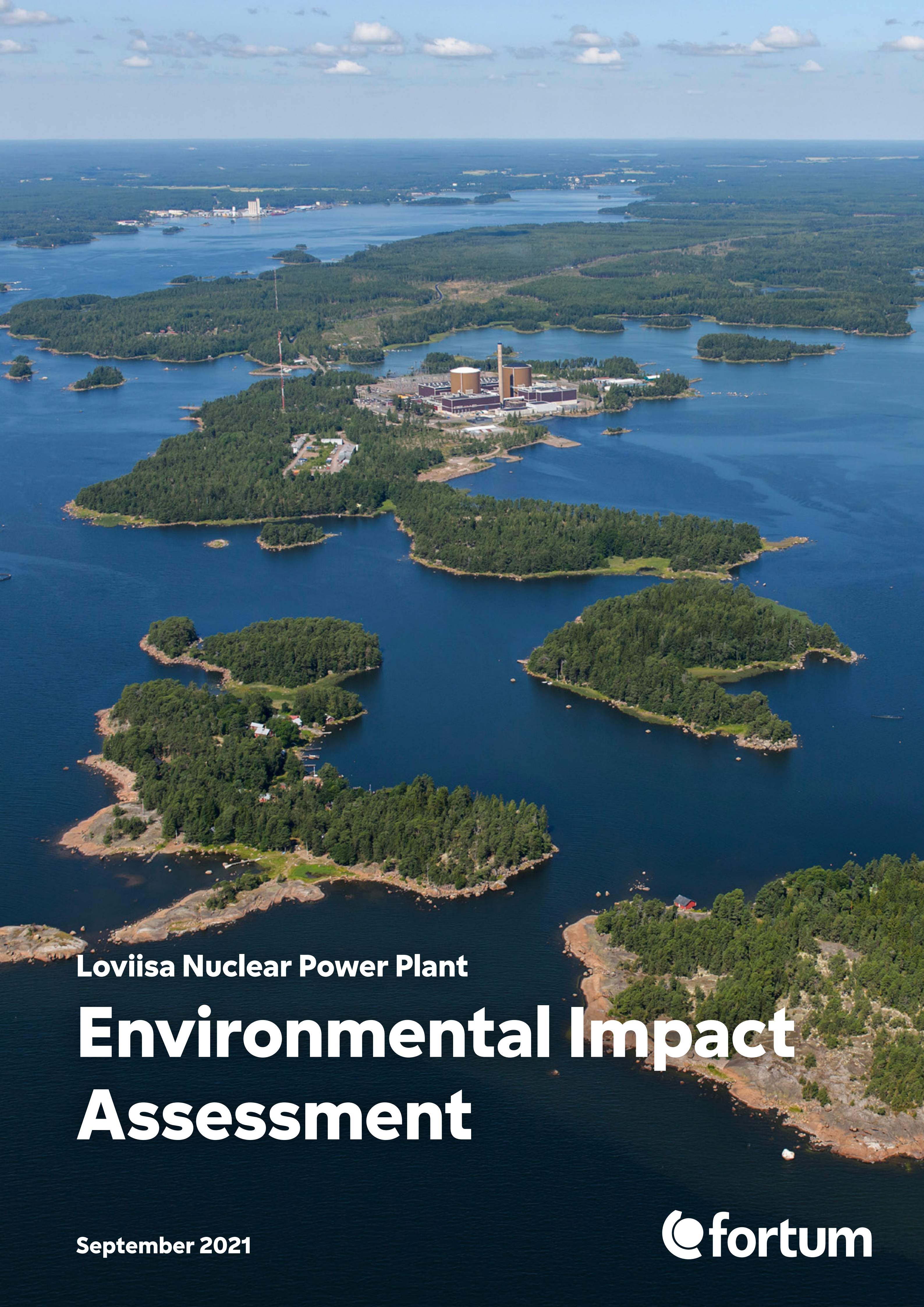

Loviisa Nuclear Power Plant

Environmental Impact Assessment

September 2021

Introduction

The assessment of transboundary environmental impacts is agreed upon in what is referred to as the Espoo Convention (Convention on Environmental Impact Assessment in a Transboundary Context). The states party to the convention have the right to participate in an environmental impact assessment procedure underway in another state when a project planned in a particular state (party of origin) is likely to have transboundary impacts in the territory of another state (affected party).

This document summarises the Environmental Impact Assessment Report for Fortum Power and Heat Oy's Loviisa nuclear power plant for the purpose of the project's international hearing in accordance with the Espoo Convention. The summary includes a presentation of the planned project, its alternatives and schedule, an outline of the environmental impact assessment procedure, and an overview of the environmental impact assessment's results in terms of the most significant impacts. It also provides an overview of the results of the transboundary impact assessment.

Further information on the project and the environmental impacts is available in the national Environmental Impact Assessment Report.

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Base maps: National Land Survey of Finland 2021

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

Loviisa nuclear power plant Environmental Impact Assessment Report

International hearing document

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1. Project owner and the project background

1.1 PROJECT OWNER

The project owner in the EIA procedure is Fortum Power and Heat Oy (Fortum), a wholly owned subsidiary and part of Fortum Group. The government of Finland holds 50.8% of Fortum Corporation's shares. In the spring of 2020, Fortum Group acquired a majority interest in Uniper SE, based in Germany. The acquisition made Fortum one of the largest energy companies in Europe and also an increasingly important operator in Russia. Uniper was consolidated with the group as of April 2020, but it continues to operate as a separate listed company.

Fortum Group and its subsidiaries employ a total of nearly 20,000 people, a little more than 2,000 of whom work in Finland. In the Nordic countries, Fortum Group is the second-largest producer of electricity and the largest electricity seller. As a producer of thermal energy, it is one of the largest in the world. The company also offers district cooling, energy efficiency services, recycling and waste solutions, as well as the Nordic countries' largest network of charging stations for electric cars. The group's subsidiary Uniper also engages in large-scale global energy trading, and owns natural gas storage terminals and other gas infrastructure.

Nuclear energy plays a significant role in Fortum Group's carbon dioxide-free electricity production. With Uniper, Fortum Group is the third largest nuclear power company in Europe. In 2020, the combined electricity production of the entire group was approximately 142 TWh, of which 20% was based on the production of nuclear power. Thanks to its large-scale nuclear, hydro- and wind power, the company is Europe's third largest producer of emission-free electricity. In 2020, the company's electricity production free of carbon dioxide emissions accounted for 73% and 45% of all such production in Europe and across the globe, respectively.

Loviisa nuclear power plant, owned and operated by Fortum Power and Heat Oy (Fortum), produces a total of approximately 8 terawatt hours (TWh) of electricity for the national grid per year. This is equal to approximately 10% of Finland's electricity consumption. For its part, Loviisa nuclear power plant supports the climate targets of Finland and the EU as well as a secure electricity supply.

1.2 PROJECT BACKGROUND

Fortum's Loviisa nuclear power plant was built in 1971–1980. It consists of two power plant units, Loviisa 1 and Loviisa 2, as well as the associated buildings and storage facilities required for the management of nuclear fuel and nuclear waste. Loviisa 1 began its commercial operation in 1977 and Loviisa 2 in 1980. Loviisa power plant has been generating electricity reliably for more than 40 years. The current operating licence issued by the Finnish government to Loviisa 1 is valid until the end of 2027, and the operating licence issued to Loviisa 2 is valid until the end of 2030.

Fortum is in the process of assessing the extension of the commercial operation of Loviisa nuclear power plant by a maximum of approximately 20 years beyond the current operating licence period. Fortum will make the decision concerning the potential extended operation of the nuclear power plant and the application for new operating licences at a later date. The other option is to proceed to the decommissioning phase once the power plant's current operating licences expire.

Fortum has been investing in the ageing management of Loviisa power plant and has carried out improvement measures throughout the operation of the power plant. The power plant units were customised to meet western safety requirements during their planning phase. Over the years, Loviisa power plant has implemented several projects that improve nuclear safety. In recent years, extensive renewals have been carried out on the automation of the power plant, and its ageing systems and equipment have been modernised. In 2014–2018, Loviisa power plant implemented the most extensive modernisation programme in the plant's history, in which Fortum invested approximately EUR 500 million. Thanks to the investments made and a skilled personnel, Loviisa power plant has excellent prerequisites with regard to the technical and safety-related requirements to continue operation after the current licence period.

With the exception of spent nuclear fuel, the radioactive waste from the power plant is processed and deposited in the final disposal facility for low- and intermediate-level waste (the L/ILW repository), located in the power plant area. The L/ILW repository is a separate nuclear facility, and its operating licence is valid until 2055. Posiva Oy is responsible for the final disposal of Loviisa power plant's spent fuel in Eurajoki, Olkiluoto. Posiva Oy's encapsulation and final disposal facility is currently under construction. Solutions therefore exist for the processing and final disposal of all nuclear fuel generated by Loviisa power plant.

This environmental impact assessment procedure (the EIA procedure) covers the extended operation of Loviisa nuclear power plant's operation or its decommissioning. In both cases, the project requires a licensing procedure in accordance with the Nuclear Energy Act and an environmental impact assessment procedure in accordance with the EIA Act (section 3, subsection 1 of the EIA Act as well as points 7 b and d of the list of projects in said Act). The EIA Report and the coordinating authority's reasoned conclusion to be issued on it will be appended to any licence and permit applications. In this project, the coordinating authority is the Ministry of Economic Affairs and Employment.

2. Project description and the options assessed

2.1 LOCATION OF LOVIISA NUCLEAR POWER PLANT

Fortum's Loviisa nuclear power plant is located on the island of Hästholmen, approximately 12 km from the centre of the town of Loviisa. The distance from the power plant to Helsinki is approximately 100 km (Figures 2-1 and 2-2). The power plant and the functions integrally related to it – such as the L/ILW repository and other waste management buildings, the coolant water intake and discharge structures as well as the office and storage buildings – are located on the island of Hästholmen. The structures located on the mainland include an accommodation area.

The functions related to the power plant's extended operation and decommissioning covered in the EIA procedure will be located in the existing power plant area and its vicinity.

Figure 2-1. Location of the town of Loviisa in Finland.

Figure 2-2. Location of Loviisa nuclear power plant.

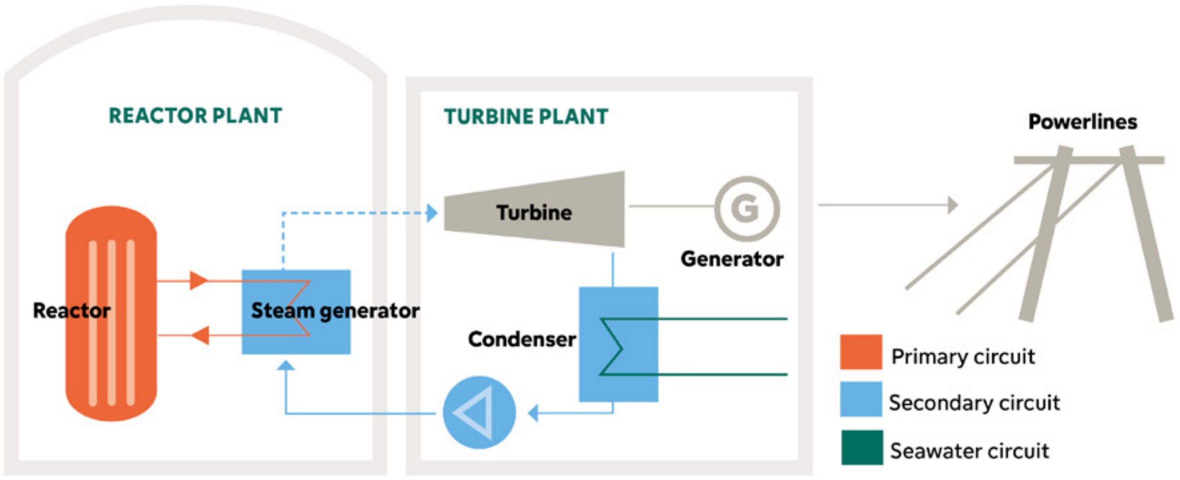

Figure 2-3. Operating principle of a pressurised water plant.

2.2 POWER PLANT'S CURRENT OPERATION

Loviisa power plant units Loviisa 1 and Loviisa 2 are pressurised water plants. Electricity generation in a nuclear power plant is based on the utilisation of thermal energy generated by a controlled fission chain reaction. Loviisa power plant is a VVER-440 pressurised water plant, the operating principle of which is illustrated at a general level in Figure 2-3.

The controlled fission reaction that takes place in the reactor core of the primary system generates heat, and the water circulating in the reactor under high pressure cools the fuel bundles in the reactor core. The water heated in the reactor is conducted to the steam generators, from where the thermal energy is transferred to the secondary system's water, which is of a lower pressure, evaporating it. The generated steam is conducted to the turbines. A generator that shares the same shaft with the turbines generates electricity for the national grid and for the power plant itself. From the turbine, the steam is conducted to a condenser, where it condenses to water. The condensed water is pumped back to the steam generators. The condenser is cooled by a separate seawater system. The seawater used for the cooling warms up and is conducted back to the sea.

The cooling water for Loviisa power plant is taken from the western side of the island of Hästholmen, using an onshore intake system, and the water, warmed by approximately 10°C, is discharged back into the sea on the eastern side of the island. The volume of sea water used by the power plant for cooling is an average of 44 m^3/s. The most significant environmental impact of the current operation of Loviisa power plant is the thermal load from the cooling water on the sea. The condition of the nearby sea area has been monitored since the late 1960s. The impacts of the cooling water are local and mainly concern the vicinity of the cooling water discharge site.

Loviisa power plant is used for the production of base load electricity; in other words, the power plant is usually operated steadily at full power to meet the continuous minimum requirement for electrical power. The nominal thermal power of each of Loviisa power plant's power plant units is 1,500 MW, and the net electric power is 507 MW. The total efficiency of the power plant units is approximately 34%. The annual production of Loviisa power plant is approximately 8 TWh. This accounts for approximately 10% of Finland's annual consumption of electricity. The availability and load factors of Loviisa power plant have been excellent.

The low- and intermediate-level waste generated during the operation of the power plant is processed in the power plant and deposited in the final disposal facility for low- and intermediate-level waste (the L/ILW repository), located 110 metres underground in the power plant area. The spent nuclear fuel is deposited for interim storage in the pools of water in the interim storages for spent nuclear fuel in the power plant area. In due course, the spent nuclear fuel will be deposited for final disposal in Posiva Oy's final disposal facility in Olkiluoto, Eurajoki.

2.3 OPTIONS TO BE REVIEWED IN THE EIA PROCEDURE

The implementation options reviewed for the project include extending the power plant's operation after the current licence period by a maximum of approximately 20 years (Option VE1) and two different zero options (Option VE0 and Option VE0+) related to the power plant's decommissioning (Table 2-1).

2.3.1 Extended operation (VE1)

Option VE1 covers an extension to Loviisa power plant's commercial operation after the current licence period (2027/2030) by a maximum of approximately 20 years. During the extension, the operation of the power plant would be similar to what it currently is; increasing the thermal power of the plant is not being planned, for example. If the operation of the power plant is extended, new buildings and structures may potentially be constructed and modernisations may be carried out in the power plant area.

Table 2-1. Options to be reviewed in the EIA procedure.

Option	Description
Extended operation (VE1)	**Extending the operation** of Loviisa nuclear power plant by a maximum of approximately 20 years after the current operating licence period, followed by decommissioning. The option also entails: • Modifications related to the extended operation (including new buildings in the power plant area, service water and wastewater connections, and increasing the capacity of the interim storages for spent nuclear fuel or expanding the other interim storage for spent nuclear fuel 2). • Operations related to decommissioning, such as those in the Options VE0 and VE0+. • The possible receiving, processing, placing in interim storage and depositing for final disposal of radioactive waste generated elsewhere in Finland.
Decommissioning (VE0)	The **decommissioning** of Loviisa nuclear power plant after the current licensing period (in 2027/2030).
Decommissioning (VE0+)	The **decommissioning** of Loviisa nuclear power plant after the current licensing period (in 2027/2030). • The possible receiving, processing, placing in interim storage and depositing for final disposal of radioactive waste generated elsewhere in Finland.

Potential modifications related to extended operation include:

- Replacing some old buildings in the power plant area with new ones. These would include an inspection or reception warehouse, a cafeteria building, a wastewater treatment plant, welding hall and a waste storage hall.
- Procuring the power plant's service water from the municipal plant and directing sanitary wastewater to the municipal sewage treatment plant. The power plant's current service water and wastewater connections would nevertheless be preserved alongside the new arrangement.
- Expanding the interim storage for spent nuclear fuel or increasing the capacity of the current interim storage (by placing more nuclear fuel in the pools of the existing interim storage, for example).

As part of Option VE1, for extending operations, the EIA Programme of Loviisa power plant investigated the possibility of carrying out water engineering projects in the area in front of the cooling water intake and the adjacent sea area. Based on the techno-economic investigations, the water engineering projects are no longer being planned, which is why they are not reviewed in the EIA procedure.

Option VE1 includes the power plant's decommissioning after the commercial operation. The operations related to decommissioning would be implemented in 2045–2090. Chapter 2.3.2 describes the operations included in the decommissioning.

In accordance with the recommendation of the National Nuclear Waste Management Cooperation Group set up by the Ministry of Economic Affairs and Employment, the possibility of receiving and handling small quantities of low- and intermediate-level waste generated elsewhere in Finland in the Loviisa power plant area, and depositing it in interim storage and final disposal there, is considered as one part of the option of extended operation (VE1). This radioactive waste could be derived from research institutions, the industrial sector, hospitals or universities. Since Loviisa power plant already has functions and facilities suitable for the handling and final disposal of radioactive waste in place, it would be natural and in line with the view of the National Nuclear Waste Management Cooperation Group that they would be available as part of the overall social solution for the management of radioactive waste.

2.3.2 Decommissioning (VE0 and VE0+)

Option VE0 reviews the power plant's decommissioning after the current licence period (2027/2030).

Decommissioning includes the dismantling of the radioactive systems and equipment of Loviisa power plant, and the final disposal of low- and intermediate-level radioactive decommissioning waste in the L/ILW repository's current halls, and the construction of new halls as required. The decommissioning includes making some operations and plant parts related to waste management independent. The purpose of these operations and plant parts is to ensure the cooling of the spent fuel and the handling of other radioactive waste within the plant site. Making a plant part independent means that the operations of the plant parts to be made independent, such as cooling and ventilation, are separated from the systems of the power plant units to which they are currently connected. In Option VE0, the operation of the L/ILW repository would continue until the 2060s.

During the operation of the power plant, preparations are made for decommissioning, including the following:

- the operation and expansion of the L/ILW repository in such a way that the radioactive decommissioning waste generated in the decommissioning of the power plant can be deposited in the L/ILW repository for final disposal;
- the preparations and plant changes required by and the operation of the buildings and structures to be made independent (including the interim storage for spent nuclear fuel, the liquid waste storage and the solidification plant).

Figure 2-4. Tentative schedules of the project options, to be specified as the plans progress.

The decommissioning phase includes the following:

- power plant dismantling, with the main focus on the dismantling of radioactive plant parts and systems;
- the handling of radioactive decommissioning waste and its final disposal in the L/ILW repository;
- the handling and reuse of conventional dismantling waste;
- the operation and dismantling of the plant parts to be made independent;
- the closure of the L/ILW repository.

The transport of spent nuclear fuel to Olkiluoto, in Eurajoki, will also be carried out during the decommissioning phase. At Olkiluoto, the spent nuclear fuel will be encapsulated and deposited for final disposal at Posiva Oy's encapsulation and final disposal facility.

Decommissioning will be based principally on Loviisa power plant's latest decommissioning plan, completed in 2018, which covers the dismantling of radioactive plant parts, waste handling and the final disposal of radioactive waste. The plan is based on what is referred to as the brownfield principle, in which the buildings in the power plant area are not dismantled. Instead, the dismantling involves only the radioactive parts.

Option VE0+ is identical to Option VE0 in all respects other than that it also takes into account the handling, interim storage and final disposal of the low-level and intermediate-level waste generated elsewhere in Finland and potentially received by Loviisa power plant.

2.4 PROJECT SCHEDULE

The tentative schedule estimates for the project options to be reviewed in the EIA procedure are provided in the following figure (Figure 2-4).

3. EIA procedure

In Finland, the requirement to carry out an EIA procedure is based on the Act on the Environmental Impact Assessment Procedure (EIA Act). In addition, this project applies the Espoo Convention on the Environmental Impact Assessment in a Transboundary Context (the international hearing).

3.1 INTERNATIONAL HEARING

The principles of international cooperation in the environmental impact assessment are defined in the UN's Convention on Environmental Impact Assessment in a Transboundary Context (SopS 67/1997, the Espoo Convention). The Espoo Convention lays down the general obligations for organising a hearing for the authorities and citizens of the member states in all projects that are likely to have significant adverse transboundary environmental impacts. The EIA Directive (2011/92/EU) also includes provisions on communications related to the project, and further requires that a member state must be able to participate, at its request, in the assessment procedure of another member state. In addition to the EIA Directive, the rights of the public to participate and their right of appeal are also regulated internationally by the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (SopS 121—122/2004, the Aarhus Convention). Among other things, the objectives of the Aarhus Convention include enabling the public to participate in environmental decision-making. The Aarhus Convention has been implemented in the EU by means of several directives, including the EIA Directive. The obligations concerning the hearing included in the Espoo Convention, the EIA Directive and the Aarhus Convention have been implemented in Finland with the EIA Act and the EIA Decree, among others. The competent authority in the international hearing of the EIA procedure in Finland is the Ministry of the Environment.

In this project, the Ministry of the Environment notified the environmental authorities of the neighbouring countries about the commencement of the EIA procedure during the EIA Programme stage, and enquired about their desire to participate in it. A document summarising the EIA Programme, translated into the language of the relevant country, and the EIA Programme translated into Swedish or English, were appended to the notification. In the international hearing pursuant to the Espoo Convention, Sweden, Estonia, Russia, Norway, Denmark, Lithuania, Germany and Austria indicated their intention to participate in the project's EIA procedure. Latvia and Poland did not consider themselves affected parties and are therefore not participating in the EIA procedure. All other parties to the Espoo Convention were furthermore notified of the project's EIA procedure. Of these parties, Austria and the Netherlands indicated their desire to be provided with a notification pursuant to the Espoo Convention. The Finnish Ministry of the Environment submitted the feedback it received from the affected states to the coordinating authority (the Ministry of Economic Affairs and Employment) for consideration in the coordinating authority's statement concerning the EIA Programme.

In the international hearing procedure of the EIA Report phase currently being organised, the hearing documents are delivered to the affected parties which have indicated their intention to participate in Finland's EIA procedure.

3.2 EIA PROCEDURE IN FINLAND

Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (the EIA Directive) has been implemented in Finland by means of the Act on the Environmental Impact Assessment Procedure (the EIA Act, 252/2017) and the Government Decree on the Environmental Impact Assessment Procedure (the EIA Decree, 277/2017). The first EIA Directive is from 1985 (85/337/EEC), and it has been amended on several occasions, as have the EIA Act and EIA Decree.

Pursuant to point 7b of the list of projects in the Finnish EIA Act, an assessment procedure in accordance with the EIA Act applies to nuclear power plants and other nuclear reactors, including the dismantling or decommissioning of these plants or reactors. In addition, the EIA procedure is applied to facilities which have been designed for, among other things, the handling of spent nuclear fuel or high-level waste, the final disposal of nuclear waste or other radioac-

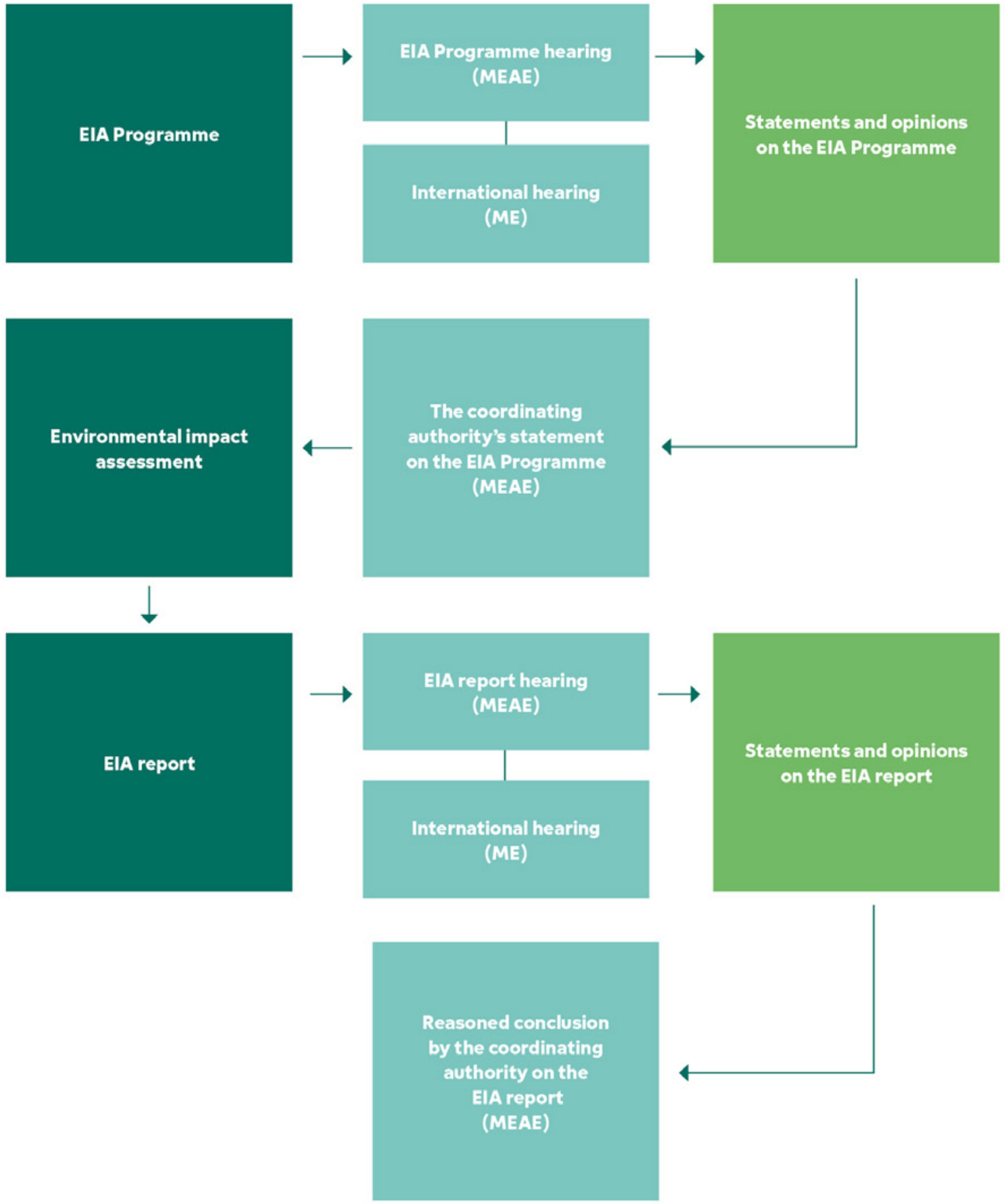

Figure 3-1. The stages of the EIA procedure. MEAE = Ministry of Economic Affairs and Employment. ME = Ministry of the Environment.

tive waste, or for the long-term storage of spent nuclear fuel, other nuclear waste or other radioactive waste elsewhere than its production location.

The purpose of the EIA procedure is to promote the assessment and consideration of environmental impacts as early as the planning stage, as well as to increase access to information and opportunities to participate in the planning of the project. The EIA procedure is carried out in Finland before the permit procedure, and its purpose is to influence the planning of the project and decision making. The authority may not grant permission for the project's implementation until it has received the assessment report and the reasoned conclusion, as well as the documents concerning the international hearing related to transboundary impacts.

The EIA procedure has two stages. The first stage involved the preparation of the EIA Programme, on which the coordinating authority gave its statement on 23 November 2020. The environmental impact assessment report (EIA Report) was drawn up during the second stage of the EIA procedure, based on the EIA Programme and the statement issued on it by the coordinating authority. The results of the assessment work were compiled in the EIA Report. The coordinating authority makes the assessment report available for public viewing in the same manner as the EIA Programme, and requests statements from various parties. As during the EIA Programme stage, an international hearing will also be held during the EIA Report stage.

Based on the EIA Report and the statements issued on it, the coordinating authority will prepare a reasoned conclusion on the project's significant environmental impacts, which must be considered in the subsequent licensing processes. The assessment report and the reasoned conclusion by the coordinating authority are appended to the licence application documents.

Figure 3-1 shows a summary of the EIA procedure phases in Finland and the procedure's interconnection with the international hearing.

3.3 SCHEDULE OF THE EIA PROCEDURE

The key stages and tentative schedule of the EIA procedure are shown in Figure 3-2.

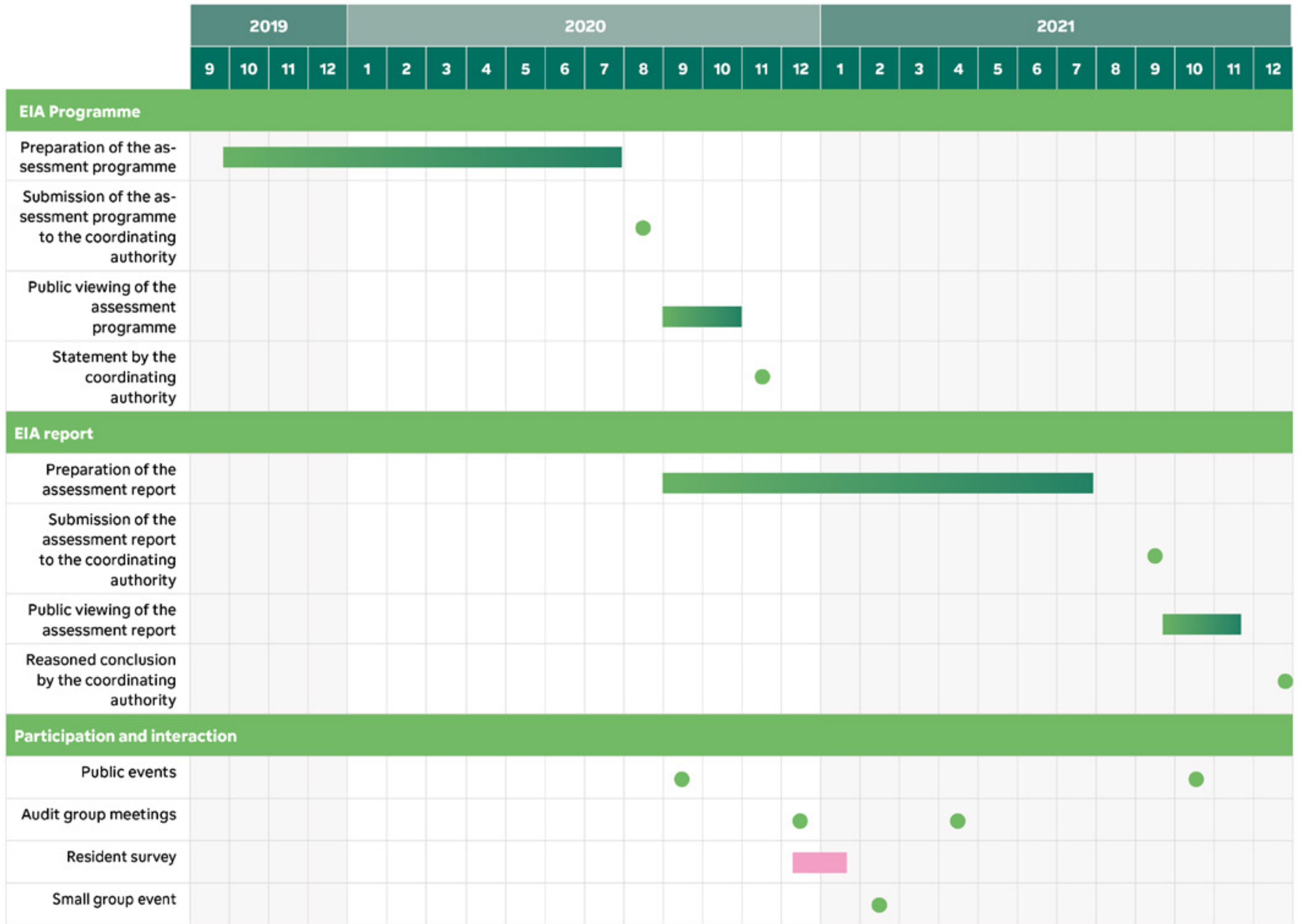

Figure 3-2. Tentative schedule of the EIA procedure.

4. Safety of the nuclear power plant

4.1 RADIATION

At Loviisa power plant, radiation protection is based on the principles of justification, optimisation and limitation, pursuant to the Radiation Act (859/2018). These principles help ensure that the overall benefits achieved from the radiation practice exceed the detriment it causes (the principle of justification), that the exposure to ionising radiation is kept as low as reasonably achievable (the principle of optimisation), and that workers' radiation dose does not exceed the dose limit set for the operation (the principle of limitation).

The most significant radiation sources during the operation of Loviisa nuclear power plant are the nuclear fuel and activation products in the primary system's water, due to which the vicinities of the primary system are inaccessible during operation.

Loviisa power plant's radioactive emissions are monitored in the power plant area and its surroundings.

The environmental radiation control programme of Loviisa focuses on measurements of external radiation, the pathways through which people are exposed to radioactivity and the indicator organisms that enrich radioactive substances, such as fern. The Radiation and Nuclear Safety Authority also carries out its own independent monitoring in the environment of Loviisa power plant. The Radiation and Nuclear Safety Authority regularly takes samples from the air in connection with plants' annual outages and collects samples from the soil and sea environment within the framework of its environmental radiation monitoring programme.

According to the European Commission, the annual doses caused by natural background radiation in the European area are approximately 1.5–6.2 mSv a year (https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Download-page). The average annual radiation dose of people living in Finland is approximately 5.9 mSv, of which roughly 4 mSv is attributable to indoor radon, some 1.1 mSv to other natural background radiation, and roughly 0.76 mSv to medical examinations. In Finland, the effective dose of a member of the public and a comparable employee attributable to a radiation practice may not exceed 1 mSv a year, and the limit for the dose attributable to a nuclear power plant's normal operation is 0.1 mSv a year. The annual effective radiation dose caused to a member of the public in Loviisa nuclear power plant's environment due to the operation of the power plant is 0.00023 mSv (average in 2009–2019).

4.2 NUCLEAR SAFETY

Safety functions aim to prevent the emergence of incidents and accidents, prevent their spread, and mitigate the consequences of accidents. The principal short-term safety functions start up automatically. In the longer term, the necessary functions can be started up by an operator. Loviisa power plant's key safety functions are:

- reactivity control, which aims to stop the chain reaction generated by the reactor;
- the removal of the residual heat generated after the chain reaction is stopped, which aims to cool the fuel and by doing so to ensure the integrity of the fuel and the primary system;
- prevention of the dispersion of radioactivity, which aims to isolate the containment building and ensure its integrity, and by doing so, to control radioactive emissions during accidents.

There are numerous systems at Loviisa power plant designed to execute these safety functions in various situations. The designs of the safety functions have accounted for the fact that some of the equipment may have failed in a situation where it is required, that the systems have been isolated from each other to prevent damage from spreading, and that the equipment remains functional in demanding operational conditions. The safety functions also apply to the pools of spent fuel located next to the reactor in the power plant units and to the separate interim storages for spent fuel. However, the implementation of their safety functions differs significantly from the solutions applicable to a reactor.

A "severe reactor accident" refers to a situation in which a considerable portion of the reactor fuel fails. A severe reactor accident could occur if the reactor's systems executing the safety functions failed to work in an accident. Systems for the management of a serious reactor accident are in place at Loviisa power plant. Together with the instructions on accident management, these systems ensure the containment building's integrity and prevent it from breaking down.

In terms of external events, Loviisa power plant has accounted for powerful lightning storms, wind, variations in sea level, high seawater temperatures, and high and low outdoor temperatures, among other things. The impact of external events has been assessed extensively, and the changes necessary to lessen their impact have been made. In terms of the key safety systems, natural phenomena manifesting at a frequency of once every ten thousand or a hundred thousand years are accounted for, depending on the consequences of such an event. Events that recur once every ten million years are prepared for with the systems, and if necessary, in the special arrangements of Loviisa power plant. For example, the power plant has prepared for a rise in sea level which, with the expected climate of 2030, will be exceeded once in a hundred million years. This level would be equivalent to a level approximately 3.8 metres higher than the current average sea level. Even according to the most pessimistic climate change scenario, the sea level in Loviisa will not rise dramatically by 2050 when the land uplift in the power plant area is accounted for.

4.3 AGEING MANAGEMENT AND MAINTENANCE OF THE POWER PLANT

The ageing management programme and procedures cover the entire Loviisa power plant. Their aim is to ensure that the plant parts function as planned despite ageing. The plant parts have been divided into ageing management categories based on their significance in terms of safety, as well as in terms of parts that limit the plant's service life, and their significance for availability. The measures and monitoring procedures to which each piece of equipment is subject are determined according to the equipment's categorisation and properties. In some cases, the measure may consist of replacing the equipment with new equipment.

Fortum invests in the ageing management of Loviisa power plant and has carried out improvement measures throughout its operation. In recent years, extensive renewals have been carried out on the automation of the power plant, and ageing systems and equipment have been modernised. In 2014–2018, Loviisa power plant implemented the most extensive modernisation programme in the plant's history, in which Fortum invested approximately EUR 500 million. Thanks to the investments and skilled personnel, Loviisa power plant has excellent prerequisites with regard to the technical and safety-related requirements for continuing operation after the current licence period.

The following assessment, development and improvement targets have been identified on the basis of the power plant's operation and ageing management, and will be applicable if operation is extended:

- measures resulting from the ageing of some automation systems, such as ensuring the availability of spare parts or a system's modernisation;
- ensuring the safety margins of the primary system and the reactor pressure vessel, particularly the safety margins applicable during operation;
- the potential modernisation of the low-pressure turbines, which would also increase the power plant's efficiency;
- renovation of the existing buildings in the power plant area and the possible construction of new buildings. The potential new buildings would include an inspection or reception warehouse, a cafeteria building, a wastewater treatment plant, welding hall and a waste storage hall.

Any possible related measures and their timing are to be decided at a later date. Loviisa power plant has experience of similar work.

4.4 SAFETY OF DECOMMISSIONING AND PLANT PARTS TO BE MADE INDEPENDENT

The radiation work to be carried out during decommissioning, such as the preparation, dismantling and waste handling work, must comply with the same safety and radiation protection principles as during the power plant's operation. The nature of the tasks and the working environment will change so that the emphasis will shift to conventional occupational safety. The dismantling of contaminated and activated equipment and systems involves the performance of many work phases which do not usually occur during operation, such as the dismantling of concrete structures in the reactor hall and one-off extra-heavy lifts. Special attention must therefore be paid to the occupational safety of a conventional dismantling site during the decommissioning.

The control of the reactivity of the spent nuclear fuel in the interim storages for spent fuel is ensured with the help of the fuel pools' scaffolding structures and boron water. If the cooling of the pools is interrupted, the removal of residual heat from the fuel is not compromised in the short term due to the fuel's very low residual heat power and the great amount of water in the pools. While restoring the cooling would be the primary goal, the residual heat could also be removed by letting the water boil and by feeding make-up water into the pools. The make-up water can be fed into the pools with the plant's active systems or through the connection points made for fire trucks, for example.

The nature and significance of external threats to safety during decommissioning are very similar to those during operation. During the dismantling phase of the plant parts to be made independent, the power plant area will no longer contain spent nuclear fuel, due to which this phase of the decommissioning will not involve nuclear safety risks.

5. Environmental impact assessment in Finland

5.1 IMPACTS TO BE ASSESSED

This environmental impact assessment assesses the environmental impact of the project under review in the manner and accuracy required by the EIA Act and EIA Decree. The assessment and description of potentially significant environmental impacts must cover the project's direct and indirect, accumulative, short-term, medium-term and long-term, permanent and temporary, positive and negative effects, as well as its combined impacts with other existing and approved projects. According to the EIA Act, an EIA procedure assesses the impacts of the operations related to the project which concern:

- 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 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.

This impact assessment also included a review of other potential impacts centrally related to the project and identified as significant, but not listed in the Finnish EIA Act.

According to section 4 of the EIA Decree, an assessment report must present an assessment and description of the potentially significant environmental impacts of the project and its reasonable options as well as a comparison of the options' environmental impacts. The results of the environmental impact assessment work in terms of each operational phase are presented per impact in Chapters 9.2–9.24 of the EIA Report.

5.2 TIME OF THE IMPACTS AND REVIEW OF OPTIONS

The options reviewed in the EIA procedure are described in Chapter 2 of this document. Chapter 9 of the EIA Report reviews the operational phases included in the options, which involve extending operation by a maximum of 20 years after the current operating licences, decommissioning and the reception of radioactive waste generated elsewhere in Finland. The options consisting of the different operational phases are compared in Chapter 10 of the EIA Report.

Extended operation is included solely in Option VE1. The operational phase of decommissioning is part of all the options (VE1, VE0 and VE0+). The reception of radioactive waste generated elsewhere in Finland may materialise in Options VE1 and VE0+, and is reviewed as a separate function.

The operational phase of extended operation included in Option VE1 extends until approximately 2050. The operational phases related to decommissioning may be implemented either between 2025 and 2065 (VE0, VE0+) or between 2045 and 2090 (VE1). Radioactive waste originating from elsewhere in Finland can be received at Loviisa power plant for as long as the systems needed for the handling and treatment of the waste are available. In Option VE1, this is possible only until 2090 and in Option VE0+, only until 2065.

5.3 APPROACH TO AND METHODS OF IMPACT ASSESSMENT

The purpose of the environmental impact assessment is to systematically identify the impacts and their significance. "Impact" refers to a change in the status of the environment caused by the project, an option of the project or the operational phase of an option, and the significance of that change. The environmental impacts may be either negative or positive. They may also be neutral, in that no changes at all to the status of the environment can be observed.

In the EIA Report, "present state" refers to the current status of the power plant area's environment, in which the power plant is in operation. The magnitude of a change can be influenced by, among other things, its scope, duration or intensity. Therefore, the change can be a direct impact on the environment caused by a change in the operations or an operation that continues for a long period of time, maintaining an impact on the environment.

The significance of an impact in the environmental impact assessment is determined by the affected aspect's capacity to tolerate the observed impact, i.e. its sensitivity, and the magnitude of the change. The significance of an impact in the assessment was determined by cross-tabulating the sensitivity of the affected aspect and the magnitude of the change in terms of the different operational phases in connection with the assessment of each impact. The significance of the impact was determined on a four-step scale: minor, moderate, high and very high. The significance of the impact may be negative or positive, or there may be no impact at all.

The approach adopted in the assessment method is described in more detail in Chapter 9.1.4 of the EIA Report, and the assessment methods employed per impact in Chapters 9.2–9.24. In respect of the transboundary impacts, the assessment methods are presented in Chapters 9.21 and 9.24 of the EIA Report, and in Chapter 6.1.1 of this document.

5.4 UNCERTAINTIES RELATED TO THE IMPACT ASSESSMENT

The EIA procedure is part of the project's planning stage, and the planning data concerning the project will be specified as the project progresses to subsequent stages, such as the licensing processes. The baseline information and impact assessment applied may therefore include various assumptions and generalisations that may cause uncertainties in the assessment of environmental impacts. The EIA Report aims to identify potential uncertainties impact-specifically and assess their significance with regard to the reliability of the impact assessments' results.

5.5 REPORTS AND OTHER MATERIALS USED IN THE ASSESSMENT

The baseline data used in the description of the present state of the environment and impact assessment are presented per impact in Chapters 9.2–9.24 of the EIA Report.

Environmental surveys and reviews have been carried out in the vicinity of the Loviisa power plant area since the 1960s. The preparation of the EIA Report has relied on the reviews, studies and surveys conducted in the area (concerning, among other things, cooling waters and wastewaters, the sea area's nutrient inputs and currents, fishing, the population in the surrounding area, economic life, traffic, flora and fauna as well as the radiation monitoring of the environment).

Separate surveys have also been carried out to support the assessment and the existing data:

1) survey of harmful substances in sediments;
2) sub-bottom profiling of the seabed;
3) cooling water modelling;
4) avifauna survey;
5) ichthyofauna surveys (test net fishing and fry research);
6) assessment of the impacts on the regional economy;
7) resident survey and small group meeting;
8) accident modelling and dose calculation.

5.6 SUMMARY OF THE PRESENT STATE OF THE ENVIRONMENT IN FINLAND

The present state of the environment in Finland is described in connection with the impact assessment of each affected aspect in Chapters 9.2–9.20 of the EIA Report. In terms of the transboundary impacts, the present state and impacts are described in Chapter 6 of this document.

The island of Hästholmen is located outside the structure of the built-up area. The power plant area is situated in the area of the Helsinki-Uusimaa Land Use Plan 2050. The Helsinki-Uusimaa Land Use Plan 2050 uses a site reservation symbol to designate an energy management zone on the island of Hästholmen where nuclear plants are allowed. The power plant area has a five-kilometre precautionary action zone, indicated in the plan. In the master plan, the area of Hästholmen is indicated as an energy management zone. To ensure the safety of the power plant and its surroundings, air traffic is prohibited in the Hästholmen area. In the landscape province division, the power plant area belongs to the landscape province of the southern coastland and the coastal area of the Gulf of Finland. In addition to the power plant, the Port of Valko stands out as a clear exception to the landscape's natural state. In 2019, Loviisa's population was 14,772. Approximately 12,400 people live within a distance of 20 kilometres of the power plant. There are plenty of recreational settlements in the vicinity of Hästholmen.

The average daily traffic on Loviisa power plant's incoming route (Atomitie) in 2019 amounted to approximately 693 vehicles, of which heavy vehicles accounted for some 5%. Noise in the surroundings of the power plant area is currently affected by Loviisa power plant, traffic noise and the sounds of nature. The noise levels have complied with the requirements of the environmental permit. Vibration in the power plant area is mostly the result of traffic, and very local in nature. Emissions into air (including sulphur and nitrogen oxides as well as dust) on the island of Hästholmen are low, and the air quality in Loviisa is good. The operations of Loviisa power plant do not generate direct greenhouse gas emissions. Small amounts of radioactive substances from the power plant are released into the air and waterway in a controlled manner after purification. The discharges of radioactive substances into the air and waterway have remained significantly below the emission limits. The radioactive emissions resulting from the power plant's normal operation are so small that it is impossible to measure the radiation dose of members of the public attributable to them. The calculated estimate is presented in Chapter 4.1.

The power plant area has been in its current use since the 1970s, due to which there is no direct use of natural resources in the area. The quarry material generated in the quarrying of the L/ILW repository has been used outside the power plant area. The nuclear fuel is procured from a nuclear fuel supplier. Finland applies the principle of an open fuel cycle, in which spent nuclear fuel is enclosed in durable capsules deposited deep in the bedrock for final disposal. The uranium reserves extracted with current methods are expected to last for roughly 100–200 years in an open fuel cycle. New methods for the exploitation of uranium reserves can be adopted in the future if the price of uranium increases. In this case, the uranium reserves would last considerably longer. In Finland, nuclear power accounted for 27.6% of the total production of electricity in 2020. Loviisa power plant's importance for the vitality of Loviisa's regional economy is significant, and up to 70.6% of all new investments in the Loviisa sub-regional area involve the energy sector.

The soil in the Hästholmen area consists primarily of stony and rocky moraine, and the bedrock consists of the rapakivi granite typical of the Loviisa area. There are no categorised groundwater areas in the vicinity of Hästholmen. A drop in the level of groundwater was observed in connection with the L/ILW repository's construction. The level dropped in varying degrees across the entire island. The island of Hästholmen is located on the boundary of the coastal and outer archipelago in the Gulf of Finland. Based on the monitoring results, cooling water increases the temperature of seawater, and temperature stratification has been found to be stronger than normal, particularly in the vicinity of the discharge location in Hästholmsfjärden. The ecological status of the bodies of water in Hästholmen's nearby sea areas (the second planning period of water resources management) ranges from bad to moderate. The ichthyofauna in the sea area surrounding Hästholmen consists of both marine fish and freshwater fish species adapted to the brackish water, and its structure does not differ from observations made elsewhere in the Gulf of Finland to any notable degree. The region of Loviisa lies in the southern boreal zone. The Natura 2000 network site closest to the power plant area is the Källaudden–Virstholmen area in the southwest.

5.7 SUMMARY OF THE ENVIRONMENTAL IMPACTS OF NORMAL OPERATIONS IN FINLAND

The environmental impacts of Loviisa power plant's normal operations are local, concerning mainly the power plant area's vicinity in Finland. In the EIA Report, the environmental impacts and their significance in terms of the different operational phases are described in Chapters 9.1–9.20. Transboundary impacts are possible primarily in the event of incidents or accidents, described in more detail in Chapter 6 of this document and Chapters 9.21, 9.22 and 9.24 of the EIA Report. Chapter 10 of the EIA Report contains a comparison of the options (VE1, VE0/VE0+) and the conclusions.

5.7.1 Environmental impacts of the different operational phases

The impact assessment reviewed the operational phases taking place after the power plant's current licence periods, which consist of either extending the operation by a maximum of 20 years or decommissioning, and the resulting environmental impacts. The handling, interim storage and final disposal of radioactive waste generated elsewhere in Finland was also reviewed as a separate function. The review accounted for the significance of the impacts impact-specifically, based on the affected aspects' sensitivity and the magnitude of the change. The impacts of the operational phase of extended operation were assessed at furthest until 2050. The assessment of the operational phase of extended operation accounted for the operations involved, all the way up to the closure of the L/ILW repository.

Operational phase of extended operation

In the operational phase of extended operation, the impacts with the greatest positive significance involve the regional economy. Loviisa power plant's impacts on the regional economy are extremely high and positive at the level of the Loviisa sub-regional area and are also visible at the level of the entire country.

The energy markets and security of supply are also expected to be subject to positive impacts of a major significance. The extended operation of Loviisa nuclear power plant would support the security of supply of Finland's energy system and reduce the need to import electricity as its consumption grows in the future.

The impacts on greenhouse gas emissions and climate change are moderate and positive in significance. The extended operation of Loviisa power plant would support Finland's goal of being carbon neutral by 2035, because the use of nuclear power in the production of electricity does not generate direct greenhouse gas emissions.

The impacts on flora, fauna and conservation areas are expected to be minor and positive, particularly in terms of the avifauna, given that the power plant's cooling water would maintain, in the event of extended operation, Hästholmsfjärden's significance as regionally important wintering grounds for waterfowl.

The thermal effect on surface waters would continue at the current level in the operational phase of extended operation. The potentially warming climate combined with the thermal load of the cooling water could increase the thermal effect in the vicinity of the discharge location. This is expected to have an at most moderate and negative local impact in Hästholmsfjärden. A slight deterioration in the status of the Klobbfjärden body of water – composed of the bay areas of Hästholmsfjärden and Klobbfjärden – resulting from the combined impact of the thermal effect and the point source diffusion of nutrients cannot be ruled out.

The impacts on the icthyofauna are expected to be moderate and negative. The continuation of the power plant's thermal effect would maintain a situation in the sea area that favours fish species adapted to warm water, such as pike-perch and cyprinids. Warmer waters could also allow non-native species to become more abundant in the area. The impact on fishing is expected to be minor and negative.

The operational phase of the power plant's extended operation is expected to have a negative impact of minor significance on land use, land use planning, the landscape, traffic as well as people's living conditions and comfort.

Emissions of radioactive substances, radiation exposure and the accumulation rate of spent nuclear fuel as well as low- and intermediate-level waste would remain on their current level, with a minor and negative significance. The radiation dose caused to residents in the surrounding area by Loviisa power plant has been clearly below one per cent of the dose constraint set by the government, which is 0.1 mSv a year.

Operational phase of decommissioning

Once the power plant is no longer in operation, its highly positive impacts on the regional economy will come to an end. Regional economy impacts which partly substitute for this will nevertheless be created for different operators and industries during the operational phase of decommissioning. These will continue to have a highly positive impact on the sub-regional area of Loviisa. The impacts on the regional economy will end entirely once the decommissioning has concluded.

The impacts on surface waters will have a moderate and positive significance in the Klobbfjärden body of water close to the discharge location when the thermal load in the sea area comes to an end. At this point, the temperature and stratification conditions of the surface water and the length of the growing season will return to the natural state. The positive impacts may appear with a delay. The decommissioning will not weaken the category of the quality factors of the ecological status or prevent the body of water from attaining a good status.

The icthyofauna is expected to be subject to impacts with moderate and positive significance when the thermal load's impact on the marine ecosystem comes to an end. The fishing opportunities in winter will return to a better level, due to which fishing is expected to be impacted in a minor and positive way.

In addition, the decommissioning is expected to have minor and positive impacts on land use, land use planning, the landscape and the use of natural resources.

The power plant's decommissioning will have a highly negative impact on the energy markets and security of supply. The power plant's decommissioning will result in a need to procure electricity free of carbon dioxide emissions for Finland to achieve its carbon neutrality objective. This requires the construction of new electricity production capacity in Finland and the increased import of electricity. The possibilities for exporting electricity from Finland will also reduce.

The impact on greenhouse gas emissions and climate change is expected to be moderate and negative. The decommissioning of Loviisa power plant will lead to a need to increase other emission-free electricity production capacity to an equal degree.

Traffic impacts are expected to be at most moderate and negative. Traffic volumes will increase on a temporary basis during the dismantling phases, possibly impairing the smooth flow of traffic. The increase in traffic volumes could increase road safety risks, particularly on Atomitie and Saaristotie.

The impacts on people's living conditions and comfort are expected to be moderate and negative, given that the power plant's decommissioning will result in a significant and observable change in the operations taking place in the power plant area. The power plant's decommissioning and termination of electricity production may result in changes to the local identity and in both concerns about the effect that the change will have on the vitality of the Loviisa region and actual changes. All in all, the various phases of the decommissioning will take several decades.

The decommissioning is also expected to have a minor and negative impact on noise, vibration, air quality and on the flora, fauna and conservation areas.

The impacts on the soil and bedrock as well as groundwater resulting from the expansion of the L/ILW repository will be minor. The dismantling of radioactive parts and the handling of decommissioning waste during the decommissioning will result in radiation exposure, which will remain below the dose limits. Following the closure of the L/ILW repository, the final disposal will meet the long-term safety requirements.

Radioactive waste generated elsewhere in Finland

The reception, handling, interim storage and final disposal of any low-level and intermediate-level waste generated elsewhere in Finland within the Loviisa power plant area would not have an impact for the most part.

However, the reception of radioactive waste generated elsewhere in Finland is expected to have a moderate and positive impact at the level of the entire country. The use of Loviisa power plant's existing functions and facilities applicable to the handling and final disposal of radioactive waste would support the overall social solution and the development of safe waste management at a national level.

The handling of radioactive waste generated elsewhere in Finland will result in minor radiation exposure. The waste handling and final disposal will be executed in such a way that their impact on the radiation doses of the personnel and members of the public in the environment is minor and that the long-term safety requirements will be met. There may also be minor negative impacts on people's living conditions and comfort.

5.7.2 Comparison of options and conclusions on the most significant environmental impacts

When reviewing and comparing the project's options (VE1, VE0 and VE0+), one must take into account that extended operation (VE1) would also include decommissioning to be carried out at a later stage and the reception of radioactive waste generated elsewhere in Finland.

The most significant difference between the options is the time at which the operational phases that would occur in the power plant area would be carried out (Figure 2-4).

The significance of the environmental impacts differs in the different operational phases. In all options, the final situation will ultimately be the same, in that operations such as they currently are in the power plant area will have ended.

In extended operation (VE1), the environmental impacts are in their entirety greater than in the other options, because the option includes the power plant's longer operating time and its decommissioning as well as the reception of radioactive waste generated elsewhere in Finland.

The option of extending the operation of Loviisa nuclear power plant (VE1) supports Finland's objective to be carbon neutral by 2035, in line with the Programme of Prime Minister Sanna Marin's Government. Extended operation would create significant economic benefits through the value chain and the multiplier effect, particularly at the local and regional levels. The most significant negative impact up until 2050 in Option VE1 is the warming impact that the cooling water discharge side would have on the sea area, the significance of which was deemed at most moderate and negative.

In Option VE1, the impacts of the cooling water would end in 2050 as a result of the end of commercial operation, as would the major positive impacts on the regional economy resulting from the power plant's extended operation. The major negative impact that the end of the power plant's commercial operation will have on the energy markets and security of supply would also materialise in 2050. During the decommissioning of the power plant, partly substituting regional economy impacts will be generated for different operators and industries, but their impact will remain smaller than the impact of the commercial operation.

In Option VE1, the power plant's operation would continue in its current form until 2050, and significant direct impacts on the regional economy would be accumulated during the additional years of operation. In addition, turnover would be generated for other industries in the Loviisa sub-regional area in 2030–2090 (2030–2080 in the regional economy modelling) in excess of EUR 800 million in the form of multiplier effects, while the value added would amount to more than EUR 460 million, and the need for labour to more than 8,900 person-years. Correspondingly, the regional economy's multiplier effects across Finland would amount to more than EUR 5,800 million in turnover, more than EUR 2,900 million in value added and more than 44,200 person-years in need for labour. Clearly more than half the regional economy impacts would concern the period between 2030 and 2050. The regional economy impacts in Option VE1 would come to an end around 2090, when the decommissioning concludes.

In Option VE1, radioactive waste generated elsewhere in Finland can be received at Loviisa power plant until around 2090. While this will not have a significant environmental impact, the reception of radioactive waste generated elsewhere in Finland will have a moderate positive impact on the level of the entire country. It would benefit the interests of the entire society by providing a safe and cost-effective final disposal solution for radioactive waste originating from various sources.

In the decommissioning option (VE0/VE0+), Loviisa nuclear power plant's commercial operation will end as the current operating licences expire, at which point the at-most moderate and negative impact that the cooling water discharge side has by warming the sea area would come to an end, as would the major regional economy impacts during the power plant's operation. A highly negative impact on the energy markets and security of supply would also materialise in 2027 and 2030.

In Option VE0/VE0+, the power plant's decommissioning, which would take place between the late 2020s and circa 2065, would generate new demand in the form of multiplier effects in the Loviisa sub-regional area to a total of roughly EUR 300 million, value added in excess of EUR 170 million and need for labour in excess of 3,800 person-years. Correspondingly, the regional economy impacts across Finland would total more than EUR 2,200 million in turnover, more than EUR 1,100 million in value added and more than 17,500 person-years in the labour requirement. In Option VE0, the regional economy impacts would be focused on the 2030s.

In Option VE0+, radioactive waste generated elsewhere in Finland could be received at Loviisa power plant until around 2065. As in VE1, this would not have significant environmental impacts, but it would promote the interests of society as a whole.

Based on the assessments made, the project's options VE1, VE0 and VE0+ are feasible in terms of their environmental impacts. The means for preventing and mitigating the adverse effects presented in the assessment report allow for mitigating the potential environmental impacts, provided that they are accounted for in the project's further planning and implementation insofar as possible.

The operation of Loviisa nuclear power plant is very stable, and its environmental impacts are well known. The techniques, processes and the means by which to mitigate the impacts are well known. In extended operation, attention would be paid to the management of the plant's ageing. These measures would serve to ensure the power plant's safe further use. The operations include monitoring the development of the best available technique (BAT), legislation's requirements for the industry and experiences from other nuclear power plants. The decommissioning plan will be updated and specified as the project progresses.

6. Assessment of transboundary impacts

Transboundary impacts are possible only in the event of a severe reactor accident. A severe reactor accident at the power plant is a highly unlikely extreme event, the materialisation of which would require several failures in the plant's systems and problems in the plant's control. Various incidents and accidents, including a severe reactor accident, have been prepared for in the plant's design and operation so that their consequences can be minimised. The fuel will be removed from the reactors to the interim storages for spent fuel during the initial phase of the decommissioning, after which a severe reactor accident will no longer be possible.

6.1 IMPACTS OF A SEVERE REACTOR ACCIDENT

In the event of a nuclear power plant accident, radioactive substances detrimental to health could end up in the environment. The assessment concerning the environmental impacts of a severe reactor accident is based on the postulation that 100 terabecquerels (TBq) of the caesium-137 (Cs-137) nuclide, which has been defined as the limit value for a severe reactor accident in Finland, are released into the environment. Furthermore, the emission would include other radionuclides in proportion to what would be expected to be released in the accident. In Finland, the limit value has been defined not to result in a need for large-scale protection of the population or long-term restrictions in the use of extensive land and water areas. From the perspective of the International Nuclear and Radiological Event Scale, the fictitious severe reactor accident reviewed would be an INES level 6 accident, which is the second most severe level on the scale.

In the severe reactor accident reviewed, the power plant is producing electricity for the national grid at full capacity when a pipe of the primary system connected to the reactor breaks (Figure 2-3). As a result of several failures, the reactor's water level drops, due to which the fuel is damaged, and radioactivity is released into the containment building. The accident is also assumed to include a leak from the containment building, as a result of which the activity is provided with a leakage route from the containment building to the atmosphere. The emission is assumed to begin some 2.5 hours after the reactor's shutdown (reactor trip) and it will be released into the atmosphere, unfiltered, at a height of approximately 31 m above ground level. The impacts of the emission were modelled by employing 22 hours as the duration of the emission in the dose calculation. The impact of the dispersion of the release was studied over a distance of 1,000 km from the power plant.

6.1.1 Methods of assessment

The modelling of the migration of radioactive substances, fallout and radiation doses was carried out with the Tuulet program developed by Fortum. The modelling is based on the Tuulet 2.0.0 program version – used for Loviisa power plant's analyses and approved by the Radiation and Nuclear Safety Authority – modified for the purpose of the environmental impact assessment to allow for an assessment of the emission up to a distance of 1,000 km from the power plant (Figure 6-1).

The radiation dose in the modelling is accumulated through both external and internal dose pathways. The modelling of the radiation dose did not include any postulated action aiming to protect the population. This means that the radiation dose-reducing effect of seeking shelter indoors and making changes in food intake has not been taken into account. The fallout and radiation doses are presented according to a 5% exceeding probability, meaning that there is a 95% probability that the fallout or radiation dose would remain smaller than the result presented here.

In accordance with the recommendations of the International Commission of Radiological Protection (ICRP), the radiation doses were estimated for one-year-old and 10-year-old children, and for adults. The exposure periods applied were two days, seven days and one year, in addition to which lifelong exposure was also considered.

With regard to extended operation, the estimates also include accidents less severe than a severe reactor accident. However, these accidents would not exceed any limits.

6.1.2 Results of the assessment

Tables 6-1 and 6-2 show the radiation doses estimated on the basis of the dispersion calculation and the fallouts, at different distances, of the nuclides causing the biggest radiation doses. Based on the results of the modelling, a severe reactor accident would not have direct health effects on the residents of the power plant's nearby areas or beyond the borders of Finland.

Based on the modelling, the greatest radiation dose at a distance of one kilometre, accounting for all age groups, is approximately 25 mSv during the first two days, and approximately 27 mSv during the first week. Radiation doses of this magnitude do not result in direct radiation effects on humans, given that a change in complete blood counts within a few days, for example, requires a radiation dose of approximately 500 mSv. A roughly 30-mSv radiation dose is equivalent to three whole-body CAT scans.

When the results of the modelling are compared to the annual average radiation dose of a person residing in Finland, which is around 5.9 mSv a year, one can conclude that the amount of radiation accumulated by a person residing in Finland from other sources over 50 years is approximately 295 mSv. In addition, a person living in a block of flats in a location in which they are exposed to abundant radon may be subject to a radiation dose in excess of 1,500 mSV due to the radon over a period of 50 years.

Based on the modelled radiation doses (Table 6-1) and fallout estimations (Table 6-2), the limit values applied in Finland for seeking shelter indoors or evacuation are met at a distance of five kilometres from the power plant.

According to the limit values applied in Finland, the area at a distance of less than one kilometre from the power plant is extremely contaminated, meaning that the area contains abundant radioactivity on all surfaces. The area at the outer limit of the power plant's precautionary action zone (at a distance of five kilometres from the plant) is heavily contaminated. The area at a distance of 80 kilometres is contaminated, and starting from a distance of 80 kilometres, the area is mildly contaminated or nearly clean. The consequences of the accident would include the clean-up of the built environment, restrictions to the recreational use of the natural areas, and arranging measurements and purification for the people residing in the area, up to a distance of less than 15 km from the power plant. The use of built-up recreational areas would also have to be restricted up to a distance of 80 kilometres. The authorities would also impose restrictions on products used as food, such as berries, mushrooms, fish, game and dairy products, based on their activity concentrations.

Figure 6-1 illustrates the distances to other countries up to a distance of 1,000 kilometres from Loviisa nuclear power plant, and Table 6-3 shows the country-specific radiation doses resulting from the radioactive emission of a severe

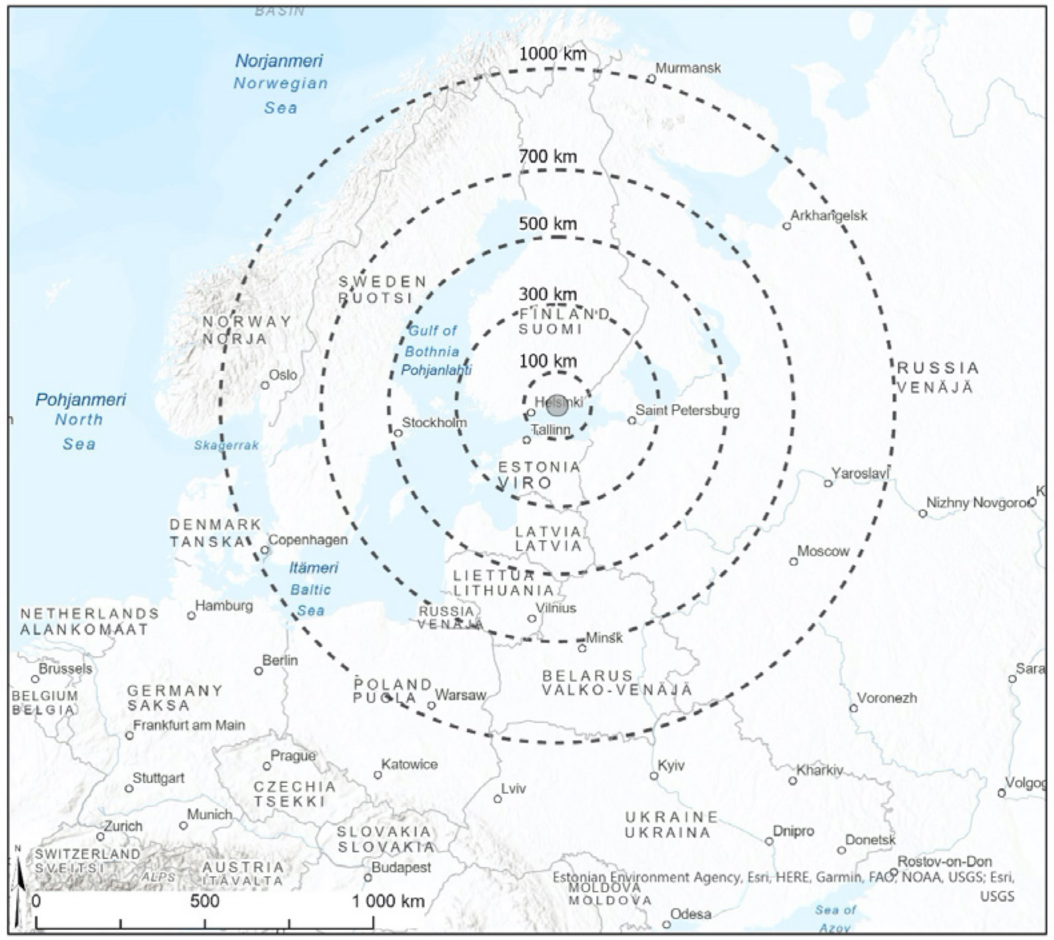

Figure 6-1. Indicative distances from Loviisa nuclear power plant, up to 1,000 km.

Table 6-1. The radiation doses caused by a severe reactor accident to a one-year-old, 10-year-old and an adult at a distance of 1–1,000 km from the emission's release point over two days, seven days, one year and the person's lifetime.

	Estimated dose of the one-year-old [mSv]				Estimated dose of the 10-year-old [mSv]				Estimated dose of the adult [mSv]			
Distance [km]	2 d	7 d	1 a	70 a	2 d	7 d	1 a	60 a	2 d	7 d	1 a	50 a
1	24.1	26.1	121.0	267.0	25.2	27.4	105.0	292.0	19.5	21.6	88.8	320.0
5	4.4	4.8	26.1	60.1	4.5	4.9	22.9	65.7	3.8	4.1	20.1	73.1
10	2.0	2.2	15.0	27.7	2.1	2.2	10.6	30.0	1.8	1.9	10.0	34.1
15	1.3	1.4	11.7	21.3	1.4	1.5	7.9	20.1	1.2	1.3	7.0	22.1
20	1.0	1.1	8.0	14.5	1.0	1.1	5.4	13.9	0.9	1.0	4.8	15.2
50	0.35	0.37	2.08	3.91	0.36	0.38	1.49	3.78	0.32	0.35	1.35	4.26
100	0.23	0.23	0.31	0.41	0.23	0.23	0.28	0.40	0.22	0.23	0.27	0.43
300	0.07	0.07	0.11	0.16	0.07	0.07	0.10	0.16	0.07	0.07	0.09	0.17
500	0.04	0.04	0.06	0.09	0.04	0.04	0.05	0.09	0.04	0.04	0.05	0.10
700	0.02	0.02	0.04	0.06	0.02	0.02	0.03	0.06	0.02	0.02	0.05	0.06
1 000	0.01	0.01	0.02	0.03	0.01	0.01	0.02	0.03	0.01	0.01	0.02	0.04

Table 6-2. The depositions of the nuclides causing the greatest radiation doses through fallout at different distances from the power plant in a severe reactor accident.

	Deposition [kBq/m²]									
Distance (km)	Cs-134	Cs-137	I-131 (aerosol)	I-131 (organic)	I-131 (element)	I-132 (aerosol)	I-132 (organic)	I-132 (element)	Te-132	Sr-90
1	706	441	4,353	0.5	1,472	5,424	0.6	1,828	4,983	1.1
5	126	79	779	0.07	181	970	0.09	225	892	0.2
10	56	35	344	0.03	65	429	0.04	81	394	0.09
15	33	21	205	0.02	35	256	0.02	43	235	0.05
20	23	21	141	0.01	22	176	0.02	28	162	0.04
50	6.3	4.0	39	0.005	4.8	49	0.006	6.0	45	0.01
100	0.4	0.3	2.6	0.0004	0.2	3.3	0.0005	0.3	3.0	0.0007
300	0.2	0.1	1.1	0.0003	0.07	1.4	0.0004	0.09	1.2	0.0003
500	0.1	0.07	0.7	0.0003	0.04	0.8	0.0003	0.05	0.8	0.0002
700	0.08	0.05	0.5	0.0002	0.03	0.6	0.0003	0.04	0.05	0.0001
1,000	0.05	0.03	0.3	0.0002	0.02	0.4	0.0002	0.03	0.03	0.0001

Table 6-3. The magnitudes of the estimated country-specific lifelong radiation doses of children and adults attributable to a severe reactor accident up to a distance of 1,000 kilometres from the power plant. The range of the radiation doses corresponds to the approximate distance to Loviisa power plant from areas within a state's borders.

Country	The approximate distance of the state's areas from Loviisa power plant (maximum, minimum) [km]	Range of one-year-old's lifelong dose [mSv]	Range of 10-year-old's lifelong dose [mSv]	Range of adult's lifelong dose [mSv]
Estonia	300, 100	≤0.16–0.41	≤0.16–0.40	≤0.17–0.43
Russia	1,000, 100	≤0.03–0.41	≤0.03–0.40	≤0.04–0.43
Sweden	1,000, 300	0.03–0.16	0.03–0.16	0.04–0.17
Latvia	500, 300	0.09–0.16	0.09–0.16	0.10–0.17
Lithuania	700, 500	≤0.06–0.09	≤0.06–0.09	≤0.06–0.10
Belarus	1,000, 500	≤0.03–0.09	≤0.03–0.09	≤0.04–0.10
Norway, Poland, Ukraine, Denmark	1,000, 700	≤0.03–0.06	≤0.03–0.06	≤0.04–0.06
Germany	1,000	≤0.03	≤0.03	≤0.04

reactor accident up to a distance of 1,000 kilometres from Loviisa nuclear power plant.

According to the European Commission, the annual doses caused by natural background radiation in the European area are approximately 1.5–6.2 mSv a year (https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Download-page). Compared to this, the radiation doses attributable to the emission of the severe reactor accident beyond Finland's borders would remain small enough to be negligible from a general statistical perspective. Table 6-3 shows the rough level of radiation doses' magnitude in various countries up to a distance of 1,000 kilometres, based on the distances employed in the modelling and shown in Figure 6-1. The estimated lifelong radiation doses for an adult are 0.43 mSv at maximum and ≤0.04 mSv at minimum. Children's estimated lifelong radiation doses are basically of an equivalent size.

The greatest transboundary radiation doses focus on the vicinity of Estonia and Russia, whose borders are, at their shortest, a distance of roughly 100 km from Loviisa nuclear power plant. When the distance grows, the radiation doses decrease. The Swedish coast is around 400 kilometres from Loviisa nuclear power plant. Based on the estimate, the lifelong dose in the area of the state of Sweden is a maximum of 0.16 mSv for children and 0.17 mSv for adults (the doses are shown conservatively from the counting point of 300 km). In northern and southern Sweden, at a distance of roughly 1,000 km, the lifelong radiation doses of children and adults are in the region of 0.03–0.04 mSv.

The radiation doses would decrease as the distance increased. The review did not include radiation doses at distances in excess of 1,000 kilometres, but these doses would not exceed the values of 0.03–0.04 mSv estimated for a distance of more than 1,000 kilometres.

6.2 OTHER IMPACTS

In addition to the impacts of a severe reactor accident, the project's options are not expected to have other transboundary impacts. For example, the radiation dose of an adult at a distance of 100 kilometres from Loviisa power plant attributable to accidents less severe than the reviewed severe reactor accident would be, at maximum, around a negligible 0.005 mSv over a year's exposure period. The radiation doses would decrease as the distance increased.

6.3 MITIGATION MEASURES

The impact of a release caused by a severe reactor accident can be mitigated by various actions that aim to protect the population, such as the administration of iodine tablets, seeking shelter indoors and evacuations carried out at different times.

If the population is evacuated before the emission reaches an area, the radiation dose caused by the accident can even be avoided completely. If the population cannot, for one reason or another, be evacuated in time, seeking shelter indoors is an effective way to reduce the radiation exposure attributable to a radioactive emission cloud.

The impacts of the fallout can be mitigated in many different ways. Paved urban areas, for instance, can be washed, and land areas can be modified by removing the soil containing the largest depositions. In a fallout situation, the principal clean-up measures target living environments in which people spend a large part of their time or with a high population density.

In the event of an emergency exposure situation, the licence holder of a nuclear power plant would work in close cooperation with the Radiation and Nuclear Safety Authority. The Radiation and Nuclear Safety Authority would assess the situation's safety significance and give recommendations on protective action to the authorities which decide on such action.

7. Monitoring and observation of impacts

In accordance with the laws and regulations, the project owner has various monitoring and observation programmes involving environmental impacts in place. In the event of extended operation, the power plant's operations would be similar to what they currently are, which is why the observation and monitoring is expected to continue in much the same manner as currently. The monitoring and observation measures are discussed in Chapter 11 of the EIA Report.

The precise emission measurements of radioactive substances ensure that the power plant's combined emissions into the air and discharges into the water do not exceed the emission limits confirmed by the Radiation and Nuclear Safety Authority, and that the environmental radiation doses fall below the specified limits.

The environment of Loviisa power plant is monitored in accordance with the environmental radiation control programme. The status of radioactive substances in the power plant's surroundings has been monitored for a long time. The environmental radiation control aims to ensure that the population's radiation exposure attributable to a nuclear power plant is kept as low as reasonably achievable, and that the limit values specified in regulations are not exceeded. The Radiation and Nuclear Safety Authority also carries out its own independent radiation monitoring in the environment of Loviisa power plant.

The dispersion of radioactive substances released into the air during the power plant's normal operation or a possible accident is assessed with the aid of the meteorological measurements of Loviisa power plant's own weather observation system. During the power plant's operation, the radiation exposure of the population in the environment is estimated annually on the basis of the meteorological measurements and emissions.

The volume and quality of the cooling water and wastewaters conducted from the power plant into the sea is monitored in accordance with the valid monitoring programme. The impact monitoring conducted in Loviisa power plant's nearby sea area includes the monitoring of the quality (physico-chemical quality) of the seawater as well as biological and fishery economics monitoring.

The monitoring also covers the operations' flue gas emissions and noise and the keeping of records on radioactive and conventional waste, regular monitoring of rock mechanics, hydrology and groundwater chemistry, and the impacts on humans, which are investigated with the aid of discussion events and resident surveys, among other things.

8. Permits, plans and decisions required by the project in Finland

8.1 DECISIONS AND LICENCES PURSUANT TO THE NUCLEAR ENERGY ACT

The power plant units of Loviisa nuclear power plant have operating licences in accordance with the Nuclear Energy Act which are valid until the end of 2027 and 2030. The operating licence of the final disposal facility for low- and intermediate-level waste (the L/ILW repository) is valid until the end of 2055. The L/ILW repository will require a new operating licence in both options (VE1 and VE0/VE0+). The power plant units will require new operating licences in the event that the power plant's operation is extended. The decommissioning of the power plant units requires the application of a decommissioning licence. The operating licence and decommissioning licence are issued by the government. The plant parts to be made independent require a separate operating licence once the operating licence of the power plant units expires, and they will begin to be dismantled as the decommissioning licence takes effect. In addition to the operating licence and decommissioning licence, the project options may require other licences in accordance with the Nuclear Energy Act.

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, a preparedness plan. Posiva is responsible for the transports of spent fuel for encapsulation and final disposal in Eurajoki, Olkiluoto. All transports of nuclear waste or radioactive substances are subject either to a notification to the Radiation and Nuclear Safety Authority or the application of a transport or safety licence in the manner required by the valid law.

8.2 OTHER PERMITS

Any radiation practice of Loviisa power plant other than the operation of nuclear energy requires a safety licence pursuant to the Radiation Act.

The potential modification of buildings in the power plant area, and the construction of the required infrastructure and any additional facilities, require a building permit. In Loviisa, the town's building and environmental board is responsible for the duties and decision-making of the building inspection authorities.

The operation of a nuclear power plant requires an environmental permit pursuant to the Environmental Protection Act and a water permit pursuant to the Water Act for the water abstraction and discharge structures. Fortum has valid environmental and water permits. The need for changes to the existing environmental and water permits will be assessed in cooperation with the authorities if an operating licence for continuing operations after 2027/2030 is applied for (and issued). According to the assessment, the impacts of Loviisa nuclear power plant will remain much the same as they are today. The permit authority is the Regional State Administrative Agency for Southern Finland.

Facilities engaged in the extensive industrial handling and storage of chemicals require a chemicals permit granted by the Finnish Safety and Chemicals Agency. Fortum's Loviisa 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 Finnish Safety and Chemicals Agency. When operations change, such as when initiating decommissioning, the necessary notifications will be made, and the required permits and licences will be applied for in accordance with the Act on Chemical Safety.

The power plant and its extended operation and decommissioning also require numerous other permits and plans, and are linked to the designs and programmes presented in Chapter 12.9–12.10 of the EIA Report.