,240 t (by 2058)	
Very low, low and intermedi-atelevel waste (per year)	approximately 50 m^3	No significant changes to annual accumulation.	
Very low, low and interme-diatelevel waste (over the plant's entire service life)	approx. 8,250 m^3 (by 2038)	approx. 8,750 m^3 (by 2048) approx. 9,250 m^3 (by 2058)	
Other waste [1)]	Recyclable waste 2,610 t/a Landfill waste 0 t/a Hazardous waste 219 t/a		
Releases of radioactive sub-stances into the air [2)]	Noble gases (Kr-87 equiv.): 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		
Other releases into the air [3)]	CO_{2e} 914 t/a NO_x 1.2 t/a SO_2 0.0 t/a Particles 0.1 t/a		CO_{2e} 927 t/a NO_x 1.2 t/a SO_2 0.0 t/a Particles 0.1 t/a
Releases of radioactive sub-stances into water [2)]	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		

Explanation	VE0 Continuing current operation of OL1 and OL2 until 2038	VE1 Extension of operation until 2048/2058	VE2 Power uprating and extension of operation until 2048/2058
Other releases into water [4]	Household waste water, total 86,550 m^3/a Phosphorus 5 kg/a Nitrogen 4,222 kg/a BOD_{7ATU} 412 kg/a		
	Process waste water, total 25,000 m^3/a Phosphorus 5 kg/a Nitrogen 100 kg/a		
Noise [5]	Nearest holiday housing (Leppäkarta) 39.4–42.1 dB Main gate 48.6–56.3 dB		
Traffic	Approximately 1,000 vehicles/day. More during annual outages.		

1) Average for OL1, OL2 and OL3 over three years.
2) Range of variation for OL1 and OL2 in 2007–2022. The highest values in the actual release ranges have been related to rare exceptions.
3) Average for OL1 and OL2 over three years.
4) Household waste water: Average for OL1, OL2 and OL3 over three years. Process waste water: Average for OL1 and OL2 over three years.
5) Range of variation for 2020–2022.

Environmental impact assessment procedure

The purpose of the EIA procedure is to assess the significant environmental impacts caused by the project and promote them being considered during the project planning stage and decisionmaking. The procedure also aims to improve access to information and opportunities to participate and influence the planning of the project.

The EIA procedure is based on the Act on the Environmental Impact Assessment Procedure (252/2017) and the related Government Decree (277/2017). The procedure has two stages. In the first stage, an environmental impact assessment programme (EIA programme) is drawn up that describes a plan of how the environmental impacts caused by the project will be assessed. In the second stage, the environmental impacts are assessed and the results are presented in the environmental impact assessment report (EIA report). The EIA procedure is performed prior to the permit process, and its purpose is to affect the planning and decisionmaking related to the project. The coordinating EIA authority for this project is the Ministry of Economic Affairs and Employment (MEAE).

For projects which may have transboundary impacts crossing the borders of Finland, an international hearing according to the EIA Act must also be arranged alongside the EIA procedure taking place in Finland. The Finnish Environment Institute is responsible for the international hearing for Finland.

The environmental impacts being assessed and the assessment methods

The table (Table 2) presents a summary of the assessment methods and the proposed areas under review, broken down by impact. For environmental impacts, the areas under review have been defined to the extent where the impacts could reach, at a maximum. In reality, environmental impacts will likely take place in an area smaller than the area under review. The EIA report presents the environmental impact assessment results and their areas of impact.

Table 2. Summary of the environmental impacts examined, methods used in the assessment and the preliminary area under review for the impacts.

Area	Assessment methods	Area under review
Land use, zoning and the constructed environment	An expert assessment of the project's relationship with the current and planned land use and zoning. Additionally, an analysis of the locations in the constructed environment and distances thereto.	Approximately 5 km from the power plant area.
Landscape and cultural environment	An expert assessment of the project's relationship with the landscape in the nearby areas and a broader landscape. Locations in the cultural environment are identified.	Approximately 5 km from the power plant area.
Traffic	A calculated assessment of the changes in traffic volumes caused by the project and an expert assessment of the impacts of transports on traffic safety.	The roads leading to the power plant area and their immediate surroundings (0–2 km).
Noise and vibration	An expert assessment of the noise emissions and vibration from the different stages of the project and transports and their dispersion within the environment.	The site area and its immediate surroundings at a radius of approximately 3 km and the nearby areas along the transport routes.
Air quality	An expert assessment of the conventional emissions into the air (carbon dioxide, nitrogen oxide, sulphur dioxide and particulate emissions) caused by the project and their impact on air quality.	Approximately 1–2 km from the power plant area.
Climate change	Calculated estimate of greenhouse gas emissions and their impacts on Finland's total emissions. The greenhouse gas emissions generated during the fuel life cycle of different forms of energy production are also compared. The risks caused by climate change are identified and preparing for them is described.	CO_{2e} emissions at the regional level and for all of Finland. Risks locally in the power plant area.
Soil, bedrock and groundwater	Expert assessment of the possible impacts of the modifications in the project, based on existing research data.	Power plant area.
Surface water	Cooling water modelling and an expert assessment of impacts on the sea area prepared on its basis. An expert assessment of the impacts of cooling water, service water intake and the treatment and discharge of wastewater.	Approximately 10 km from the power plant area.
Fish stocks and fishery	An expert assessment prepared on the basis of studies on fish stocks and a surface water impact assessment.	Approximately 10 km from the power plant area.
Vegetation, animals and conservation areas	An expert assessment of impacts on the natural environment and conservation areas, based on the results from other impact assessments, for example.	Approximately 10 km from the power plant area.
People's living conditions, comfort and health	An expert assessment based on the calculated and qualitative assessments performed in the other impact areas (regional economy, noise, emissions, traffic and landscape, among other things).	Approximately 20 km from the power plant area.
Regional economy	A regional economy analysis based on an analysis of the current situation and resource flow modelling.	At the level for all of Finland.
Releases of radioactive substances and radiation	An expert assessment of the radioactive releases into the air and sea caused by the project. Radiation monitoring in the nearby areas of the power plant is implemented according to the existing monitoring programme, and the assessment is based on monitoring data. Radiation doses from the releases are estimated by means of calculation.	Environmental radiation monitoring approximately 10 km from the site area, radiation dose calculation approximately 100 km from the site area.
Use of natural resources	An expert assessment of nuclear fuel procurement and the impacts of its supply chain at the general level.	The nuclear fuel supply chain at the general level.

Area	Assessment methods	Area under review
Waste and byproducts	An expert assessment of the project's waste flows, their handling, opportunities for utilisation and final disposal. The description of the impacts from the transports and final disposal of spent nuclear fuel utilises the analyses already completed.	Olkiluoto area.
Energy markets	An expert assessment of the development of the energy markets and their changes for the project alternatives.	At the level for all of Finland.
Incidents and accidents	A modelling of an imaginary severe reactor accident where 100 TBq of the Cs-137 nuclide is released into the atmosphere. The results of the modelling establish the fallout and radiation doses caused by the release. An expert assessment of the impacts.	1,000 km from the power plant area.
Joint impacts	An expert assessment of joint impacts concerning the OL3 plant unit and the other actors and related projects in the area.	Areas near Olkiluoto.
Transboundary impacts	An assessment based on separate analyses and modellings regarding whether the impacts of the project may extend across the borders of Finland.	1,000 km from the power plant area.

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.

Two public events will be arranged during the EIA procedure, the first of which is held at the programme stage and the second at the report stage. The events will be 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. The date and place of the public events will be communicated in the coordinating authority's public notice on the EIA programme and report.

A monitoring group is set up during the EIA report stage that is intended to promote the transfer and exchange of information between the project owner, the authorities and the key stakeholders in the area. Representatives from the municipality of Eurajoki, nearby municipalities and local stakeholders and various experts and authorities may be called to participate in the monitoring group and its meetings.

The EIA programme and report will be published on the website of the Ministry of Economic Affairs and Employment. The documents will be 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. TVO will also communicate on the progress of the project and, for example, the press conferences and public information events being arranged.

1. The project and the alternatives being considered

1.1. Project owner

The project owner for the EIA procedure is Teollisuuden Voima Oyj (TVO). TVO produces clean energy domestically, all year round and regardless of the weather at Olkiluoto in Eurajoki using three nuclear power plant units: Olkiluoto 1 (OL1), Olkiluoto 2 (OL2) and Olkiluoto 3 (OL3). The annual production from the OL1 and OL2 plant units is on average 14.4 TWh per year; in 2022, for example, this amounted to approx. 17% of all electricity consumed in Finland. After the start of regular electricity production at the OL3 plant unit in April 2023, TVO now produces approximately 30% of all electricity in Finland.

TVO has been generating electricity for its owners safely and reliably for more than 40 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.

1.2. The project and its background

The nuclear power plant units Olkiluoto 1 and Olkiluoto 2 (OL1 and OL2) located in the Olkiluoto power plant area are identical boiling water reactors. They were commissioned in 1978 (OL1) and 1980 (OL2). 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 original planned service life of the OL1 and OL2 plant units was 40 years, until 2018. Their service life was already extended earlier to 60 years, which will be met in 2038. The project involves analysing the possible extension of the service life until 2048 or, alternatively, until 2058.

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 increase 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 3).

In the 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. In connection with the power uprating, the operation of the plant units would be extended until 2048 or 2058. The extensive and demanding 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.

Development of electrical power output at the OL1 and OL2 plant units

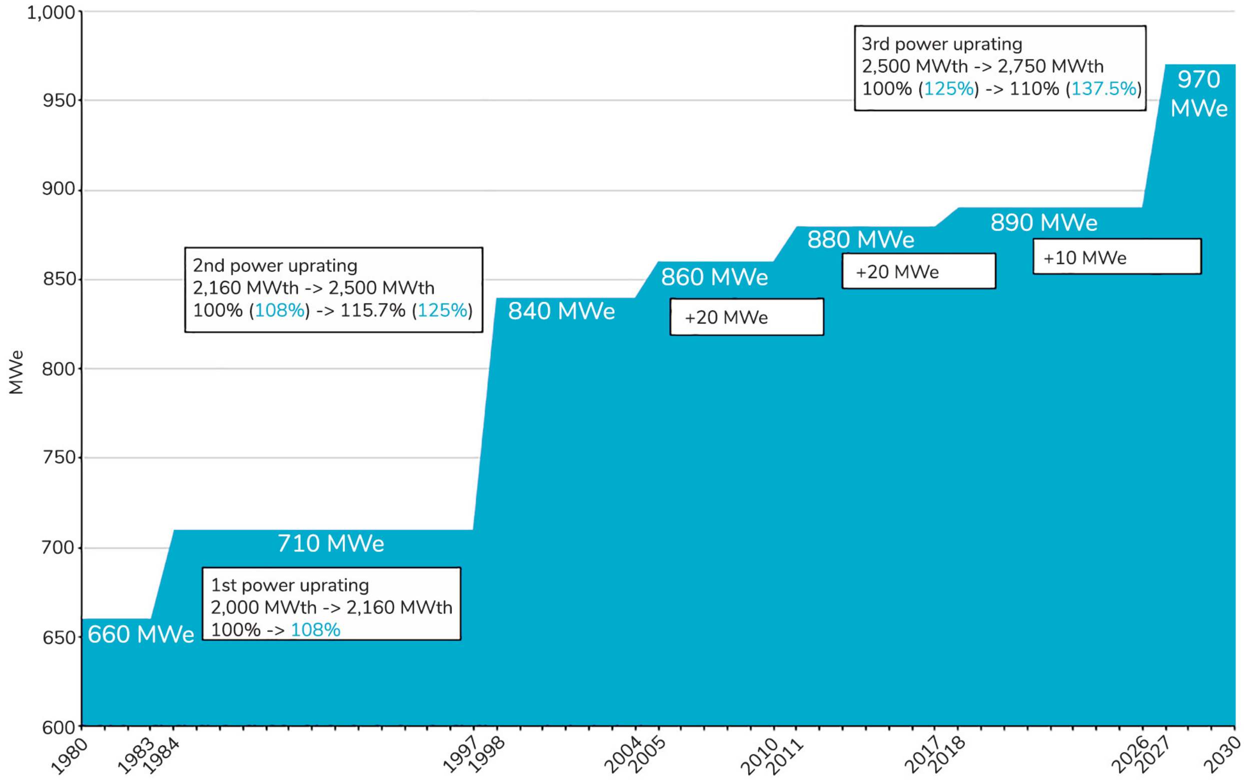


Figure 3. Power upratings at Olkiluoto's OL1 and OL2 plant units.

1.3. The alternatives examined 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 (VE1a) or 2058 (VE1b) and continuing the operation at an uprated power level until 2048 (VE2a) or 2058 (VE2b). In the zero alternative, the operation of the plant units will continue until the expiration of the current operating licence in 2038 (VE0). The alternatives being considered are presented in the enclosed figure (Figure 4).

The current operating licence for the OL1 and OL2 plant units under the Nuclear Energy Act (990/1987) is in force until 2038. A new operating licence must be applied for in all project alternatives. In the case of alternatives VE2a and VE2b, this will be done by the end of 2028 and, in alternatives VE1a and VE1b, at the latest before 2038 when the current operating licence expires. According to the terms of the valid operating licence, TVO must draw up a periodic safety assessment for the OL1 and OL2 plant units and submit it to the Radiation and Nuclear Safety Authority (STUK) for approval by the end of 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 current operating licence period. If the operation of the plant units is continued, decommissioning will take place after the new operating licence period. The decommissioning of nuclear power plants is subject to licence and regulated according to the Nuclear Energy Act and Decree and the Radiation and Nuclear Safety Authority'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.

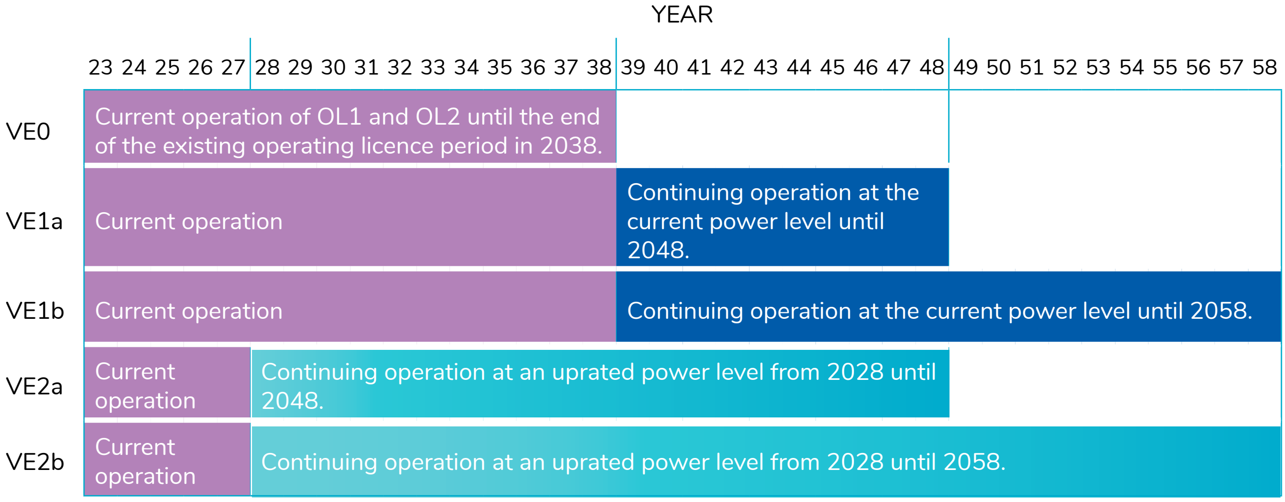


Figure 4. The alternatives examined in the EIA procedure and their preliminary planned schedules.

1.4. Project planning and implementation schedule

In recent years, as part of service life management for the OL1 and OL2 nuclear power plant units at Olkiluoto, TVO has been analysing the possibility of extending the service life of the plant units and uprating their thermal power. The alternatives selected for further review from the analyses are presented in chapter 1.3.

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, the 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 defined 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 utilised at the project's EIA report stage. The EIA procedure has been estimated to last until the end of 2024.

According to the preliminary schedule for the power uprating project, the plant modifications and operating tests required for the power uprating may be implemented in the 2020s. They could also be implemented in the 2030s. No decision has been made on the implementation or its schedule. The earliest possible implementation time for the power uprating would be in 2028, assuming that all necessary permits for the implementation have been granted.

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.

1.5. Location of the project and space requirements

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 and Posiva Oy's encapsulation plant and disposal facility for spent nuclear fuel. Key functions of the Olkiluoto power plant area are presented in the enclosed figure (Figure 6).

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 site area 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 site area.

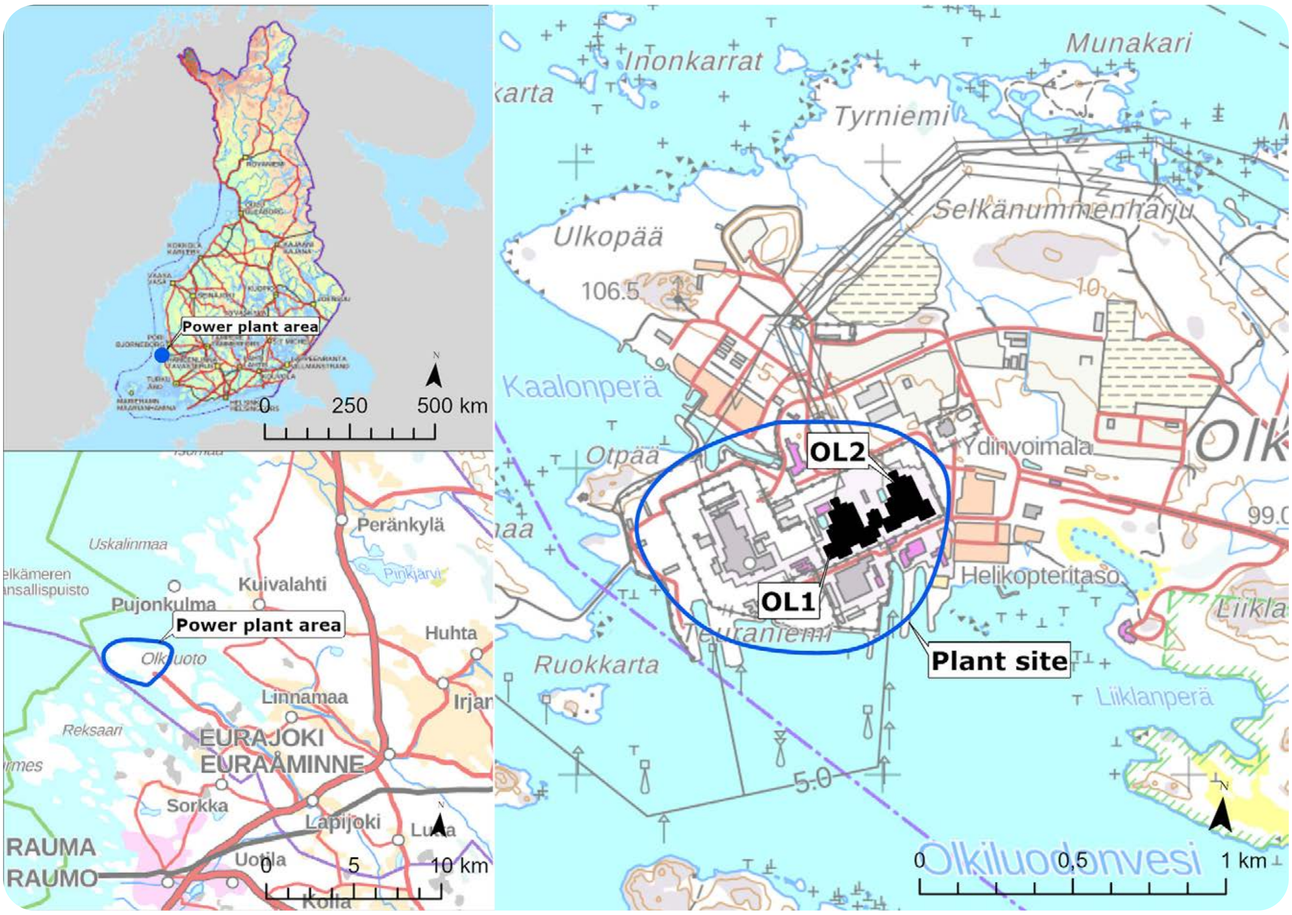


Figure 5. The location of the Olkiluoto power plant area and the location of the OL1 and OL2 plant units within the site area.

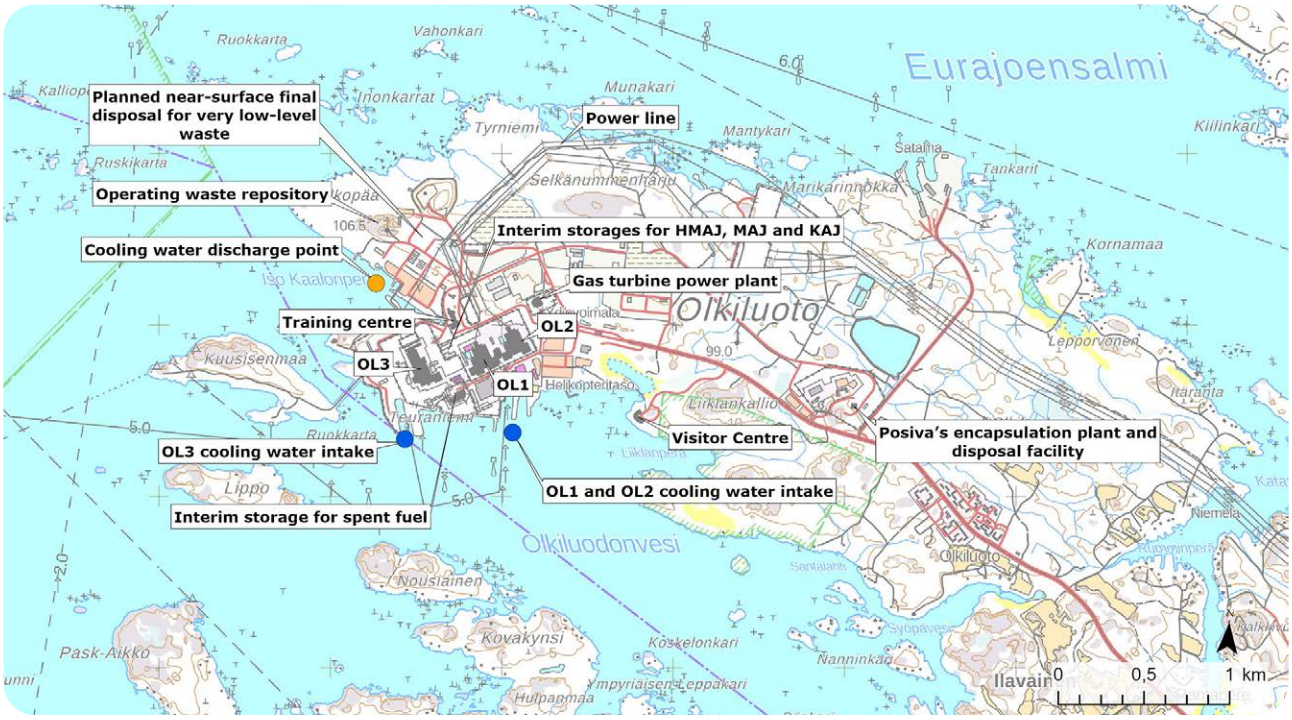


Figure 6. Functions in the Olkiluoto power plant area.

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 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), which TVO has operated 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. 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 (Posiva) 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 TVO and Fortum Power and Heat Oy and its technical implementation 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.

2. Current operation

This chapter describes on a general level the current operation of the OL1 and OL2 plant units that are being examined in this EIA procedure. The OL1 and OL2 plant units have been generating electricity for the good of Finnish society for more than 40 years already. During their years of operation, the plant units have been modernised in many ways and their safety has also been improved. The current net electrical output of the OL1 and OL2 plant units is 890 megawatts (MW) and their annual electricity production is approximately 14.4 terawatt hours (TWh) in total, corresponding to approximately 17% of the electricity consumption in Finland. Since the early 1990s, the capacity factors for OL1 and OL2 have been between 93-97%. High load factors indicate that the plant units operate reliably.

2.1. Principle of operation

Energy production in a nuclear power plant is based on fission occurring in the uranium fuel and a controlled chain reaction. During fission, a neutron collides with the nucleus of a U-235 isotope, splitting it. The splitting releases 2 to 3 new neutrons and fission products. Some of the released neutrons continue the chain reaction. A large amount of energy is released as the result of each splitting. This allows very small amounts of uranium fuel to generate large amounts of heat. For example, one gram of fissile material corresponds to 24,000 kilowatt hours of energy. 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.

OL1 and OL2 are of a boiling water reactor type (BWR) (Figure 7). In the pressure vessel 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, 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.

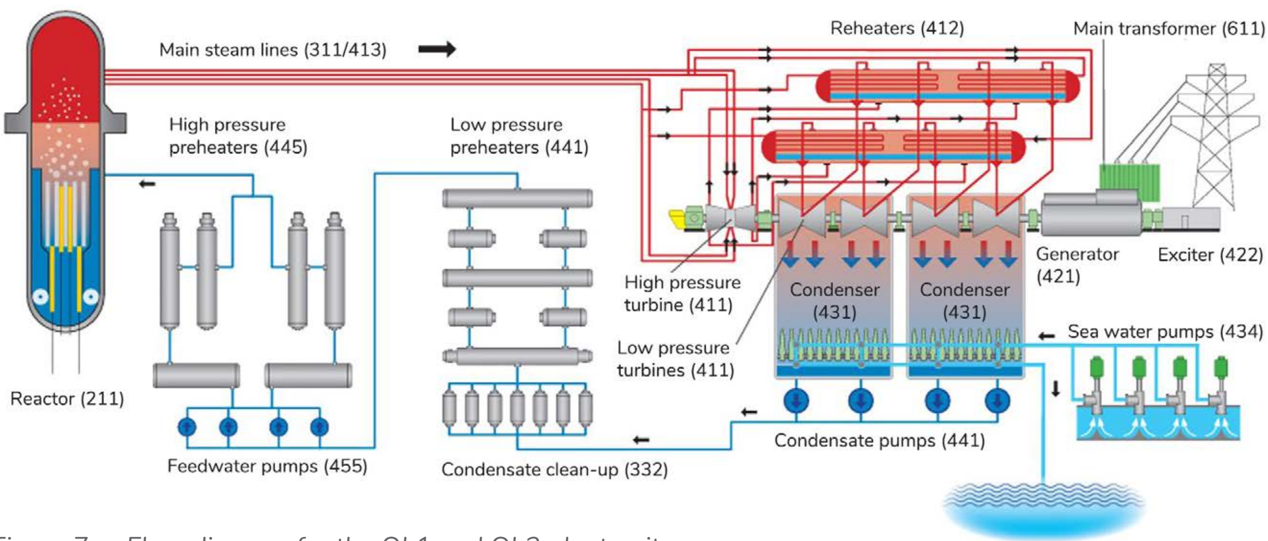
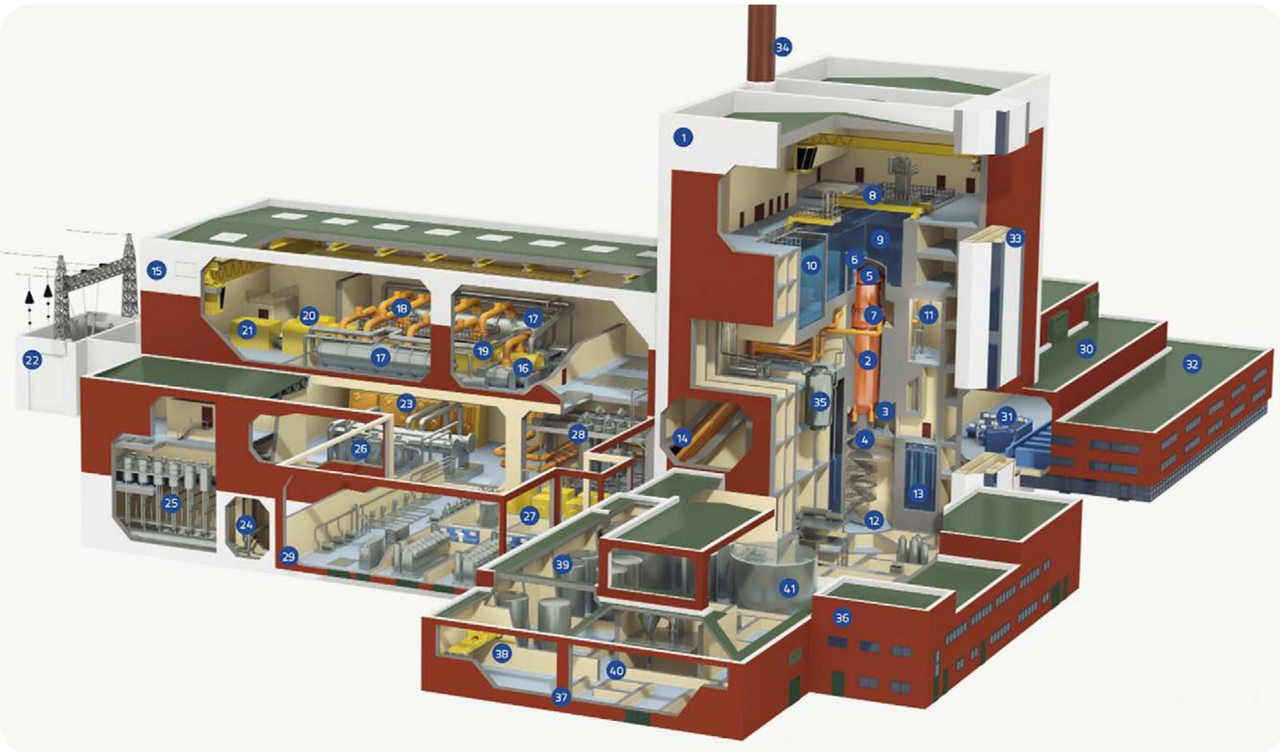


Figure 7. Flow diagram for the OL1 and OL2 plant units.

OL1 and OL2 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 waste handling building and hot workshop, for example. The figure below (Figure 8) presents a cross-section of OL1 and OL2.



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 8. Cross-section of OL1 and OL2.

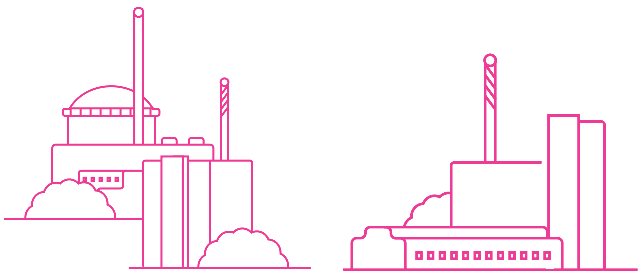
2.2. Procurement and use of nuclear fuel

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 cooling water 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 cladded 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 of low-enrichment uranium for their fuel. TVO procures its fuel via a distributed procurement chain, and there are several suppliers for each stage of the chain. TVO has long-term contracts with leading fuel and uranium suppliers which 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. The countries with the highest uranium production are Kazakhstan, Canada, Australia and Namibia.

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.

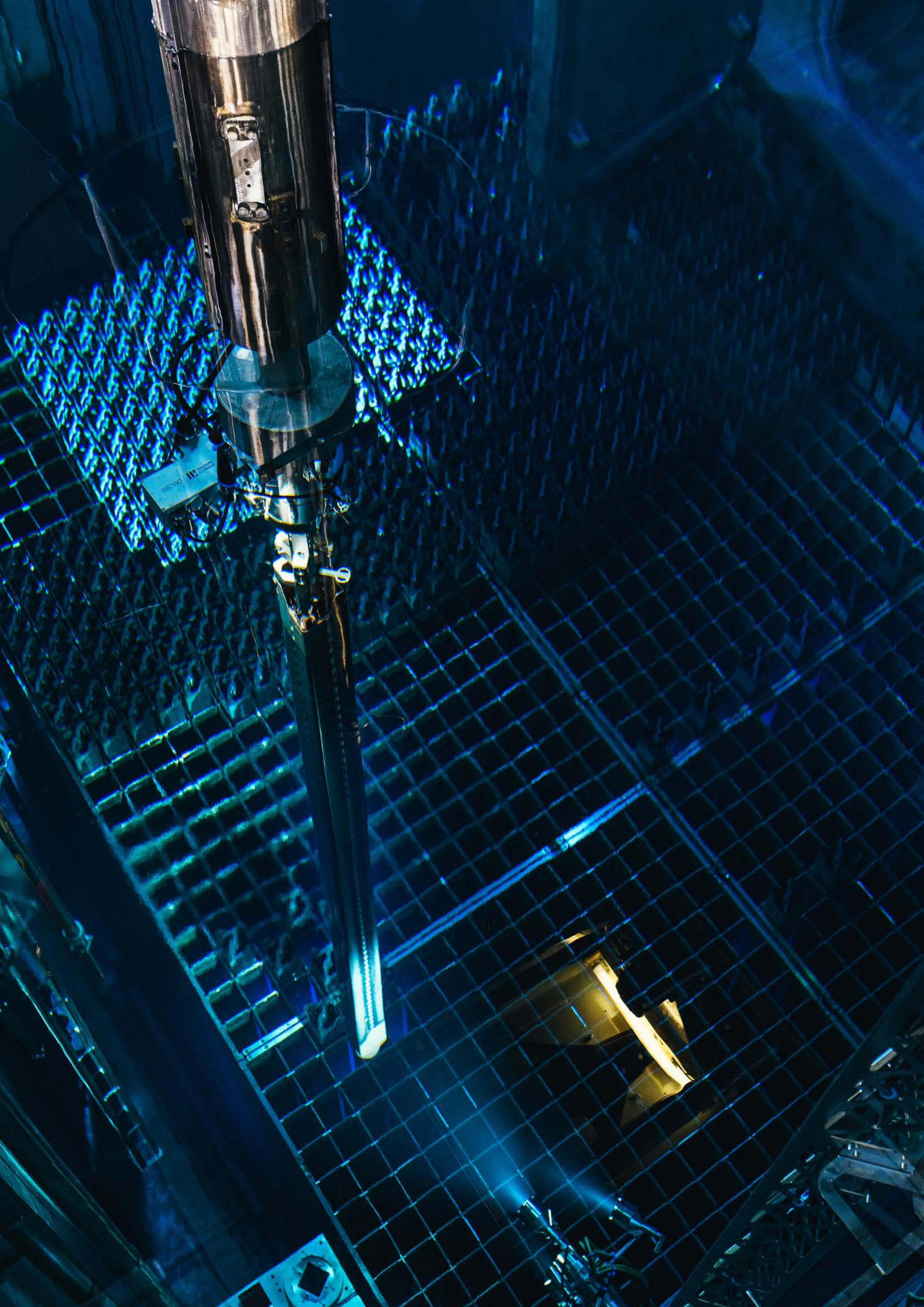


2.3. Waste management

The operation of a nuclear power plant generates radioactive nuclear waste, which includes spent nuclear fuel and very low-level, low-level and intermediate-level operating waste (such as maintenance waste and waste from water treatment). The operation of a nuclear power plant also generates conventional waste and hazardous waste.

According to the Nuclear Energy Act (990/1987), nuclear waste must be handled, stored and permanently disposed of in Finland. The Nuclear Energy Decree (161/1988) further defines the nuclear waste to be permanently disposed of in Finnish ground or bedrock. More specific requirements for the final disposal of nuclear waste are set in the Radiation and Nuclear Safety Authority's (STUK) Regulation on the Safety of Disposal of Nuclear Waste (Y/4/2018) and in STUK's YVL Guides (nuclear safety guides). The final disposal of nuclear waste in bedrock is based on the utilisation of multiple release barriers which are used to ensure that radioactivity originating from nuclear waste cannot enter the environment or come within the reach of humans.

Conventional waste is handled in the same manner as corresponding waste elsewhere in the industrial sector, according to the laws, decrees and regulations in force. All waste generated at Olkiluoto is sorted and processed. Sorted waste is primarily routed to reuse as materials and, secondarily, to reuse as energy. Efforts are made to reduce hazardous waste with the optimal use of chemicals, among other things.



2.3.1. Spent nuclear fuel

During operation, nuclear fuel becomes highly radioactive inside the reactor. In Finland, spent fuel is not reprocessed; it is high-level radioactive nuclear waste that must be placed in final disposal. At the OL1 and OL2 plant units, 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. 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. Water acts as a radiation shield and cools the spent fuel. The radioactivity and heat generation of the spent fuel are reduced further during the storage period.

From the interim storage, the spent fuel will, in time, be transported to Posiva's encapsulation plant. 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 slightly more than 400 metres.

The operation of the OL1 and OL2 plant units generates approximately 19 tonnes of spent nuclear fuel per year (Table 3).

2.3.2. Very low, low and intermediate-level operating waste

Operating waste may be divided into two main classes: maintenance waste and wet waste. Waste is divided into very low, low and intermediate-level waste. At present, the most part of operating waste from the OL1 and OL2 plant units is immediately processed and packed for possible further processing, storage and final disposal.

Operating waste is initially stored in the waste storage facility of the plant units or, according to their radioactivity, transferred to the interim storage for very low-level waste (HMAJ storage), low-level waste (MAJ storage) or intermediate-level waste (KAJ 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 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. Ion exchange resin is bituminised and other liquid waste is solidified with concrete.

According to its radioactivity concentration, operating waste is placed in final disposal either in the operating waste repository (VLJ repository) or in the near-surface final disposal facility for very low-level waste (HMAJ repository) that is currently being planned. Some of the operating waste may be cleared from regulatory control when their activity level is below the limits set by STUK. This waste may be processed similarly to conventional waste.

The operation of the OL1 and OL2 plant units generates approximately 50 m^3 of very low, low and intermediate-level waste per year (Table 3).

2.3.3. 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 and waste oil) that is not radioactive. Conventional waste is reutilised as either material or energy. The annual waste quantities vary depending on the scope of work carried out in the annual outage (Table 3). Waste is managed according to the requirements of the legislation and the environmental permit for the Olkiluoto nuclear power plant.

2.4. Water requirements and supply

The power plant units use cooling water for cooling the turbine condensers. The cooling water 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 consumed by the OL1 and OL2 plant units is approximately 38 m^3/s per unit, with the OL3 plant unit consuming approximately 57 m^3/s. Therefore, the total consumption is approximately 133 m^3/s. 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).

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 addition to cooling water, a nuclear power plant also requires raw water. The raw freshwater required in the power plant area is taken from the lower reaches of Eurajoki, upstream of Tiironkoski rapids. Raw water extracted from Eurajoki is pumped along a pipe of approximately 9 km in length to the Korvensuo pool at Olkiluoto. 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, 272,000 m^3 of raw water is extracted from Eurajoki per year. Of this water, approximately one half is used as household water and half as process water, fire-fighting water and other uses. The required demineralised process water is manufactured at the demineralisation plant using ion exchange technology.

Alongside the current water supply line from Tiironkoski, TVO has constructed a new line from Lapinjoki river to Olkiluoto. The line has a total length of approximately 15 km. The aim is for the project to be completed by the end of 2023. The project secures raw water supply and security of water supply for the Olkiluoto nuclear facilities.

2.5. Loads on water systems

The sea water used as cooling water in the power plant's turbine condensers will warm up by approximately 10°C on average. 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 (Table 3). The thermal load has remained fairly stable in recent years.

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, rinse water from the travelling basket filters of the sea water pumphouses and rainwater and raw water. Following appropriate processing, this water is routed into the sea via the discharge tunnel, along with the cooling water.

Conventional releases that are routed into the water systems are mainly generated through nutrient loads from the wastewater of the sanitary facilities of the power plant area and the wash water and rinse water of the non-radioactive industrial facilities. Sanitary wastewater is processed at the Olkiluoto wastewater treatment plant, following which the purified water is routed into the sea. Releases from the wastewater treatment plant were a fraction of the nutrient load of Eurajoki river which runs to the north of Olkiluoto. After 2023, the household wastewater mentioned above will be routed via the Eurajoki–Rauma transit sewer duct for processing at the treatment plant jointly operated by the City of Rauma and the forestry industry. Processing wastewater in a larger unit allows for the more efficient purification of wastewater and reduces its load on the water system.

2.6. Releases of radioactive substances

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 (Table 3). 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 millisievert. 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 3). 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.

2.7. Conventional releases into the air

Conventional releases into the air from the power plant (carbon dioxide, nitrogen oxide, sulphur dioxide and particulate emissions) consist of emissions from the backup boilers and emergency diesel generators (Table 3). The task of the emergency diesel generators is to automatically ensure power supply to the nuclear power plant in a possible yet unlikely loss of power scenario. In order to ensure safety, the diesels undergo test operation in accordance with the requirements of the Technical Specifications (Operating Limits and Conditions), which means that their emissions cannot be reduced. Releases into the air are also generated from the passenger and service traffic to the power plant and various forms of transport.

2.8. Traffic

Traffic during the operation of a power plant consists primarily of commuting and maintenance traffic, as well as transports of fresh nuclear fuel, various pieces of equipment, chemicals, fuel oil, gases and waste management. Traffic volume for maintenance and goods transport at TVO’s Olkiluoto plant unit area is approximately 50 vehicles per day (Table 3). Transport mainly takes place between 9 am and 4 pm on weekdays. 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 spent fuel into the KPA storage. Transports of spent nuclear fuel from the KPA storage to Posiva's encapsulation plant and disposal facility are estimated to begin during the 2020s.

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 (Table 3). 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 7-9 am and 4-5 pm. During annual outages, the number of workers visiting the plant increases by approximately 1,000 people.

2.9. Noise and vibration

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; in these cases, environmental noise has, for the most part, been below the noise guideline values set by the Government (Table 3). High noise levels have been measured at TVO's main gate over the years due to passing traffic. The operation of the power plant causes no vibration; however, heavy traffic may cause vibration in the immediate vicinity of roads.

2.10. Chemicals

Olkiluoto power plant uses 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, sodium hypochlorite, sodium hydroxide and sulphuric acid.

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.

2.11. Nuclear safety and radiation safety

2.11.1. 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 the Radiation and Nuclear Safety Authority (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/2/2018), security arrangements in the use of nuclear energy (STUK Y/3/2020) and the safety of 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 ionising 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 Ministry of Economic Affairs and Employment 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 2023d)*.

The limit values defined for the operation of a nuclear power plant are included in 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. 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.

2.11.2. Nuclear safety

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.

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.

In order to ensure safe operation, TVO is systematically analysing the level of safety. 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.
- 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 the environment.

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 were 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 changed 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.

2.11.3. Radiation and its monitoring

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. During the normal operation of the OL1 and OL2 plant units, radiation doses incurred by the personnel are clearly below the statutory dose limits.

Radioactive releases from the OL1 and OL2 plant units are monitored by means of the power plant's 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 the power plant. Structural radiation protection, radiation monitoring for the personnel, release monitoring and environmental radiation monitoring are implemented under STUK's supervision.

The Nuclear Energy Decree (161/1988) defines the limit values for radiation doses incurred by the population as a result of the operation of a nuclear power plant. The limit value for the annual dose incurred by an individual from the normal operation of a nuclear power plant is 0.1 mSv (millisievert), 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.

2.11.4. 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 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. The first annual outage for plant unit OL3 is held in March–April 2024.

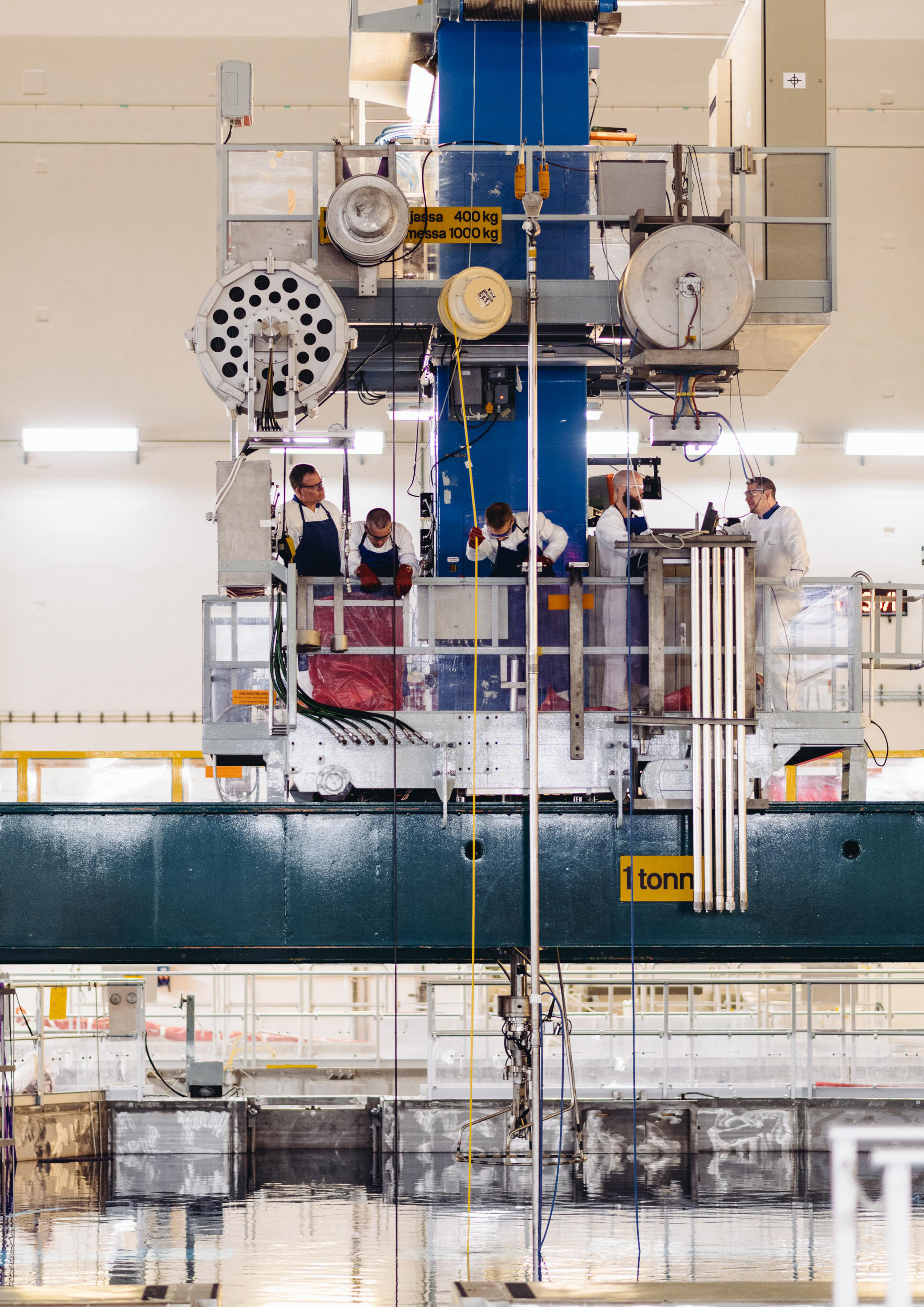
2.12. Decommissioning

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.

If the operation of the OL1 and OL2 plant units is not continued, the decommissioning of the power plant will take place following the current operating licence period. If the operation of the power plant units is continued, decommissioning will take place after the new operating licence period.

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 decommissioning plan presents all the stages related to decommissioning and the present plans for them at the time of writing. 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.


jassa 400 kg
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3. Project description

3.1. Service life extension

Continuing the operation of the OL1 and OL2 plant units is related to both implementation alternatives being examined in this EIA procedure, which are as follows:

- continuing operation at the current power level until 2048 (VE1a) or 2058 (VE1b)
- continuing operation at an uprated power level until 2048 (VE2a) or 2058 (VE2b).

This chapter describes the changes related solely to service life extension when compared to current operation. Changes to the current situation brought about by power uprating are described in chapter 3.2. A summary of the implementation alternatives and their differences when compared to the current situation is shown in the table (Table 3).

3.1.1. Ageing management and maintenance at the power plant

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 above 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: 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.

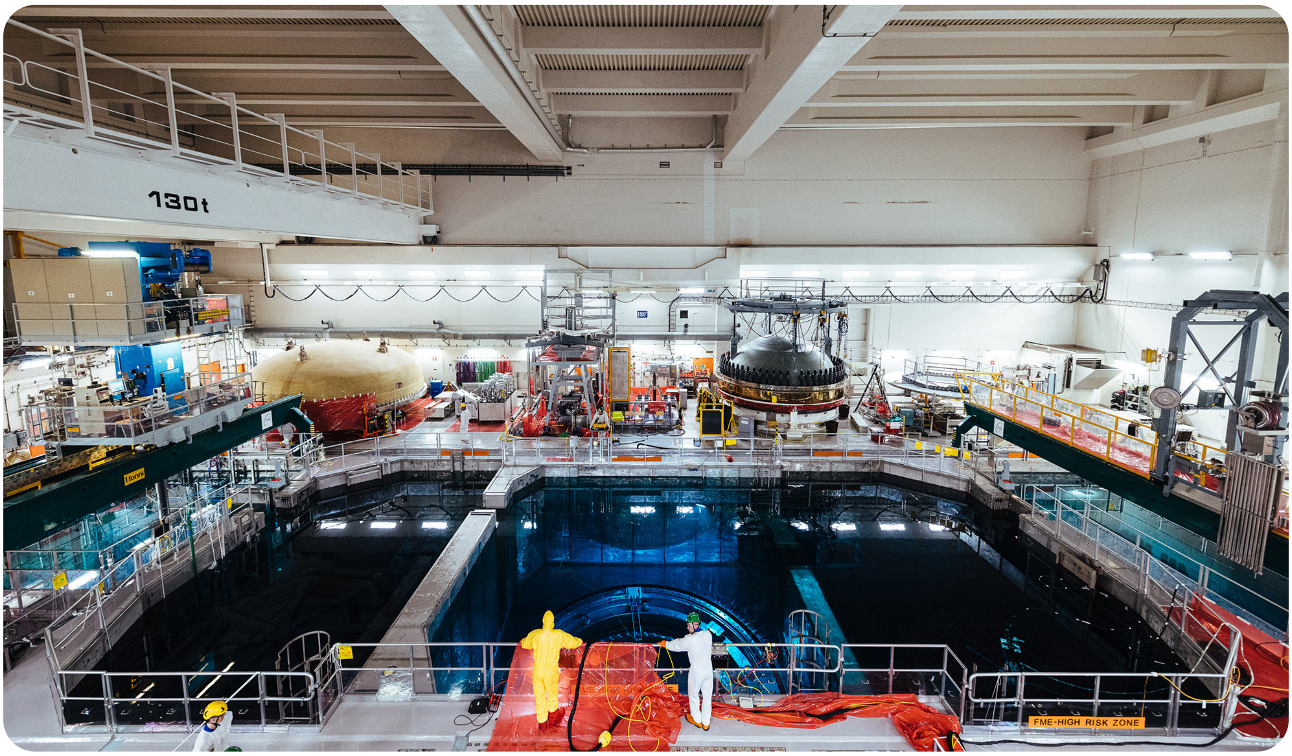
The systems, structures and components of a power plant are subject to various types of stress during operation. This results in normal wear as a result of equipment operation or the fatigue of their structural materials, which may result in degraded integrity and operability. The authority requirements 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. Among other things, this comprises test operation of the equipment, quality control inspections and maintenance. This allows for ensuring that the systems, structures and components operate as planned. In order to ensure operability, equipment replacements are performed due to ageing.

The OL1 and OL2 plant units are qualified for a service life of 60 years. In practice, this means that the load analyses and operational capabilities of the systems and their components have been demonstrated to be sufficient for a 60-year service life. When the service life of the plant units is extended until 2048, the qualification of the systems must be demonstrated for a service life of 70 years. If the service life of the plant units is extended until 2058, the qualification of the systems must be demonstrated for a service life of 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. In addition to requalification, the ageing management programme and practices cover the entire power plant unit. 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 and periodic tests are used to ensure that systems, structures and components meet the operability requirements under normal operating conditions as well as during incidents and accidents.

During the service life extension, the same basic principles for nuclear safety and radiation as described in chapter 2.11 will be observed, 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.

3.1.2. Maintenance and improvement work

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.



3.1.3. Other changes to current operation

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, Table 3). In the case of service life extension, however, the total volume 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 approximately 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 for some reason, storage capacity at the KPA storage may need to be increased.

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 uranium tonnes of spent nuclear fuel, which included the Olkiluoto 4 and Loviisa 3 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.

Extending the service life will not have a significant impact on the annual accumulation of very low, low and intermediate-level waste. In accordance with the years of operation, the total amount of waste will increase by approx. 500 m^3 by 2048 and approx. 1,000 m^3 by 2058 (Table 3). The total capacity of the VLJ repository is estimated to be sufficient for the final disposal of the additional waste generated by the service life extension and power uprating. At the moment, a substantial part of the waste placed in the VLJ repository is very low-level waste (<100 kBq/kg). 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. The near-surface final disposal repository would be used for the final disposal of very low-level operating waste from the Olkiluoto nuclear facilities, which would reduce the waste volumes placed in the VLJ repository as regards very low-level waste *(Teollisuuden Voima Oyj 2021)*. According to the current schedules, near-surface final disposal will begin at Olkiluoto in the mid-2020s. The annual volumes of conventional waste will remain at the same level.

The service life extension does not change the power plant's current annual water requirement and supply. The thermal power routed into the water system and the volume and temperature of cooling water will remain the same (Table 3). The cooling water intake and discharge locations will remain as they are. The annual releases of radioactive substances or conventional releases into the air will also not change as a result of the service life extension (Table 3). Extending the service life will not significantly increase the volume of traffic towards the power plant area or have a significant impact on noise or vibration in the area (Table 3).

3.2. Uprating the thermal power

Chapter 3.1 describes the changes related to service life extension in both implementation alternatives (VE1 and VE2). This chapter describes the additional changes bought about by the power uprating when compared to the current situation. A summary of the implementation alternatives and their differences when compared to the current situation is shown in the table (Table 3).

3.2.1. Planned plant 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 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 reparameterisation of existing systems without essentially changing their functionality. The preliminary plan is to implement the plant modifications required for the possible power uprating in the 2020s. 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.

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 consists of a demineralised make-up water tank that is common to both plant units and two pump units with their fuel tanks. 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 new battery energy storage system that would be used for supporting the national grid would be similar to the one already located in the power plant area. It would consist of a building containing batteries and a power transformer used for joining the national grid.

3.2.2. Other changes to current operation

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 98,000 terajoules to 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. (Table 3) The cooling water intake and discharge locations will remain as they are. There will be no changes to service water.

In the power uprating scenario, the amount of nuclear fuel used each year will not increase. 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 but, during the KPA storage stage, this will no longer affect the cooling requirements of the KPA storage or the thermal load.

The power uprating will not have a significant impact on the annual accumulation of very low, low and intermediate-level waste. In accordance with the years of operation, the total amount of waste will increase by approx. 500 m^3 by 2048 and approx. 1,000 m^3 by 2058 (Table 3). The total capacity of the VLJ repository is estimated to be sufficient for the final disposal of the additional waste generated by the service life extension and power uprating.

The annual releases of radioactive substances or conventional releases into the air will not change materially as a result of the power uprating (Table 3). The additional construction will not significantly increase the volume of traffic towards the power plant area or have a significant impact on noise or vibration in the area, since no excavation work is required for the additional construction (Table 3).

3.3. Summary of the alternatives

The enclosed table (Table 3) presents key figures for OL1 and OL2 during the current operation (VE0) and compares them to extending the service life at the current power level (VE1) and extending the service life at an uprated power level (VE2).

Table 3. *Key figures in the various alternatives.*

Explanation	VE0 Continuing current operation of OL1 and OL2 until 2038	VE1 Extension of operation until 2048/2058	VE2 Power uprating and extension of operation until 2048/2058
Plant type	Boiling water reactor		
Electrical power output	890 MW		970 MW
Thermal power output	2,500 MW		2,750 MW
Efficiency	35.6%		35.3%
Reactor operating pressure	70 bar		
Annual electricity production	approx. 7 TWh/plant unit		approx. 7.6 TWh/plant unit
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		
Cooling water temperature	Temperature increase of approx. 10 °C		Temperature increase of approx. 11 °C
Volume of service water	Approx. 272,000 m^3 of raw water for Olkiluoto, of which approximately one half is used as household water and half as process water, fire-fighting water and other uses.		
Fuel	Uranium dioxide UO_2		
Number of fuel assemblies	500 pcs		
Fuel consumption	approx. 18 t/a		
Spent nuclear fuel (per year)	approx. 19 t/a		
Spent nuclear fuel (over the plant's entire service life)	approx. 2,483 t (by 2038)	approx. 2,861 t (by 2048) approx. 3,240 t (by 2058)	
Very low, low and intermediatelevel waste (per year)	approximately 50 m^3	No significant changes to annual accumulation.	
Very low, low and intermediatelevel waste (over the plant's entire service life)	approx. 8,250 m^3 (by 2038)	approx. 8,750 m^3 (by 2048) approx. 9,250 m^3 (by 2058)	
Other waste [1)]	Recyclable waste 2,610 t/a Landfill waste 0 t/a Hazardous waste 219 t/a		

Explanation	VE0 Continuing current operation of OL1 and OL2 until 2038	VE1 Extension of operation until 2048/2058	VE2 Power uprating and extension of operation until 2048/2058
Releases of radioactive substances into the air [2]	Noble gases (Kr-87 equiv.): 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		
Other releases into the air [3]	CO_{2e} 914 t/a NO_x 1.2 t/a SO_2 0.0 t/a Particles 0.1 t/a		CO_{2e} 927 t/a NO_x 1.2 t/a SO_2 0.0 t/a Particles 0.1 t/a
Releases of radioactive substances into water [2]	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		
Other releases into water [4]	Household waste water, total 86,550 m^3/a Phosphorus 5 kg/a Nitrogen 4,222 kg/a BOD_{7ATU} 412 kg/a		
	Process waste water, total 25,000 m^3/a Phosphorus 5 kg/a Nitrogen 100 kg/a		
Noise [5]	Nearest holiday housing (Leppäkarta) 39.4–42.1 dB Main gate 48.6–56.3 dB		
Traffic	Approximately 1,000 vehicles/day. More during annual outages.		

1) Average for OL1, OL2 and OL3 over three years.
2) Range of variation for OL1 and OL2 in 2007–2022. The highest values in the actual release ranges have been related to rare exceptions.
3) Average for OL1 and OL2 over three years.
4) Household waste water: Average for OL1, OL2 and OL3 over three years. Process waste water: Average for OL1 and OL2 over three years.
5) Range of variation for 2020–2022.

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 European Union's EIA directive (2011/92/EU) 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 EIA 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. Uprating the thermal power of a reactor is one of the projects to be assessed according to section 7b (nuclear power plants).

4.2. Parties

The parties to the EIA procedure in this project are presented in the table below (Table 4).

Table 4. 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 in accordance with the EIA legislation). The authors of the EIA programme and their qualifications are listed in Appendix 2.
Other parties	» Finnish Environment Institute (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. The EIA procedure starts when the project owner submits the assessment programme (EIA programme) to the coordinating authority. The EIA programme defines how the EIA procedure is arranged. 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;
- A schedule.

The coordinating authority will notify the other authorities and the municipalities in the project's area of impact that the EIA programme is on display for public inspection. The display for public inspection will last from 30 to 60 days. Following this, the coordinating authority will compile the statements and opinions received regarding the EIA programme and draw up its own statement on the EIA programme, which will conclude the first stage of the EIA procedure. Simultaneously, an international hearing will take place (chapter 4.4).

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. The coordinating authority sets the assessment report, similarly to the EIA programme, on display for public inspection (for 30–60 days). An international hearing will also be held during the EIA report stage. 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 and places it on display for public inspection. The assessment report and the coordinating authority's reasoned conclusion are enclosed with the permit application documents.

The figure below (Figure 9) presents a summary of the stages of the EIA procedure in Finland and how the international hearing links to it.

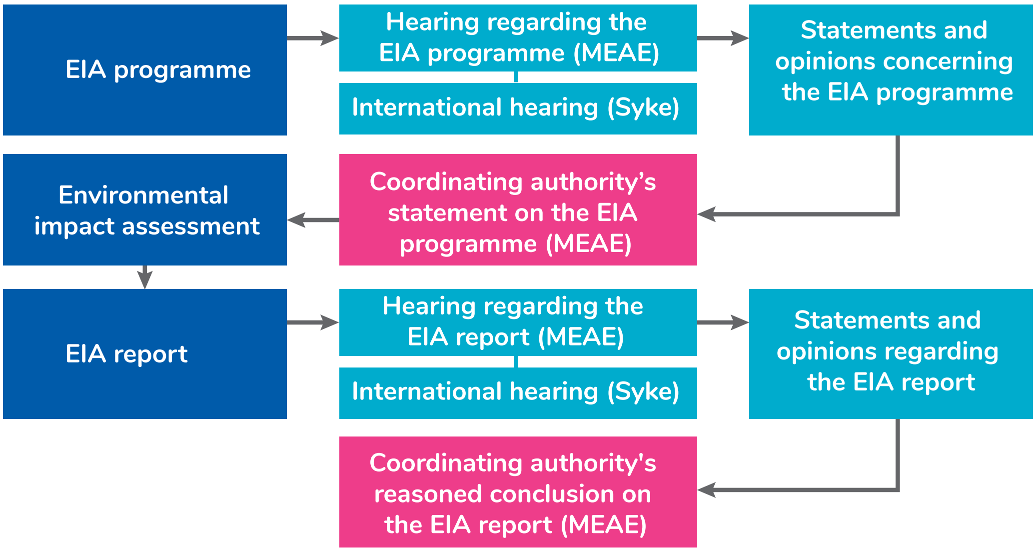


Figure 9. Stages of the EIA procedure. MEAE = Ministry of Economic Affairs and Employment. Syke = Finnish Environment Institute.

4.4. International hearing

The principles of international cooperation in environmental impact assessment are defined in the Espoo Convention (SopS 67/1997) and the Aarhus Convention (SopS 121–122/2004). These have been enacted within the EU by means of several directives, such as the EIA Directive (2011/92/EU) 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).

If the environmental impacts of a project may cross national borders, an international hearing is arranged for the environmental impact assessment in cooperation with another country. In this case, the Finnish Environment Institute which acts as the coordinating authority for the international hearing, notifies the target countries that an EIA procedure has been started for the project and enquires whether they are willing to participate in the EIA procedure. A summary document for the EIA programme that has been translated into the target country's language and the EIA programme translated into Swedish or English will be enclosed with the notification. The Finnish Environment Institute will relay the received feedback to the coordinating authority for the EIA (MEAE) to be taken into account in the Ministry's statement on the EIA programme. In accordance with the EIA Act, the coordinating authority will submit its statement and the translations of its essential parts to the Finnish Environment Institute for further submittal to the European Union member states for information.

A corresponding international hearing will be arranged at the later EIA report stage to the target countries who have expressed that they will participate in the Finnish EIA procedure.

4.5. Schedule for the EIA procedure

The key stages and preliminary schedule for the EIA procedure are presented in the figure below (Figure 10).

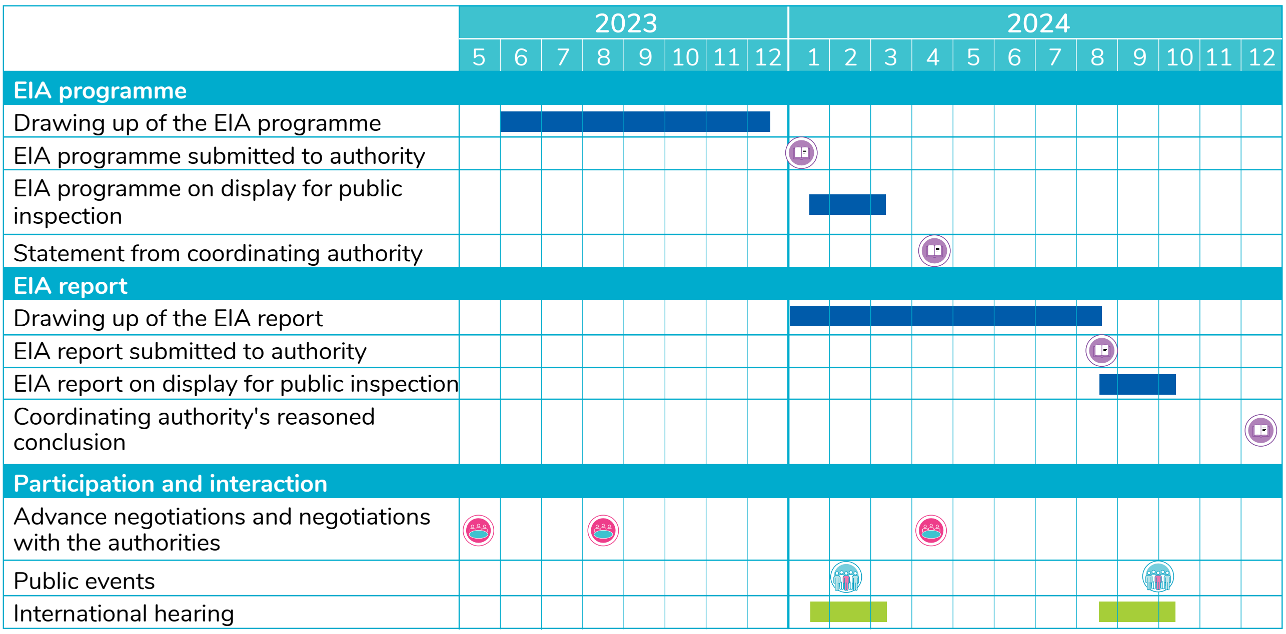


Figure 10. Preliminary schedule for the EIA procedure.

4.6. 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 programme is submitted or while the assessment procedure is under way, an advance negotiation may be arranged between the project owner, coordinating authority and other key authorities. The aim for the advance negotiation is 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. In this project, advance negotiations were arranged between the coordinating authority, the authority responsible for the international hearing and the project owner.

Furthermore, other negotiations involving various authorities may be arranged during the programme and report stages, if necessary.

Monitoring group

A monitoring group is set up during the EIA report stage that is intended to promote the transfer and exchange of information between the project owner, the authorities and the key stakeholders in the area. Representatives from the municipality of Eurajoki, nearby municipalities and local stakeholders and various experts and authorities may be called to participate in the monitoring group and its meetings. Representatives from the project owner, the EIA consultant and the coordinating authority will also take part in the work of the monitoring group.

Public events during the EIA procedure

Two public events will be arranged during the EIA procedure, one of which is held at the programme stage and another at the report stage. The events will be 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. The date and place of the public events will be communicated in the coordinating authority's public notice on the EIA programme and report.

Communications

The EIA programme and report will be published on the website of the Ministry of Economic Affairs and Employment. The documents will be 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. TVO will also communicate on the progress of the project and, for example, the press conferences and public information events being arranged.

5. Current state of the environment

5.1. Land use and zoning

5.1.1. Societal structure and land use

Olkiluoto is an island located in the municipality of Eurajoki, in 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 northwest of the centre of Eurajoki. Olkiluoto Island is 6 km long and 2.5 km wide. Teollisuuden Voima Oyj owns approx. 90% of the land areas on Olkiluoto Island. TVO also partially owns the water areas on the northern and southern side of the island.

Olkiluoto Island has a surface area of approximately 900 hectares; the area constructed for nuclear power and final disposal is located in the western part of the island and spans approximately 170 hectares. The nuclear power plant units OL1 and OL2 are located at the western end of Olkiluoto (Figure 5). The newly commissioned OL3 is located to the west of these units. 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 wastewater 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. Olkiluoto Harbour is located along the middle of the island's northern shore, and the island's eastern and south-eastern ends contain agricultural areas and scattered holiday housing and permanent housing (see chapter 5.10). 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.

There is a precautionary action zone spanning to a distance of five 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's guide (YVL A.11) and regulation on emergency preparedness arrangements at a nuclear power plant *(STUK Y/2/2018)* shall be observed.

5.1.2. Zoning

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.

The Satakunta provincial plan (Figure 11) 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 Section 52 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 five kilometres 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.

In the Satakunta provincial plan, the Tankokari harbour at Olkiluoto is indicated as a harbour area (ls), while Liiklankari is indicated as a nature conservation area (SL) and a Natura 2000 network area (nat).

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

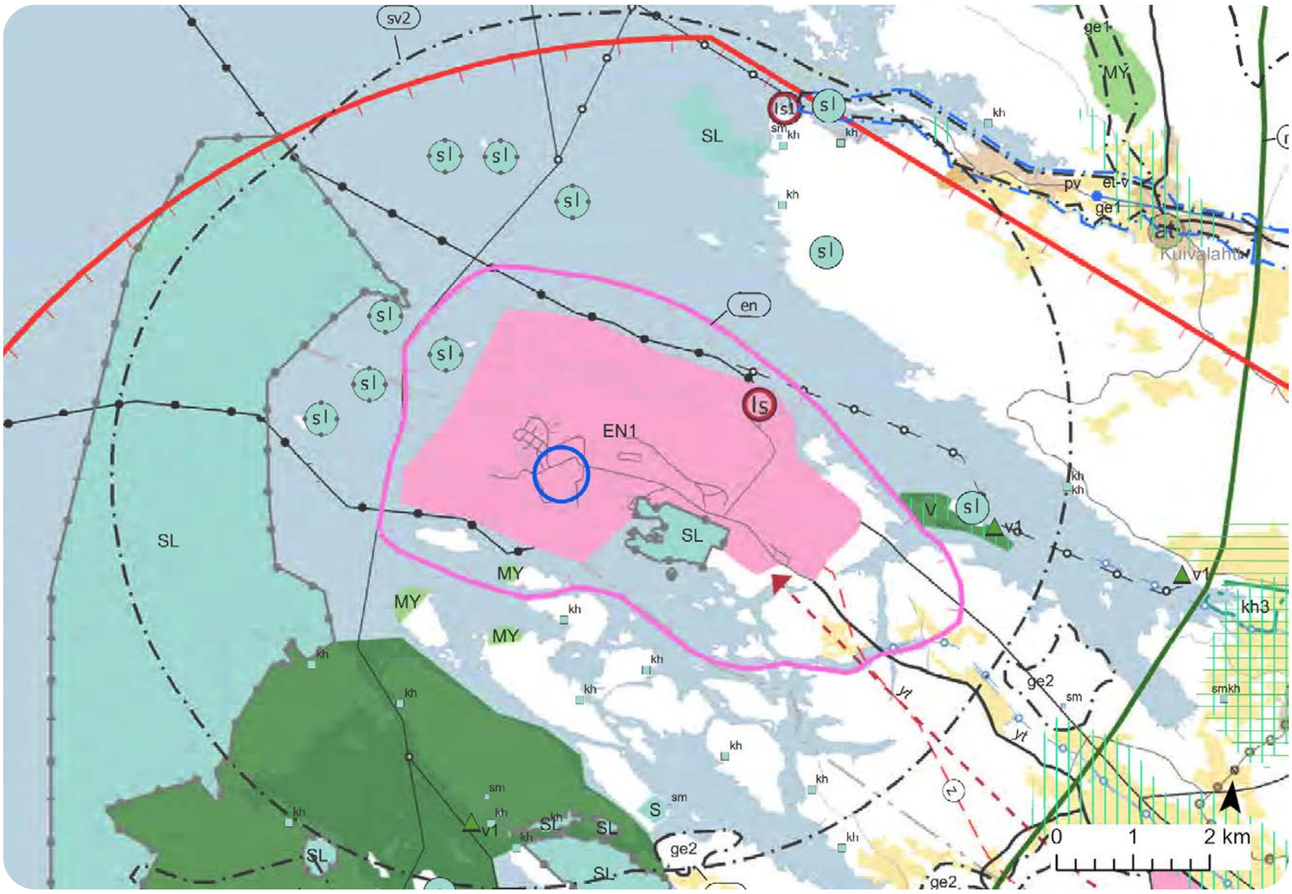
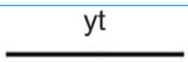
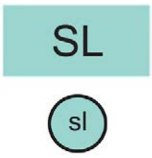


Figure 11. Excerpt from the Satakunta provincial plan.

The zone designations and regulations located near the power plant area are listed in the table below (Table 5). The location of the OL1 and OL2 plant units is marked with a blue circle in the picture (Figure 11).

Table 5. Zone designations and regulations located near the power plant area.

EN	**ENERGY SUPPLY AREA** 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.
en	**TARGET AREA FOR DEVELOPING ENERGY SUPPLY** 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.
SV	**PRECAUTIONARY ACTION ZONE** 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.
ls	**HARBOUR AREA** 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.

	**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.
	**GUIDELINE FOR POWER LINE** The designation indicates guidelines for power lines of at least 110 kV.
	**IMPORTANT CONNECTING ROAD**
	**CONNECTION REQUIREMENT FOR ROAD TRAFFIC**
	**AREA WITH DOMINANT AGRICULTURE AND FORESTRY THAT HAS SPECIAL ENVIRON-MENTAL VALUES** The designation indicates areas dominated by agriculture and forestry that have specific values related to culture, landscapes, nature and the environment.
	**AREA BELONGING TO NATURA 2000 NETWORK** The designation indicates areas belonging to the Natura 2000 network pursuant to decisions by the Government.
	**NATURE RESERVE** The designation indicates nature reserves that are or will be protected by virtue of the Nature Conservation Act.
	**TARGET AREA FOR URBAN DEVELOPMENT** 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.

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. OL1 and OL2 are located in the subarea intended for the actual nuclear power plants (v) and the subarea where nuclear waste facilities may be placed (yj). (Figure 12)

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 kilometres 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 were 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.

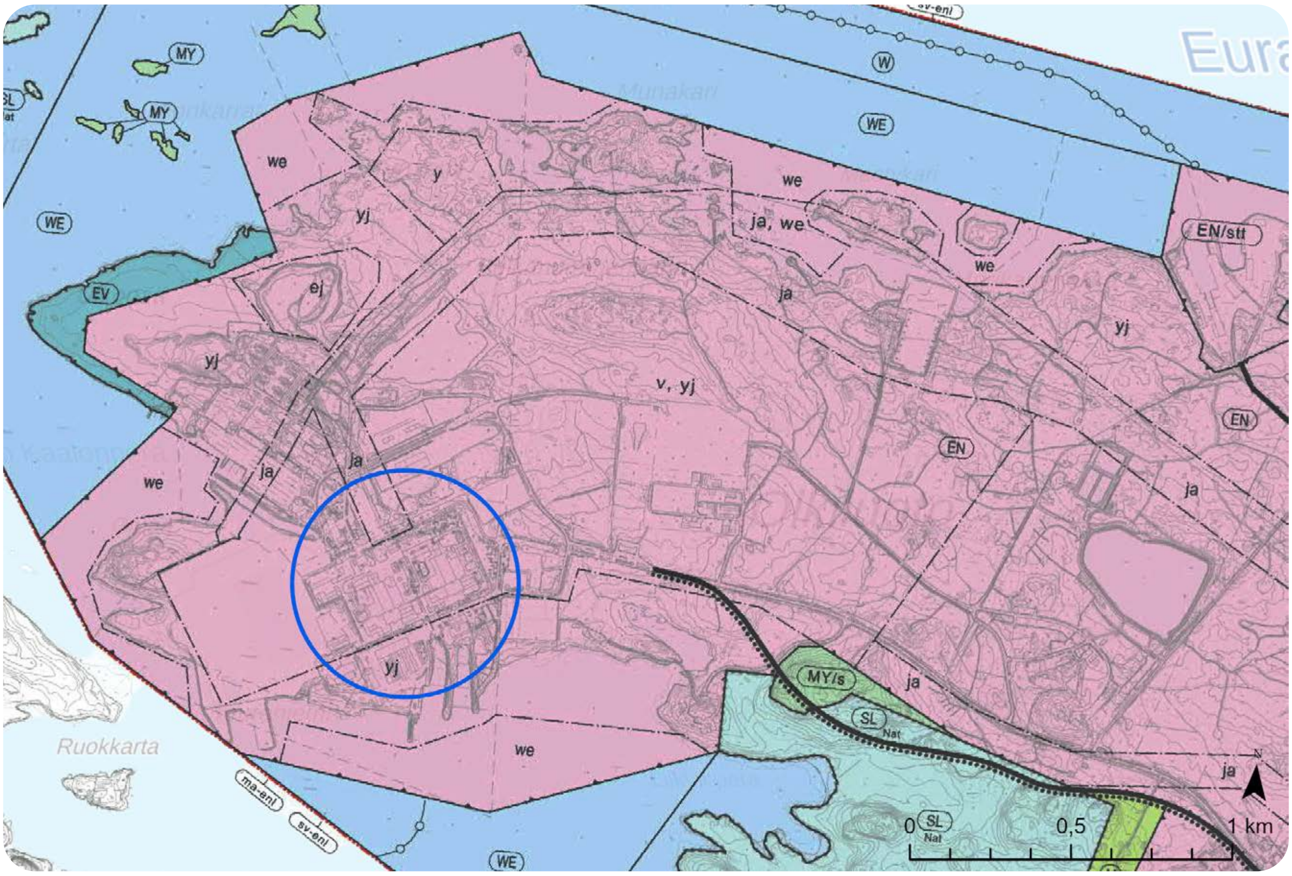


Figure 12. Excerpt from the Olkiluoto partial master plan. The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

The Eurajoki master plan for shore areas covers all the shore areas and islands in Eurajoki (Figure 13). 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 14). 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). Several nature reserves that are intended for implementation by the state are located to the west of the power plant area.

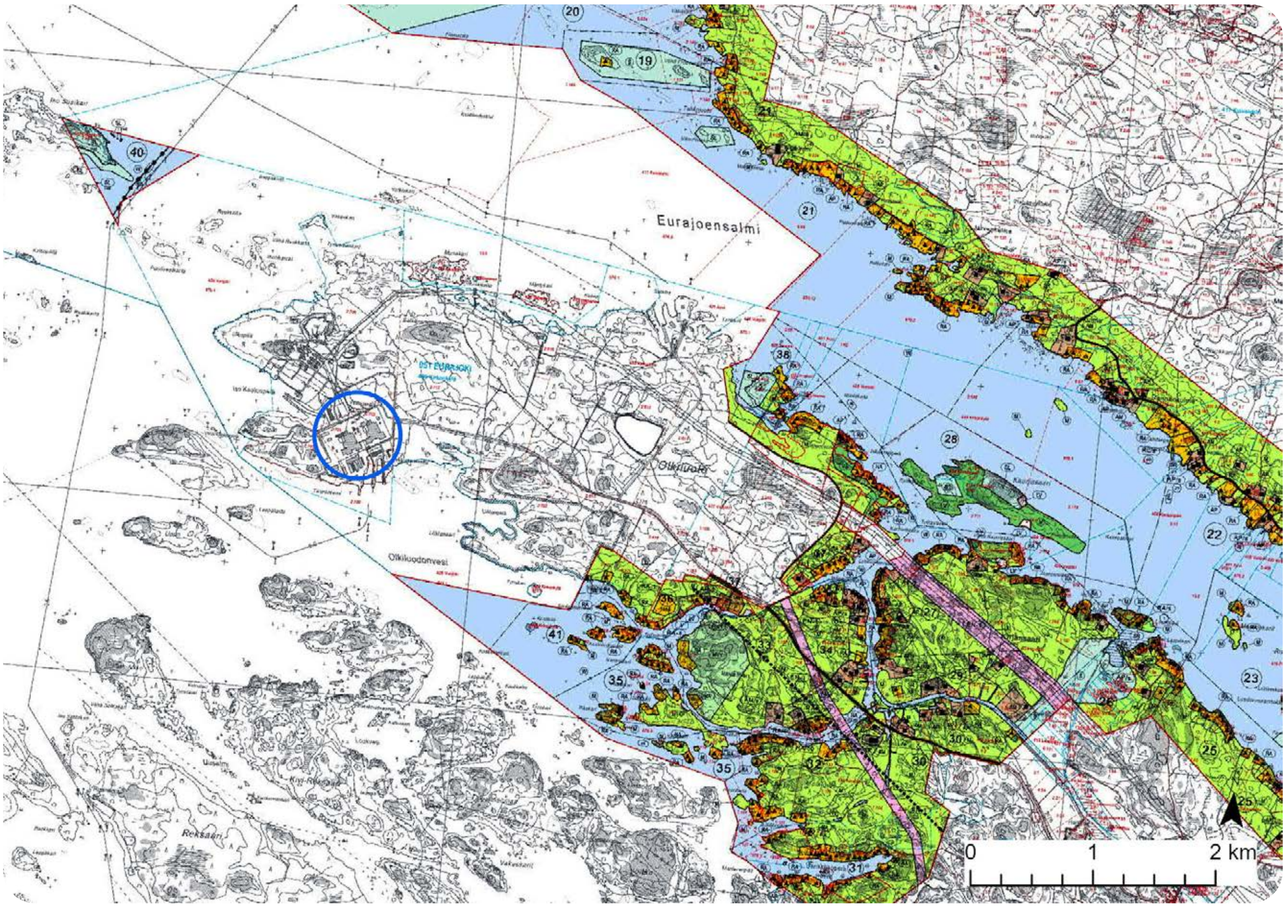


Figure 13. Excerpt from the master plan for shore areas in Eurajoki and its amendment (2000 and 2015). The location of the OL1 and OL2 plant units is marked with a blue circle in the picture, and they are not located within the master plan for shore areas.

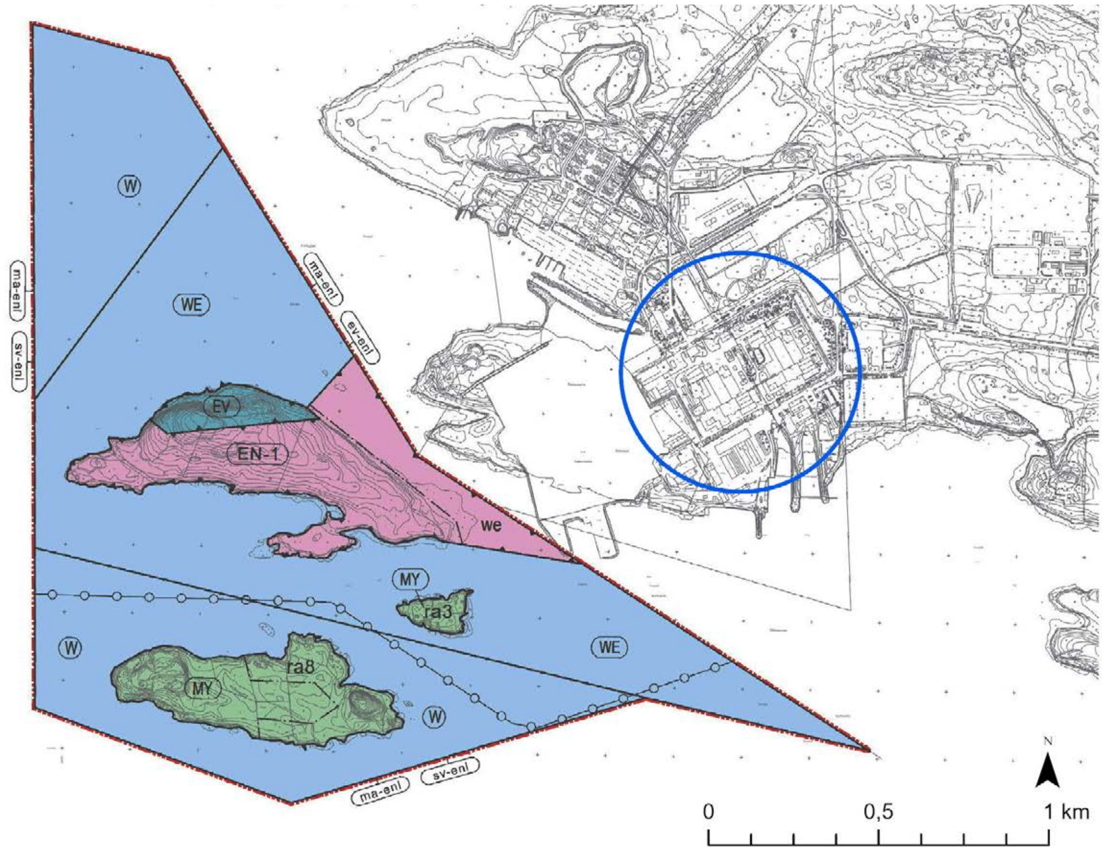


Figure 14. Excerpt from the partial master plan for northern shore areas in Rauma and its amendment (2000 and 2008). The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

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 15). The project area is designated as block area 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 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 project 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.

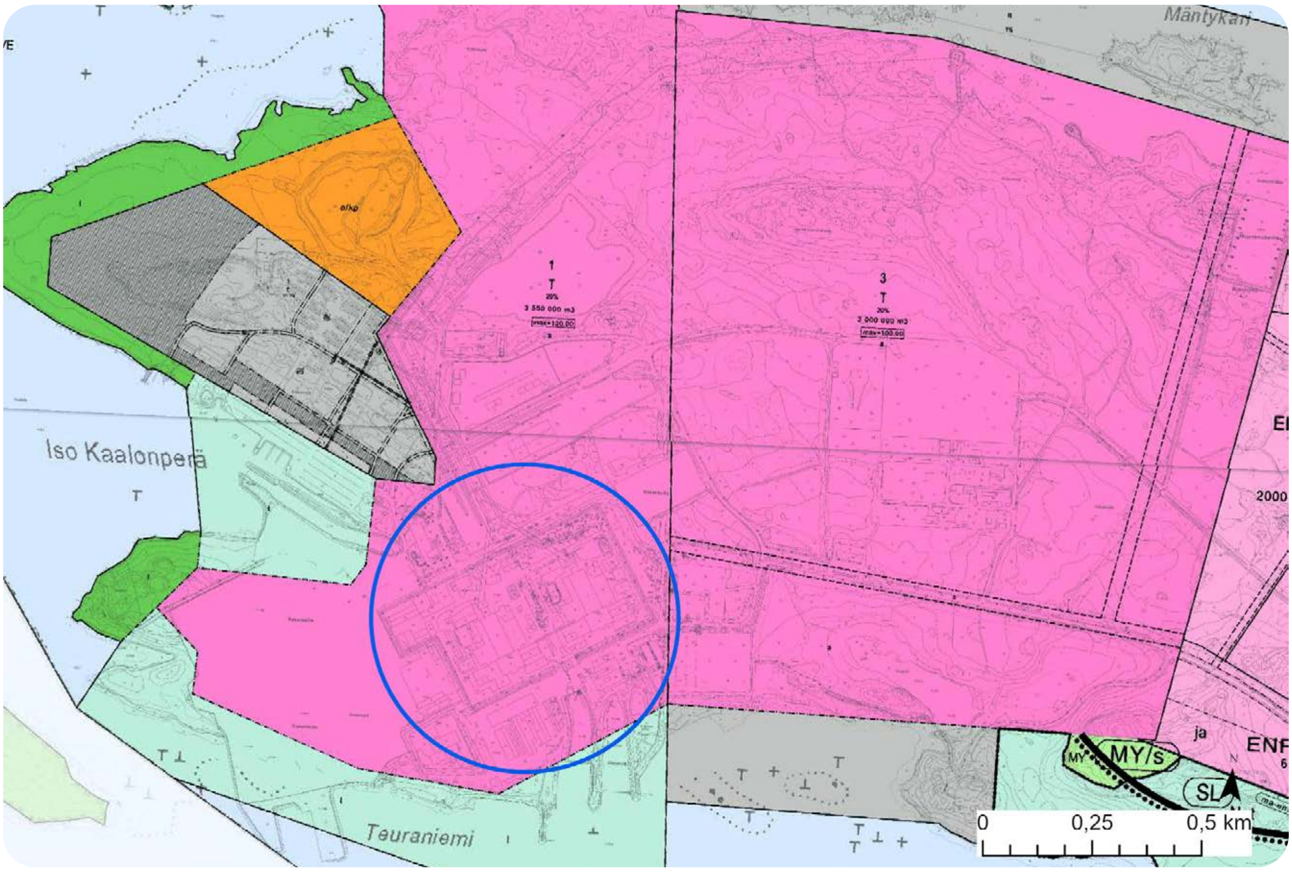


Figure 15. Excerpt from the current local detailed plan. The amendment of the building plan for Eurajoki parish village (1997) is in force in the project area. The location of the OL1 and OL2 plant units is marked with a blue circle in the picture.

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 16). 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 regarding the construction of the 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. Areas where the structures and equipment required by the power plant and disposal repositories for very low-level waste may be constructed are indicated with building area designations (en-1). The plan area is located approximately 350–400 m to the north-west of units OL1 and OL2.

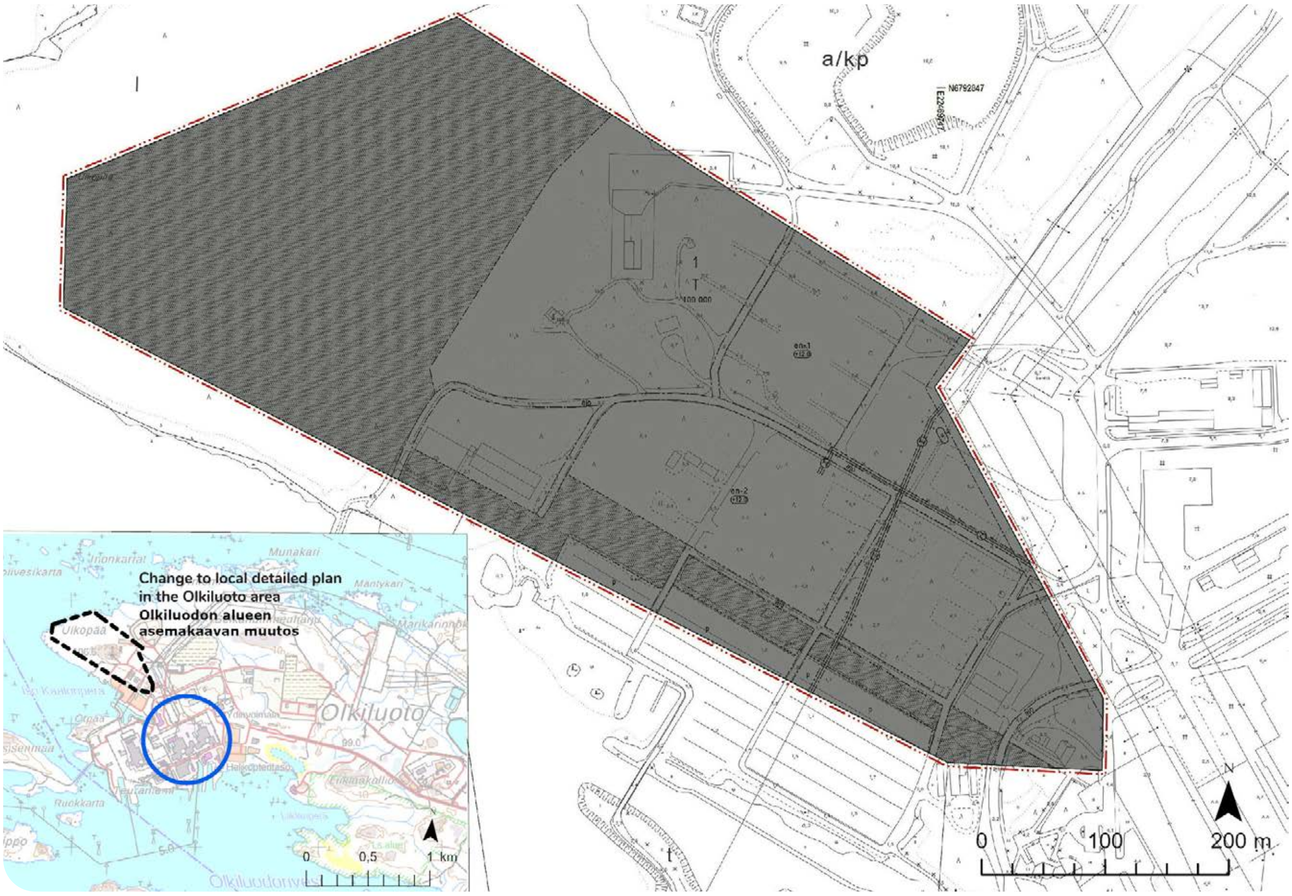


Figure 16. Amendment to the local detailed plan for the Olkiluoto area became legally valid on 2 Jan 2023. At present, the amendment to the local detailed plan is not visible in the current local detailed plan for the municipality of Eurajoki (Figure 15, orange area). The location of the OL1 and OL2 plant units is marked with a blue circle in the 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 project area.

With the expansion of land use in the Olkiluoto energy supply area, the City of Rauma started in 2008 the work for drawing up an amendment to the local detailed plans of the Kuusisenmaa, Leppäkarta and Vähä-Kaalonperä islands and their surrounding areas. In the east, the zoning area is limited by the municipal border of Eurajoki and the power plant area of Olkiluoto. However, the project was no longer included in the 2023 zoning review for the City of Rauma.

Pending plans

No local detailed plan or master plan projects are currently pending in the power plant area or its vicinity.

5.1.3. National land use goals

National land use goals are part of the land use planning system pursuant to the Land Use and Building Act (132/1999). The Government decided on the new national land use goals in 2017 and they entered into force in 2018. 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 key themes in the national land use goals are 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.

5.2. Landscape and cultural environment

5.2.1. General description of the landscape

In the provincial distribution of landscapes, Olkiluoto 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 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 1993)*.

Figure 17. Aerial photograph of the site area. (National Land Survey of Finland 2022)

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 17). The shore landscape at Olkiluoto itself is varying, with minute features and a fragmented shoreline. In addition to industrial structures, the power plant area is surrounded by strips of shore land with forest and reeds. When heading west, the island region and its landscape image become more fragmented. A wide corridor for powerlines heads towards the continent from the area, splitting the forest region. The plant units can be viewed from the south across Olkiluodonvesi.

5.2.2. 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 (Figure 18). The nearest provincially significant cultural environment is located approximately 5 km southeast of the project area (Kaunissaari). The nearest nationally significant constructed cultural environment (RKY), Sorkka village, is located about 8 km to the southeast of the project area.

No objects protected by virtue of the Antiquities Act are located in the power plant area or its immediate vicinity *(Finnish Heritage Agency 2020)*.

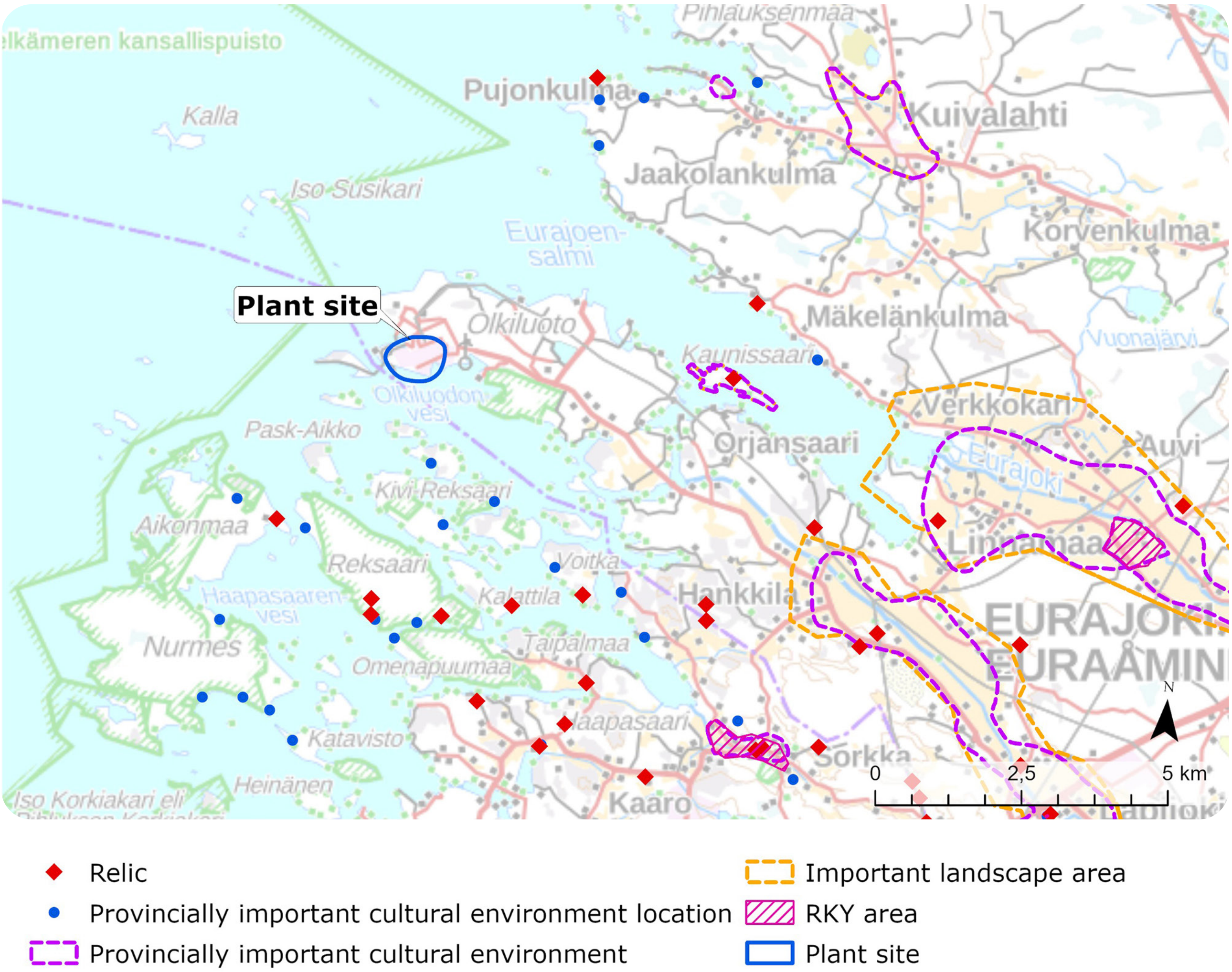


Figure 18. Landscape areas, cultural environments and fixed antiquities located in the vicinity of the power plant area.

5.3. Traffic

5.3.1. Roads

The Olkiluoto area has functional transport connections with roads, parking areas and harbours (Figure 19). 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. Olkiluodontie intersects several smaller roads. The road section 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. Olkiluoto is also accessible by road from Rauma via Sorkka and from the centre of Eurajoki via Linnamaa.

Traffic volumes along Olkiluodontie vary greatly, in particular during construction projects in the area and the annual outages of the nuclear power plant units. The busiest section of Olkiluodontie is around 1 km from the intersection of main road 8. In 2022, the average daily traffic at the beginning of Olkiluodontie was approximately 3,185 vehicles per day, of which there were around 216 heavy vehicles per day *(Finnish Transport Infrastructure Agency 2022)*. The largest share of traffic is commuting. In 2022, the average daily traffic on main road 8 between Rauma and Eurajoki was approximately 10,900 vehicles per day, of which heavy traffic accounted for 1,050 vehicles *(Finnish Transport Infrastructure Agency 2022)*.

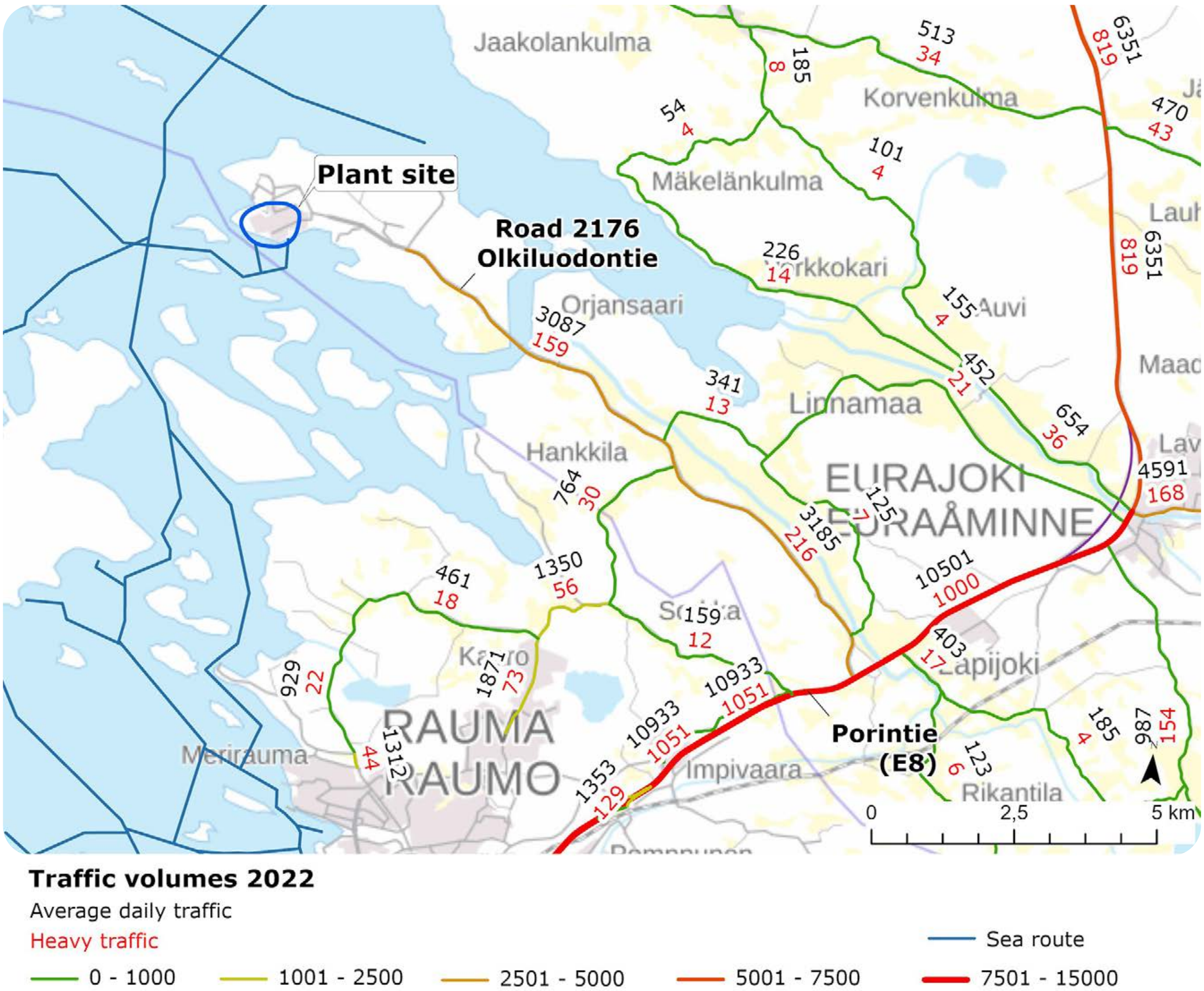


Figure 19. Roads and sea routes leading to the Olkiluoto power plant area

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, 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 leading to Olkiluoto. *(Finnish Transport Infrastructure Agency 2023)* If the project is implemented, it will improve the safety of the Olkiluoto intersection, as some of the traffic will use the new connection.

5.3.2. Sea routes

Olkiluoto harbour is located in the northern part of Olkiluoto Island, on the shore of Eurajoki strait, approximately 20 km north of Rauma. 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 piers for the Olkiluoto nuclear power plant are located to the south of Olkiluoto island, with a shipping route of five metres 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.

5.4. Noise and vibration

The noise level in the Olkiluoto power plant area and its immediate vicinity is primarily affected by the industrial functions in the area. The main sources of noise at the OL1, OL2 and OL3 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. In addition to the plant units, noise level in the vicinity of Olkiluoto is affected by the operations of Posiva, the harbour functions, the rock crushing facility and Fingrid Oyj's gas turbine plant that acts as a back-up power plant for TVO's operations and the national grid. The noise level in the environment is also affected by traffic in the area.

According to the provisions in the environmental permit, TVO carries out noise measurements each year. In the measurements for 2015–2022, noise level has varied between 35.9 and 50.7 dB at the nearest holiday house at Ruokkarta (aka Leppäkarta or Leppäkari). The Government's noise guideline value of 45 dB for areas used for holiday housing was only exceeded in 2017, whereas in other years the noise level was clearly below the guideline value (Government decision on noise level guideline values, 993/1992). In the measurements performed in 2022, noise level at the nearest holiday house on Ruokkarta Island was 42.1 dB. On Nousiainen Island, which also has holiday housing, the noise level was 40.7 dB. No clear trend is visible in the noise levels measured during the follow-up; instead, noise level has remained fairly similar, even though variation can be seen between different years.

At the measurement point closest to residential housing, which is located to the east of the power plant at the Raunola/Luonto road crossing, the noise level was 44.8 dB in the latest measurement in 2022. The residential building is at a distance of approximately 3 km from TVO's plant units. This level does not exceed the Government's daytime guideline value for noise of 55 dB in residential areas.

High noise levels (57.6–61.5 dB) have been measured at TVO's main gate over the years due to passing traffic. In 2022, the highest noise level of 52.4 dB was measured next to the OL1 water inlet channel. During the measurement, a few vehicles passed that increased the noise level. The second highest noise level (48.6 dB) was measured near the main gate where passing vehicles caused noise.

A total noise model has been created for Olkiluoto Island *(Ramboll 2021)*. Based on the analysis, the most significant source of environmental noise on Olkiluoto Island are the rock crushing operations at Posiva's worksite for the disposal repository for spent nuclear fuel that are carried out in phases over the course of the year, during the day. The day-time noise level average for the crushing operations alone, at the nearest holiday houses located to the south of TVO's power plant units, clearly falls below the average level of 40 dB; however, at the Munakari holiday houses located on the northern edge of Olkiluoto Island, the average day-time noise level is approximately 45 dB during a crushing campaign.

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 vibration in the immediate vicinity of roads.

5.5. Climate and air quality

5.5.1. Climate

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 on the coast between Rauma and Pori to approximately +4 degrees in the north-east. Annual precipitation on the coast of the Bothnian Sea is slightly below 600 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. *(Ilmasto-opas 2023)*. The prevailing wind direction is from the southwest *(Ilmatieteenlaitos 2023)*.

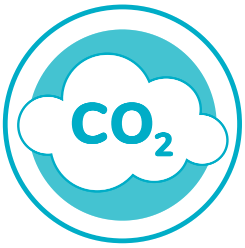
Olkiluoto is located on the coast of the Bothnian Sea in a maritime climate, characterised by stable temperature conditions. In the spring, temperatures near the coast are clearly lower than further inland. In autumn, the warm sea evens out the temperature differences during the day, and there are few 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), climate on Earth had, by the year 2017, warmed up by approximately 1°C when compared to the pre-industrial 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. *(Ilmatieteenlaitos 2023b)*

During the current century, climate in Satakunta is estimated to warm up by approximately 1.9–5.1°C when compared to the reference period of 1981–2010. 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 per cent 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. *(Ilmasto-opas 2023)*. 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)*

5.5.2. Releases into the and air quality



Releases into the air from the OL1 and OL2 plant units may be releases with a minor negative impact on air quality (e.g. nitrogen oxides, particle emissions) or greenhouse gas emissions affecting climate change (e.g. carbon dioxide).

There is no air quality monitoring in Eurajoki. The nearest monitoring point is in Rauma. In Eurajoki, releases that degrade air quality are likely to be generated mainly from smaller industrial facilities, discrete heating for homes, traffic and other small sources (such as fireplaces in homes), but the amount of releases caused by them has not been assessed. Releases are also affected by loads from elsewhere.

Greenhouse gas emissions from the municipality of Eurajoki in 2021 amounted to 65,600 kilotonnes of carbon dioxide equivalent (kt CO_{2e}) in total. Compared to 2005, emissions have been reduced by 31%. In 2021, the main part of the total emissions was caused by traffic (29.4%), agriculture (18.6%) and machinery (10.7%). *(Finnish Environment Institute 2023a)* 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 2023a)*. 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 2022, exclusive of the LULUCF sector, amounted to an estimated 45.8 million tonnes CO_{2e}. Emissions were estimated to be down by approximately 2.0 million tonnes from 2021. *(Statistics Finland 2023a)*

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)*

5.6. Soil, bedrock and groundwater

The soil, bedrock and groundwater conditions on Olkiluoto Island are very well known, as the area has been studied for more than 30 years. 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.

Posiva's final disposal facility for spent nuclear fuel, which is being excavated into bedrock to approximately 400 m below the ground surface, is located approximately 1.5 km east of TVO's site area. On the basis of site studies performed by Posiva, the Olkiluoto Site Description was created in 2018. It contains, among other things, a description of the geological and hydrogeological structure of the area, groundwater chemistry and flow conditions for groundwater *(Posiva 2018)*. The geological and hydrogeological structural model for the Olkiluoto area is updated on the basis of increased research and follow-up data as the excavation work for the underground premises of the disposal facility progresses. 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)*. Follow-up in accordance with the monitoring programme is performed at aboveground groundwater pipes and deep boreholes as well as at the underground disposal facility, for example.

5.6.1. 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 20). 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.

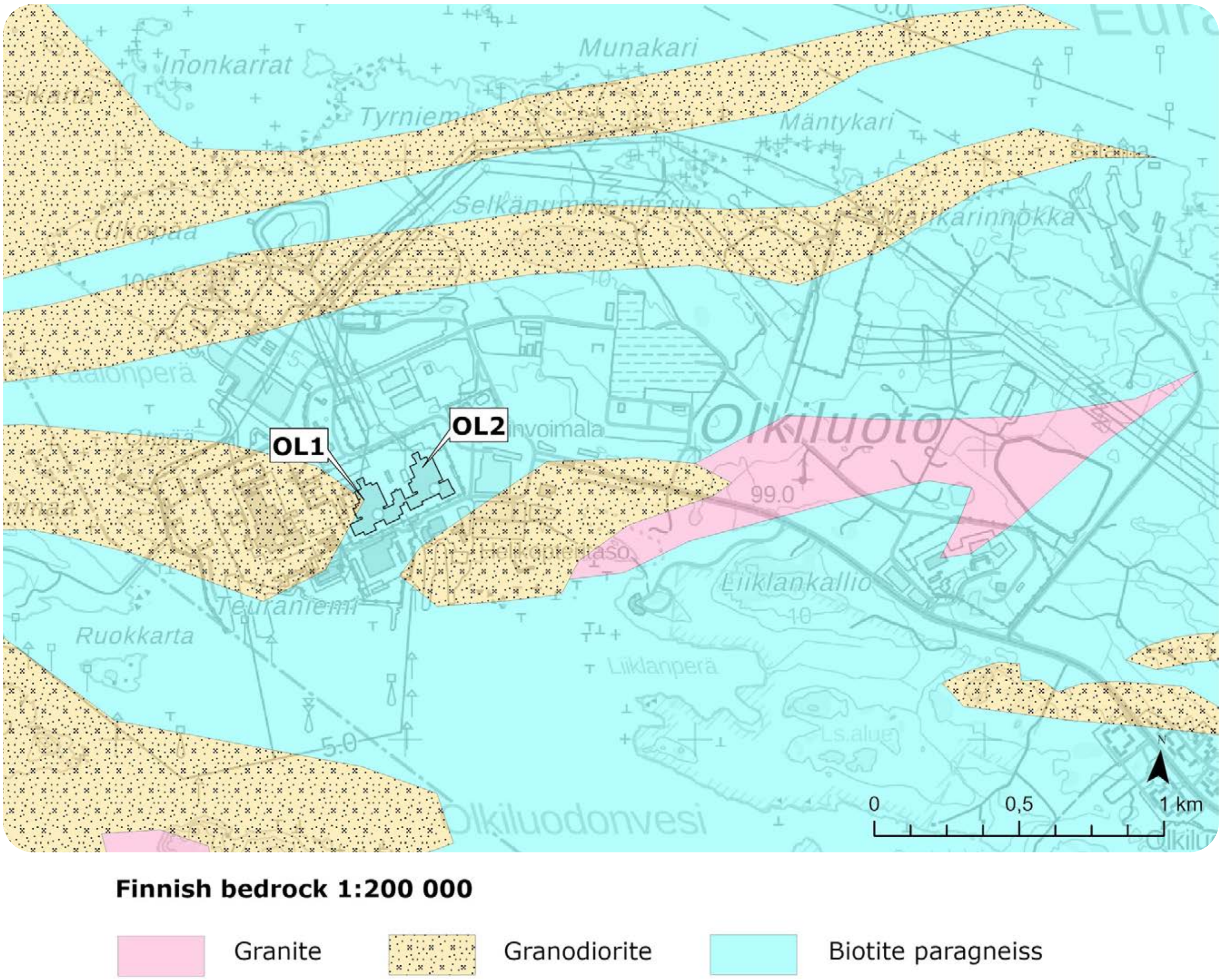


Figure 20. Bedrock in the power plant area and its surroundings.

5.6.2. Soil

Soil in the Olkiluoto area mostly consists of rocky moraine. Low sections also feature thin layers of clay and peat (Figure 21). 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 metres, 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.

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

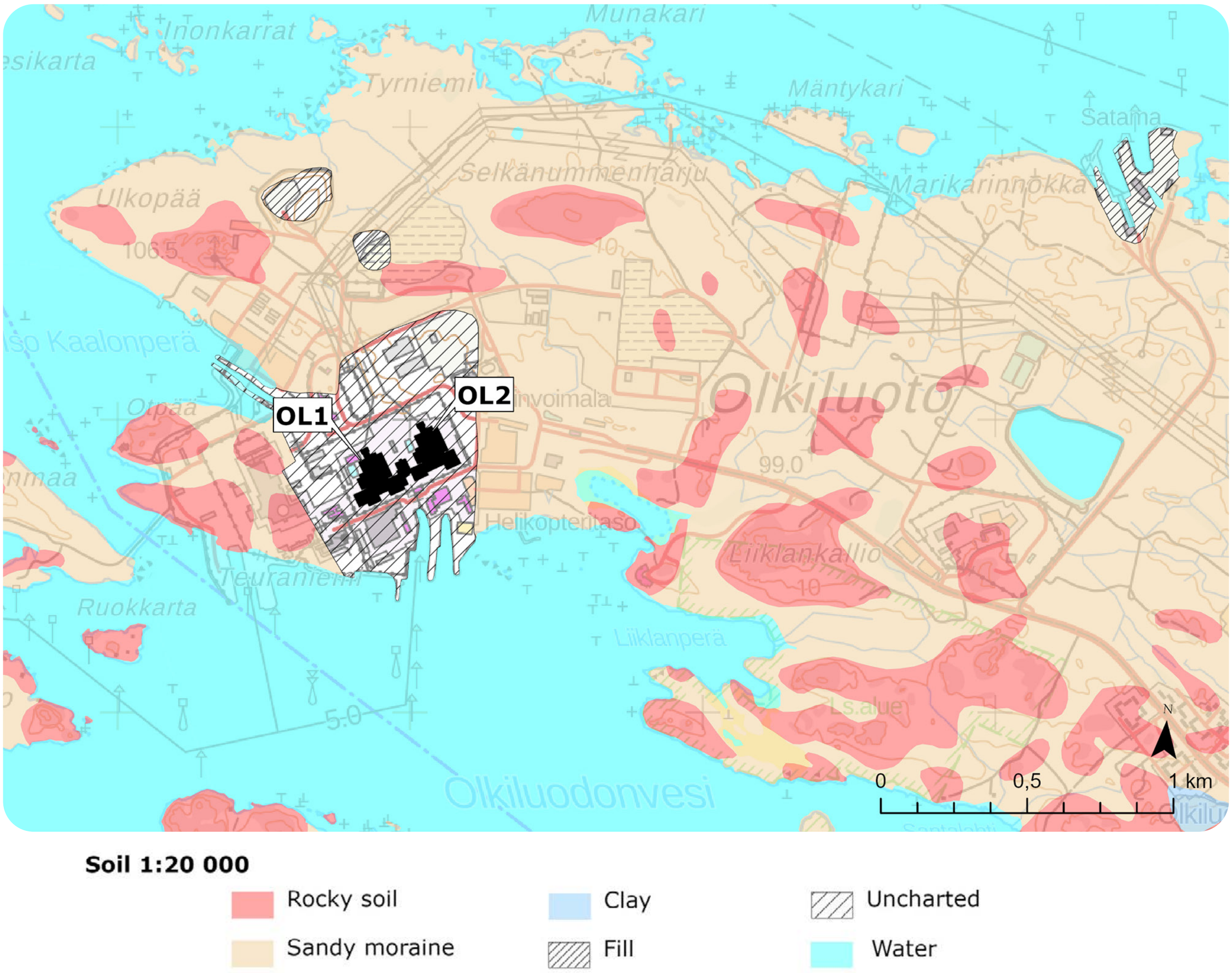


Figure 21. Soil map for the power plant area and its surroundings.

5.6.3. 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.

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 six kilometres northeast of the power plant (Figure 22). 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)*.

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, groundwater level in shallow borehole OL-PP31 was on average 1.43 m.a.s.l. *(Posiva 2023)*. 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, groundwater level was on average 0.15 m.a.s.l in groundwater pipe OL-PVP41A and 0.1 m.a.s.l. 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 using various shallow (approx. 0–40 m) and deep (approx. 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 23) *(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.

The excavation of underground spaces for Posiva's disposal facility for spent nuclear fuel affects 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. The monitoring programme for Olkiluoto describes the changes to Olkiluoto's groundwater chemistry, barometric altitudes and directions of flow caused by the excavation of underground facilities. In the Olkiluoto area, the excavation of underground facilities may cause a reduction in groundwater level.

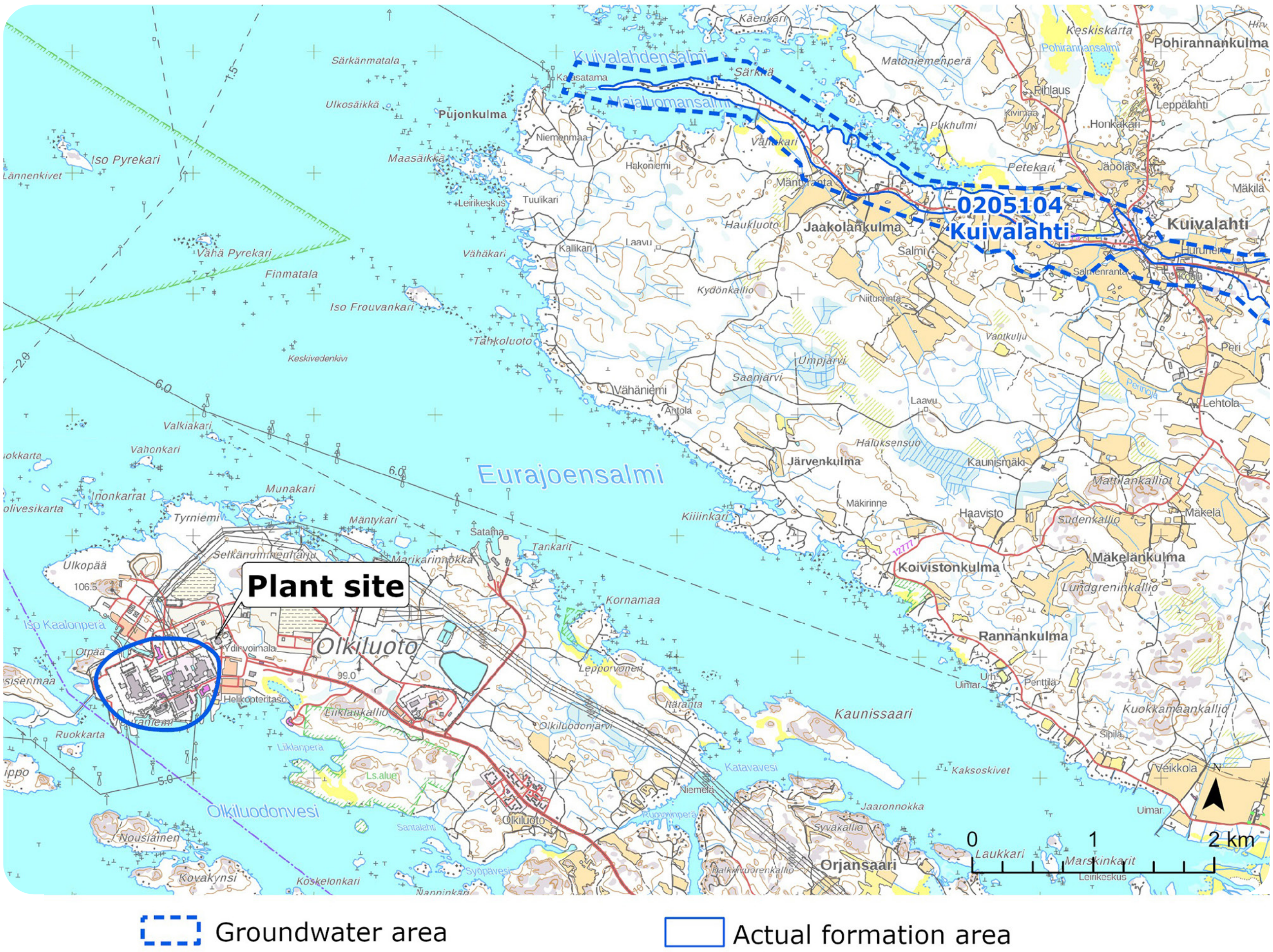


Figure 22. The classified groundwater area that is located the nearest to the power plant area.

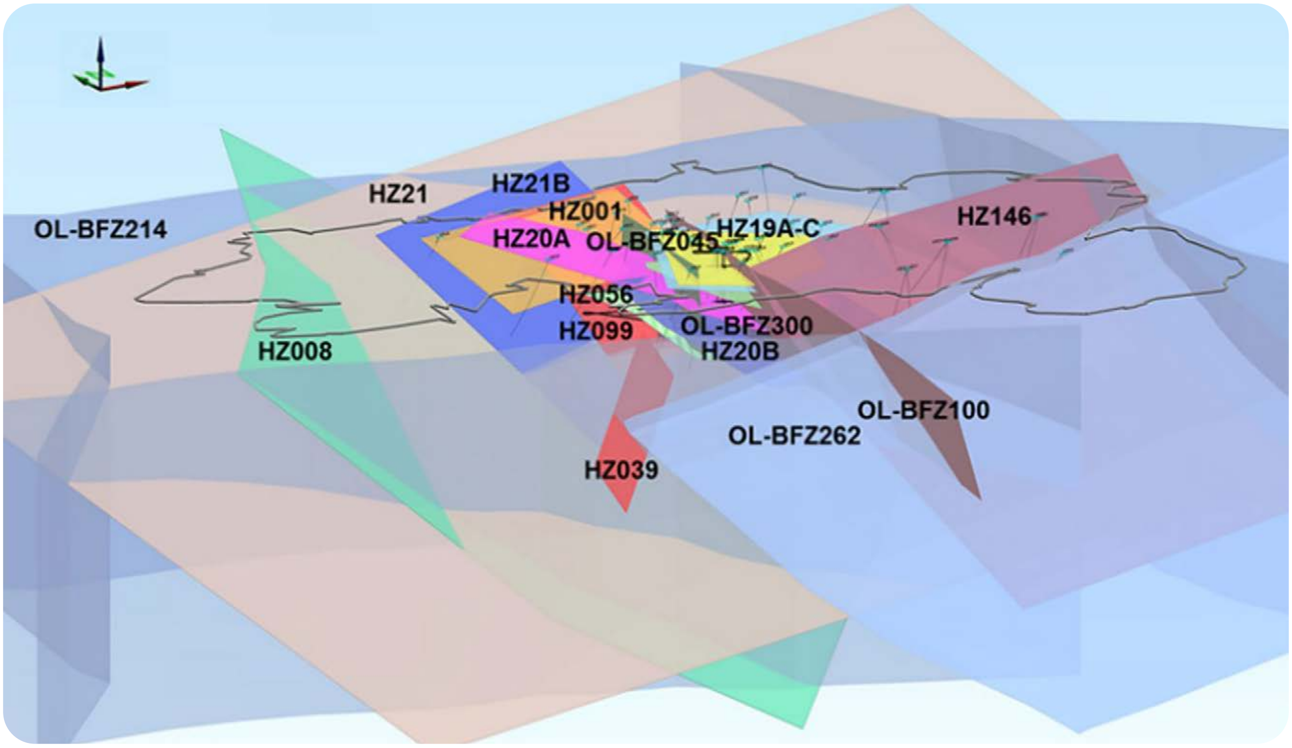


Figure 23. Hydrogeological model of Olkiluoto. (Vaittinen et al. 2020; Posiva 2021a).

5.6.4. 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)*.

5.7. Surface water

5.7.1. General description of the sea area

Olkiluoto Island is located on the coastal area of the Bothnian Sea. Olkiluoto is bordered by Eurajoensalmi in the north and a sea area known as Olkiluodonvesi in the south and west. In the east, a narrow strait separates the island from the continent. 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 water quality and nutrient load in the sea area.

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 approx. 30 kilometres 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 *(Bonde et al. 2012)*.

Environmental monitoring has been carried out in the sea area in front of Olkiluoto since 1979. 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 monitoring points where monitoring of water quality, phytoplankton and benthic fauna is regularly performed (Table 6; Figure 24). Surveys of aquatic vegetation have also been performed in the project area. 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 6. Environmental monitoring points in the sea area off Olkiluoto and their locations; 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	21.42615	61.29519	16.5	Luvia–Rauma open sea	SEU

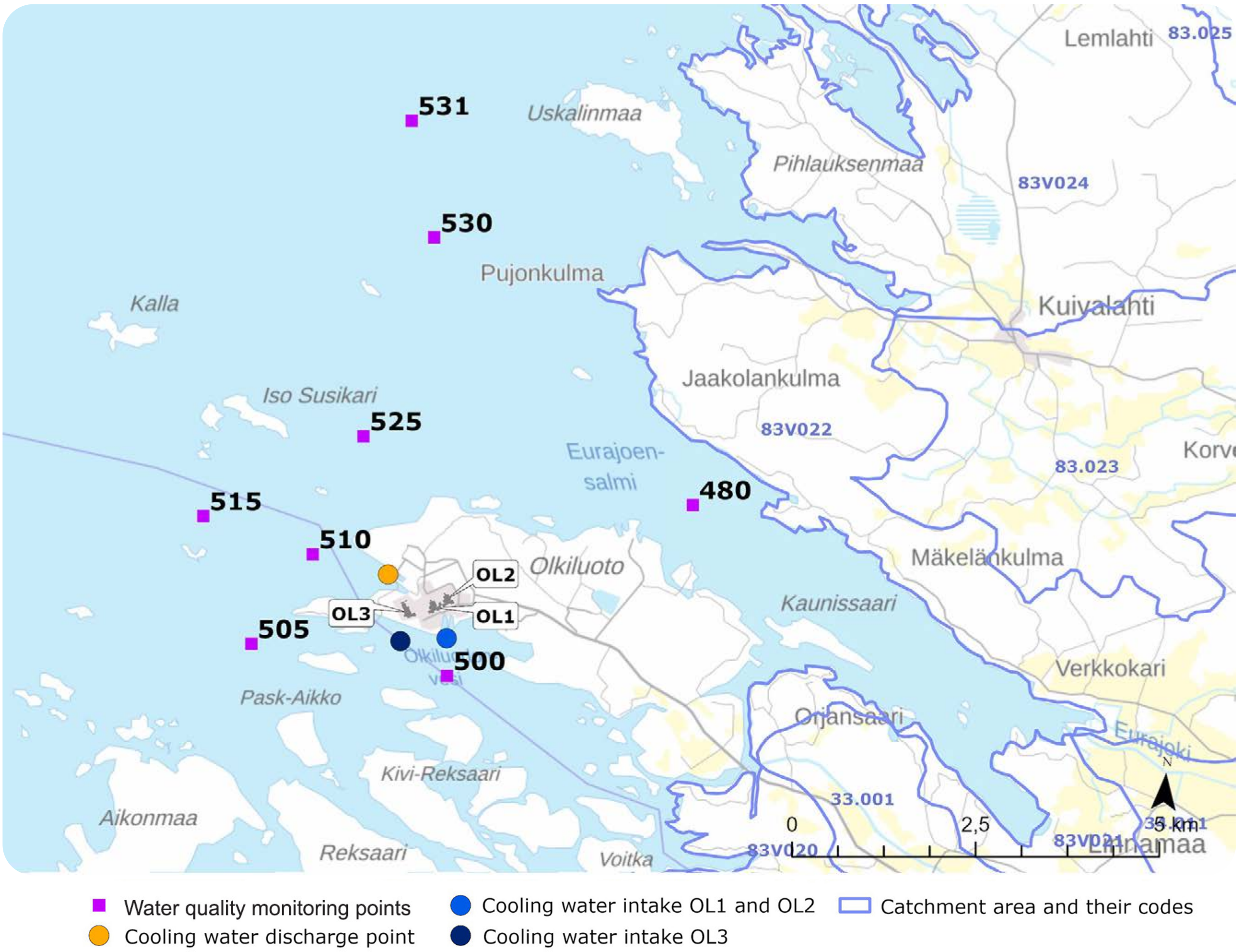


Figure 24. Environmental monitoring points in the Olkiluoto sea area (480–531) and the power plant's cooling water intake and discharge points. Wastewater from the power plant's wastewater treatment plant is also routed to the same point as the cooling water.

5.7.2. Nutrient load

In the Bothnian Sea, the total phosphorus load is 580 t/a and the nitrogen load is 17,100 t/a, of which more than 75% is caused by human activity *(Laamanen et al. 2021)*. The Bothnian Sea receives 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 land *(Westberg et al. 2021)*. Kokemäenjoki River is the largest individual load source, 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, but most of the loads in the Bothnian Sea area scattered loads.

The most significant nutrient load sources in the Olkiluoto sea area are the rivers Eurajoki and Lapinjoki that run into Eurajoensalmi. Fish farming also takes place near the project area; the nearest location is approximately 10 km away. The thermal load caused by the Olkiluoto power plant affects the state of the sea area locally, extending the growing season. A wastewater treatment plant is also located in the Olkiluoto power plant area, and it is where the sanitary water from the plant is treated. The operation of the wastewater treatment plant has been compliant with the requirements of the environmental permit, examined as an annual average *(KYVY tutkimus Oy 2021, 2022, 2023)*. During the construction of the OL3 plant unit, the load caused by sanitary water has been clearly higher after the mid-2000s. Load from the wastewater treatment plant is expected to decrease now that the OL3 plant unit has been commissioned. In 2022, the volume of wastewater processed by the plant was smaller than in previous years *(KYVY tutkimus Oy 2023)*. In the future, wastewater from Olkiluoto will be routed via the Eurajoki–Rauma transit sewer duct for processing at the treatment plant jointly operated by the City of Rauma and the forestry industry (see chapter 2.5).

5.7.3. Thermal load

The OL1 and OL2 plant units use 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 2012–2022, 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). In 2022, the total cooling water volume for the OL3 plant unit during test operation was 1.11 bn m^3. The cooling water volume for the KPA storage is low (0.01 bn m^3) and the thermal load caused by it has been included in the total thermal loads of the sea area. The total thermal load from the OL1 and OL2 plant units into the sea has been on average 95,100 TJ (88,900–98,500 TJ). In 2022, the total thermal load for all plant units was 111,900 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 at most 205,000 TJ per year.

The temperature in the cooling water discharge area has not exceeded the target value set in the environmental permit, which is 30°C as a weekly average at a distance of 500 m from the mouth of the cooling water discharge channel. The thermal impact from the power plant's cooling water mainly affects the surface layer of the water. Cooling water is routed along discharge tunnels and the outlet channel into the epilimnion on Kaalonperänlahti (Figure 24), where the thermal impact is the largest. 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. During open water season, the increase in sea water 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 kilometres from the coast. *(KYVY tutkimus Oy 2023)*

5.7.4. Current and stratification conditions

The dominant water current direction on the coast of the Bothnian Bay 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, water flow is affected by the topography of the sea area, the contours of the sea floor, the height of sea water, 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 *(Paakkinen et al. 2019)*. The 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.

In the Bothnian Sea, water is stratified depth-wise in terms of temperature in the summer. Generally speaking, the stratification in the Bothnian Bay substantially differs from the conditions in the central parts of the Baltic Sea. Stratification is much weaker 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 ym. 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 2013–2022, 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 25). However, no significant temperature differences can be observed in benthic water (Figure 25). In winter, the impact of cooling water is the clearest at point Olki 510, where the 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 *2023)*.

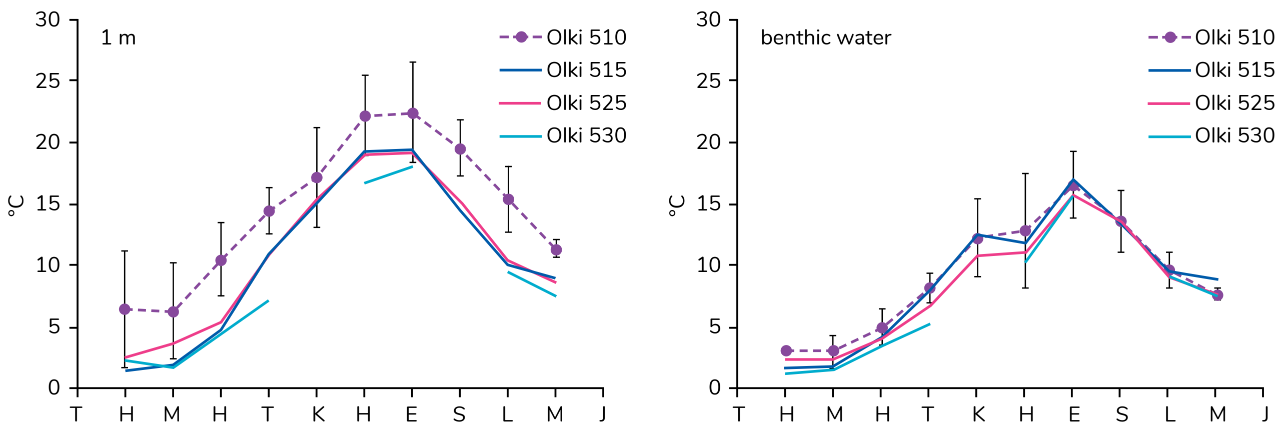


Figure 25. Variation in monthly average water temperatures in the epilimnion (1 m) and benthic water at monitoring points off Olkiluoto during the past 10 years. During the period under review, the average temperature for the epilimnion at monitoring point Olki 510, which is closest to the discharge point for cooling water, was clearly higher than at the other stations. The hypolimnion shows no significant temperature differences between monitoring points.

5.7.5. 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 km^2. During the past ten years, ice conditions on the Baltic Sea have been mild, only winters 2012–2013 and 2017–2018 were classified as moderate *(Ilmatieteen laitoksen jäätilastot)*. In the past ten years, ice cover was at its largest at 170,000 km^2 in winter 2017–2018. During the winter of 2019–2020, 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 *(Ilmatieteenlaitos 2022)*. 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, ice cover is formed later and, correspondingly, ice will melt earlier in the spring than on average *(KVVY tutkimus Oy 2023)*. Cooling water from the nuclear power plant keeps the sea area to the west of Olkiluoto open during the winter. The size of the open 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 have affected the currents and ice conditions. As a result of climate change, ice cover in the Baltic Sea has been forecast to reduce by 50–80% and the time during which the Bothnian Sea is covered by ice to be shortened by 1–2 months *(HELCOM 2013)*.

5.7.6. Water quality

The quality of the sea water is affected by the point loads located in the area and scattered loads from a wider area (see chapter 5.7.2). The total phosphorus concentration of the sea area typically varies between 14 and 20 µg/l and the total nitrogen concentration varies between 265 and 326 µg/l. Eutrophication has been observed in the Olkiluoto sea area in recent decades *(Leinikki 2017, Laari and Hakanen 2020)*. Based on the average total phosphorus concentration and the chlorophyll a concentration, which describes the amount of plankton algae, the Olkiluoto sea area is slightly eutrophic *(Paakkinen et al. 2019, Laari and Hakanen 2020)*.

During the past ten years, the highest total nitrogen concentrations in the epilimnion have been repeatedly measured at Eurajoensalmi strait, monitoring point Olki 480 (Table 7), 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 point Olki 510, which is located closest to the discharge channel for the power plant's cooling water and wastewater (Table 7). 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. 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 August 2022, exceptionally high nutrient concentrations were measured in the hypolimnion at point Olki 510, which were caused by an exceptionally warm summer and low-oxygen conditions in benthic water (oxygen 2.7 mg/l). However, the average concentrations of nutrients in 2022 were at the same level as in previous years.

The oxygen situation in the Olkiluoto sea area is generally good, approx. 8 µg/l in summer and 13 µg/l in winter. The water pH value is 7.9 for the epilimnion and hypolimnion. Average sea water salinity has remained fairly stable and at typical levels for brackish water. Differences between the surface layer and the hypolimnion layer are small (Table 7). At point Olki 480, the salinity of the epilimnion is slightly lower than at the other points, indicating the impact of river water (Table 7).

Table 7. 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 2013–2022. Results for chlorophyll a measured as a composite sample from the trophogenic layer in 2020–2022.

epilimnion	480	500	505	510	515	525	530
visibility depth (m)	2.4	2.8	3.4	3.1	3.4	3.3	3.9
temperature (°C)	12.4	13.3	12.8	16.3	12.4	13.0	10.5
salinity	4.9	5.7	5.7	5.6	5.7	5.6	5.7
pH	7.9	8.0	8.0	7.9	8.0	8.0	8.0
oxygen (mg/l)	10.6	10.9	10.8	11.0	10.9	10.7	10.6
total nitrogen (µg/l)	452.9	253.5	266.6	272.1	261.6	275.8	252.6
ammonia nitrogen (µg/l)	22.1	5.1	5.8	7.4	5.4	6.4	6.3
nitrite-nitrate-nitrogen (µg/l)	147.2	15.1	18.8	24.5	19.3	29.0	17.5
total phosphorus (µg/l)	19.7	25.5	17.1	25.1	17.0	17.2	15.4
phosphate phosphorus (µg/l)	3.3	4.5	5.0	5.1	5.2	4.6	4.8
chlorophyll a (µg/l)	6.6	3.9	4.1	4.3	2.5	3.3	2.7
hypolimnion	**480**	**500**	**505**	**510**	**515**	**525**	**530**
temperature (°C)	10.5	11.6	8.9	10.4	10.1	9.7	8.8
salinity	5.5	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	10.8	10.4	10.4	10.7	10.6	10.5
total nitrogen (µg/l)	281.7	253.6	265.3	283.4	255.5	249.2	239.7
ammonia nitrogen (µg/l)	9.1	5.5	16.6	32.2	7.1	6.8	7.2
nitrite-nitrate-nitrogen (µg/l)	29.9	16.0	20.0	20.8	19.9	21.3	18.9
total phosphorus (µg/l)	17.6	22.7	20.8	28.5	17.1	16.5	16.4
phosphate phosphorus (µg/l)	4.2	4.7	8.4	13.8	6.2	6.0	6.6

5.7.7. Aquatic organisms

Phytoplankton

The species of phytoplankton in the area and their biomass vary in ways that are typical of the Baltic Sea and Bothnian Sea (*Hällfors and Lehtinen 2012*). Generally speaking, the biomass for phytoplankton in the Olkiluoto sea area has been at a slightly eutrophic level (*Paakkinen et al. 2019, Laari and Hakanen 2020*). Biomass for phytoplankton is at its highest in April, during the spring bloom, and mostly consists of diatoms and dinoflagellates (*Paakkinen et al. 2019*). Following spring bloom, the total biomass will go down, but in late summer, cyanobacteria will become more plentiful and form a second biomass peak. In September, diatoms will become more plentiful, and total biomass has remained relatively high especially at monitoring points Olki 505 and 510 which are located closest to the cooling water discharge channel (*Paakkinen et al. 2019*).

The eutrophy level of a sea area is estimated by measuring the concentration of leaf green or chlorophyll a in phytoplankton, which indicates the amount of phytoplankton biomass. Chlorophyll concentration 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. Chlorophyll is measured at the monitoring points in April and August. On average, chlorophyll concentrations have varied between 2.5 and 6.6 µg/l during the past five years. 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 (Table 7). Chlorophyll concentrations have also been occasionally high near the cooling water discharge channel at point Olki 510.

Visibility depth, which indicates the opacity of water, has varied between 2.4 and 4.0 m at the monitoring points (Table 7). Visibility depth was at its lowest at point Olki 480 due to the clouding effect of river water. Visibility depth increased from the inner archipelago towards the open sea, and was at its highest at the outermost monitoring point Olki 530 (Table 7).

Aquatic vegetation

The impact of cooling water from the Olkiluoto power plant on aquatic vegetation has been regularly investigated using the line diving method. The latest aquatic vegetation surveys were performed in 2016 and 2022 (Figure 26, *Leinikki 2017, 2022*). However, the monitoring line closest to the mouth of the cooling water discharge channel (line A) was excluded from the surveys already in 2010, as the powerful flow generated by the cooling water made performing the survey more difficult *(Laaksonen and 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)*. 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)*.

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 largest changes in aquatic vegetation were observed for the second time on line B which is closest to the mouth of the cooling water discharge channel (Figure 26). In 2010, the dominant species on the line 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)*. Changes in the dominant species also indicate significant changes in the living environment.

Two species occur in the sea area that are listed as near threatened species in the Finnish assessment of endangered species, Fucus vesiculosus and Rhodomela confervoides *(Hyvärinen et al. 2019)*. *Fucus vesiculosus* was discovered in 2016 and 2022 on the outer study 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 research lines closest to Olkiluoto, 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 sea, eutrophication was considered to be at the same level as in 2010 and 2016 *(Leinikki 2017, 2022)*.

Figure 26. The location of the aquatic vegetation research lines (B-G) and the cooling water discharge point in the area near Olkiluoto in 2010, 2016 and 2022 (Leinikki 2017, 2022).

Benthic fauna

The sea bed in the area most commonly consists of rock, moraine or muddy clay *(Paakkinen et al. 2019)*. Benthic fauna in the Olkiluoto area has been regularly studied as part of the power plant's environmental monitoring. For the time being, no anoxic or oxygen-low sea beds that could have a negative impact on the local benthic fauna have been found to occur in the Olkiluoto sea area. 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 *(Ministry of the Environment's Administrative Branch, Hertta database 2023)*. 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 27). 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). The Benthic Biotic Index (BBI) is mostly good at the monitoring points. No major differences can be observed between the monitoring points on the basis of benthic fauna *(Paakkinen et al. 2018)*.

Invasive species occur in the sea area near Olkiluoto power plant. Cordylophora caspia and Mytilopsis leucophaeata have been found in the cooling water channels *(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 sea water systems in July–October. In 2022, Mytilopsis leucophaeata was encountered for the first time 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 condensate water of power plants *(Laine et al. 2006)*. However, a rise in sea water temperature as the result of climate change may promote the spreading of the species into wider areas. Furthermore, Laonome xeprovala was observed in the 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)*.

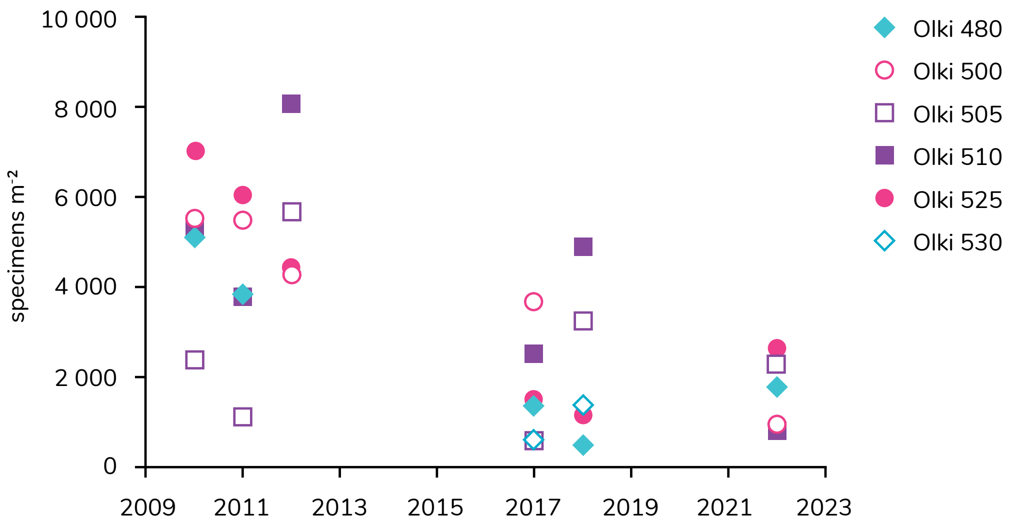


Figure 27. The densities of benthic fauna have declined in the sea area near the power plant during the past 10 years.

5.7.8. Strategies and policies in the sea area

Plan for water resources management

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. 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. 2021)*

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, eds. 2021)*

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) (Figure 28). 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 in 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, Ministry of the Environment's Administrative Branch, Hertta database*).

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 28, Table 8). 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 8). 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 8). Above all, the status of the Eurajoensalmi water body is degraded by the nutrient load carried by river water.

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. No major changes caused by human activity can be observed in the Olkiluoto sea area. (The open Hertta database of the Ministry of the Environment's Administrative Branch).

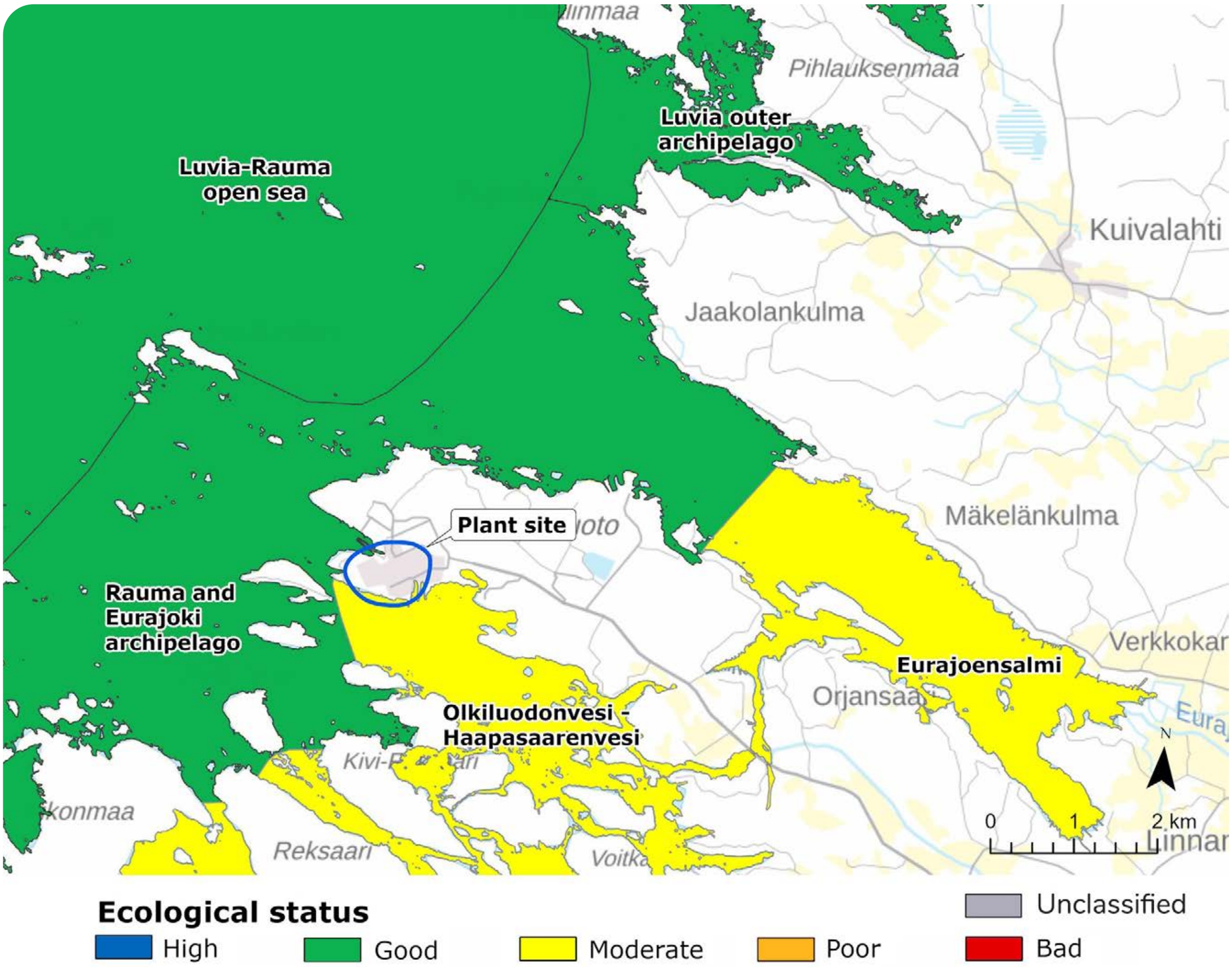


Figure 28. Water bodies in the Olkiluoto sea area and their ecological status during the 3rd planning period for water resources management.

Table 8. 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.

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)	poor (0.38)
chrolophyll a (G/M Ses 2.7; Seu 2.1 µg l-1)	good 2.7 µg/l	moderate 2.5 µg/l	moderate 3.4 µg/l	poor 6.2 µg/l
Total biomass	-	good 0.32 mg/l	-	-
Other aquatic plants - macroal-gae; Fucus zone lower limit	moderate 2.6 m	-		
Benthic fauna	good 0.78	good 0.68	good 0.69	-
BBI index	good 0.9 EQR	good 0.7 EQR	good 0.7 EQR	-
Physicochemical	good	good	moderate	poor
total phosphorus (G/M Ses 20; Seu 14 µg/l)	good 19.4 µg/l	moderate 14.2 µg/l	good 19.5 µg/l	poor 27.2 µg/l
total nitrogen (G/M Ses 315; Seu 275 µg l-1)	moderate 318.3 µg/l	good 265.2 µg/l	moderate 325.5 µg/l	poor 436.3 µg/l
visible depth (G/M Ses 3.3; Seu 4.1 m)	moderate 3.2 m	good 4.2 m	moderate 2.6 m	bad 1.4 m
Hydro-morphological	moderate	high	good	good
morphology	moderate	good	good	good
accessibility	high	high	high	high

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.

According to these criteria, the Bothnian Sea is at a good status as regards hydrographic changes, invasive species and the quality factors involving the purity of fish used as food, but at a bad status as regards the indicators for eutrophication and radioactivity. The status of the Bothnian Sea has not yet been assessed in terms of litter, energy or underwater noise *(Laamanen et al. 2021)*. Of the contributors to the commercial fishing indicator, pikeperch, Baltic herring and perch are at a good status, whereas Baltic sprat is at a poor status. Of the contributors to the quality indicator for biodiversity, the benthic fauna environments in the circalittoral and outer sea, zooplankton in the open sea, grey seal and sea birds are at a good status. Open sea phytoplankton, trout, and the Baltic ringed seal and porpoise are at a poor status *(Laamanen et al. 2021)*.

Locally, the factors that may affect the status of the Olkiluoto sea area are the spreading of invasive species, eutrophication caused by human activity and any possible changes to regional hydrography caused by cooling water from the power plant. As regards industrial cooling water creating pressure on quality indicator 11 of a good status, the Marine Strategy states that impacts are typically local and extend to a few kilometres from the power plant *(Laamanen et al. 2021)*.

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 2021)* 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 recommends management targets in order to minimise nutrient loads originating from human activity and preventing the spread of invasive species.

Maritime spatial planning

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. According to the Finnish maritime spatial plan for 2030, the southern Bothnian Sea area is mainly being developed for use in renewable energy. Sea water will continue to be used as cooling water for 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 2030)*.

5.8. Fish stocks and fishery

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. *(Ojala 2023, Ojala 2022)*

Coastal test fishing with nets has been performed in three different fishing areas: near the cooling water inlet (Fishing area 1), near the discharge point for cooling water and treated wastewater (Fishing area 2) and in a reference area (Fishing area 3) (Figure 29). 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. Perch was the most common species in all fishing areas, with roach being the second most common.

Much larger unit catches of roach (2,107 g/net day) were obtained on the cooling water discharge side than on the cooling water intake side (548 g/net day) or the reference area (796 g/net day). Roach's share of biomass on the cooling water discharge area (38%) was also clearly higher than on the cooling water intake side (7%) or the reference area (23%). 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) was clearly smaller in the reference area than in the other two areas. *(Ojala 2023)*. Differences in the unit catches of perch were also observed between the different fishing areas. The largest unit catches were obtained from the cooling water inlet side (6,169 g/net day), whereas in fishing area 2 (2,689 g/net day) and fishing area 3 (1,826 g/net day) the catches were clearly smaller.

Based on the fishing survey targeting recreational fishers, 113 households engaged in fishing off Olkiluoto in 2021. The 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. Factors disturbing recreational fishing included an excess number of cormorants and seals, abundance of aquatic vegetation, rapid soiling of nets and the clouding of water. *(Ojala 2022)*

In 2021, one full-time commercial fisher operated in the sea area off Olkiluoto, as was the case in 2017 and 2019. In 2021, fishing took place almost all year long, and it utilised fyke nets, herring nets and bottom nets with mesh sizes of 43 mm and 55 mm. There were a total of 11,581 net days, of which bottom nets were used for the largest part (79%). However, fyke nets brought in the largest part of the catch. As in earlier monitored years, roach was the most common and most important species caught. Other significant species were perch, bream and pike. Based on the responses provided by the fisher, cormorants have a negative impact on fishing. Seals, cloudy water, abundant aquatic vegetation and soiled river water also negatively affected fishing. *(Ojala 2022)*

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 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.

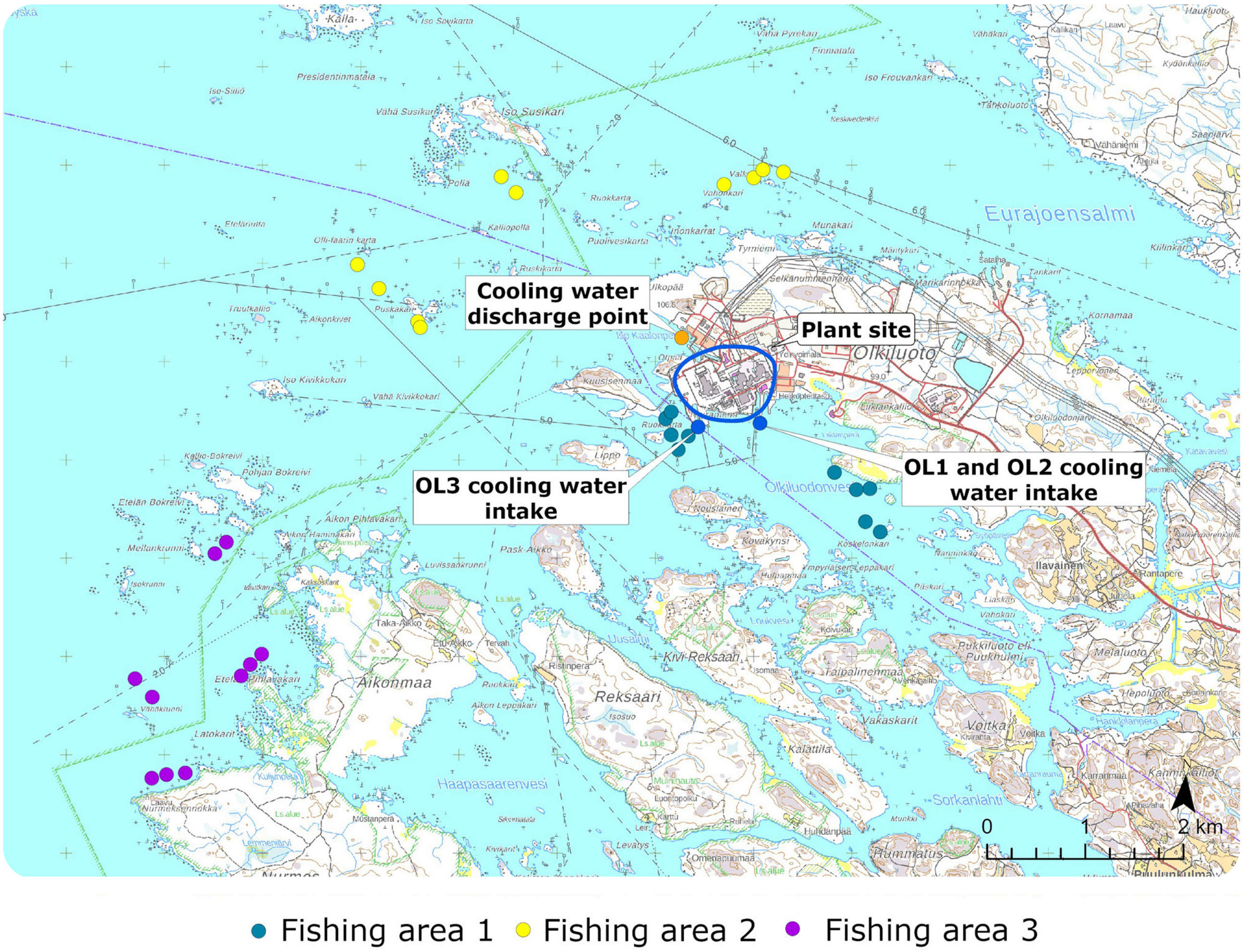


Figure 29. Fishing areas 1, 2 and 3 used in the Coastal test net fishing of the sea area off Olkiluoto.

5.9. Flora, fauna and conservation areas

The site area is located on Olkiluoto Island, which has an area of approximately 900 hectares 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 is affected by heavy human activity, but several natural habitats occur in the unconstructed areas. Approximately half of the forests on the island are fresh heaths of the Vaccinium myrtillus type, 20% are grove-like 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, rocky soil and groves *(Ramboll 2014)*. The noteworthy forest locations on the island's land areas are the black alder meadow of Flutanperä, the old 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.

Of the species in Annex IV(a) to the Habitats Directive, the Clouded Apollo was spotted in the area of Olkiluoto Island in 1999 and suitable habitats can be found in the eastern parts of the island *(Ramboll 2014)*.

Land bird pair density on Olkiluoto Island is high, but the species are fairly ordinary and no bird areas of particular value are known to exist on the island *(Ramboll 2014)*. The island's most abundant bird areas in terms of species and pairs are located on the islets to the northwest of Olkiluoto: Tyrniemenkari and the Tyrniemi shore areas (Ramboll 2014). Noteworthy species of aquatic birds include the lesser black-backed gull and the horned grebe.

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) (Figure 30). A part of the Rauma Archipelago Natura area is also 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. Four other nature reserves on private land are located to the south of Olkiluoto, while one reserve is located to the southeas.

5.9.1. Natura areas

The Rauma archipelago SAC area (FI0200073), part of the Natura network, is located near Olkiluoto Island. It has a total area of 5350 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 0.8 km away from the power plant site.

The Natura area has a total of 15 protected habitat types, of which reefs or, 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 a Natura area are on the islands of Iso Susikari and Pöllä, located approximately 2.5 km north-west of the site area *(Finnish Environment Institute 2023b)*. The Natura area for Rauma archipelago protects one animal species, the grey seal *(Halichoerus grypus)*.

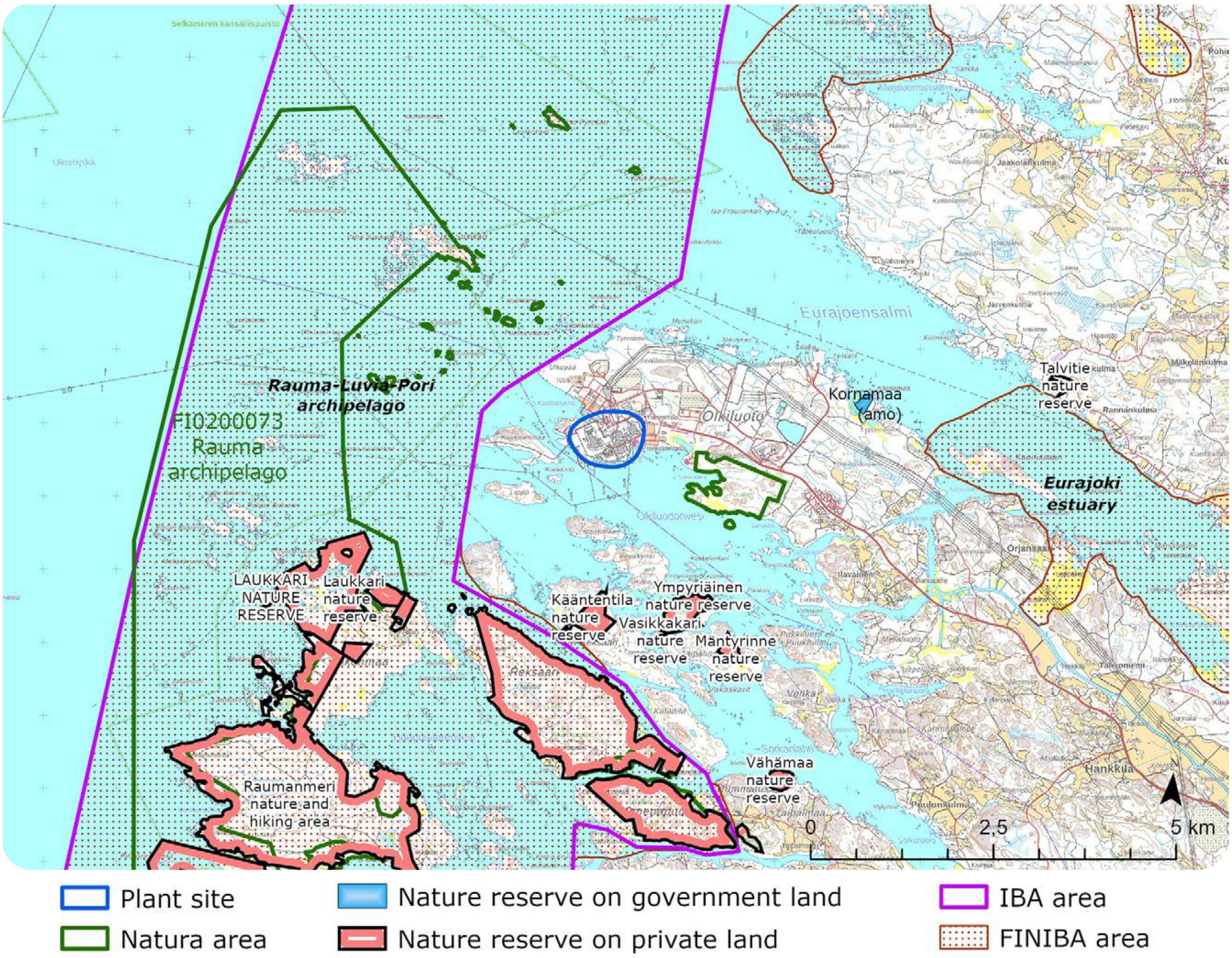


Figure 30. Natura areas, other conservation areas and IBA and FINIBA areas located within a range of five kilometres from the site area.

5.9.2. IBA and FINIBA areas

The Rauma–Luvia archipelago IBA area, spanning 27,371 ha and located entirely within the Rauma–Luvia–Pori archipelago FINIBA area, is near the site area. The FINIBA area outside of the IBA area covers the Eurajoki estuary and Kuivalahti (Figure 30). At its nearest, the IBA area is at a distance of 400 m from the site area. The area is important for birds that nest on the islands and islets.

5.9.3. Nature reserves on government land

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 one kilometre from the site area to the northwest. Furthermore, Kornamaa located to the northeast of Olkiluoto Island is part of the Bothnian Sea National Park (Figure 30). 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 Act on nature conservation (9/2023) apply to the national park.

5.9.4. Nature reserves on private land

The southern side of Olkiluoto Island has several nature reserves on private land. Of these, the Ympyriäinen nature reserve (YSA239819) located on the island of Ympyriäinen is closest to the power plant. 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 Natura area of the Rauma archipelago. The Raumanmeri nature and outdoor area (YSA236619) established in 2016 is also located in the neighbouring areas of the Olkiluoto site area. It includes several islands off Rauma. The area overlaps in part with the Natura area of the Rauma archipelago.

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.

5.9.5. Other locations of value

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 2023b)*. 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 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 outer Rauma archipelago. The red algae and bladder wrack communities habitat type is classified as endangered (EN) in the Finnish habitat assessment *(Kontula & Rainio 2018)*.

5.9.6. Endangered and noteworthy species

Fourleaf mare’s tail *(Hippuris tetraphylla)* was last observed in the Olkiluoto area in the 1960s; in the Finnish classification of endangered species, it is rated as vulnerable (VU) *(Hyvärinen et al. 2019)*. It is also a species in Annexes II and IV(b) to the EU’s Habitat Directive. Inventory of fourleaf mare’s tail was taken in the area in 2014, at which time no observations were made (Ramboll 2014).

Noteworthy species of bird occur in the area near Olkiluoto, the most important of which are the velvet scoter, black-backed gull, tufted duck and the horned grebe *(Ramboll 2014)*. Their most important nesting areas are on the islets to the northwest of Olkiluoto.

5.10. People and communities

5.10.1. Habitation, sensitive locations and recreational use

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 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 2022, 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 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/2/2018). 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).

No sensitive locations such as schools, day nurseries, healthcare services or 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.

No recreational use takes place in the power plant area. There are restrictions on land use and mobility within the area. The nearest recreational location is the Bothnian Sea National Park, located to the northwest of the power plant area, which is at a distance of approximately 1.7 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 4 km east of the site area. There are also lean-tos 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. The Olkiluoto area also has a Visitor Centre that is visited by approximately 15,000–18,000 guests each year.

The residential buildings, holiday houses and sensitive locations are marked in the figure next page (Figure 31) 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 32).

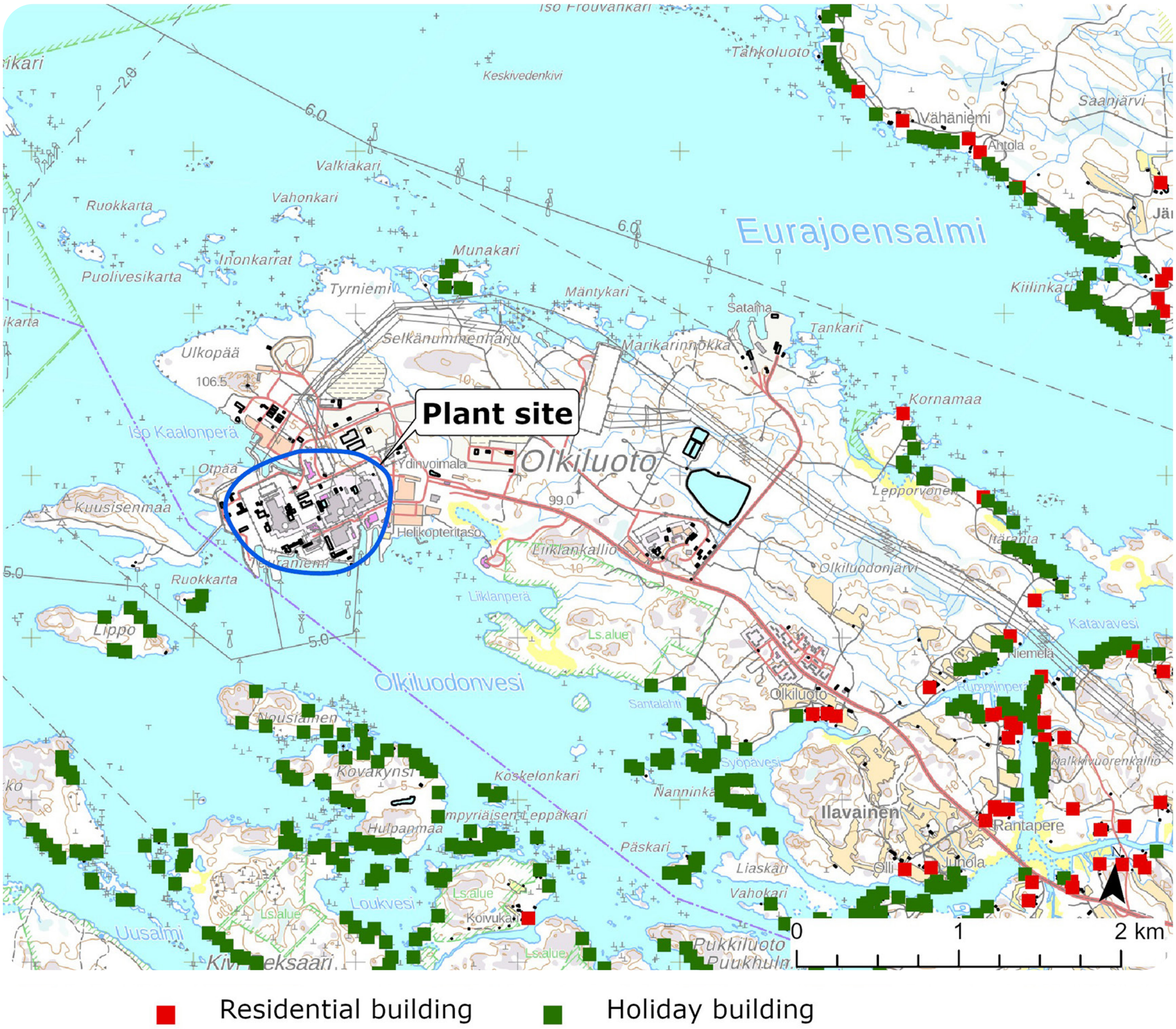


Figure 31. Residential and holiday buildings closest to the site area.

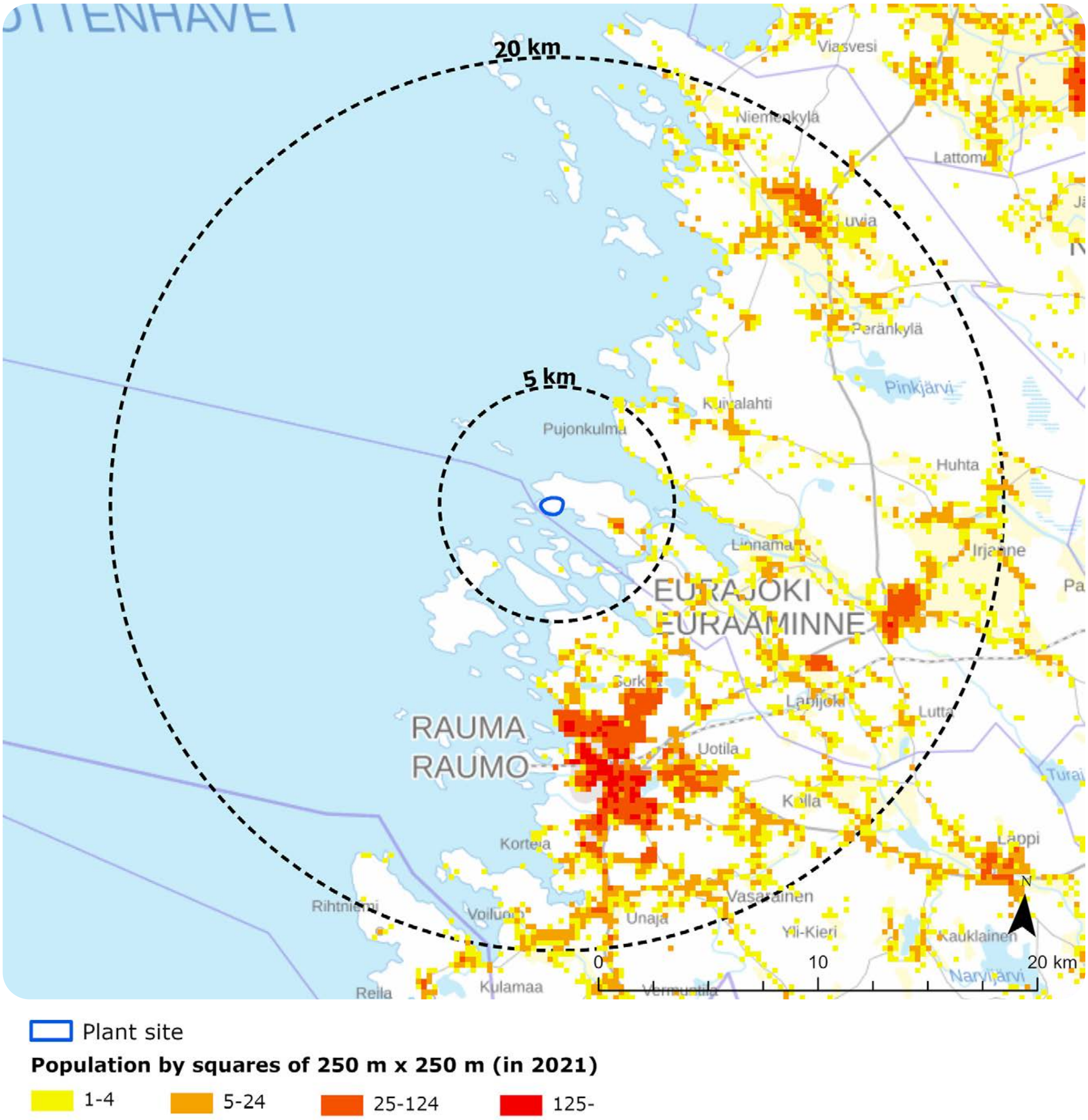


Figure 32. Distribution of the population within a distance of 5 and 20 kilometres from the site area in 2021.

5.10.2. Population and sources of livelihood

In 2022, the population of Eurajoki was 9,236. The population was down by approximately 98 from 2021. *(Eurajoki 2023b; Statistics Finland 2023b)* Population is forecast to continue to decline *(Statistics Finland 2023c)*. In the demographics of Eurajoki, people aged 15 to 64 accounted for 56.6%, people over 64 accounted for 26.7% and people under 15 accounted for 16.7% *(Statistics Finland 2023b)*.

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 *(Statistics Finland 2023b)*.

Table 9. Key figures for Eurajoki in 2020/2021. (Statistics Finland 2023b)

Eurajoki	Indicator
Degree of urbanisation, %, 2021	64
Population, 2021	9,334
Population change from previous year, %, 2021	-1.2
Population share of residents under 15 years old, %, 2021	16.7
Population share of residents between 15 and 64 years old, %, 2021	56.6
Population share of residents above 64 years old, %, 2021	26.7
Population share of Swedish-speaking residents, %, 2021	0.3
Population share of foreign nationals, %, 2021	2.9
Excess of births, persons, 2021	-54
Net migration/emigration between municipalities, persons, 2021	-41
Number of families, 2021	2,722
Number of households, 2021	4,118
Share of households living in terraced houses and single-family houses, %, 2021	93.9
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 age, %, 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
Level of employment, %, 2021	77.7
Share of people working in their municipality of residence, %, 2020	44.2
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, 2020	3,806
Share of jobs in primary production, %, 2020	4

Eurajoki	Indicator
Share of jobs in secondary production, %, 2020	50.2
Share of jobs in services, %, 2020	45.1
Self-sufficiency for jobs, 2020	98.9
Annual margin, EUR/resident, 2020	408.2
Loans, EUR/resident, 2020	1,106.10
Consolidated loans, EUR/resident, 2020	1,696.40
Education and culture activities in total, net operating costs, EUR/resident, 2020	2,238.90
Social and healthcare activities in total, net operating costs, EUR/resident, 2020	3,906.80
Degree of urbanisation, %, 2021	64
Population, 2021	9,334
Population change from previous year, %, 2021	-1.2
Population share of residents under 15 years old, %, 2021	16.7
Population share of residents between 15 and 64 years old, %, 2021	56.6
Population share of residents above 64 years old, %, 2021	26.7
Population share of Swedish-speaking residents, %, 2021	0.3
Population share of foreign nationals, %, 2021	2.9

5.10.3. Regional economy

The total output for Satakunta in 2021 was approximately EUR 15.6 billion. From the total output, approximately 1% was created in primary production, approx. 55% in secondary production, approx. 8% in construction, approx. 19% in commerce and approx. 17% in services *(Statistics Finland 2023d)*. In Eurajoki and the Rauma region, the importance of secondary production in the regional economy is emphasised more than in the rest of Satakunta (Figure 33).

Of the approximately 50,000 people employed in Satakunta in 2021, approximately 4% worked in primary production, approx. 36% in secondary production, approx. 11% in construction, approx. 13% in commerce and approx. 36% in services *(Statistics Finland 2023d)*. Employment is focused on services clearly more than the total output due to the sector's labour intensive nature. In the Rauma region and in Eurajoki in particular, the importance of secondary production in employment is emphasised in regional economy clearly more than in the rest of Satakunta (Figure 34).

Of the sectors within secondary production, a large employment effect in Eurajoki can be seen in sector 35: supply of electricity, gas and heat, cooling operations. Above all, this is the result of TVO's direct operation within the municipality.

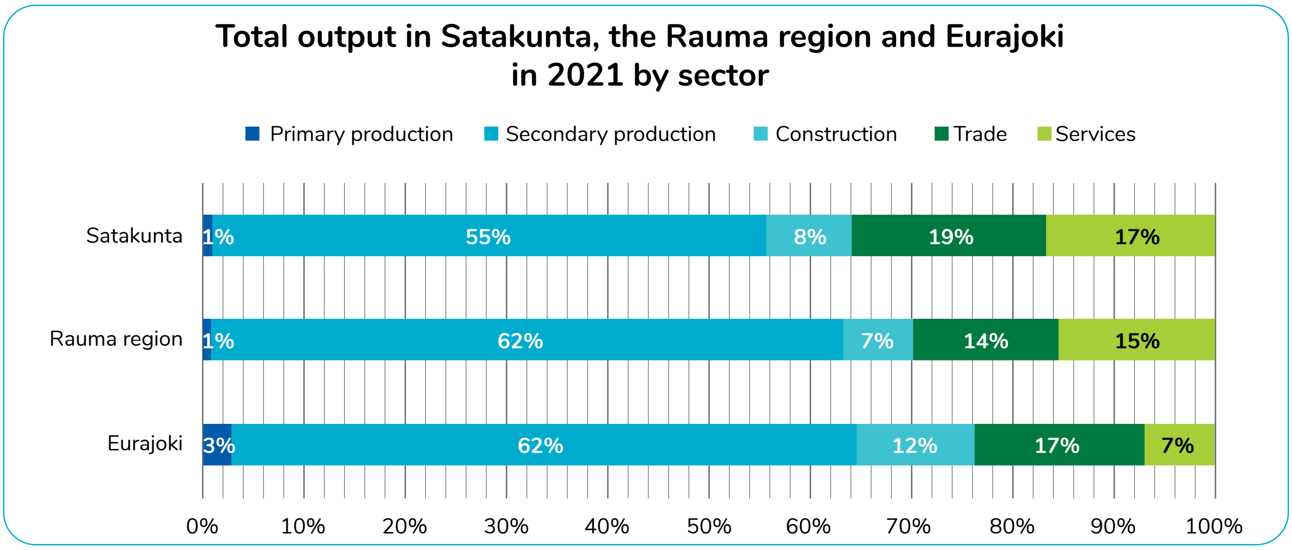


Figure 33. Total output in Satakunta, the Rauma region and Eurajoki in 2021 by sector contribution. (Statistics Finland 2023d)

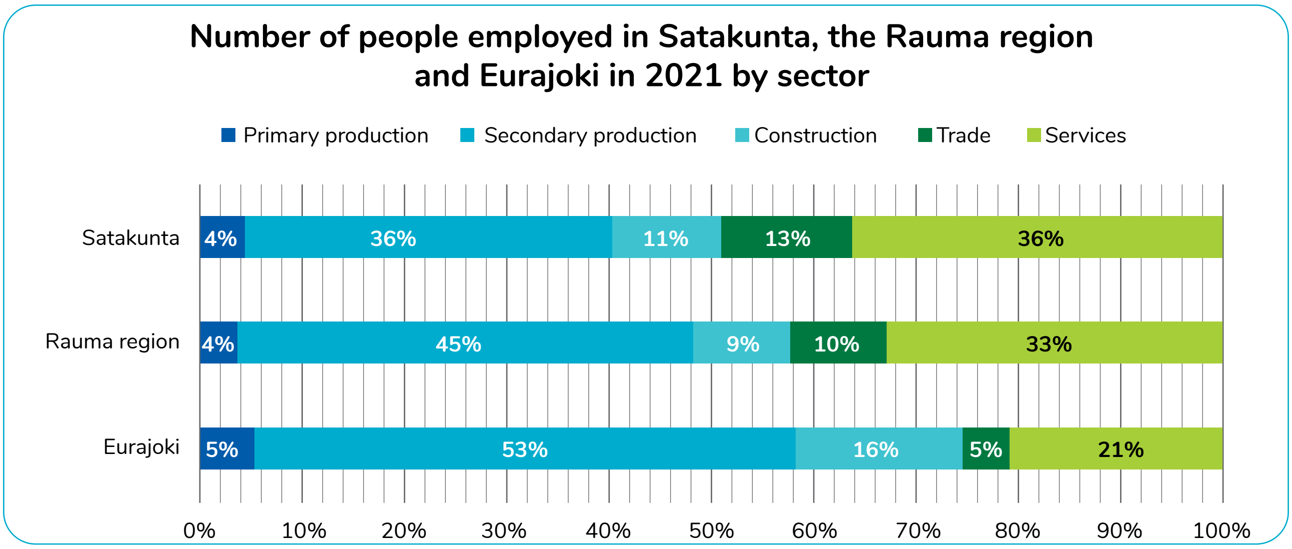


Figure 34. Number of people employed in Satakunta, the Rauma region and Eurajoki in 2021 by sector contribution. (Statistics Finland 2023d)

5.10.4. Health

The morbidity index of the Finnish health and wellbeing database 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. Standardised by age, the morbidity index in Eurajoki was 88.6, which is lower than the average for the entire country (100.0) and the Satakunta wellbeing services county (101.2). (*THL 2023*).

Age-standardised cancer index in the Eurajoki region in 2019 was 109.7. The index for Eurajoki is slightly higher than for Finland on average (100), but lower than the average for the Satakunta wellbeing services county (117.2).

5.11. Releases of radioactive substances and radiation exposure

Environmental studies of the Olkiluoto nuclear power plant and the monitoring of the status of radioactive substances in the environment were started already before the commissioning of the OL1 and OL2 plant units. Currently, the surroundings of the power plant are monitored in a versatile and comprehensive manner. The surveillance programmes must be submitted to STUK for approval, and STUK also conducts its own independent oversight.

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)*

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.

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 during the year when the measurement is arranged.

5.11.1. 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 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 35 and Figure 36; *STUK 2023a*). 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 2023b)*

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, 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 2023a and 2023b)*

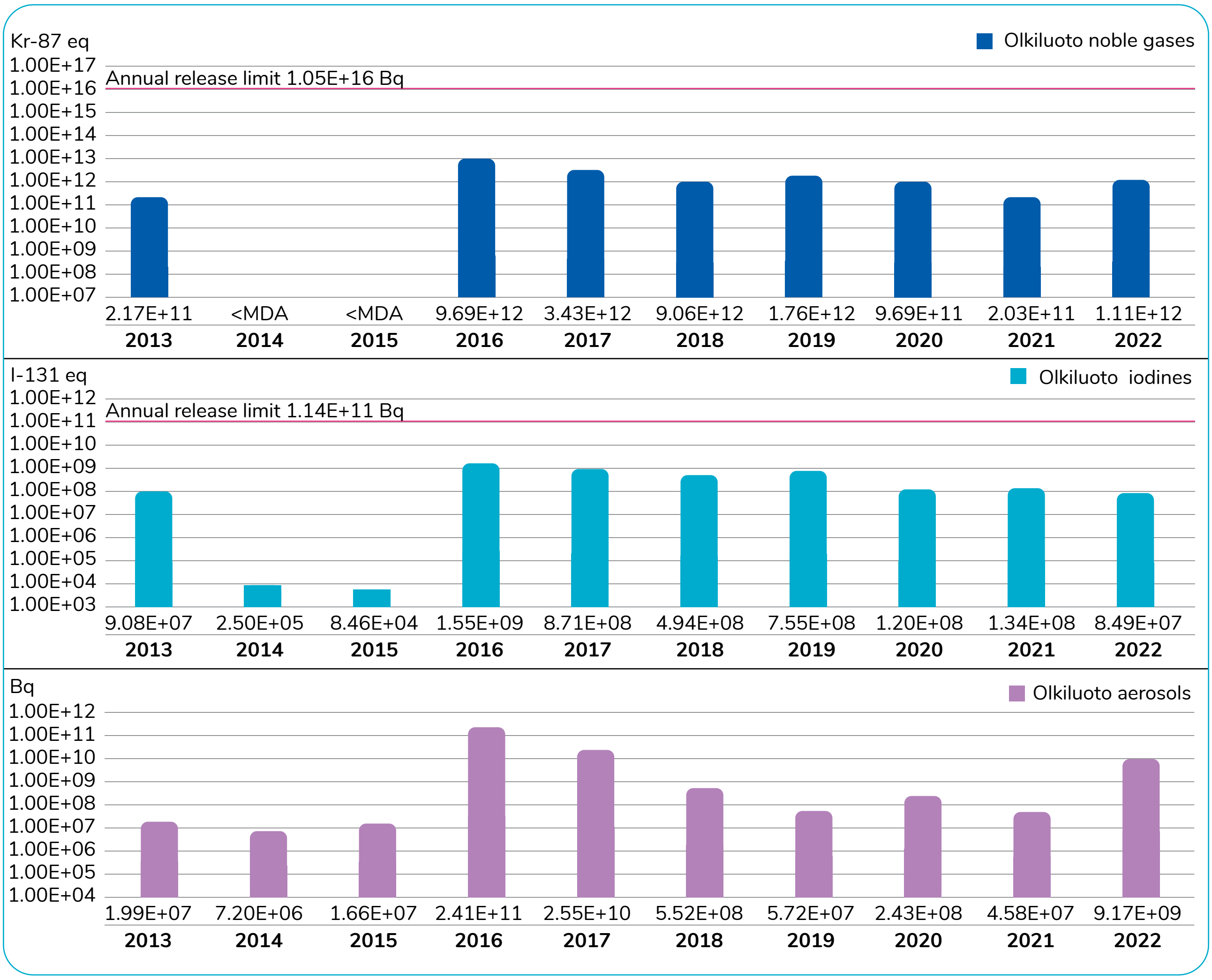


Figure 35. Release limits and actual annual radioactive releases into the air from the Olkiluoto nuclear power plant in terms of noble gases, iodine and aerosols in 2013–2022. No separate release limit has been defined for aerosols or other release types. (STUK 2023a)

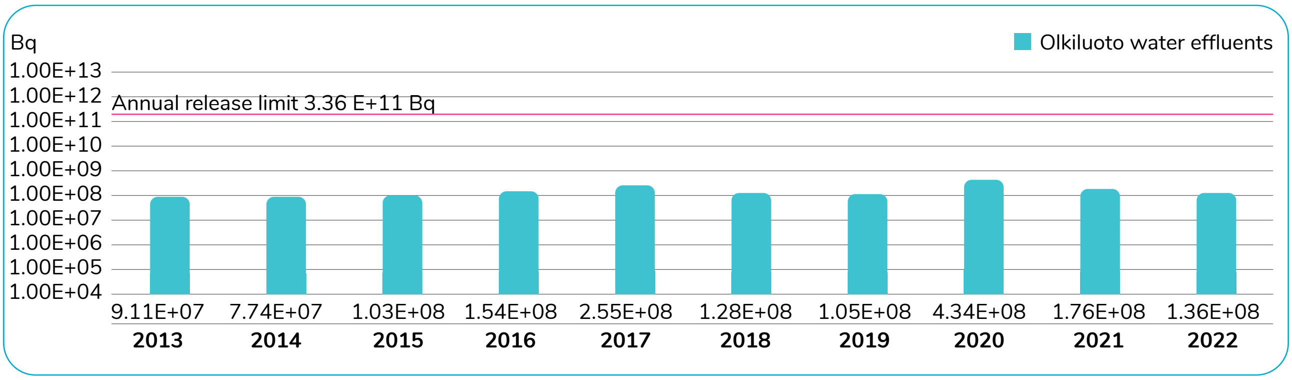


Figure 36. Annual release limit and actual annual radioactive releases into the water system from the Olkiluoto nuclear power plant in 2013–2022. (STUK 2023a)

5.11.2. Radiation exposure

Radiation exposure of the residents in the surrounding areas

Releases from nuclear power plants are effectively diluted by the vast volume of air and water around the power plants, 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 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 millisievert (mSv) per year. *(STUK 2023b)* .This is approximately one sixtieth of the average radiation dose of 5.9 mSv that Finns receive from different sources during the year *(STUK 2023b and 2023c)*.

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 millisievert set in the Nuclear Energy Decree (161/1988), which corresponds to 100 microsievert (Figure 37, *STUK 2023a and 2023b*).

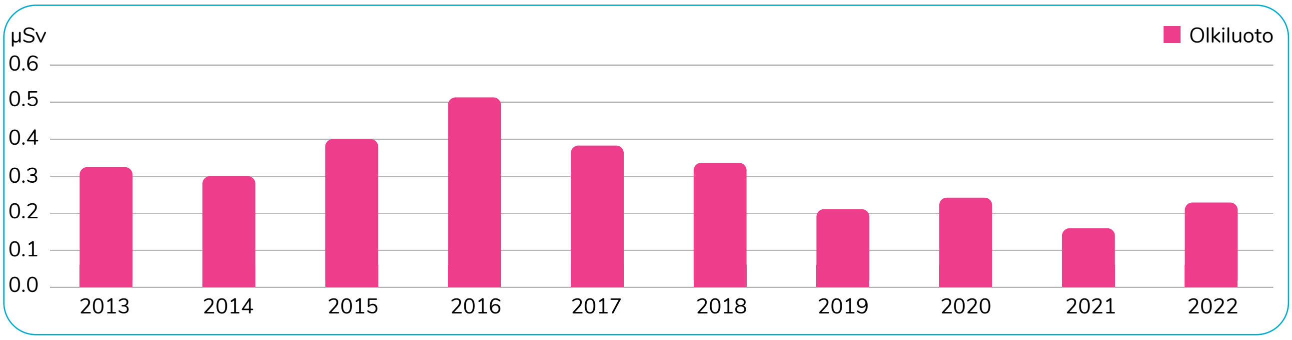


Figure 37. The calculated dose for the most exposed individual in the vicinity of Olkiluoto in 2013–2022. (STUK 2023a)

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 millisievert (mSv) per year (*Government Decree on ionising 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 38, *STUK 2023a*) 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 has not yet had an annual outage, which is why its share of the radiation doses at Olkiluoto in 2022 was still less than 1%.

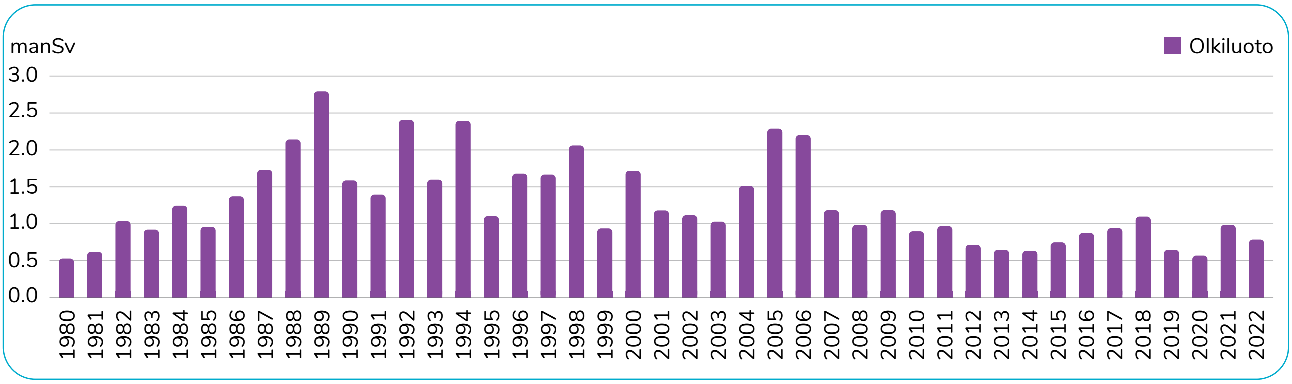


Figure 38. The collective (total) radiation doses of employees at the Olkiluoto nuclear power plant in 1980–2022. The new OL3 plant unit has not yet had an annual outage, which is why its share of the radiation doses at Olkiluoto in 2022 was still less than 1%. (STUK 2023a)

6. The impacts being assessed and the assessment methods

6.1. Starting points for implementing the assessment

6.1.1. Impacts to be assessed

The purpose of the environmental impact assessment is to systematically identify and assess the generated impacts 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. In this EIA procedure, the current state refers to the present state of the nearby areas of Olkiluoto nuclear power plant area, where the OL1, OL2 and OL3 plant units are in operation.

The purpose of an environmental impact assessment is to assess, 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 and
- the mutual interaction between the aforementioned factors.

The impacts may be either negative or positive as regards the environment, or there may be no changes when compared to the current situation.

The assessment report presents, among other things, an estimate and description of the likely significant environmental impacts of the project and its reasonable alternatives. The environmental impact assessment takes into account impacts during any possible modifications and operation. Furthermore, the project's possible joint impacts with other functions or other planned projects are assessed.

The impacts to be assessed and the planned methods for assessment are described in the following chapters, broken down by impact.

6.1.2. The principles for assessing the significance of the impacts

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 (Figure 39).

The magnitude of the change caused by the project is defined and assessed on the basis of several variables. When assessing the magnitude of the change, its scope, duration and strength are considered. A direction is also determined for the change, that is, whether the impact is positive or negative. In terms of geographical scope, the impact may be regional or local or cross the Finnish national borders. In terms of duration, the impact may be temporary, short-term, long-term or permanent. Other factors such as the recurrence and timing of the change and its accumulation and restorability are also examined. In some cases, the magnitude of measurable changes can be modelled from the initial data (for example, the spreading of cooling water into the sea area). 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.

The sensitivity of an affected aspect is determined on the basis of the characteristic features and current status of the target or area. The affected aspect's sensitivity to change describes the capability of the asset to receive, withstand or tolerate changes caused by the project. 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. For impacts affecting humans, the number of people using or experiencing the aspect and their experience are also taken into account.

In the assessment procedure, the magnitude of the change, the sensitivity of the affected aspect and the resulting significance of the impact are assessed using a scale of four steps: minor, moderate, large and very large (Figure 40).

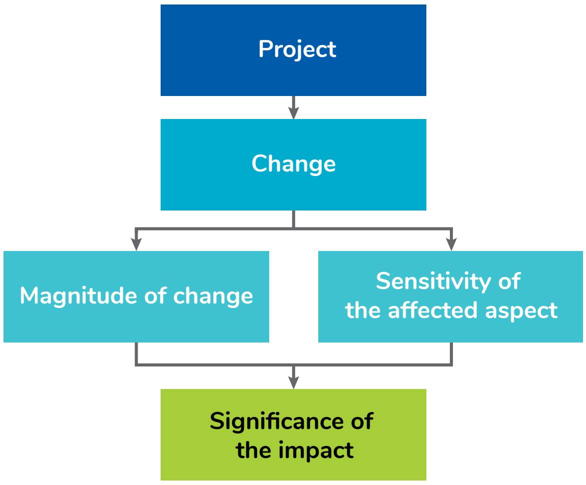


Figure 39. Factors affecting the significance of the impact.

the magnitude of the change

the sensitivity of the affected aspect	negative: very large	negative: Suuri	negative: mode-rate	negative: minor	no change	positive: minor	positive: mode-rate	positive: Suuri	positive: very large
minor	large	mode-rate	minor	minor	no effect	minor	minor	mode-rate	large
mode-rate	large	large	mode-rate	minor	no effect	minor	mode-rate	large	large
large	very large	large	large	mode-rate	no effect	mode-rate	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 40. Assessing the significance of the impact on the basis of the sensitivity of the affected aspect and the magnitude of the change.

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6.1.3. Key environmental impacts

The environmental impact assessment focuses on examining the impacts that have been identified as being the most important for the project, as regards its various alternatives. Based on the initial planning data, the following have been identified as key environmental impacts at this stage:

In the scenario where the service life is extended, the impacts on the environment would be similar to those of the current operation, but the impacts will continue beyond the current operating licence period, up to 2048 or 2058. In the power uprating scenario, there will be some changes to the OL1 and OL2 plant units' current operation, the most significant of which is the increase in thermal load from the cooling water. Based on preliminary information, the temperature of the cooling water discharged into the sea area would increase by approximately 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.

In the scenario where the service life is extended and power is uprated, the waste volumes and volume of spent nuclear fuel generated by the OL1 and OL2 plant units will remain the same at the annual level, but the volumes will grow according to the years of operation. The nuclear power plant has existing methods and plans for handling, storage and final disposal, which will not be materially affected by continuing the operation and uprating the power. Posiva will, if necessary, examine the licensed capacity in the disposal facility for spent nuclear fuel so that the capacity of the disposal facility will match the spent nuclear fuel generated by the nuclear power plants of TVO and Fortum Power and Heat Oy in Finland during their service lives.

In the scenario where the service life of the OL1 and OL2 plant units is extended and their power is uprated, the most significant positive impacts will most likely be related to regional economy. The nuclear power plant's impacts on the regional economy are extremely high at the level of the Eurajoki area and also visible at the level of the entire country.The energy market is also expected to be subject to positive impacts of a major significance. Extending the service life of the OL1 and OL2 plant units and their potential power uprating will improve Finland's self-sufficiency in terms of energy, promote the clean energy transition and support the functionality of Finland's energy system and availability of electricity.

A preliminary assessment indicates that the project will have significant positive impacts on greenhouse gas emissions and mitigation of climate change, among other things. Extending the service life of the OL1 and OL2 plant units and uprating their power would support Finland's goal of being carbon neutral by 2035, because the use of nuclear power in the production of electricity generates a very minor amount of greenhouse gas emissions.

6.1.4. Area under review

In this environmental impact assessment, the site area refers 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.

During the environmental impact assessment, the aim is to define the area under review in terms of environmental impacts to be so large that no significant environmental impacts can be assumed to occur outside of the area under review. The area of impact will be redefined if it is discovered during the assessment procedure that an environmental impact has a wider area of impact than anticipated. The preliminary areas under review for each impact are set forth in the following chapters.

6.1.5. Documentation being used

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 can be used in the environmental impact assessment. Furthermore, the environmental impact assessment uses 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 as well as the planned assessment methods are described in the following chapters, broken down by impact.

6.2. Land use and zoning

During the impact assessment, the impacts of the project on community structure, land use and zoning will be assessed and described as expert work. In the assessment, the project plan is compared to the current and planned land use in the area. The suitability of the area from the zoning perspective is assessed on the basis of existing master plans, their background information and any possible pending zoning projects. The initial data being used consists of base map documentation, an analysis of the current community structure and the provincial plans, master plans and local detailed plans that are in force in the project area and its vicinity. The review considers the national and regional goals and pending zoning projects. The impacts are assessed at the local, provincial and, if necessary, the national level. The focus of the assessment is on impacts affecting the nearby areas (5 km).

6.3. Landscape and cultural heritage

The assessment of landscape impacts examines whether the project causes changes to the landscape or impacts on objects of the cultural environment. A description is 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 being used consists 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 focus of the assessment of landscape impacts is on impacts affecting the nearby areas (5 km).

6.4. Traffic

Traffic impacts are 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 accounts for traffic arriving at and departing from the power plant area. Transport arrangements inside the power plant area are also assessed. Data describing the present state is compared to the maximum volumes of traffic, taking into account normal operation and annual outages.

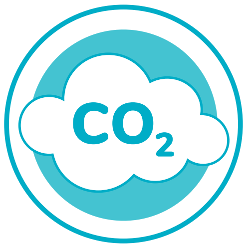
The current traffic volumes for roads leading to the power plant area are compiled from the Finnish Transport Infrastructure Agency's data *(Finnish Transport Infrastructure Agency 2022)*. In terms of road safety, accident statistics of the roads leading to the power plant area or other available documentation can be utilised. Various map reviews will also be utilised in terms of the properties of the road and sensitive aspects, among other things. The area under review comprises the roads leading to the power plant area and their immediate surroundings (0–2 km). The impacts on the load of the traffic network, the flow of traffic and road safety attributable to changes in traffic volumes are assessed as an expert assessment. Special attention is paid to any possible sensitive aspects located along the routes, such as housing, schools, day nurseries and recreational areas.

6.5. Noise and vibration

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

The assessment of noise impacts is based on the project's design data and existing data concerning the current noise level in the surrounding areas. On the basis of noise emissions from the project, the distribution of noise into the environment is assessed as an expert assessment, and the noise levels caused by the project are 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 are 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 are accounted for.

6.6. Air quality



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. Conventional releases into the air caused by the operation of the power plant's backup boilers and emergency diesel generators (carbon dioxide, nitrogen oxide, sulphur dioxide and particulate emissions) are presented on the basis of the power plant's operating times and an estimate of fuel consumption. The impacts are assessed by comparing the emissions with the emissions limits. Exhaust gas emissions resulting from traffic are estimated as an expert assessment of their impact on air quality based on the design data and traffic volume information. The assessment also considers dust emissions caused by any possible modifications and construction work as well as traffic. The impacts are assessed locally, at a radius of approximately 1–2 km from the power plant area.

6.7. Climate change

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.

Direct greenhouse gas emissions from the project, which mainly result from the CO_{2e} emissions from the power plant's emergency diesel generators and fuel used for transport, are assessed on the basis of the fuel being used, its consumption and the estimated kilometres driven by vehicle type. In terms of indirect greenhouse gas emissions, the greenhouse gas emissions occurring during the life cycle of the fuel being used in energy generation are re-viewed in comparison with other forms of energy production, based on published analyses concerning the life cycle studies of various fuels *(e.g. Bruckner et al. 2014, World nuclear association 2016)*. The assessment also examines the impact generated by the service life extension and power uprating of the OL1 and OL2 plant units from the point of view of Finland's national carbon neutrality target, by comparing the replacement of zero-carbon electricity generated by nuclear power with other means of electricity generation.

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.

6.8. Soil, bedrock and groundwater

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. If necessary, any possible locations with contaminated soil in the area are determined before starting construction activities.

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 for the assessment.

6.9. Surface water

The impacts of the nuclear power plant units on the quality of the sea water off Olkiluoto and the marine biological environment have been studied 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. The most significant impact affecting the sea area is the thermal load resulting from the dis-charge of cooling water. Otherwise, the load caused by the Olkiluoto power plant area, which originates from municipal wastewater, for example, is minor when compared to the other loads on the sea area (see chapter 5.7.2).

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 aquatic organisms as well as 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 methods for which are described in the paragraphs below. The area under review in the assessment comprises the nearby sea areas of Olkiluoto to a radius of approximately 10 km.

The thermal impact 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 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 present 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 and 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.

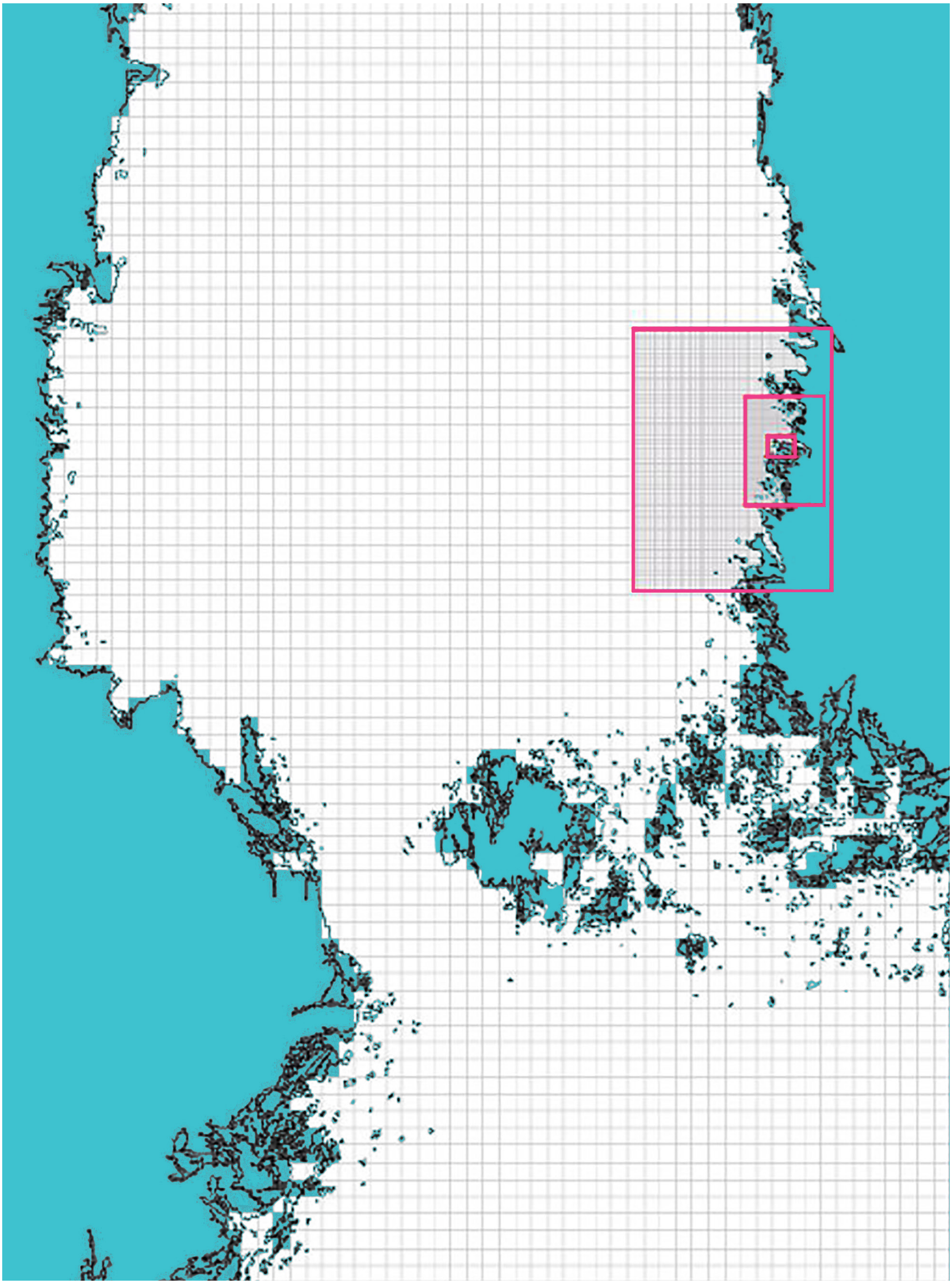


Figure 41. Entire model grid with nested sections delimited in red. The sizes of the elementary cells, from largest to smallest, are 5 km, 1 km, 200 m and 40 m.

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 41). 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. Depth-wise, 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 approx. 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.

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 on 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.

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 approx. 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 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 and 2058. Since the time periods being examined are far in the future, the impacts of climate change will also be assessed. The modelling scenarios (Table 10) have been chosen so that the impacts of the alternatives presented in the environmental impact assessment (see Figure 4) can be assessed.

Table 10. Scenarios modelled in the EIA.

Scenario	Description
Current status (alternatives VE0, VE1a and VE1b)	OL1, OL2 and OL3 operate at their current power level until 2038, 2048 or 2058
Power uprating (alternatives VE2a and VE2b)	OL1 and OL2 operate at an uprated power level and OL3 operates 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 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 2023c)*, 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 will become more common and prolonged, whereas harsh cold periods will gradually disappear. Wind speeds are expected to remain approximately at the present level. According to the report from the Intergovernmental Panel on Climate Change (IPCC), 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. The scenario selected to depict climate change was SSP5-8.5, which represents very high greenhouse gas emissions. 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 11).

Table 11. Changes using the year 2058 SSP5-8.5 climate change scenario when compared to the situation in 2020.

Year	Summer		Winter	
	Addition to temperature (°C)	Addition to flow rates and precipitation (%)	Addition to temperature (°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 12). 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 12. 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	x			
OL1, OL2 and OL3 current power level	x	i	i	x
OL1 and OL2 uprated power and OL3 current power level			i	x

The accuracy of the model is improved by using monitoring 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 is calculated using several alternative parameter combinations and the alternative that best fits the measurements is selected. The calibration uses all reference periods together. Therefore, all comparison simulations and scenarios use the same model parameters.

The results of the modelling are presented as time series, tables and map pictures visualising the dispersion of temperature.

6.10. Fish stocks and fishery

The assessment of impacts affecting fish stocks and fishery utilises monitoring studies performed in the sea area near the power plant area, information on the fish stocks and fisheries in the sea area and information in the research literature concerning data on the impacts of cooling water on fish stocks and invasive species, also outside of the project area. The assessment of the impact targeting fish stocks and fishery also utilises the results from the impact assessment targeting surface waters, including the cooling water modelling (chapter 6.9). The indirect impacts that the activities with an impact on the quality of water would have on the fish and fishery will be assessed in the form of an expert assessment. The area under review will extend to approximately 10 km from the power plant area.

6.11. Flora, fauna and conservation areas

The impact assessment describes the current status of the natural environment in the area and assesses 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 are also examined as regards biodiversity and interactions. The area under review will extend to approximately 10 km from the power plant area, especially in the sea area.

The impact assessment considers the impact assessments implemented during the EIA report stage, especially as regards surface waters (chapter 6.9). The impact assessment examines analyses performed in the area and data available from public sources, the most important of which include 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 regionally important. Impacts affecting Natura areas and nature reserves are 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. The assessment also considers any possible joint impacts with other projects. If it is discovered during the course of the planning that impacts that degrade natural values may affect a Natura area, a Natura assessment pursuant to Section 65 of the Nature Conservation Act will be drawn up during the report stage.

6.12. People's living conditions, comfort and health

6.12.1. People's living conditions and comfort

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;
- the opinions submitted on the EIA programme;
- feedback received from the monitoring group meeting arranged at the EIA report stage;
- other feedback received during the assessment procedure (e.g. public events);
- population data, map data and other statistical data.

The impact on people's living conditions and comfort is assessed with the aid of guidelines prepared by the National Research and Development Centre for Welfare and Health (*"Ihmisiin kohdistuvien vaikutusten arvioiminen", Kauppinen and 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.

6.12.2. Health

The purpose of the assessment of health impacts is to analyse the likely indirect and direct health detriments which the project 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. The possible health detriments caused by the project are examined as an expert assessment, based mainly on the results achieved from the assessments of noise, vibration and air quality impacts. The magnitude of the impacts is assessed in proportion to the health-based limit and guideline values that are 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 increases the risk of possible health detriments occurring, whereas the likelihood of impacts is low if the values are not exceeded. 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.

In addition to the possible detrimental health impacts caused by air quality, noise and vibration as well as groundwater and surface water, the radiation dose is estimated by means of calculations. As regards the releases of radioactive substances and radiation, the impact assessment methods have been described in chapter 6.14.

6.13. Regional economy

The impacts of the project on the regional economy are assessed by utilising resource flow modelling. The assessment will be implemented using Ramboll's resource flow model that was developed under assignment from Sitra in cooperation between Ramboll Finland and Luke during 2013–2015 *(Hokkanen et al. 2015)*. Before the impact assessment, information in the resource flow model will be 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). In addition to modelling changes in the economy, the resource flow model also allows for examining and assessing the broader significance of the various actors as part of the area's activity.

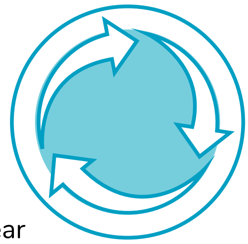
The assessment analyses the direct regional economy impacts of the project alternatives and the multiplicative effects that production and consumption have on employment, total output, added value and tax income as a result of the operations. The assessment of the impacts on the regional economy thereby considers 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.

The modelling will be performed in two parts and in stages. At the start of the impact assessment, an analysis of the present socioeconomical status of the area will be performed. Following this, the resource flow model will be used to model and assess the impacts of the different project alternatives on the economy (forecast situation). The changes to regional economy resulting from the alternatives will be made visible as the difference between the forecast situation and current situation. The results from the model describe the impacts on the businesses in the area, the regional economy and elsewhere in Finland.

6.14. Releases of radioactive substances and radiation

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.

6.15. Use of natural resources



The impact assessment reviews 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 that is required for continuing the operation of the nuclear power plant will be 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 is also presented, based on, among other things, estimates concerning the current status of uranium reserves and related forecasts.

6.16. Waste and byproducts

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 power plant. The environmental impacts related to these are assessed based on, among other things, the characteristics 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 assessment for the encapsulation plant and disposal facility performed by Posiva (Posiva Oy 2008 and 2012), the main results of which are described in the EIA report. The risk and implementation analysis concerning transports is also utilised.

6.17. Energy markets

The impacts on the energy market and availability of electricity 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 energy market will be examined while taking into account the schedule for the various project alternatives.

6.18. Incidents and accidents

In the EIA report, a severe reactor accident is examined 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.

The EIA report describes 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. Any identified incidents and accidents may be prevented and limited by technical and administrative means. These are described at a general level in the EIA report.

6.19. Joint impacts

The joint impacts of the project's functions with the OL3 plant unit and the other functions and projects in the nearby area are assessed in the EIA report per impact. Other projects and actors near the project area are identified and described. Furthermore, the impacts of related projects are described on the basis of existing and published environmental impact assessments *(e.g. Posiva Oy 2008 and 2012)*.

6.20. Transboundary impacts

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 beyond 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 dispersion in the accident will be studied up to a distance of 1,000 km from the power plant. Furthermore, 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.

6.21. Summary of the assessment methods and a proposal for limiting the examined area of impact

The site area refers to the Olkiluoto area where the current functions of the OL1 and OL2 plant units are located and where the project's planned changes to the plant units will take place. Environmental impacts are examined, in particular, in the site area and its nearby areas, but the area under review will also be extended to a wider area, if necessary. For environmental impacts, the areas under review have been defined to the extent where the impacts could reach, at a maximum. In reality, environmental impacts will likely take place in an area smaller than the area under review. The EIA report presents the environmental impact assessment results and their areas of impact.

The following (Table 13) presents a summary of the assessment methods and the proposed areas under review, broken down by impact.

Table 13. Summary of the environmental impacts examined, methods used in the assessment and the preliminary area under review for the impacts.

Area	Assessment methods	Area under review
Land use, zoning and the constructed environment	An expert assessment of the project's relationship with the current and planned land use and zoning. Additionally, an analysis of the locations in the constructed environment and distances thereto.	Approximately 5 km from the power plant area.
Landscape and cultural environment	An expert assessment of the project's relationship with the landscape in the nearby areas and a broader landscape. Locations in the cultural environment are identified.	Approximately 5 km from the power plant area.
Traffic	A calculated assessment of the changes in traffic volumes caused by the project and an expert assessment of the impacts of transports on traffic safety.	The roads leading to the power plant area and their immediate surroundings (0–2 km).
Noise and vibration	An expert assessment of the noise emissions and vibration from the different stages of the project and transports and their dispersion within the environment.	The site area and its immediate surroundings at a radius of approximately 3 km and the nearby areas along the transport routes.
Air quality	An expert assessment of the conventional emissions into the air (carbon dioxide, nitrogen oxide, sulphur dioxide and particulate emissions) caused by the project and their impact on air quality.	Approximately 1–2 km from the power plant area.
Climate change	Calculated estimate of greenhouse gas emissions and their impacts on Finland's total emissions. The greenhouse gas emissions generated during the fuel life cycle of different forms of energy production are also compared. The risks caused by climate change are identified and preparing for them is described.	CO_{2e} emissions at the regional level and for all of Finland. Risks locally in the power plant area.
Soil, bedrock and groundwater	Expert assessment of the possible impacts of the modifications in the project, based on existing research data.	Power plant area.
Surface water	Cooling water modelling and an expert assessment of impacts on the sea area prepared on its basis. An expert assessment of the impacts of cooling water, service water intake and the treatment and discharge of wastewater.	Approximately 10 km from the power plant area.
Fish stocks and fishery	An expert assessment prepared on the basis of studies on fish stocks and a surface water impact assessment.	Approximately 10 km from the power plant area.
Vegetation, animals and conservation areas	An expert assessment of impacts on the natural environment and conservation areas, based on the results from other impact assessments, for example.	Approximately 10 km from the power plant area.
People's living conditions, comfort and health	An expert assessment based on the calculated and qualitative assessments performed in the other impact areas (regional economy, noise, emissions, traffic and landscape, among other things).	Approximately 20 km from the power plant area.
Regional economy	A regional economy analysis based on an analysis of the current situation and resource flow modelling.	At the level for all of Finland.
Releases of radioactive substances and radiation	An expert assessment of the radioactive releases into the air and sea caused by the project. Radiation monitoring in the nearby areas of the power plant is implemented according to the existing monitoring programme, and the assessment is based on monitoring data. Radiation doses from the releases are estimated by means of calculation.	Environmental radiation monitoring approximately 10 km from the site area, radiation dose calculation approximately 100 km from the site area.
Use of natural resources	An expert assessment of nuclear fuel procurement and the impacts of its supply chain at the general level.	The nuclear fuel supply chain at the general level.

Area	Assessment methods	Area under review
Waste and byproducts	An expert assessment of the project's waste flows, their handling, opportunities for utilisation and final disposal. The description of the impacts from the transports and final disposal of spent nuclear fuel utilises the analyses already completed.	Olkiluoto area.
Energy markets	An expert assessment of the development of the energy markets and their changes for the project alternatives.	At the level for all of Finland.
Incidents and accidents	A modelling of an imaginary severe reactor accident where 100 TBq of the Cs-137 nuclide is released into the atmosphere. The results of the modelling establish the fallout and radiation doses caused by the release. An expert assessment of the impacts.	1,000 km from the power plant area.
Joint impacts	An expert assessment of joint impacts concerning the OL3 plant unit and the other actors and related projects in the area.	Areas near Olkiluoto.
Transboundary impacts	An assessment based on separate analyses and modellings regarding whether the impacts of the project may extend across the borders of Finland.	1,000 km from the power plant area.

7. Uncertainty factors

The design data concerning the project are specified as the project proceeds to its later stages, such as the permit processes. Therefore, there may be various assumptions and generalisations related to the initial data and impact assessments that are being used at this time, which may cause uncertainty in the environmental impact assessment work. The EIA report describes the identified potential uncertainty factors and estimates their significance in terms of the reliability of the results from the impact assessments.

8. Prevention and mitigation of harmful impacts

As part of the environmental impact assessment work, possibilities for preventing or mitigating the project's potential harmful impacts through design and implementation, among other things, are examined. The EIA report presents the identified means for preventing and mitigating detriments.

9. Monitoring of impacts

In connection with the environmental impact assessment, the project owner's existing monitoring programmes for environmental impacts are reviewed and the potential need for updating them is assessed. This is described in the EIA report.

10. The project's licence and permit process and 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.

10.1. Decisions and licences according to the Nuclear Energy Act

10.1.1. Operating licence

Operating licence for the nuclear power plant

The OL1 and OL2 plant units have an operating licence pursuant to the Nuclear Energy Act that is in force until the end of 2038. In order to extend the service life of the OL1 and OL2 plant units, a new operating licence must be sought. In the scenario involving power uprating, the aim is to combine the periodic safety assessment and the new operating licence application required by the uprated power and service life extension. The operating licence is 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 licence for the OL1 and OL2 plant units comprises the operation of the interim storage facilities for nuclear waste (KAJ, MAJ, KPA), and if service lives are extended at the OL1 and OL2 plant units, 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.

Olkiluoto Island also houses Posiva's encapsulation plant and disposal facility for spent nuclear fuel, for which Posiva sought an operating licence in late 2021. The Government will decide on granting the operating licence. The final disposal of spent nuclear fuel is planned to begin in the mid-2020s.

10.1.2. 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 current operating licence period. If the operation of the plant units is continued, decommissioning will take place after the new operating licence period. 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.

10.1.3. Other licences in accordance with the Nuclear Energy Act

A permit for the operation of the disposal facility for very low-level nuclear waste (near-surface final disposal) that is being planned for the area of the Olkiluoto nuclear power plant is being sought in a manner where operation would begin in the mid-2020s.

The operation of the nuclear facilities at Olkiluoto may require other licences under the Nuclear Energy Act in the future, and they will be applied for when necessary. 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.

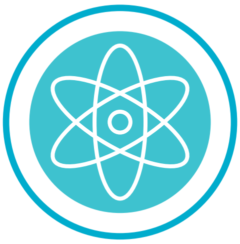
10.2. Licences in accordance with the Radiation Act

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 3 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. The radiation practice in industry and research will be continued to an extent deemed necessary in the event that the operation is extended. The safety licence is updated as necessary.

10.3. 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, 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. Posiva is responsible for the transport of spent nuclear fuel to encapsulation and final disposal at Olkiluoto in Eurajoki.

10.4. Other permits

10.4.1. 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.

10.4.2. 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. Separate action permits may be required for smaller structures, such as containers of temporary warehouses if they are not included in the building permit application.

10.4.3. 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. 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)*. 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.

10.4.4. 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 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.

10.4.5. Other permits and plans

A restriction on movement has been put in place around the power plant area by virtue of Section 52 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 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.

10.5. The project's relation to plans and programmes

The project may have interfaces with various 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. These may include the following, for example

- Paris Agreement.
- The EU's climate and energy policy for 2020 and 2030.
- Finland's National Energy and Climate Strategy.
- The new Climate and Energy Strategy.
- National Air Pollution Control Programme 2030.
- Water Framework Directive, water management plans and action programmes.
- Marine Strategy Directive and Finland's Marine Strategy.
- Convention on the Protection of the Marine Environment of the Baltic Sea and the Action Plan.
- Natura 2000 network.
- National land use goals.
- National programme for spent nuclear fuel and radioactive waste management.

The most significant plans and programmes are identified and listed in the EIA report, and the relationship of the project regarding them will be assessed.

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APPENDIX

Appendix 1: Terms and abbreviations

Table 14. Terms and abbreviations used and their explanations.

Abbreviation	Explanation
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.
dB	Decibel, or a unit of the sound pressure level, which has a logarithmic scale. An increase of 10 dB increases noise by tenfold.
ELY centre	Centre for Economic Development, Transport and the Environment.
FINIBA areas	Nationally important bird areas in Finland.
HMAJ	Very low-level waste (average activity level ≤100 kBq/kg).
IBA areas	Internationally important bird areas.
International hearing	A hearing procedure in accordance with the Espoo Convention on the assessment of the transboundary environmental impacts, in which different countries can participate.
KAJ	Intermediate-level waste (typical activity 1–10,000 MBq/kg).
KAJ storage	Storage for intermediate-level waste.
KPA	Spent nuclear fuel.
KPA storage	Storage for spent fuel.
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).
MAJ	Low-level waste (typical activity at most 1 MBq/kg).
MAJ storage	Storage for low-level waste.
OL1	Nuclear power plant unit Olkiluoto 1.
OL2	Nuclear power plant unit Olkiluoto 2.
OL3	Nuclear power plant unit Olkiluoto 3.
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.
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.
STUK	The Radiation and Nuclear Safety Authority, which is the authority supervising safety in Finland, a research institution and an expert organisation.
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 exposure. The unit for the radiation dose is the sievert (Sv).

Abbreviation	Explanation
MEAE	Ministry of Economic Affairs and Employment. Acts as the coordinating authority (liaison authority) in the environmental impact assessment procedure.
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 nuclear power plants. Operating waste is generated in the handling of radioactive liquids and gases, and in maintenance and repair work carried out in the radiation controlled area, for example.
Nuclear material	Special fissionable materials and source materials, such as uranium, thorium and plutonium, 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 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), Olkiluoto 2 (OL2) and Olkiluoto 3 (OL3).
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 “combustion products” are isotopes of lighter elements generated in the chain reactions. Most of them are radioactive.
Coordinating authority	The coordinating authority for this EIA procedure is the Ministry of Economic Affairs and Employment (MEAE).
EIA	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: EIA working group

The environmental impact assessment programme has been drawn up by Ramboll Finland Oy as consulting work ordered by TVO. The experts presented in the following table have participated in the EIA working group.

Table 15. Working group for the EIA consultant.

Name and role	Qualifications
Antti Lepola Project Leader	**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 production and the environmental impacts of industry. Mr Lepola has participated in nearly 100 EIA procedures and acted as project manager in more than 30 EIA procedures.
Anna-Katri Räihä EIA project manager and expert, climate and air quality, natural resources (sub-consultant)	**M. Sc. (Environmental economy)** Ms Räihä has 15 years of experience in environmental consulting and project leadership related to environmental projects in various industrial fields. Her core competences include environmental 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 numerous 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.
Sanna Sopanen EIA coordinator, surface water	**PhD (Aquatic Ecology)** Ms Sopanen has broad expertise in analyses related to surface water quality and the marine environment that spans 20 years. Her special expertise is related to the interactions in the marine ecosystem and the factors influencing them in both inland waters and sea areas. Ms Sopanen has participated in several environmental impact assessments (EIA), licensing and zoning projects, nature analyses, Natura assessments and various water system analyses as an expert in impacts on water systems.
Niko Mäkinen land use and zoning	**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 special expertise also covers action area solutions and exceptions, especially in shore areas.
Silja Raappana landscape	**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 landscape analyses and acquainted herself with cultural-historical sites.
Leena Manelius traffic	**M.Sc. (Construction engineering)** Ms Malenius 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.

Name and role	Qualifications
Timo Korkee Noise and vibration	**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 in Tampere. Mr Korkee has more than 20 years of working experience in various noise analyses and noise prevention projects. Timo's 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, Timo 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 projects related to EIAs and environmental permits and as a project manager for noise analysis projects.
Ida Tapiola soil, bedrock and groundwater	**M.Sc. (Soil geology)** Ms Tapiola has more than five years of experience in expert and project coordinator duties, especially as regards groundwater and follow-up of environmental impacts. She has special experience in the assessment of impacts to soil, bedrock and groundwater, EIA projects within industry and in environmental licensing.
Saara Mäkelin surface water	**MA (Aquatic sciences)** Ms Mäkelin has worked for five years as a marine biologist, and she also has expertise in limnology and fishery science. She has a good overall picture of the structure and operation of water ecosystems and the water system impacts of environmental changes.
Arto Inkala Cooling water modelling (sub-consultant)	**Dr. Eng. (Applied mathematics)** Mr Inkala has more than 20 years of experience in the mathematical modelling of water systems 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 fish stocks and fishery	**MA (Aquatic sciences))** Mr Pulli works as an environmental designer and project manager, especially in projects related to surface waters and fish stocks. Launo has experience in implementing versatile impact assessments, fish stock and water quality studies and environmental analyses in all of Finland since 2018.
Teemu Roikonen fish stocks and fishery	**MA (Fishery science)** Mr Roikonen works as an expert and project manager in versatile projects targeting water systems. His key tasks include, among other things, coordinating and reporting on analyses and monitoring projects related to water systems, impact assessments and the creation of permit applications and supervision plans in accordance with the Water Act. He also has ample experience in versatile field work in water environments.
Ella von Weissenberg flora, fauna and conservation areas	**MA (Aquatic sciences)** A marine biologist by training, Ms von Weissenberg is writing her dissertation on the impacts of temperature on plankton communities in the Baltic Sea. 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) and the assessment of impacts on nature in several different EIA projects.
Eeva-Riitta Jänönen living conditions and comfort	**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 assessment of impacts targeting living conditions and comfort. She also has experience in interaction, such as arranging workshops and meetings for discussion as well as resident surveys.
Mikko Happo health	**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.
Samuel Rintamäki regional economy and energy markets	**M.Sc. (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 projects; he has also participated in several projects related to the development of regional business life and the industrial environment.

Name and role	Qualifications
Kirsi Tyrmi geographical location data	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.
Anni Mannonen waste and byproducts	**M.Sc. (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 assessment of climate impacts.


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