Application for a Construction License pursuant to Section 18 of the Nuclear Energy Act (990/1987) for the Hanhikivi 1 Nuclear Power Plant

June 2015

Updated August 5, 2015

FENNOVOIMA

Application for a Construction License pursuant to Section 18 of the Nuclear Energy Act (990/1987) for the Hanhikivi 1 Nuclear Power Plant

June 2015

Updated August 5, 2015

Content

Construction License Application for Hanhikivi 1 nuclear power plant

Appendices

Information about Fennovoima

Fennovoima's organization and available expertise

Nuclear power plant site

Safety of the nuclear power plant

Nuclear fuel and nuclear waste management at the nuclear power plant

Construction License Application for Hanhikivi 1 nuclear power plant

Construction License Application for Hanhikivi 1 nuclear power plant

Application

In this application, Fennovoima Oy (hereinafter referred to as "Fennovoima" or "the company") requests from the Government a license pursuant to section 18 of the Nuclear Energy Act (990/1987) to construct a nuclear power plant as referred to in section 3, subsection 1, paragraph 5 a of the Nuclear Energy Act at the planned site on the Hanhikivi headland, Pyhäjoki. The plant unity to be built will comprise a nuclear power plant unit intended for the production of electricity, and nuclear facilities required for the operation of the power plant and located at the same plant site, including storage facilities for fresh nuclear fuel, processing and storage facilities for low and intermediate level reactor waste, and interim storage facilities for spent nuclear fuel.

Applicant

Fennovoima is a Finnish limited liability company whose business identity code is 2125678-5. The company is domiciled in Helsinki, Finland. An extract from the trade register, the articles of association and shareholders' register of the company are appended to this application as Appendix 1A.

Fennovoima was founded for the purpose of producing electricity at cost price for the needs of its owners, and the company operates in accordance with the Mankala principle. After the completion of the nuclear power plant, the company shareholders will be, under the Mankala principle, entitled to the electricity produced at the facility in proportion to their ownership. They are also obligated to cover all the costs incurred by the company in its electricity production operations as has been stated in the articles of association and the shareholders' agreement. In this application, companies that are entitled to the electricity produced by Fennovoima based on their direct or indirect ownership of shares are referred to as Fennovoima's shareholders.

In the Government's decision-in-principle M 6/2014 vp, described in the decisions-in-principle section of this application, the Government stated that a minimum of 60% of Fennovoima's ownership must be held by operators domiciled within the EU or the EFTA. Of Fennovoima's share capital, 66% is owned by Voimaosakeyhtiö SF, and 34% by RAOS Voima Oy. More than 60% of Fennovoima's ownership is held by operators who have committed to further financing of the project, and who are domiciled within the EU or EFTA. For a more detailed description of Fennovoima's ownership base, see Appendix 1B of this application.

Project

Fennovoima will build at the plant site on the Hanhikivi headland, Pyhäjoki, one nuclear power plant unit with a thermal power of 3,220 MW and an electrical power output of 1,200 MW and other nuclear facilities stated in the decision-in-principle and required for the operation of the power plant unit.

Fennovoima will use the nuclear power plant to produce energy for its owners. The unit's planned service life is 60 years.

Fennovoima's nuclear power plant unit is supplied by RAOS Project Oy, which is a part of the Rosatom Group. The plant type is Rosatom's AES-2006 pressurized water reactor. The plant supply contract concluded by Fennovoima is based on a turnkey delivery model to be carried out by one main supplier. This means that the plant supplier will be responsible for the majority of the design of the nuclear power plant, acquisition of components, and construction of the facilities. Fennovoima's scope of work will mainly consist of the construction of administrative buildings, such as the office facilities and the visitor center. Fennovoima will also be responsible for building the interim storage facility for spent nuclear fuel and the repository for low and intermediate level reactor waste.

The interim storage facility for spent nuclear fuel will be a building separated from the rest of the facilities. A construction license for the storage facility is applied for by this application, but the detailed design and construction of the facility will not be carried out until the nuclear power plant unit is operational.

The repository for low and intermediate level reactor waste will be built at a later stage, and it will be used for the final disposal of the low and intermediate level nuclear waste generated in the operation and decommissioning of the nuclear power plant. Construction and operating licenses for the repository will be applied for at a later stage.

Decisions-in-principle

Fennovoima's nuclear power plant construction project has been found to be in line with the overall good of society in the decision-in-principle pursuant to section 11 of the Nuclear Energy Act, and thus meets the requirement set out in section 5 of the Nuclear Energy Act.

In its application dated January 14, 2009, Fennovoima applied for a decision-in-principle pursuant to section 11 of the Nuclear Energy Act regarding the construction of a nuclear power plant and nuclear facilities required for its operation. On May 6, 2010 the Government issued a decision-in-principle for Fennovoima's project (M 4/2010 vp) where the project was found to be in line with the overall good of society. On July 1, 2010 the Finnish Parliament decided that the decision-in-principle shall remain in force.

Due to changes having taken place in Fennovoima's shareholder base and plant alternatives after the original decision-in-principle was granted, Fennovoima submitted to the Government an application for a supplement to the decision-in-principle on March 4, 2014. On September 18, 2014, the Government issued a decision-in-principle (M 6/2014 vp) based on the application for a supplement. According to the decision-in-principle, the construction of a new nuclear power plant and the nuclear facilities required for its operation at the Pyhäjoki plant site in accordance with the valid Government decision M 4/2010 vp, supplemented in the manner presented by Fennovoima in the application filed on March 4, 2014, remains in line with the overall good of society. In its decision, the Government provided the supplement to the earlier decision-in-principle as applied for. On December 5, 2014 the Finnish Parliament decided that the decision-in-principle shall remain in force.

On the basis of the decision-in-principle, Fennovoima is permitted to construct one nuclear power plant unit with a maximum thermal output of 4,900 MW, and a repository for the low and intermediate level reactor waste from the nuclear power plant. The decision-in-principle also includes the nuclear facilities described above and located at the same plant site that are required for the nuclear power plant operations. These facilities will be used for the storage of fresh nuclear fuel, for the processing and storage of low and intermediate level reactor waste, and for the interim storage of spent nuclear fuel.

On September 20, 2013, Fennovoima submitted to the European Commission an investment notification in accordance with Article 41 of the Euratom Treaty. The Commission expressed its view on the Hanhikivi 1 project on June 3, 2015.

Plant site

In October 2011, Fennovoima selected the Hanhikivi headland in Pyhäjoki, Northern Ostrobothnia, as the site of the nuclear power plant.

Based on studies conducted by Fennovoima, the selected site meets the environmental and safety requirements set for a nuclear power plant site. In its statement regarding Fennovoima's decision-in-principle, as well as the supplement to the decision-in-principle, the Radiation and Nuclear Safety Authority (STUK) found that there are no features at the Pyhäjoki site that would prevent the construction of the new nuclear power plant and the related nuclear facilities referred to in the application for a decision-in-principle in compliance with the safety requirements.

In 2008, Fennovoima carried out an environmental impact assessment (EIA) procedure to assess the impacts from the construction and operation of a nuclear power plant of 1,500–2,500 MW consisting of one or two reactors at three alternative locations. Due to the changes that had taken place in plant alternatives, Fennovoima carried out in 2013–2014 the EIA procedure to assess the environmental impacts of the construction and operation of a nuclear power plant with an approximate power output of 1,200 MW at the selected plant site on the Hanhikivi headland. According to the environmental impact assessment report, the project will have no adverse environmental impacts that would be unacceptable or could not be mitigated to an acceptable level. The measures to manage the environmental impacts during the construction and operation of the nuclear power plant are presented in Appendix 3A of this application.

In its statement on the EIA report, issued as the coordinating authority of the EIA procedure, the Ministry of Employment and the Economy required Fennovoima to carry out additional surveys to investigate the power plant's impact on the marine environment and fishery during its operation. The results of these additional surveys are introduced in Appendix 3B of this application.

Land use in the Hanhikivi headland is prescribed by the Hanhikivi regional land use plan for nuclear power and the Raahe and Pyhäjoki component master plans and local detailed plans for the nuclear power plant area. The land use planning required for the nuclear power plant project is in force at all three levels of land use planning.

As of June 2015, a total of 504 hectares of land and water areas belonging to the Hanhikivi headland are under the management of Fennovoima. The 397.3 hectares that Fennovoima owns have been acquired through voluntary real estate transactions.

In addition, on December 11, 2014, the Government granted Fennovoima the power of eminent domain, based on the Act on the Redemption of Immoveable Property and Special Rights (603/1977), to acquire the areas defined in the Pyhäjoki and Raahe land use plans for the Hanhikivi nuclear power project and its support functions. In the same decision, the Government granted Fennovoima the right to take possession of the land and water areas subject to the power of eminent domain, a total of approximately 108 hectares, before the time referred to in section 57, subsection 1 of the Act on the Redemption of Immoveable Property and Special Rights. Complaints have been filed regarding the power of eminent domain with the Supreme Administrative Court. The complaint procedure is currently ongoing.

Since the granting of the power of eminent domain, Fennovoima has completed voluntary real estate transactions on two properties subject to the power of eminent domain. Two other areas subject to the power of eminent domain were taken possession of via eminent domain proceedings on March 25, 2015 (entry 2014–494430, MMLm/29405/33/2014). Fennovoima controls all the areas required for the nuclear power plant and its support functions either via direct ownership or based on the power of eminent domain and the right to take possession.

For a more detailed description of Fennovoima's nuclear power plant site and the land areas required for the construction of the nuclear power plant, see Appendix 3C of this application.

Schedule and manner of implementation

The preparation and procurement phases of Fennovoima's project have been completed. The procurement phase ended in December 2013 with the signing of a plant supply contract between Fennovoima and JSC Rusatom Overseas. In April 2015, the plant supply contract signed by Fennovoima and JSC Rusatom Overseas was assigned to RAOS Project Oy, a Finnish subsidiary of JSC Rusatom Overseas. The transfer of the contract is described in more detail in Appendix 4A of this application.

The delivery of the plant will be based on a turnkey delivery model carried out by one main supplier. This means that the plant supplier will be responsible for the majority of the design of the nuclear power plant, acquisition of components, and construction of the facilities. Fennovoima's scope of work will mainly consist of the construction of administrative buildings, such as the office facilities and the visitor center. Fennovoima will also be responsible for building the interim storage facility for spent nuclear fuel and the repository for low and intermediate level reactor waste.

Preparatory work on the plant site began in fall 2014 with the construction of a connection road to the site. Preparations for work at the site will continue until the construction license is granted. Nuclear power plant construction work subject to a license can only begin after the construction license has been granted, which is expected to take place early in 2018. According to plans, Fennovoima will apply for an operating license for the nuclear power plant during the final stages of the construction phase, around 2021. Commercial operation of the nuclear power plant has been planned to begin in 2024.

During the operation of the power plant, an interim storage facility for spent nuclear fuel, included in this application, will be built at the plant site. The construction work has been planned to begin in 2025. The interim storage facility is planned to be commissioned in 2030.

The schedule and implementation of the project are presented in more detail in Appendix 2A of this application.

Organization and expertise

Fennovoima has developed its organization and expertise to ensure that the company is able to fulfill its obligations as the buyer of the nuclear power plant and future license holder. These obligations include, in particular, the requirement specification for the nuclear power plant, review of plant design, the assessment of safety independent of the plant supplier, and project and quality management. Fennovoima will supervise the project progress, the plant design work, and the quality of the project implementation at all stages of the project in active cooperation with the plant supplier and the main subcontractors. As the future license holder, Fennovoima will be responsible for the safety of the plant. Fennovoima aims to run a safe, smoothly functioning construction site where occupational safety and employment matters are appropriately handled and the gray economy is effectively rejected.

In spring 2014, after the signing of the plant supply contract, Fennovoima began extensive recruitment campaigns. In mid-June 2015, Fennovoima personnel included 221 employees (June 15, 2015). The number of personnel in the company is planned to be approximately 370 in 2017, at the end of the licensing phase. At the end of the construction phase, the number of personnel in Fennovoima's organization is estimated at 500. Of this number, 240 people will be operating personnel, planned to be recruited to the company starting from 2019. The competence and experience generated during the construction of the plant will be utilized when forming the operating organization.

Fennovoima has recruited to the company nuclear power professionals with extensive experience in the preparation, design and construction of a nuclear power plant. Fennovoima has also recruited quality management professionals and specialists with solid project management competence in addition to their competencies within their own fields of expertise. The organization and management system of Fennovoima have been developed to support the implementation of the nuclear power plant project. One of the purposes of Fennovoima's management system is to ensure that nuclear and radiation safety is given priority in all the operations of the company. Fennovoima will pay special attention to a good safety culture and its development both within its own organization and in the organizations of the plant supplier and its subcontractors.

Fennovoima will also use external consultant and expert services in the project. The expert services to be used are mostly purchased from engineering and consulting companies that have experience in large projects in the nuclear energy industry or in other industries.

Fennovoima has in its use the required expertise for the safe execution of a nuclear power project in compliance with the regulations.

Fennovoima’s organization and the available expertise are presented in more detail in Appendix 2A of this application. An outline of Fennovoima's operating organization is presented in Appendix 2B.

Financial resources

The financial resources of Fennovoima's nuclear power project are based on the solid financial situation of its shareholders and on their commitment to cover the costs of power production in accordance with the Mankala principle. After the completion of the construction of the nuclear power plant, the company's shareholders will be, under the Mankala principle, entitled to the electricity produced at the facility in proportion to their shares of ownership and will be obliged to cover all the costs incurred by the company in electricity production as stated in the articles of association and shareholders’ agreement.

Because a nuclear power plant project requires substantial capital expenditure and the construction and commissioning phase lasts for several years, the owners must be committed and have the necessary financial resources to the implementation of the project. Fennovoima's shareholder base consists, among others, of listed industrial enterprises, municipal power utilities and the Russian state nuclear energy corporation Rosatom Group. With decisions made in spring 2014, Fennovoima's shareholders have given their commitment to the implementation and financing of the Hanhikivi 1 project.

The shareholders have agreed on equity investments and decided that the Rosatom Group, as the plant supplier and minority shareholder, will be responsible for acquiring long-term loans during the construction phase.

Fennovoima has the necessary financial resources to carry out the nuclear power plant project.

The financial resources of Fennovoima's project, as well as its economic viability, the project's cost estimate, and financing plan are described in Appendix 1C of this application.

Nuclear power plant type

The AES-2006 reactor type chosen by Fennovoima is a pressurized water reactor with an electrical output of approximately 1,200 MW. The plant type is based on the VVER plants developed by the Rosatom Group.

The long history of modern pressurized water reactors such as the AES-2006 has resulted in similar basic technology being used by all plant suppliers, and the main safety features – power control, reactor cooling and preventing the spread of radioactive releases – are based on similar solutions. The technical functionality and safety solutions of the AES-2006 thus represent well-established technology. Among the most noteworthy features of the AES-2006 representing new technology are the extensive utilization of passive cooling systems, the core catcher used in the management of severe reactor accidents, the programmable automation system, and the reactor containment able to withstand a collision of a large passenger airplane.

Fennovoima has reviewed the operating and safety principles of Rosatom's AES-2006 and found that the plant can be designed and constructed to meet the safety requirements set by Finnish authorities, and any other requirements that Fennovoima has set for the nuclear power plant. In its preliminary safety assessment, the Radiation and Nuclear Safety Authority (STUK) also stated that the AES-2006 plant alternative, chosen by Fennovoima, can meet the Finnish nuclear and radiation safety requirements following the implementation of design modifications, additional analyses and qualification procedures.

Constant observance of safety principles is a fundamental precondition for the safe construction, operation and decommissioning of Fennovoima's nuclear power plant. Detailed regulations governing the observance of safety principles are given in Government decrees and in the regulatory guides for nuclear safety: the YVL Guides issued by STUK. Fennovoima executes its project in accordance with valid laws, decrees, official requirements and guidelines, and will not authorize any solutions that are in conflict with the safety principles presented in Appendix 4B of this application.

The nuclear power plant type chosen by Fennovoima, and the planned suppliers of the main components, are presented in Appendix 4A of this application.

Appendix 4B of this application includes a report of the safety principles followed in the project, as well as Fennovoima's assessment of how they will be fulfilled. The safety principles presented in Chapters 2 and 2 a of the Nuclear Energy Act will be fulfilled in Fennovoima's project.

Security arrangements

According to section 3, paragraph 6 of the Nuclear Energy Act, "security" means the measures needed to protect the use of nuclear energy against illegal activity in the nuclear facility, its precincts, and other places or vehicles where nuclear energy is used. Fennovoima will prepare the preliminary plans and measures of the nuclear power plant's security arrangements together with the police, local rescue authorities and the Radiation and Nuclear Safety Authority (STUK).

Fennovoima will own sufficient areas on the Hanhikivi headland to implement appropriate security arrangements. On June 3, 2015, the company filed a request that restrictions to movement and sojourns in the nuclear power plant area are established, based on Chapter 9, section 8 of the Police Act (872/2011), in order to maintain the clarity in the security arrangements and their legal authorization.

The security arrangements for the Hanhikivi 1 nuclear power plant are described in Appendix 4B of this application.

Nuclear fuel management

In December 2013, Fennovoima and JSC TVEL, which is a part of the Rosatom Group, signed a contract for the integrated fuel delivery for the Hanhikivi 1 nuclear power plant. The fuel contract covers the uranium required for the fuel, as well as the manufacturing of the nuclear fuel for the first operating cycle, and reload batches for the following eight years. Fennovoima will also maintain a safety stock of approximately two reload batches at the plant. When the current contract expires, Fennovoima will have the possibility to ask for bids for the whole nuclear fuel supply contract or for parts of it.

Fennovoima has chosen to use reprocessed uranium fuel during the first operating years. Nuclear fuel manufactured from reprocessed uranium is not essentially different from fuel manufactured from natural uranium. Based on the contract, Fennovoima will also be able to choose fuel manufactured from natural uranium. The nuclear fuel to be delivered to Fennovoima's nuclear power plant will be similar to that used in existing light water reactors, and it is designed and manufactured using proven technologies.

Fennovoima will ensure that the necessary nuclear safeguards to prevent nuclear proliferation are implemented in accordance with Finnish legislation and international conventions. Fennovoima will also oversee the design, production and transportation of the nuclear fuel to ensure its quality and safety.

Fennovoima's plans for nuclear fuel management are described in Appendix 5A of this application.

Nuclear waste management

According to section 9 of the Nuclear Energy Act, the nuclear power plant license holder is under the nuclear waste management obligation and is responsible for all measures to recover, store, process and dispose of the nuclear waste generated during the operation of the plant.

Fennovoima has the necessary plans and expertise available to it to arrange the management of the nuclear waste of the nuclear power plant. According to current estimates, approximately 5,400 m^3 of very low level, low level and intermediate level waste will be generated during the operation of the nuclear power plant. The volume of decommissioning waste is estimated at 12,000 m^3. Spent nuclear fuel equivalent to between 1,200 and 1,800 tonnes of uranium is estimated to be generated at the power plant.

The management of very low level, low level and intermediate level reactor waste will be carried out for the most part using the processing methods used at the nuclear power plants currently in operation.

Fennovoima's decision-in-principle also includes the low and intermediate level waste repository to be built on the Hanhikivi headland. Construction and operating licenses for the repository will be applied for separately closer to the time of construction. The use of the repository for low and intermediate level reactor waste is estimated to start in the 2030s.

Before final disposal, spent nuclear fuel will be stored at the plant site in an interim storage facility. The interim storage period is necessary to reduce the residual heat power and radiation level of the nuclear fuel to allow the final disposal preparations. Interim storage of spent fuel will be carried out using the pool storage or dry storage method. Both methods use proven technologies and can be constructed to fulfill Finnish safety requirements. Fennovoima will supplement the construction license application material submitted to the Radiation and Nuclear Safety Authority (STUK) by the end of 2015 by adding a requirement specification concerning the interim storage concepts, and a plan for when it will submit the final interim storage facility design documentation to STUK for review closer to the construction time of the facility.

According to current plans, final disposal of nuclear fuel from Fennovoima's power plant is not expected to begin earlier than in the 2090s. In accordance with the decision-in-principle, Fennovoima will, by the end of June 2016, present to the Ministry of Employment and the

Economy either a final disposal cooperation agreement made with the parties currently under the nuclear waste management obligation, or an environmental impact assessment program for its own final disposal facility for spent nuclear fuel.

Fennovoima's primary objective is to negotiate, by the end of June 2016, an agreement on the final disposal of spent nuclear fuel with the parties currently under the nuclear waste management obligation. Fennovoima has also begun preparations for an environmental impact assessment program for its own final disposal facility for spent nuclear fuel.

Fennovoima's overall plan for nuclear waste management is described in Appendix 5B of this application.

Submitting construction license materials to STUK

When applying for a construction license from the Government, Fennovoima will submit to the Radiation and Nuclear Safety Authority (STUK) the reports referred to in section 35 of the Nuclear Energy Decree in the extent defined in the licensing plan also to be submitted to STUK. Preparation of materials and their delivery to review by the authorities will take place in phases starting with the overall safety and design bases so that the approval of STUK for the documents referred to in section 35 of the Nuclear Energy Decree will be obtained by the time of construction license granting, as specified in the schedule provided in Appendix 2A of this application. The construction license application materials submitted to STUK include an account of the arrangements for the implementation of control by STUK pursuant to section 19, paragraph 7 of the Nuclear Energy Act.

Fulfillment of the prerequisites for granting a construction license, and enforceability of the license decision

Based on what has been stated above, Fennovoima considers the prerequisites for granting a construction license, set out in section 18 of the Nuclear Energy Act, to be fulfilled and that a construction license can be granted for Fennovoima's nuclear power plant project.

Fennovoima also considers that the nature of the construction license decision requires that for a reason of public interest, it shall be enforced without any delay due to the processing of potential appeals. The period required for the processing of possible appeals would result in undue delay in the project and uncertainty for project implementation.

For this reason, based on section 31 of the Administrative Judicial Procedure Act (586/1996), Fennovoima requests that the Government state in the construction license decision that the decision shall be immediately enforceable.

Helsinki, June 30, 2015

Yours faithfully,
Fennovoima Oy

Juhani Pitkäkoski
Chairman of the Board

Toni Hemminki
CEO

Information about Fennovoima

Appendix 1A

Fennovoima Ltd trade register extract, articles of association and shareholder register

Summary

As required by section 32 of the Nuclear Energy Decree (161/1988), this appendix includes the applicant's trade register extract in accordance with section 24, subsection 1, paragraph 1, and a copy of the articles of association and shareholder register in accordance with subsection 1, paragraph 2.

Appendix 1A of the application submitted to the government by Fennovoima includes the following documents as required by the aforementioned Decree:

1. Fennovoima Ltd trade register extract, issued June 26, 2015
2. A copy of Fennovoima articles of association, issued June 26, 2015
3. A list of Fennovoima Ltd's shareholders, issued June 30, 2015

The Fennovoima Ltd trade register extract or the articles of association are not included in this publication created from the application.

FENNOVOIMA

SHAREHOLDER REGISTER

Shareholder	Address	Business ID	Share numbers	Number of shares	Series	Date and basis of registration
RAOS Voima Oy	Salmisaarenaukio 1, FI-00180 Helsinki, Finland	2596476-2	1057 - 1600	544	B	15.4.2014 Share transaction
Voimaosakeyhtiö SF	Salmisaarenaukio 1, FI-00180 Helsinki, Finland	2069398-3	1 - 1056	1056	A	11.7.2007 Establishment of the company

Number of shares, total 1600

Helsinki June 30th, 2015

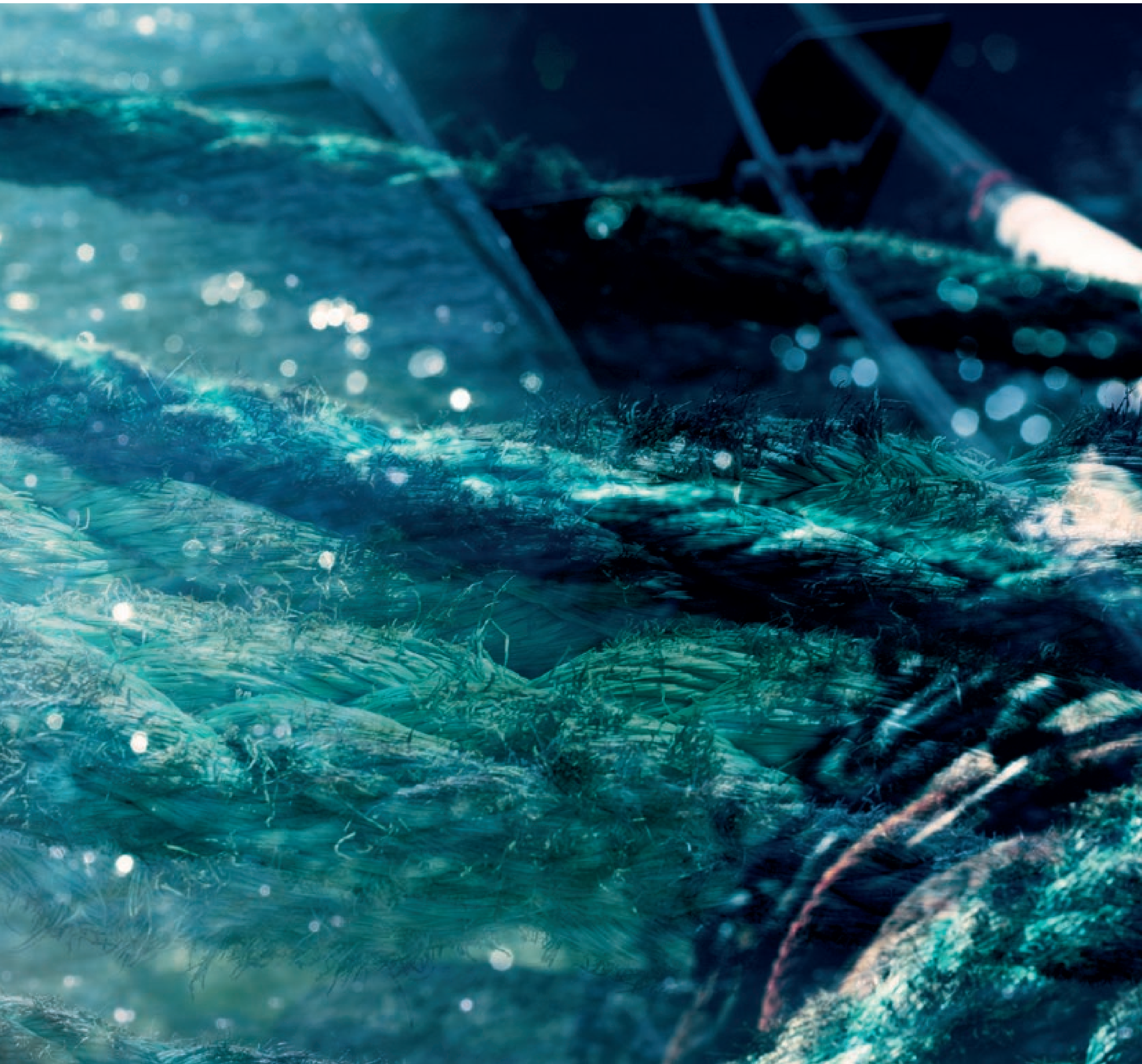
On behalf of Fennovoima Ltd's Board of Directors

Juhani Pitkäkoski
Chairman of the BoD

Information about Fennovoima
Appendix 1B

Fennovoima's ownership base

Updated August 5, 2015



Summary

This appendix constitutes an "other description considered necessary by the authorities" to be attached to the construction license application in accordance with section 32, paragraph 15 of the Nuclear Energy Decree (161/1988). This appendix also responds to the requirement presented by the Government in the decision-in-principle granted on September 18, 2014 (M 6/2014 vp) regarding Fennovoima's ownership base.

In the decision-in-principle M 6/2014 vp, the Government stated that a minimum of 60% of Fennovoima's ownership must be held by entities domiciled within the EU or the EFTA. More than 60% of Fennovoima's ownership is held by entities who have committed to further financing of the project, and who are domiciled within the EU or EFTA. The prerequisite set by the Government for the granting of the construction license regarding Fennovoima's ownership base is thus fulfilled.

Fennovoima's ownership base

Ownership structure of Fennovoima

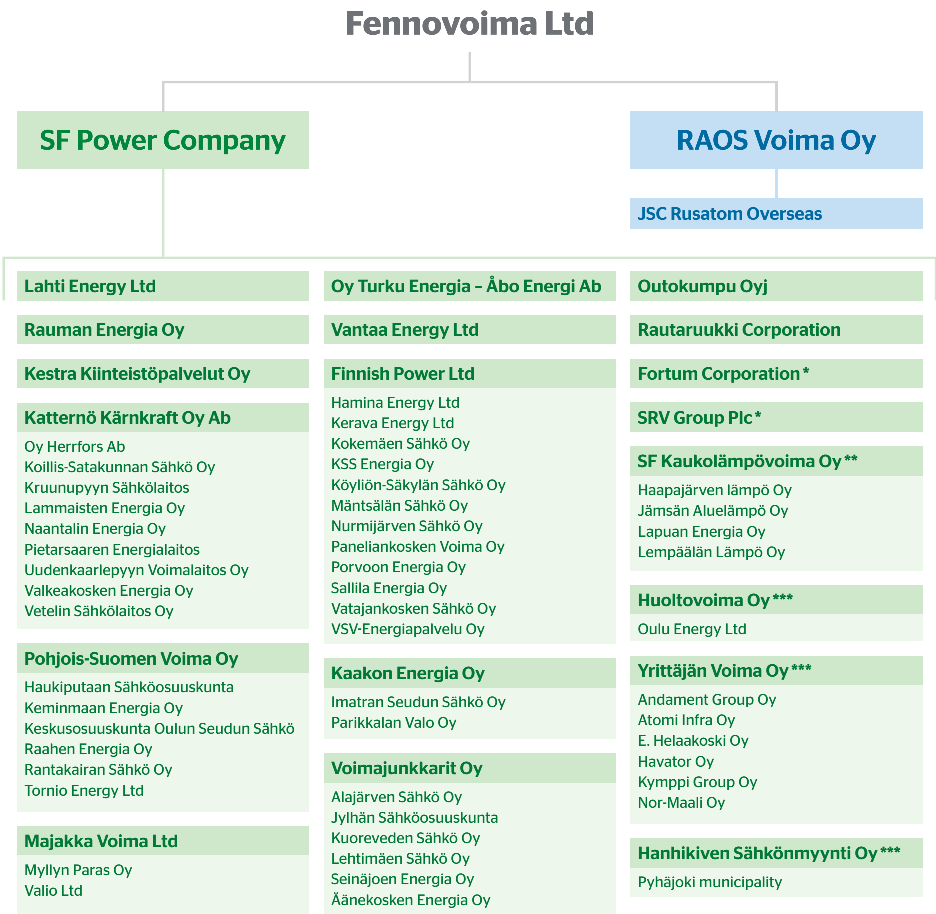
Fennovoima has two share series and two shareholders. For a shareholders' register of Fennovoima's shareholders, see Appendix 1A of this application.

Constituting 66% of Fennovoima's share capital, the Series A shares are owned by Voimaosakeyhtiö SF, a consortium of Finnish companies. The largest individual owners of Voimaosakeyhtiö SF are Outokumpu Oyj, Finnish Power Ltd and Fortum Corporation. Other owners include municipal energy utilities and other industrial companies, among others.

Constituting 34% of Fennovoima's share capital, the Series B shares are owned by RAOS Voima Oy. Fully owned by JSC Rusatom Overseas, RAOS Voima Oy is a Finnish sister company of Fennovoima's plant supplier, RAOS Project Oy. RAOS Voima Oy became a minority shareholder in Fennovoima in March 2014.

More than 60% of Fennovoima's ownership is held by entities who have committed to further financing of the project, and who are domiciled within the EU or EFTA.

Figure 1B-1 shows the shareholders of Fennovoima.



* Participates directly or via a subsidiary
** Current trade name FVKT Suomi Osakeyhtiö
*** Company to be founded

Figure 1B-1. Fennovoima shareholders that have committed to further financing of the project.

Information about Fennovoima

Appendix 1C

A description of the financial resources and economic viability of Fennovoima's nuclear power plant project, and the project's cost estimate and financing plan

Summary

As required by section 32, paragraphs 11 and 12 of the Nuclear Energy Decree (161/1988), this appendix includes a description of the economic viability of the nuclear facility project and its other financial prerequisites, and the cost estimate and financing plan for the nuclear facility project.

The production costs of nuclear power are competitive in comparison to many other electricity generation methods. During its planned operational life of 60 years, the nuclear power plant will produce electricity at a highly predictable cost level.

The total investment cost of the Hanhikivi 1 project is estimated to be EUR 6.5–7 billion, equivalent to approximately EUR 6 billion in terms of 2015 money

Fennovoima's wide base of shareholders provides the financial basis for the implementation of the Hanhikivi 1 project. In accordance with the Mankala principle, after the completion of the construction of the nuclear power plant, the shareholders will be entitled to receive electricity from the nuclear power plant in proportion to their shares of ownership and will be obliged to cover all the costs incurred by the company in electricity production as stated in the articles of association and shareholders' agreement.

Furthermore, the shareholders have agreed on equity investments and decided that JSC Rusatom Overseas, the parent company of Fennovoima's plant supplier and minority shareholder, will be responsible for obtaining long-term loans during the construction phase.

A description of the financial resources and economic viability of Fennovoima's nuclear power plant project, and the project's cost estimate and financing plan

Financial resources of the project

Fennovoima Oy is a Finnish energy company founded in 2007. The purpose of the company is to build new nuclear power capacity in Finland and to produce electricity for its shareholders at a stable and reasonable price. The company was founded exclusively for the purpose of drafting, designing, constructing and operating a nuclear power plant.

As a company, Fennovoima does not seek to make a profit; it will sell the electricity produced to its shareholders at predictable cost price. This business model is generally called the "Mankala principle". After the completion of the construction of the nuclear power plant, the shareholders will be entitled to receive electricity from the nuclear power plant in proportion to their shares of ownership and will be obliged to cover all the costs incurred by the company in electricity production as stated in the articles of association and shareholders' agreement.

The financial resources of Fennovoima's nuclear power project are based on the financial condition of its shareholders and on their commitment to cover the costs of power production in accordance with the Mankala principle. Because a nuclear power plant requires substantial capital expenditure and its construction and commissioning phase lasts for several years, its owners must be committed to the implementation of the project and have the necessary financial resources to fulfill this commitment. Fennovoima's shareholder base consists among others of listed industrial corporations, municipal owned power utilities and the Russian state nuclear energy corporation Rosatom.

For a more detailed description of Fennovoima's ownership base, see Appendix 1B of this application.

Financing plan for the nuclear power plant project

According to the overall schedule prepared by Fennovoima's plant supplier, production of electricity at the Hanhikivi 1 nuclear power plant will begin in 2024. Capital expenditure will be at its highest when the power plant is completed and electricity production begins. The planned operating life of Fennovoima's nuclear power plant, used as a basis for calculations in the plant's financing plan and the project's financial estimates, is 60 years.

In addition to the design and construction of the nuclear power plant, Fennovoima's financing plan covers nuclear waste management, decommissioning of the plant and provision for nuclear damage as required by the Nuclear Liability Act.

Cost estimate

The total investment costs of the project cover all costs incurred from the time of launching of the project until the time of completion and commissioning of the power plant. Included in the total investment costs are the costs of the fixed-price plant supply contract, the costs of Fennovoima's project organization, the costs of ancillary projects implemented at the plant site included in Fennovoima's scope of work, the costs relating to nuclear waste management incurred during the construction phase of the power plant, any financing incurred during the construction period, and the cost of the first load of nuclear fuel.

The total investment cost of the Hanhikivi 1 project is estimated to be EUR 6.5–7 billion, equivalent to approximately EUR 6 billion in terms of 2015 money. The estimate is based on the total price of the nuclear power plant delivery agreed in the plant supply contract, the nuclear fuel contract and the plans ordered or prepared by Fennovoima.

Sources of financing

The project is to be financed with shareholders' equity investments and debt financing obtained from various sources.

Fennovoima's owner company Voimaosakeyhtiö SF and JSC Rusatom Overseas, the parent company of the other owner company, RAOS Voima Oy, have agreed, together with Fennovoima, on the shareholders' equity investment obligation and the obligation to arrange loan capital. The shareholders' equity investment obligation will be divided in proportion to their shares of ownership, and JSC Rusatom Overseas will be responsible for obtaining long-term debt financing during the construction phase.

The share of equity is approximately 25%, with the share of loan capital amounting to approximately 75%. According to the agreement, the total amount of equity investments is approximately EUR 1.7 billion, with the final installment to be made in conjunction with the commercial commissioning of the plant. JSC Rusatom Overseas has committed to obtaining the debt financing required in the construction phase. To cover this financing need, the company plans to employ multiple sources of financing, including export credit from Russia and other supplier countries. The first part of the project's debt financing consists of approximately EUR 2.4 billion in funding granted to the Hanhikivi 1 project by the Russian National Wealth Fund. JSC Rosatom Overseas will grant the sum to Fennovoima as a shareholder loan. Fennovoima and JSC Rusatom Overseas signed the shareholder loan agreement in spring 2015, which was also the time when Fennovoima withdrew the first installment of the loan.

The shareholder loan shall be disbursed within 18 years after the beginning of the commercial operation of the power plant. The plan is to refinance the debt incurred in the construction phase during the operating phase. The funds required to disburse the loans will be collected from the shareholders during the operating phase as a part of the cost price of electricity. The disbursement of loans and the interest expenses are included in the fixed production costs referred to in Fennovoima's articles of association.

Financing of nuclear waste management and decommissioning of the plant

In accordance with section 9 of the Nuclear Energy Act (990/1987), a licensee with nuclear waste management obligation is responsible for all costs incurred in the appropriate management of nuclear waste generated in the operations of the nuclear power plant, even after the power plant is no longer in operation. The licensee is also responsible for the appropriate decommissioning of the nuclear power plant.

In Finland, the funds required to pay for nuclear waste management and decommissioning are collected on an annual basis from the licensee while the nuclear power plant is in operation. The funds needed for the nuclear waste management of the nuclear power plants operating in Finland are collected in compliance with a uniform procedure and deposited in the national Nuclear Waste Management Fund. This ensures that the funds required to pay for nuclear waste management are secure and available in all circumstances.

Fennovoima's annual costs of nuclear waste management and decommissioning will be included in the cost price that shareholders will pay for the electricity they use. Fennovoima's shareholders will finance the costs of nuclear waste management and decommissioning in full.

According to section 52 of the Nuclear Energy act, Fennovoima will have in the future an option to borrow back 75% of the funds deposited in the national Nuclear Waste Management Fund against full collateral to be provided. Should a need arise, this source of financing may be utilized in the operating phase if Fennovoima considers it beneficial for optimizing the financing of the company's operations. Appendix 5B of this application includes an estimate of the total costs of nuclear waste management.

Economic viability of the nuclear power plant project

From the shareholders' point of view, the economic viability of the power plant investment is determined on the basis of the return generated during the operating life of the power plant, the capital investments required and the risks involved in the project. Each of Fennovoima's shareholders has made an individual assessment of the economic viability of the project before deciding whether to participate in, and commit to, the project.

Costs of nuclear energy and other electricity production methods

The International Energy Agency (IEA) and the Organization for Economic Cooperation and Development (OECD) engage in regular cooperation to publish global comparisons of electricity production costs. The comparisons are prepared by numerous representatives of the industry and research institutes, mainly from OECD countries. The comparison utilizes the discounted cash flow method.

According to the latest Projected Costs of Generating Electricity report, published in 2010 by the IEA and the OECD, at a real discount rate of 5%, capital-intensive but carbon emission-free forms of production, such as nuclear power, are the most competitive sources of base load power (see Figure 1C-1). However, an increase in the discount rate or a decrease in the price of emission allowances would diminish the advantages of nuclear power over coal and gas power. The report also takes into account the significance of differences between the various countries.

In Finland, comparisons of the costs of various forms of electricity production have appeared in a number of reports. Among them are reports published by Lappeenranta University of Technology, the latest of which came out in 2012 (Vakkilainen et al. 2012). Figure 1C-2 presents the most important results of the comparison, which, as regards nuclear power, are similar to those yielded by the international comparative study conducted by the IEA and the OECD.

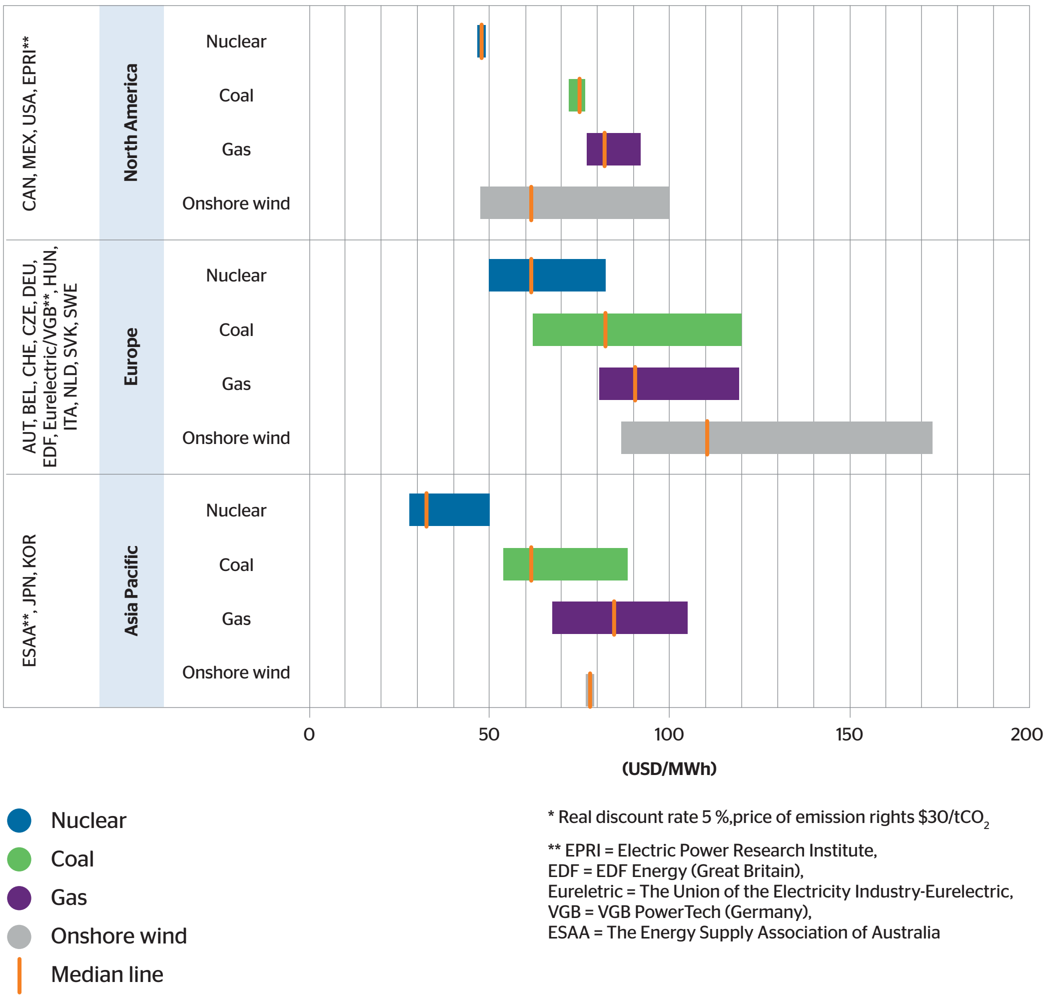


Figure 1C-1. An international comparison of electricity production costs* (Projected Costs of Generating Electricity, 2010 edition).

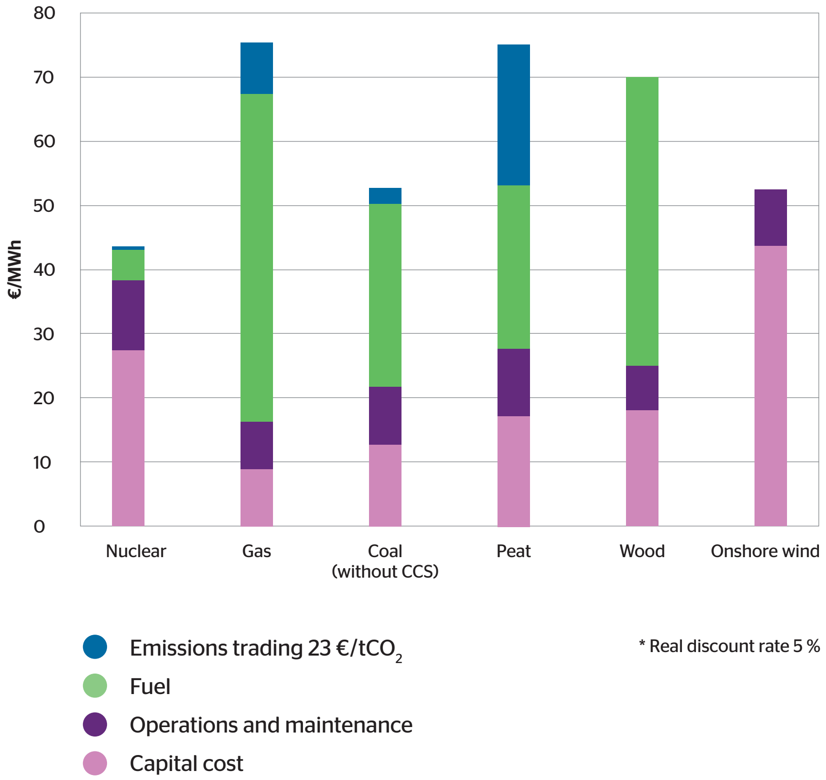


Figure 1C-2. A domestic comparison of electricity production costs* (Vakkilainen et al. 2012).

The inclusion of emission allowance trading in the calculations further improves the economic viability of domestic nuclear power in comparison to the production forms examined that generate carbon dioxide emissions.

Furthermore, Figure 1C-2 visualizes how the various cost components combine to build up the total electricity production costs. In comparison to other forms of production, nuclear power and onshore wind power are clearly the most capital-intensive. While the investment costs incurred during the construction phase of the power plant thus have a significant impact on the economic viability of nuclear power, they also make the cost structure of nuclear power more stable and easily predictable. Moreover, costs incurred during the operating life of the plant have a relatively small impact on the total costs of nuclear power production. Therefore, fluctuations in the prices of fuel or currencies do not jeopardize the economic viability of nuclear power.

The at cost price of electricity

The cost price of electricity produced in Fennovoima's nuclear power plant – referred to as the Mankala price – is comprised of the power plant's fixed and variable electricity production costs in accordance with the articles of association. The cost of equity invested by the shareholders is not included in the cost price.

Fennovoima has prepared detailed assessments of the cost price based on the concluded contracts, best available information and estimates. The cost price will be higher in the first years of plant operation, and will decrease gradually at later stages of operation.

All Fennovoima's shareholders will be obliged to pay their share of the electricity production costs. As the cost price charged by Fennovoima from its owners is comprised of the actual costs of the power plant, there are uncertainties and risks associated with the cost price and the related assessments. Therefore, the direct owners of Fennovoima, Voimaosakeyhtiö SF and RAOS Voima Oy, have agreed on certain guarantees with an impact on the cost price of electricity. These guarantees significantly lower the risks associated with the cost price of electricity faced by Voimaosakeyhtiö SF, and consequently its shareholders, during the early years of commercial operation. Taking these guarantees into account, the cost price charged from Voimaosakeyhtiö SF during the early years of the operating phase is estimated to be approximately EUR 50 per megawatt-hour.

The cost price paid by RAOS Voima Oy for its portion of electricity will be determined on the basis of Fennovoima's fixed and variable production costs, with the price paid by Voimaosakeyhtiö SF for electricity subtracted. This agreement significantly lowers the risks associated with the production costs faced by Fennovoima's Finnish shareholders.

Importance of predictability and price stability

The price of electricity has fluctuated strongly over the last ten years, and there are uncertainties about future price trends as well. The wholesale electricity market offers rather good opportunities for hedging against price fluctuations with a perspective of a few years. However, securing a stable and competitive price further in the future without investments in electricity production of one's own has proved difficult.

Uncertainty about electricity price trends makes it more difficult for industrial users of electricity to decide on investments in production. Profitability estimates for new investment projects with long payback periods are susceptible to electricity price trends.

As the nuclear power plant will produce electricity at a stable and predictable cost level throughout its several decades-lasting operating phase, it will definitely do its part in improving the shareholders' potential to make investments in Finland.

Strategic decentralization of electricity procurement

There are uncertainties in the future costs developments of all electricity production forms. It is possible to lower the overall risk relating to electricity procurement by decentralizing procurement to different forms of electricity production. It may be assumed that future investments in electricity production in the EU will be primarily targeted to emission-free forms of production. Most of Fennovoima's Finnish shareholders are endeavoring to develop their business and control the risks relating to electricity procurement by investing in emission-free forms of production. The shareholders are engaging both in independent projects and in various extensive joint projects.

Provision for financial risks and uncertainties

Large, complex investment projects such as the Hanhikivi 1 project involve risks and uncertainties relating to costs, financing, schedules, implementation, etc. The following contains a description of the financial risks and uncertainties associated with the Hanhikivi 1 project and the measures taken to provide for these.

Cost overrun

Cost overruns may occur if the rate of inflation exceeds expectations, the price level of raw materials changes, the workforce costs or the amount of work differ from the estimates, etc. Changes in the operating environment, legislation or other requirements may also lead to cost overruns. The risk of cost overruns is usually contractually shared between the plant supplier and the purchaser.

Fennovoima has a fixed-price plant supply contract, and changes in factors such as the price level of raw materials or currency exchange rates have no impact on the final price of the plant. The plant supply contract between Fennovoima and the plant supplier for the Hanhikivi 1 project is thus prepared in such manner that the largest risk of cost overruns is borne by the plant supplier.

Delays in the project

In the plant supply contract between Fennovoima and the plant supplier for the Hanhikivi 1 project, the plant supplier is committed to a fixed implementation schedule. Should the first startup of the plant be delayed from the agreed date due to reasons attributable to the plant supplier, the plant supplier is obliged to pay a contractual penalty.

Availability and terms of debt financing

The implementation of the Hanhikivi 1 project requires a significant amount of capital, and there are uncertainties and risks associated with the availability and price of the capital needed. Fennovoima's shareholders have agreed that JSC Rusatom Overseas, the parent company of both Fennovoima's plant supplier, RAOS Project Oy, and its minority shareholder, RAOS Voima Oy, will assume responsibility for obtaining long-term loan financing during the construction phase. However, uncertainties associated with Russia's economy may have an influence on the availability and terms of financing from Russia. Fennovoima has made contractual arrangements to provide for these risks.

Production volume of the plant

The plant's net output may differ from planned, or the plant outages may take longer than expected. The risks related to the plant output will be partly borne by the plant supplier; the plant supply contract includes a plant performance guarantee, committing the plant supplier to a certain net output, and an availability guarantee that refers to the required capacity factor during the period of guarantee. As all of the electricity produced at the plant will be delivered to Fennovoima's shareholders, the shareholders bear their part of the risks associated with the annual production volume during the operation of the plant. These risks will be more pronounced in the early stages of the operating phase.

Operating costs

As Fennovoima's shareholders are obliged to cover all fixed and variable costs relating to electricity production in accordance with the Mankala principle, they bear the risks associated with the plant's operating costs. Since Fennovoima has signed a fixed-price fuel contract with JSC TVEL, the risks associated with the cost of nuclear fuel will remain low during the early years of operation.

Risks pertaining to the market price of electricity

Investments in electricity production involve a risk relating to the future market price of electricity and the price level at which the company making the investment is able to sell the electricity produced. The risk concerning the market price of electricity has been transferred in full to the shareholders in accordance with the Mankala principle. In the Hanhikivi 1 project, the market price risk is distributed among all the shareholders in proportion to their shares of ownership.

Insurances

The plant supply contract specifies the construction-phase insurance arrangements as agreed upon with the plant supplier. The plant supplier and Fennovoima will obtain insurance coverage as agreed between the parties. The insurance policies will cover all parties participating in the project at the construction site (e.g. property and liability insurance) as well as outside the site (e.g. transportation insurance).

Provision for nuclear damage as required under the Nuclear Liability Act

As a forthcoming nuclear power plant operating license holder subject to the Nuclear Liability Act (484/1972), Fennovoima will be liable for nuclear damage caused by nuclear incidents at its nuclear facility.

The liability for nuclear damage is defined as a strict liability, which means that Fennovoima will be liable for any damage even if it has not been caused by any omission or negligence on the part of Fennovoima.

A reform of nuclear liability legislation has been ongoing for a long time. Changes required by international nuclear liability conventions and their supplementary protocols were included in the Nuclear Liability Act as early as 2005, but the changes have not entered into force. The 2005 Act on the Amendment of the Nuclear Liability Act (493/2005) is to be enforced by a government decree as soon as the preconditions for ratification by Finland exist.

As there was no certainty of when this would happen, unlimited liability of the operator of a nuclear facility in Finland was enforced by enacting a temporary act (581/2011). The act has been in force since January 1, 2012 and will remain in force until the Nuclear Liability Act 493/2005 is enforced by a government decree.

According to the valid nuclear liability legislation, Fennovoima will thus have unlimited liability as an operator of a nuclear facility for all nuclear damage occurring in Finland and caused by a single nuclear incident. Fennovoima's maximum liability for nuclear damage occurring outside Finland and caused by a single nuclear incident (excluding interest and any legal expenses) will be 600 million Special Drawing Rights of the International Monetary Fund (corresponding to approximately EUR 700 million).

Fennovoima is required to obtain nuclear liability insurance, subject to approval by the Financial Supervisory Authority, as required in the Nuclear Liability Act or in the corresponding legislation of another contracting state. The temporary legislation increased the amount of required liability insurance for operators of nuclear facilities from 175 million Special Drawing Rights of the International Monetary Fund (approximately EUR 205 million) to 600 million Special Drawing Rights (approximately EUR 700 million).

Fennovoima will obtain liability insurance or deposit a corresponding collateral before the commissioning of the nuclear power plant.

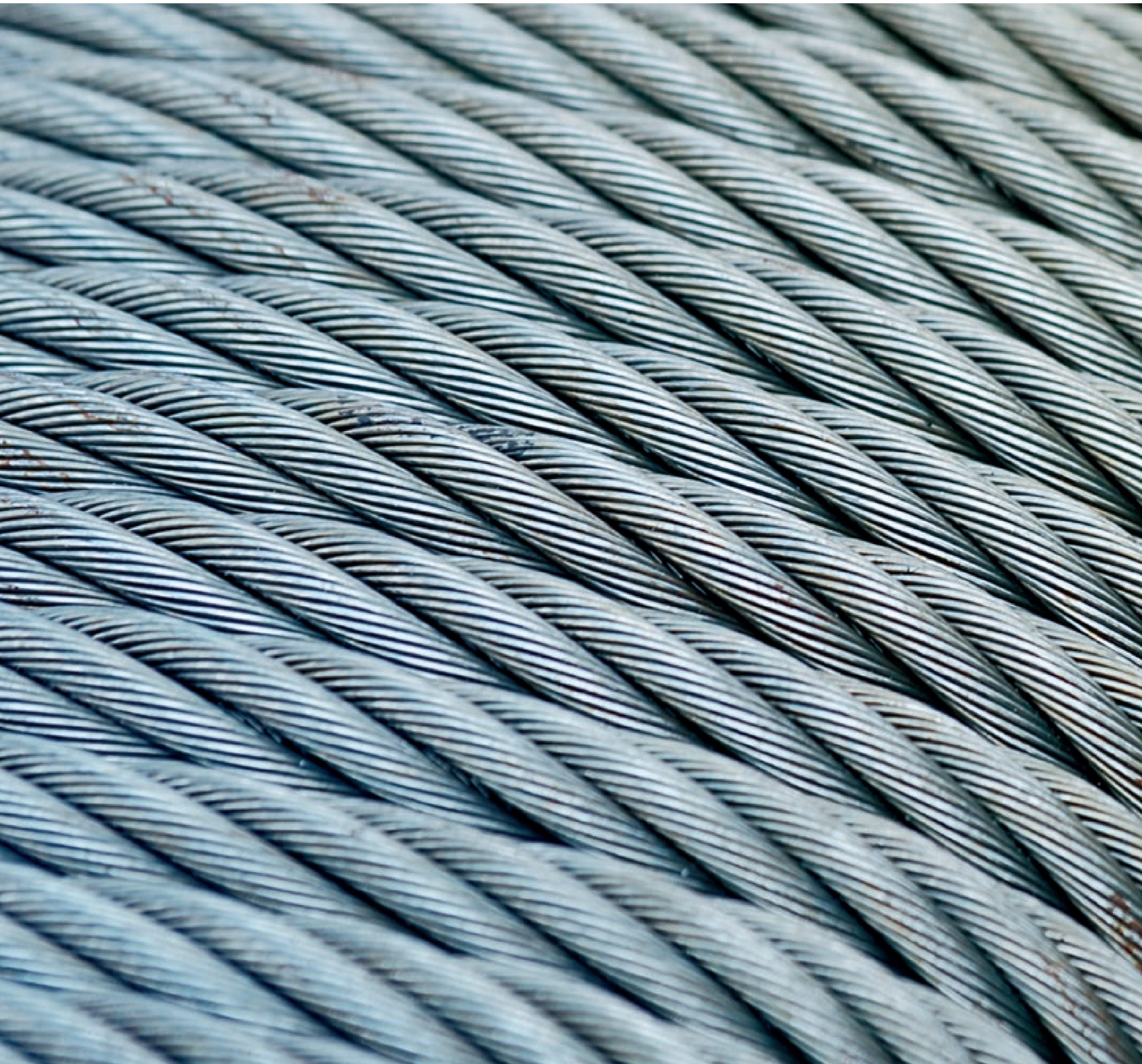
Counterparty risk

In the Hanhikivi 1 project, a significant part of the risks have been transferred to various companies belonging to the Rosatom Group. A large part of the risks relating to the practical execution of the project have been transferred to the plant supplier in the plant supply contract. Furthermore, a number of financing risks and risks relating to production volumes and operating costs have been transferred to the plant supplier in the contract between the shareholders. As the Rosatom Group has committed itself to the project in the role of a significant minority shareholder, the plant supplier has very strong reason to ensure that the project is implemented in an efficient and careful manner.

References

Projected costs of generating electricity, 2010 edition. IEA & NEA & OECD. http://www.iea.org/publications/freepublications/publication/projected_costs.pdf (Accessed March 31, 2015).

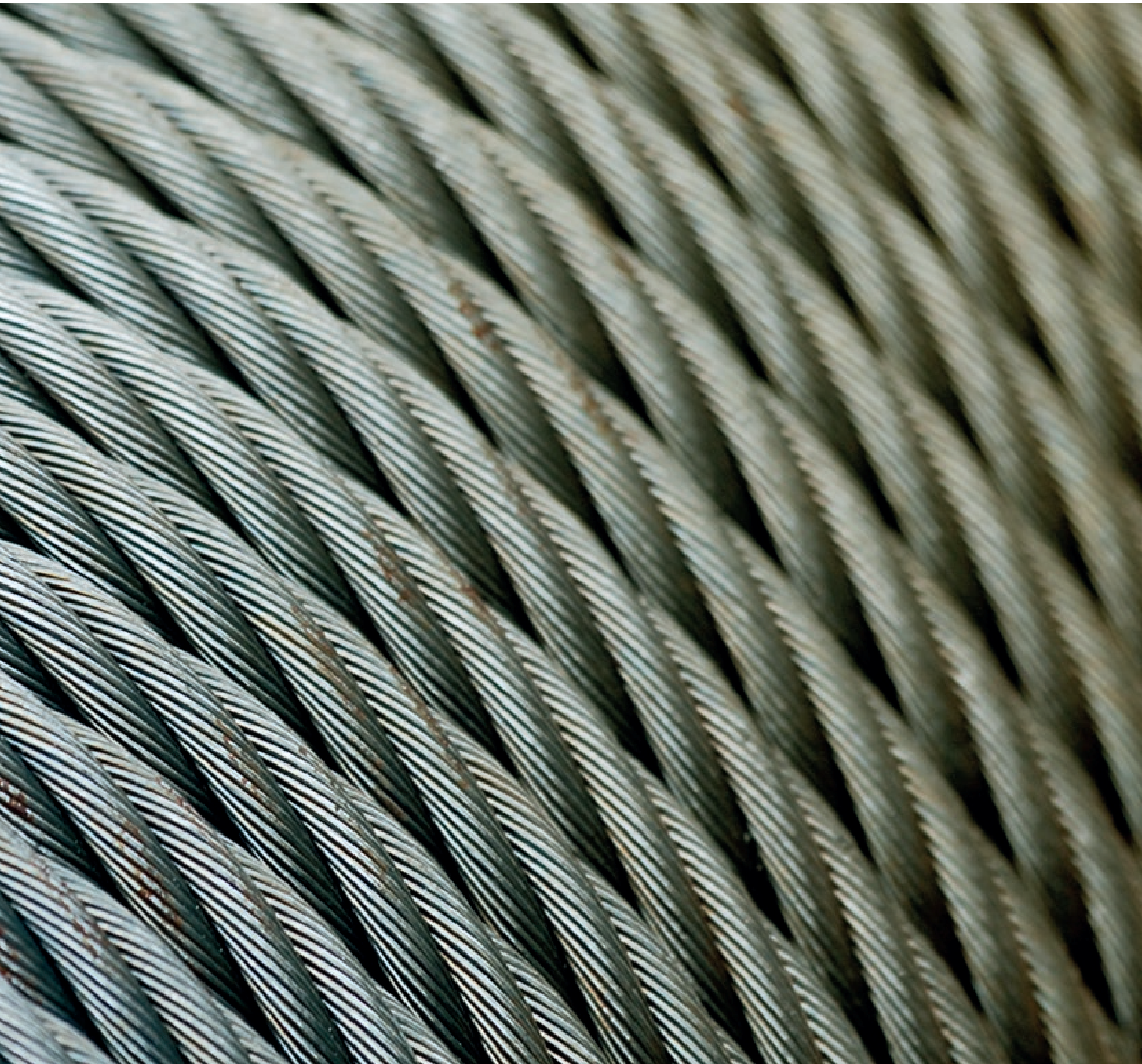
Vakkilainen, E., Kivistö, A. and Tarjanne, R. 2012. Sähkön tuotantokustannusvertailu. Tutkimusraportti 27. Lappeenranta University of Technology, School of Technology, LUT Energy. In Finnish.



Information about Fennovoima

Appendix 1D

Fennovoima Ltd financial statements 2010–2014



Summary

This appendix includes the applicant's financial statements in accordance with section 32, paragraph 13 of the Nuclear Energy Decree (161/1988) from the last five years.

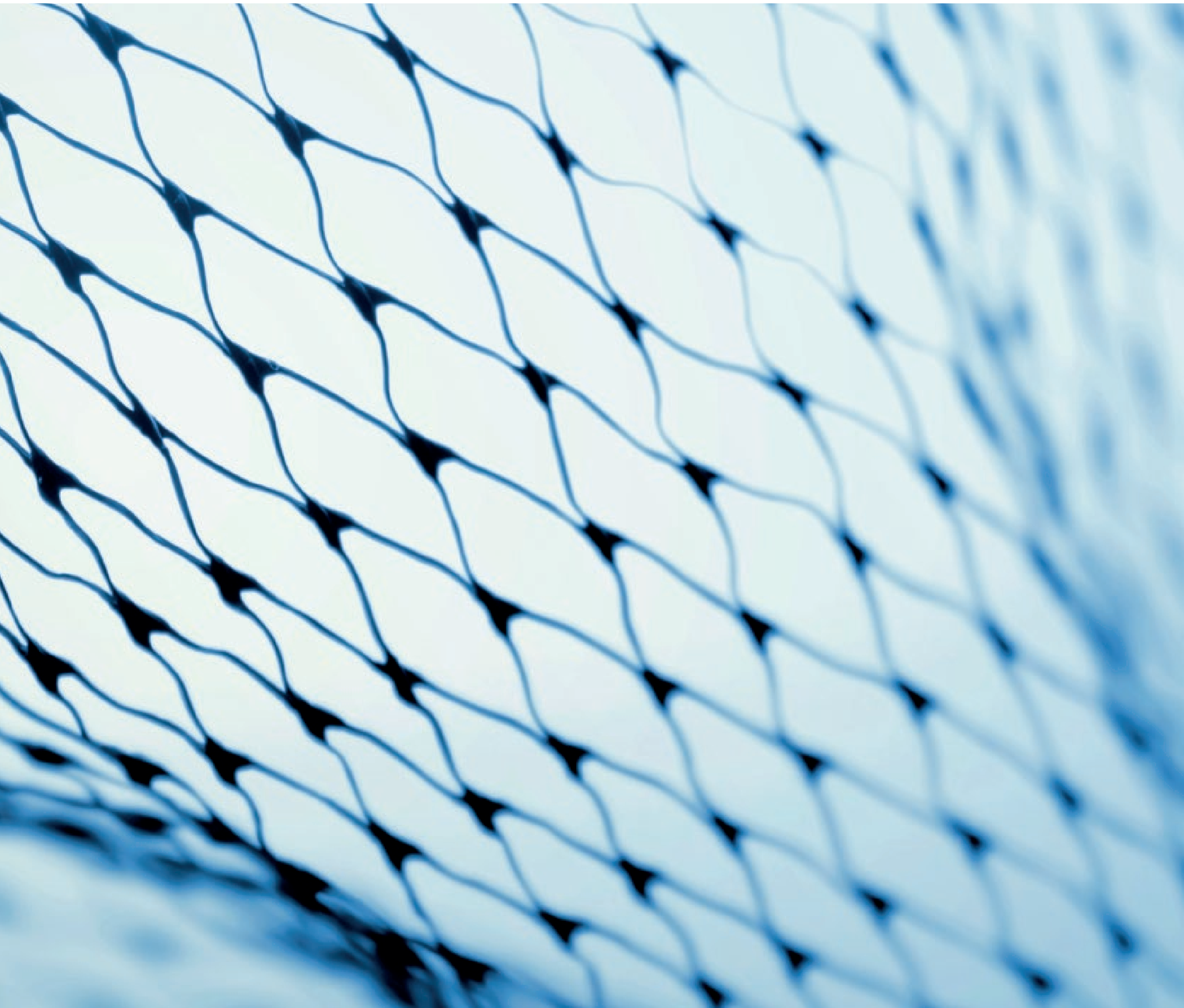
Appendix 1D of the application submitted to the government by Fennovoima includes the following documents as required by the aforementioned Decree:

1. Fennovoima Ltd financial statements 2010
2. Fennovoima Ltd financial statements 2011
3. Fennovoima Ltd financial statements 2012
4. Fennovoima Ltd financial statements 2013
5. Fennovoima Ltd financial statements 2014

The financial statements are not included in this publication created from the application.

Appendix 2A

Description of the project implementation, the expertise available to Fennovoima, and Fennovoima organization during the licensing and construction phases



Summary

As required by section 32, paragraph 14 of the Nuclear Energy Decree (161/1988), this appendix includes a description of the expertise available to the applicant, as well as the organization in the construction phase of the nuclear power plant project. The appendix contains an account of the various phases of project implementation, Fennovoima's organization during the licensing and construction phases, the expertise available to Fennovoima, and the methods for competence development

Fennovoima's nuclear power plant project, Hanhikivi 1, is divided into five phases: preparation, procurement, licensing, construction and operation. The licensing phase began in 2014. Construction of the nuclear power plant is planned to begin in 2018, and commercial operation in 2024.

The organization of each phase has special characteristics. In the licensing and construction phases, Fennovoima's organization is arranged to meet the requirements of project-oriented operations.

Section 9 of the Nuclear Energy Act (990/1987) unambiguously states that the licensee of a nuclear facility has the obligation to assure safe use of nuclear energy at all stages of operations. This responsibility cannot be delegated to other organizations. Safety and security can only be ensured by having the appropriate and sufficient expertise available to Fennovoima during each phase of the Hanhikivi 1 project. Fennovoima will ensure in each phase that necessary expertise is available within the organization, and that the expertise will be maintained and developed throughout the project with attention to the needs of the operating phase. Expertise related to project management, supervision of design and installation, quality management, and supply chain management is essential in the construction phase. Fennovoima complements its own expertise with external experts when necessary.

Description of the project implementation, the expertise available to Fennovoima, and Fennovoima organization during the licensing and construction phases

Project phases

Fennovoima's Hanhikivi 1 nuclear power plant project is divided into five phases: preparation, procurement, licensing, construction and operation. Figure 2A-1 presents the overall project schedule.

Preparation and procurement phases

Fennovoima carried out the preparation and procurement phases of the Hanhikivi 1 nuclear power plant project in 2007–2013. The major events of the preparation phase were the first Environmental Impact Assessment (EIA) Procedure, and the granting of the decision-in-principle. Fennovoima submitted the environmental impact assessment report for the nuclear power plant construction project to the Ministry of Employment and the Economy on October 9, 2008. On May 6, 2010, the Finnish Government issued to Fennovoima a favorable decision-in-principle, which the Parliament ratified on July 1, 2010.

During the preparation phase, on October 5, 2011, the Hanhikivi headland located in the municipality of Pyhäjoki was selected as the plant site. From 2010 to 2013, Fennovoima engaged in negotiations with the plant supplier candidates. In December 2013, the negotiations con-

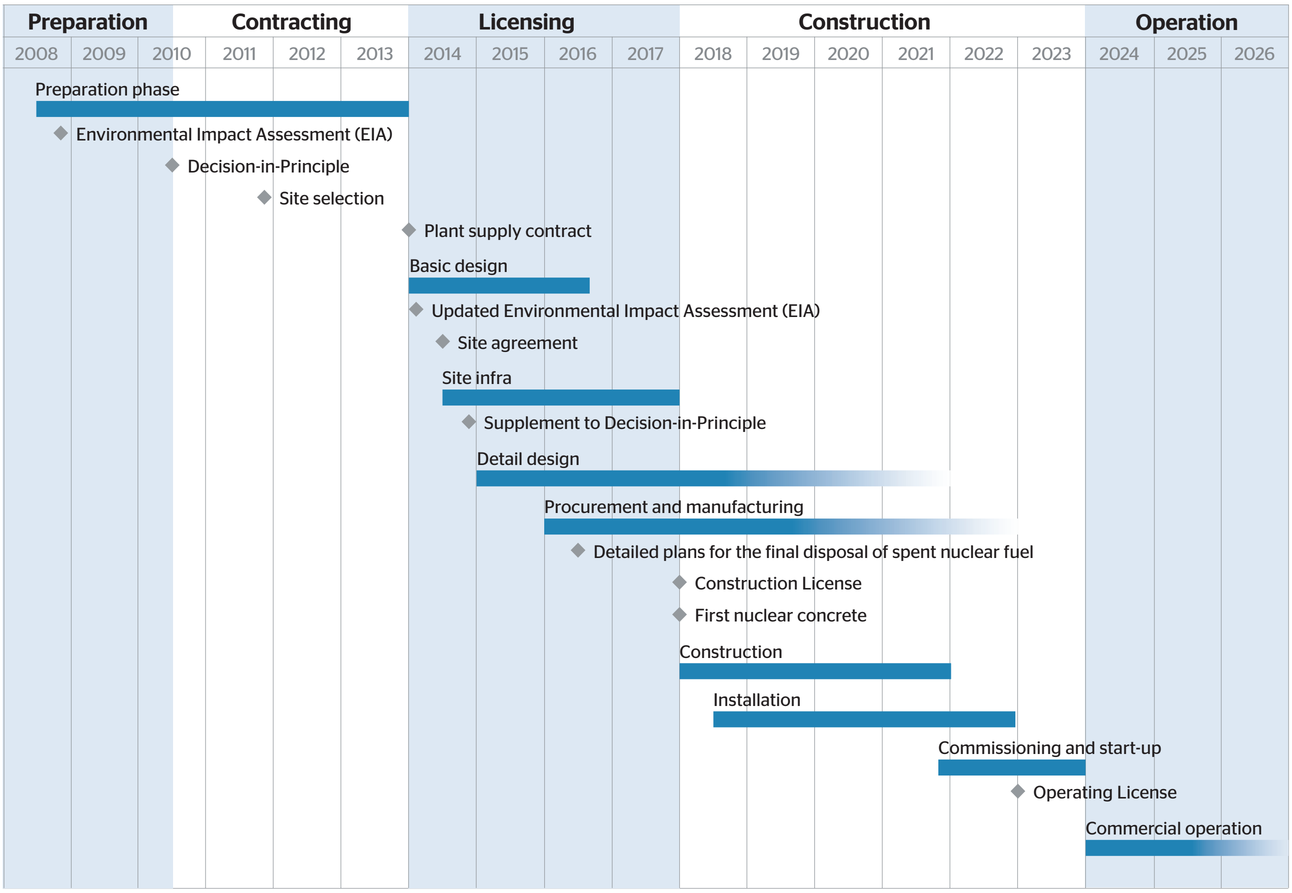


Figure 2A-1. Project schedule.

cluded with the signing of a contract on the supply of an AES-2006 pressurized water reactor between Fennovoima and the Russian supplier JSC Rusatom Overseas.

Since the AES-2006 plant type was not considered in the original environmental impact assessment, Fennovoima submitted a new environmental impact assessment report to the Ministry of Employment and the Economy on February 13, 2014.

Due to changes, which took place in Fennovoima's ownership base and plant alternatives since the original decision-in-principle was granted, Fennovoima filed an application for a supplement to the valid decision-in-principle on March 4, 2014. The Government approved the supplement to Fennovoima's decision-in-principle on September 18, 2014, and the Parliament decided on December 5, 2014 that the decision-in-principle shall remain in force.

Fennovoima has developed and grown its organization during the preparation and procurement phases. Fennovoima has paid particular attention to developing the management system, improving the competencies of the personnel, and developing safety culture within the organization.

Licensing phase

Since the signing of the plant supply contract, Fennovoima's nuclear power plant project has proceeded to the licensing phase, scheduled for 2014–2017. During this period, the basic plant safety principles will be defined and the basic design of the plant will be made. The basic design also includes the design of systems that have impact on plant safety. In the licensing phase, the focus is on preparing, together with the plant supplier, the materials required by the Government and the Radiation and Nuclear Safety Authority (STUK) for the construction license.

During both the basic and detailed design of the plant, Fennovoima will support the design organizations and ensure that the plant design meets the safety requirements set by the Finnish authorities, and any other requirements set by Fennovoima for the nuclear power plant. Design reviews by Fennovoima are an important part of the design process. Personnel sent by Fennovoima will work within the plant supplier's design organization to support the design engineers and to perform routine supervision and inspections.

Supplier evaluations of the subcontracting chain are an essential part of supply chain management carried out by Fennovoima. Fennovoima closely supervises the selection and work of subcontractors relevant to nuclear safety in particular. Manufacturing of components with long lead times begin already during the licensing phase, and Fennovoima supervises the design and manufacture of these components from the beginning by reviewing plans and by monitoring the work at the design and manufacturing sites.

During the licensing phase, Fennovoima will continue to develop its organization and management system to prepare for the construction phase. Fennovoima will also ensure that the management system of the plant supplier complies with the Finnish regulations. Operation models for co-operation between Fennovoima, plant supplier and the authorities shall be developed to ensure smooth collaboration in conformance with the regulations.

During the licensing phase, the plant site is prepared for the nuclear power plant construction operations. Preparation of the plant site includes surveys and investigations, as well as the construction of the site infrastructure.

Nuclear waste management plans will be further specified during the licensing phase, particularly in the area of interim storage and final disposal of spent nuclear fuel. Plans for the final disposal of spent nuclear fuel will be added to the construction license application by the end of June 2016. An overall plan for nuclear waste management is included in Appendix 5B of this application.

The licensing phase will conclude with the granting of the construction license. After that, Fennovoima will proceed to applying the licenses required during the construction phase, and eventually the operating license.

Construction phase

The construction phase of the Hanhikivi 1 project has been scheduled for 2018–2023. Most of the equipment and components will be manufactured during the construction phase. At the plant site, the buildings will be constructed, and systems and components installed.

The design organizations, manufacturers and contractors are responsible for the execution and organization of their own work. Fennovoima will supervise the operations, management systems and procedures of those organizations also during the construction phase. Fennovoima will supervise the work conformity, and ensure the fulfillment of the safety and quality requirements.

Fennovoima will pay particular attention to high safety culture during the entire project. Already during construction, the requirements related to nuclear safety and the safe operation of the plant will be taken into account. Fennovoima aims to run a safe and functional construction site, where labor issues are handled appropriately and the grey economy is efficiently prevented. To achieve these objectives, Fennovoima has been cooperating with labor market organizations and authorities from the beginning of the project. The plant supply contract between Fennovoima and the plant supplier contains several requirements concerning employment conditions and the prevention of the grey economy. In May 2014, Fennovoima, JSC Rusatom Overseas and the labor market organizations signed a site agreement on the common rules to be applied at the construction site.

During the construction phase, Fennovoima will develop its organization and expertise to prepare for the operating phase. The commissioning of the nuclear power plant and preparations for the operating phase will begin at the end of the construction phase. During commissioning Fennovoima verifies the conformity of the power plant with requirements, ensures that the organization is adequate, and the procedures for operating the plant are on place. During the commissioning, the plant is officially handed over from the plant supplier to Fennovoima. Commissioning will begin with tests and trial runs and continues with making systems operational. Commissioning ends in trial runs, which are done in steps covering the entire plant. Commissioning of the plant takes place at the final stages of the construction phase and the beginning of the operating phase. Commissioning is performed according to the commissioning plan, which is submitted to STUK. A preliminary version of the plan is submitted to STUK already during the construction license application process.

As required by the Nuclear Energy Act, Fennovoima will apply for a nuclear power plant operating license during the construction phase, estimated in 2021. The operating license application to be submitted to the Government will be comprised of the documents listed in sections 33–34 of the Nuclear Energy Decree, and of the documents submitted to STUK in the same connection in compliance with section 36 of the Nuclear Energy Decree.

The construction phase will conclude with the start of commercial operation of the plant.

Operating phase

The commercial operation of the Hanhikivi 1 nuclear power plant, that is the operating phase, is planned to begin in 2024. During the operating phase, Fennovoima, as the licensee, will be responsible for safe operation of the Nuclear Power Plant and that the operation complies with the requirements set for the operating phase.

Key issues during the operating phase are to ensure the availability of competent personnel and the planning of the maintenance and modifications during the operation.

Continuous improvement of safety is a central part of Fennovoima's safety culture. As required by the Government Decree on the Safety of Nuclear Power Plants (717/2013), Fennovoima will gather the operating experience from its own nuclear power plant as well as from other nuclear operators, research, and the development of technology during the entire operating life of the facility. The objective is to identify opportunities for improving safety.

The planned operating life of Fennovoima's nuclear power plant is 60 years, and Fennovoima is prepared to apply for a renewal of the operating license during the operation of the plant. Fennovoima's operating organization will have the prerequisites to prepare the documentation required for an operating license application.

During the operating phase, the overall safety of the plant will be reassessed at intervals of no more than ten years in connection with a periodic safety review or the renewal of the operating license.

Fennovoima's organization in the licensing and construction phases

In the licensing and construction phases of the Hanhikivi 1 nuclear power plant project, special characteristics of the phases define the development needs of the organization. During the licensing phase, Fennovoima's organization will grow with recruiting the necessary amount of personnel who have the right expertise in the competence areas essential for the phase, such as project management, engineering, nuclear safety and quality management. In the construction phase, competencies and resources related to installation supervision and inspections will be required in particular. At the end of the construction phase, the emphasis in the organization will shift as the recruitment and training of operating personnel begins. When establishing the operating organization, the competencies created within the company during the construction phase will be utilized as far as possible. For a more detailed description of the personnel in the operating phase, see Appendix 2B of the application.

Figure 2A-2 shows the number of Fennovoima's own personnel in the licensing and construction phases from 2014 to 2023. The largest relative increase in the number of personnel will take place between 2014 and 2016, when specialists are needed particularly for the supervision and review of plant design. In addition to Fennovoima's own personnel, external experts are used, particularly in the licensing and construction phases, to complement Fennovoima's internal expertise and to balance out the work load when the number of required human resources is temporarily high. External experts are needed, particularly in the areas of engineering, construction and project management, and in design supervision duties. The need for external experts during the licensing phase is estimated at approximately one fifth of the entire personnel. Fennovoima will in ensure that it has a sufficient number of qualified personnel suitable for their tasks as required by section 7 i of the Nuclear Energy Act.
The number of personnel required in the various phases of the project has been estimated by competence area. The number of personnel will vary depending on the work load. Table 2A-1 presents the distribution of the personnel available to Fennovoima across functions in the licensing and construction phases.

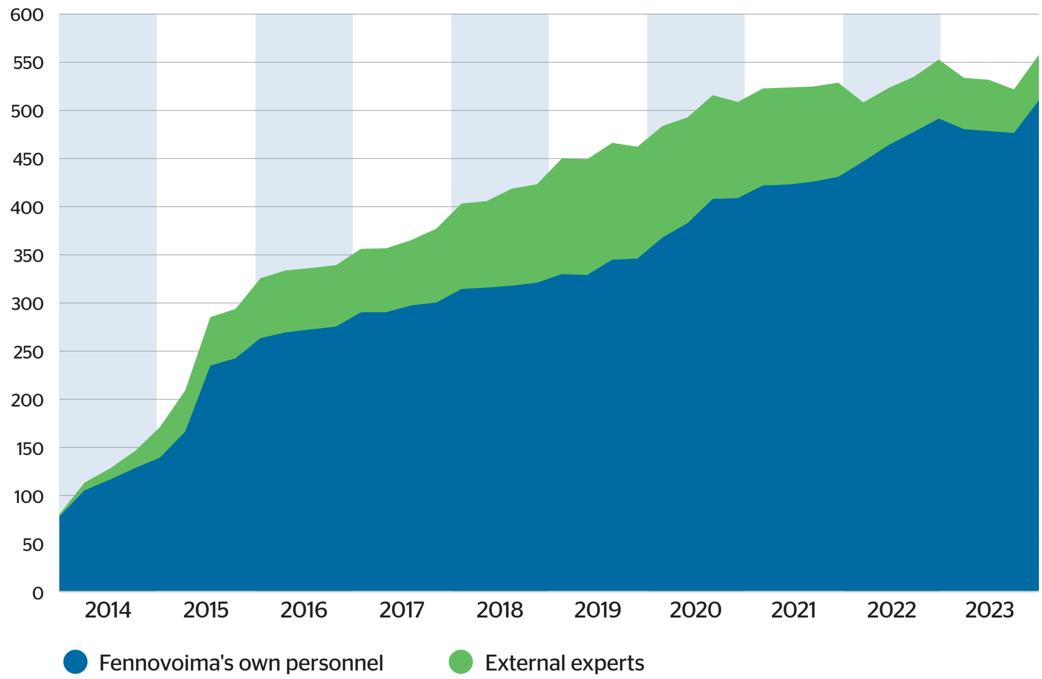


Figure 2A-2. Fennovoima's estimated number of personnel in 2014-2023.

Table 2A-1. Number of Fennovoima's personnel in the licensing and construction phases by function.

Function	Licensing phase 2014-2017	Construction phase 2018-2023
Project management	20–30	20–30
Safety and security	25–30	35–45
Quality and document management	20–25	20–25
Power plant technology including operation and maintenance expertise	170–180	320–340
Construction	45–55	50–60
Administration	55–60	55–60

Organization in the licensing phase

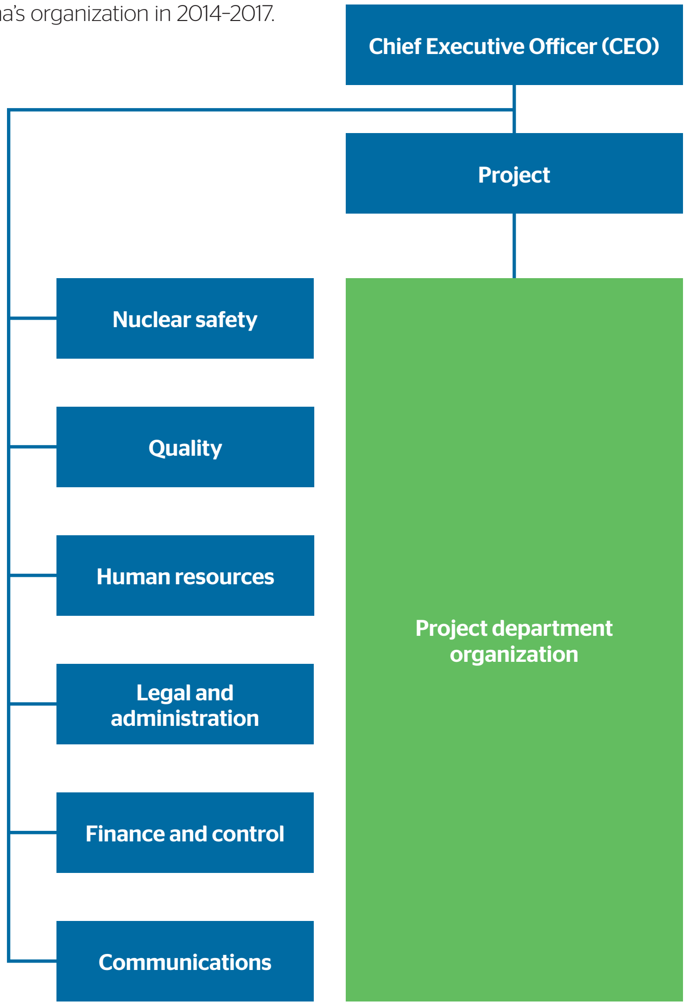
In the licensing phase between 2014 and 2017, Fennovoima's operations focus on the supervision of plant design, quality and project management, and the application of various permits and licenses. The largest department in Fennovoima's organization in this phase will be the project department, with the nuclear safety and quality departments closely supporting it. Figure 2A-3 presents Fennovoima's organization in 2014–2017.

At the beginning of June 2015, the number of Fennovoima personnel stood at 221 (June 15, 2015). At the end of the licensing phase, in 2017, the number of personnel available to Fennovoima is planned to be approximately 370.

Fennovoima as the licensee has planned the organization with attention to the safety-significant nature of the nuclear power plant project, and has also taken the safety aspect into consideration in the decision-making and management structure and the division of responsibilities. The structure, responsibilities and operations of Fennovoima's organization have been arranged to meet the requirements of the Nuclear Energy Act and other laws and decrees binding the company.

In the licensing phase, Fennovoima will apply for STUK's approval for the responsible manager and his or her deputy for the construction of the nuclear facility as required by nuclear energy legislation. At the same time, Fennovoima will apply for STUK's approval for the persons in charge of security arrangements, emergency preparedness, and nuclear safeguards, as well as their deputies. For a more detailed description of Fennovoima's project department in the licensing phase, see Figure 2A-4. The project department consists of several units: the project management office, program planning, contract management (including supply chain management), engineering unit, and construction, as well as the project areas of the Nuclear Island, Turbine Island and Balance of Plant together with Fennovoima's Owner's scope of work. The progress of the project is controlled and monitored within these areas. This organizational structure will ensure the optimal engineering expertise for the areas of the Nuclear and Turbine islands, as well as Fen-

Figure 2A-3. Structure of Fennovoima's organization in 2014–2017.



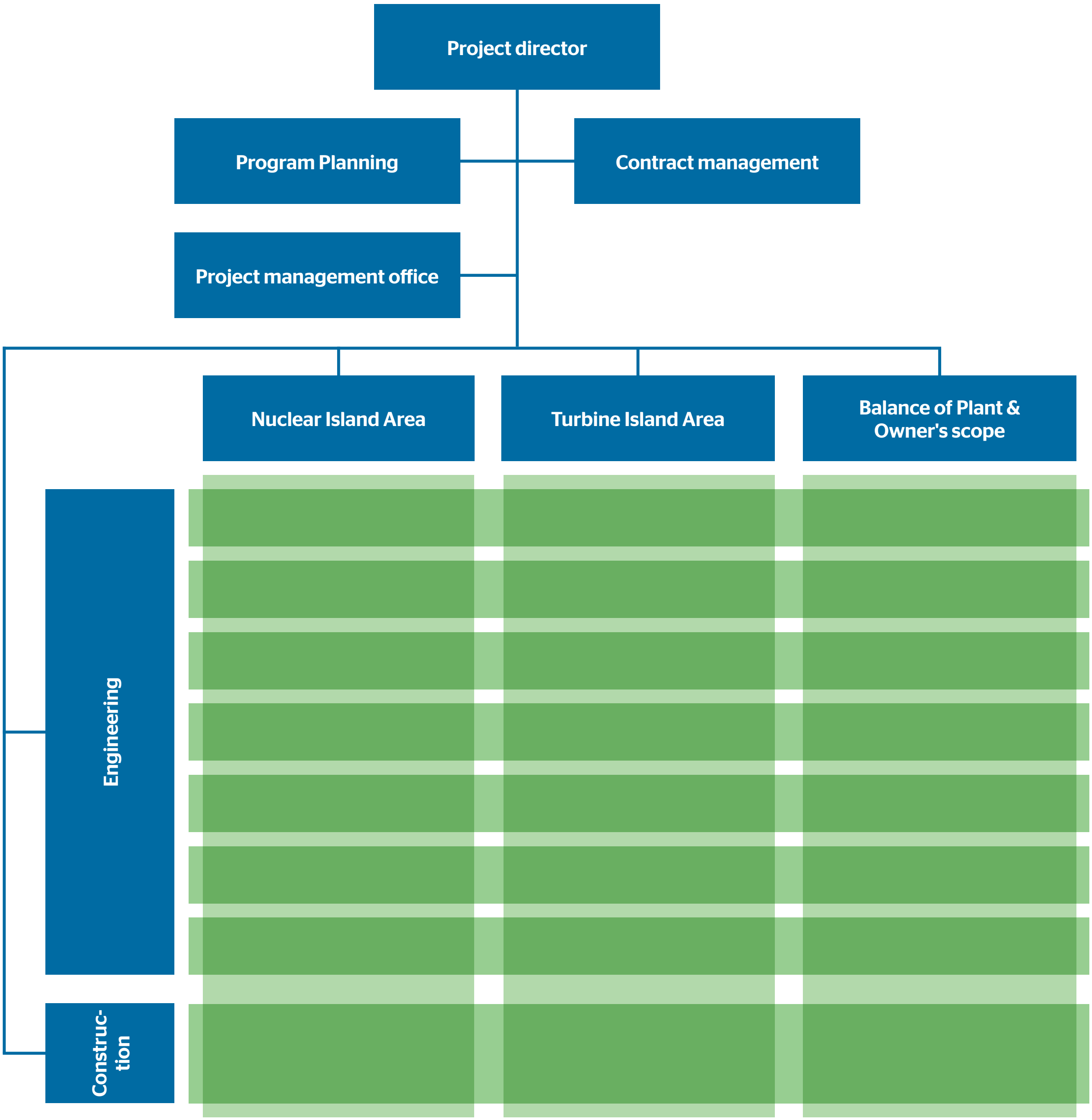


Figure 2A-4. Project organization in the licensing phase in 2014–2017.

novoima's own scope of work. The Project Execution Committee appointed by Fennovoima's Board of Directors will support the project management and supervise the progress of the project, identify targets for development and monitor the achievement of project objectives.

Organization in the construction phase

During the construction phase, where the focus shifts from planning to the execution of the project, the structure of Fennovoima's organization is planned to remain roughly the same as in the licensing phase (Figure 2A-3). Particular areas of emphasis within Fennovoima's organization include the expertise required for the supervision of construction work and the supervision of the manufacturing and installation of equipment and systems, and the expertise on quality management and authority correspondence.

The matrix structure of the project department is planned to be retained when proceeding from the licensing phase to the construction phase. In the construction phase, more of Fennovoima's functions and personnel will mobilize to Pyhäjoki. Figure 2A-5 shows the overall structure of the project organization in the construction phase.

In the construction phase, the resourcing will have reached a steady state, and the number of personnel will increase at a considerably lower rate than during the licensing phase. Resourcing will still mainly focus on technical personnel with the necessary competence for the supervision of construction operations and the inspection of equipment and systems. In the construction phase, Fennovoima will apply for STUK's approval for the responsible manager and his or her deputy for the operation of the nuclear facility as required by nuclear energy legislation. At the same time, Fennovoima will apply for STUK's approval for the persons in charge of security arrangements, emergency preparedness, and nuclear safeguards, as well as their deputies.

In the construction phase, a separate commissioning unit will be established under the project department. At the end of the construction phase, Fennovoima will convert the project organization, responsible for the implementation of the project, into an operating organization,

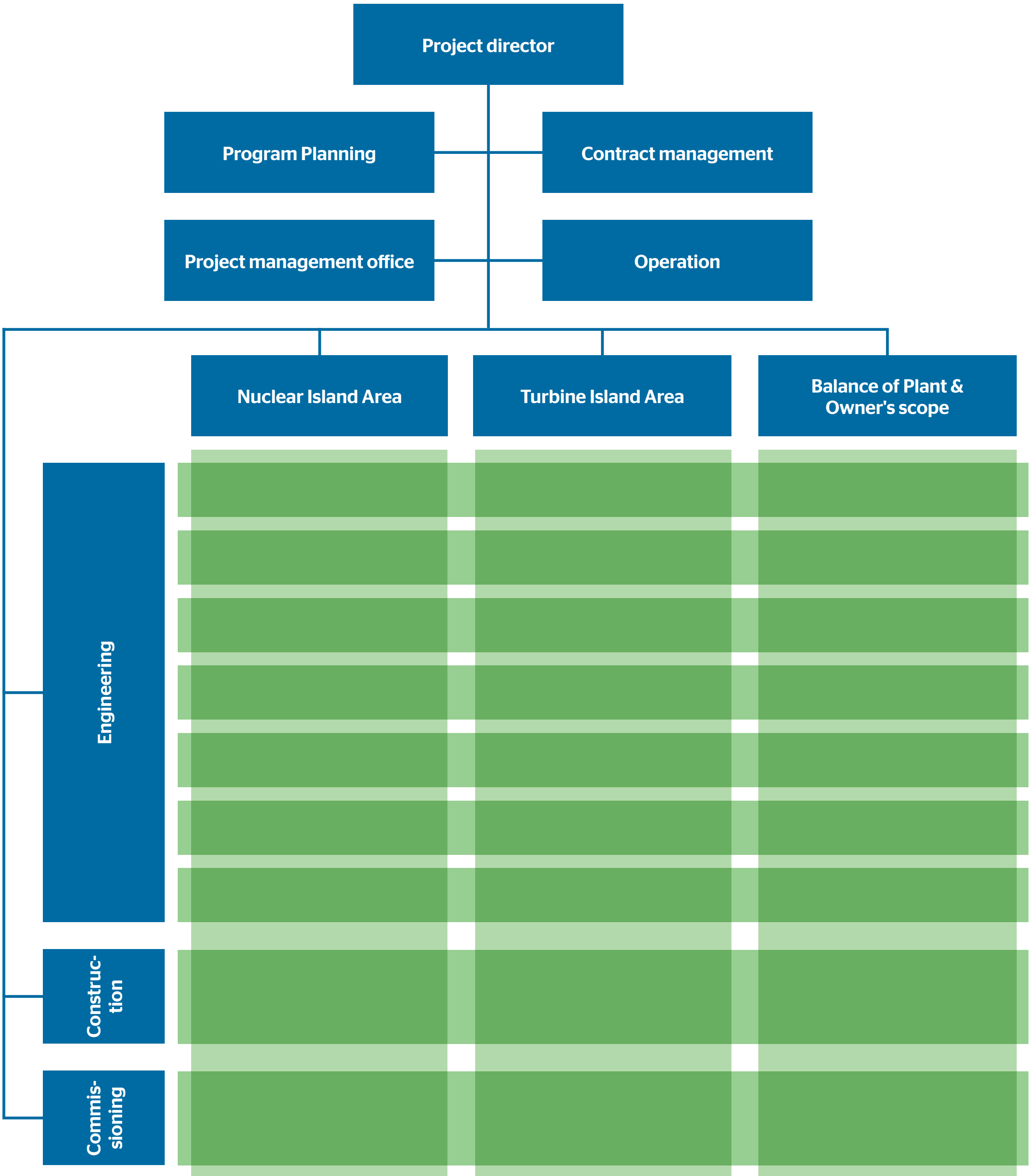


Figure 2A-5. The overall structure of the project organization in the construction phase.

maintaining knowledge of the plant's design, construction and commissioning within the nuclear power plant's operating organization. Safe and smooth continuity of operations can be ensured by retaining the experience and competence accumulated during the project.

At the end of the construction phase, the number of personnel in Fennovoima's organization is estimated at 500. Of this number, 240 people will be operating personnel, planned to be recruited starting from 2019. The first part of the operating organization's recruitment effort will focus on plant operators, who will begin their training approximately four years before the commissioning of the plant. An estimate of the distribution of personnel across functions in the construction phase is presented in Table 2A-1. For an outline of Fennovoima's operating personnel, see Appendix 2B of this application.

Expertise available to Fennovoima

Fennovoima will ensure that it has necessary expertise and competence in all phases of the project, and will complement these with external experts when necessary. Fennovoima recruits experienced professionals from the nuclear energy and other industries. The professionals recruited from other industries are expected to possess solid competence and experience in their own field of expertise. Experience of other major construction projects will provide a specialist with a good starting point for working as a specialist in a nuclear plant project. To ensure continuity of own expertise, specialists of various fields still in the early stages of their careers will be recruited by Fennovoima to work with the more experienced professionals.

In mid-June 2015, 72% of Fennovoima's personnel had a university degree in engineering or science, or another suitable degree. Of these, eight had completed a licentiate or doctoral degree. A total of 90% of the personnel had a Bachelor's or Master's degree.

Through induction and continuous training of the personnel, Fennovoima will ensure that the personnel is familiar with the requirements of the nuclear industry, and develops and maintains high safety culture. The personnel will also be trained to understand the special characteristics of project-oriented operations and the international nature of the project.

Nuclear safety expertise

In all the phases of the project, Fennovoima will have at its disposal the nuclear safety expertise required for the safe construction and operation of the nuclear power plant. Competence areas important for ensuring nuclear safety include deterministic and probabilistic safety analyses, reactor physics, nuclear fuel and waste management, radiation protection, security and emergency preparedness, and safety culture. Fennovoima has recruited experienced specialists in various areas of nuclear safety.

Fennovoima will develop its competences in nuclear safety by participating in various domestic and international trainings and by international cooperation, among other things. Fennovoima will also ensure that the entire personnel and other available human resources will have the necessary competence and knowledge of Finnish nuclear energy legislation. Fennovoima will provide training on nuclear energy legislation to its entire staff and offer its personnel opportunities to participate in Finnish nuclear energy trainings and international trainings in order to ensure the nuclear energy competence of each member of the personnel and of the overall organization.

Fennovoima will monitor the development of best practices as well as the technology and research in the nuclear industry. The nuclear safety unit ensures that all Fennovoima personnel and other people working for the organization have the necessary competence to take nuclear safety into account within their own areas of responsibility. Fennovoima will develop and maintain high safety culture within its organization. Fennovoima will also use various networks in developing its nuclear safety expertise, and will actively participate in the work of domestic and international nuclear energy associations.

Engineering and construction expertise

Expertise in engineering will be required in Fennovoima's organization for the entire duration of the Hanhikivi 1 project. Specific competence areas include the engineering management, process and systems design, requirement management, quality control, and thorough competence in various technical fields such as electrical engineering, automation, and mechanical engineering.

Fennovoima has recruited experienced specialists from various technical fields. Fennovoima will also train its entire personnel in nuclear technology and, in particular, in the characteristics of the selected plant type as required by the tasks of each member of personnel.

In addition to engineering competence, Fennovoima's resource planning takes into account the structural engineering and construction engineering competences required at the nuclear power plant project. Fennovoima's organization already includes geological and construction engineering expertise before the beginning of the construction phase. During the construction phase, this area of expertise will be further strengthened through additional recruitment and the use of external experts. During the construction phase, the operating and maintenance organizations will also be grown.

Quality management expertise

Quality management will be among the most important competence areas in the Hanhikivi 1 project. An essential task of Fennovoima's quality organization is to develop Fennovoima's management system to meet the requirements of international quality management standards and the nuclear energy industry requirements. The quality department is also responsible for evaluating suppliers, managing nonconformities, and coordinating corrective actions. The quality department operates as an independent unit separate from the rest of the project organization to ensure the independence of quality-related decisions. Quality management professionals also work in various technical areas in the quality assurance and quality control, manufacturing, construction and installations.

Fennovoima will ensure that its personnel and other experts possess the necessary skills and understanding of quality management. Fennovoima emphasizes the importance of quality in achieving the highest level of nuclear safety, and requires commitment from its personnel to high-quality work. Continuous improvement is one of the key principles on which Fennovoima's work is based.

In the procurement and licensing phases, Fennovoima pays particular attention to quality management and the development of the management system, and has several experienced quality management professionals in its organization.

Project management expertise

Project management has been defined as one of Fennovoima's most important competence areas. The most important competence areas within project management are strategic planning, scope management, interface management, schedule and cost management, management by objectives, resource management and risk management.

The specialists working in project management possess expertise and experience in project management. Particular emphasis is placed on experience of managing and working in large-scale projects. In addition to project management skills, important areas of the specialists' competence and its development include safety, quality and nuclear technology, as well as an understanding of nuclear energy legislation and requirements. In addition to people working in actual project management duties, other personnel will also be trained to the principles and methods of project management.

Fennovoima's competence development

Fennovoima has developed methods for developing its personnel's competencies to fulfill the requirements of the Nuclear Energy Act and the YVL Guides. In competence development, the requirements of the law and various authorities and other bodies are taken into account. In addition to professional knowledge and skills, Fennovoima pays attention to the development of nuclear safety and quality competencies of its personnel.

The skills and competence areas required for the construction of a nuclear power plant have been defined in Fennovoima's competence model. The personnel's competencies and the needs for competence development are regularly monitored with competence surveys carried out in connection with personal development discussions. The discussions are used to ensure that the competencies and qualifications of the employee meet the requirements of the position, and to set objectives for the development of the competencies.

Fennovoima shall prepare an annual training plan, which takes into account the training needs raised from the development discussions and on other training needs identified within the organization with respect for example to official requirements. Training will be organized to the extent necessary so that adequate competence in each area is guaranteed within the company. Fennovoima will also ensure that work-related qualifications are up to date, and training to renew the qualifications is arranged in a timely manner. According to the 2015 training plan, each member of Fennovoima's personnel receives an average of nine days of training per year.

Fennovoima funds the Finnish Research Programme on Nuclear Power Plant Safety (SAFIR) and participates in the work of the steering groups of the research projects within the program. Fennovoima also participates in the Finnish Research Programme on Nuclear Waste Management (KYT). By participating in research, Fennovoima acquires the most recent research information, which can then be utilized in competence development.

Other expertise available to Fennovoima Expertise within the Rosatom Group and subcontractors

Rosatom Group is one of the world's largest nuclear energy industry corporations. It consists of more than 250 organizations and employs more than 260,000 people. Rosatom has continuously developed its VVER type nuclear power plants to meet the latest safety requirements. Rosatom has several ongoing nuclear power plant projects in Russia and abroad. Of Rosatom's nuclear power plant projects of the AES-2006 plant type chosen by Fennovoima, the construction work is most advanced at the Leningrad II-1 nuclear power plant unit, located in Sosnovy Bor in Russia.

Fennovoima is able to utilize the expertise and resources of Rosatom in various phases of Hanhikivi 1 project. Fennovoima's plant supply contract includes the agreement on training on the plant technology to be provided to Fennovoima's personnel, as well as extensive operator training. Fennovoima will also be able to cooperate with other nuclear power plants of Rosatom in the operator training.

Other available expertise

In addition to own personnel, Fennovoima will also use other services of external experts as considered necessary during the project. Decisions on the use of external expertise will be made on a case-by-case basis to ensure that Fennovoima will, in all circumstances, possess sufficient internal expertise in key areas of the project, as well as the potential and ability to monitor and control the suppliers involved in the project. The expert services to be used will be purchased from service providers such as engineering and consulting firms that have experience of large projects in the nuclear industry or in other industries. Fennovoima will select its partners in accordance with the supplier selection process defined in the management system.

External expertise will also be used for assessments in which the independence from the company's operations is essential. Such tasks are evaluations of Fennovoima and its management system, as well as assessments and analyses carried out to validate the plant supplier's safety analyses.

Fennovoima's organization and available expertise
Appendix 2B

An outline of Fennovoima's planned operating phase organization

Summary

As required by section 32, paragraph 8 of the Nuclear Energy Decree (161/1988), this appendix includes an outline of the nuclear power plant's planned operating organization during the operating phase. Fennovoima's operating organization will be formed during the licensing and construction phases, and a detailed description of it will be included in the nuclear power plant's operating license application.

For the operating phase, Fennovoima will convert its project organization, responsible for the implementation of the project into operating organization. The necessary information of the design, construction and commissioning of the plant will be transferred to the operating organization. Fennovoima will make sure that the experience and information accumulated during the implementation of the project will carry through to the operation of the plant.

During the licensing and construction phases, Fennovoima will ensure that the organization includes an adequate number of skilled personnel with the required expertise for the safe operation of the plant. This will be ensured by extensive training and development programs. Fennovoima's organization in the operating phase is planned to be comprised of eight departments. The number of internal personnel is planned to be approximately 400 in the operating phase, with an additional outsourced personnel of 100 people.

An outline of Fennovoima's planned operating phase organization

Organization and requirements in the operating phase

The company will be reorganized when the operating phase begins (during commissioning). The requirements and emphasis of the organization shift from project competencies, inspection of plant design and construction operations towards the operating phase. In the operating phase, the focus of the organization will be on operative personnel required for the safe operation of the nuclear power plant, and on maintenance and the planning and implementation of plant modifications. Safety always takes precedence in the operation of the plant, and operating experience will be systematically monitored and assessed.

In the operating phase, Fennovoima, as the licensee and operator of the plant, will be responsible for maintaining the appropriate safety level in all operations and for fulfilling the requirements set for the operating phase in laws, decrees and the YVL Guides (nuclear safety guides) published by the Radiation and Nuclear Safety Authority (STUK). When the project organization is converted into the operating organization, it will receive all the necessary information concerning the design, construction and commissioning of the plant. Competence development programs will be established to secure the competencies required for the safe and efficient operation of the plant. The development programs will cover the basic, further and refresher training of the personnel, as well as practical training. Fennovoima will thus ensure that the experience and information accumulated during the implementation of the project will carry through to the operation of the plant.

Structure of the operating organization and personnel resource needs

Fennovoima's operating organization will consist of eight departments: operation, plant engineering, nuclear safety, quality, human resources, legal matters and administration, financial, and communications department. Fennovoima defines the number of personnel and structure of its operating organization as follows:

- Management of nuclear safety, quality control and inspection operations will be independent from actual operating activities.
- The safe operating and maintenance tasks during normal operation, operating transients, emergencies and accidents can be carried out in compliance with the requirements in all situations.
- Sufficient expertise is available at all times for ensuring the safety of the power plant and for carrying out safety analyses and safety assessments.
- Sufficient expertise is available at all times for the maintenance of plant configuration, management of compliance, planning of modifications and maintenance of plant documentation.
- Essential competence development and training can be managed internally.
- Competence of management resources has been ensured, and the resources are adequate for the planning, management and assessment of personnel resources.
- The operation and maintenance of the plant is carried out in a planned and cost-efficient manner.

During the licensing and construction phases, Fennovoima will carry out recruitment and induction operations and implement development programs to ensure the adequate number and competencies of the personnel for the operating phase. The structure of the organization, the

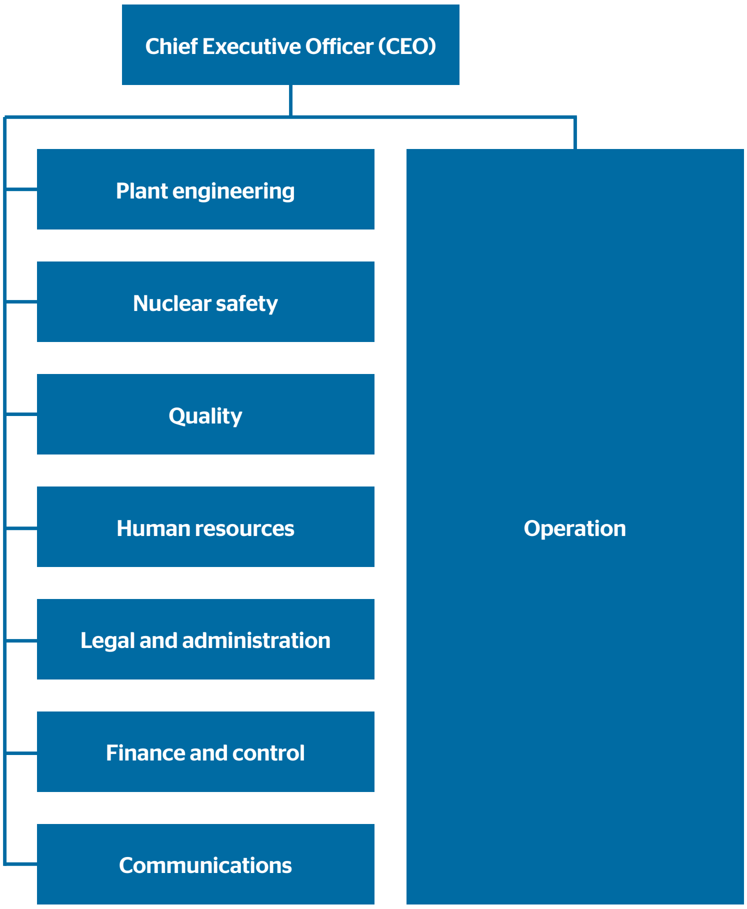


Figure 2B-1. An outline of the operating phase organization.

tasks and responsibilities of the personnel, and the decision-making procedures will be defined in the company's organizational handbook. The organizational models of other Finnish nuclear power companies, among other sources, have been used as the basis for planning Fennovoima's human resources. Fennovoima's operating organization will be defined in more detailed in the nuclear power plant's operating license application.

An outline of the planned operating phase organization is presented in Figure 2B-1.

The number of internal personnel will be approximately 400 in the operating phase, with an additional outsourced personnel of 100 people. Outsourced services will include general support functions such as security, cleaning and catering services.

A significant part of personnel in the nuclear power plant's operating and engineering departments will consist of the project organization that will be broken down after the construction phase. The project organization will no longer be needed when the operating phase has begun, and some of the project personnel will transfer into the operating organization. In order to complete the project's guarantee phases, the operating organization must contain project and contract management personnel for approximately three years after the commencement of the commercial operation of the plant. The schedule of establishing the operating organization will be defined based on the duration of the training of operating personnel, and whether the personnel will participate in the supervision of equipment installation and the commissioning of the plant.

Table 2B-1 presents the estimated number of personnel at various departments in the operating phase.

Operating department

The operating department of the nuclear power plant will be responsible for all the operating activities of the power plant. The operating department will consist of the operating and maintenance units and the operating support unit.

The operating unit will be responsible for plant operation, planning of operation, preparation and maintenance of operating procedures, the training of nuclear power plant operators, and for its share of the operating experience feedback. The operating unit will include the operating personnel that work in shifts. The minimum number of personnel in a shift will be five: a shift supervisor, reactor operator, turbine operator and two field operators. The composition of an operating shift will depend on the final design solutions of the plant. In each shift, there will always be the necessary number of personnel to ensure the safe operation of the plant in all operating conditions (during normal operation, operating transients, emergencies and accidents). Procedures such as a control room operation validation program will be used to ensure this.

The maintenance unit will be responsible for the maintenance of the nuclear power plant's equipment, structures and systems. The maintenance unit will also plan and manage the annual outages, and will be responsible for their logistics, planning of modifications, and the procurement and storage of spare parts, supplies and tools.

The operating support unit will be responsible for the plant chemistry, radiation protection and the handling of fuel and waste.

The planned number of personnel for the operating department is 220–240 people.

Plant engineering department

The plant engineering department will be responsible for the management of compliance, plant configuration and aging, and for its share of the planning of technical modifications to the plant. It will also be responsible providing the expertise and project management for system design solutions. The engineering department will consist of the configuration management unit and units of various technological fields. The planned number of personnel for the engineering department is 40–50 people.

Nuclear safety department

The duties of the nuclear safety department will include the management of the licensing and official proceedings related to nuclear and radiation safety and the transfer and transportation of fuel. The nuclear safety department will also be responsible for the control of nuclear materials, security and emergency response arrangements, safety culture, safety analyses, operating safety and other matters falling into the scope of corporate security, such as information security, the fire brigade and site security services.

The nuclear safety department will provide independent monitoring of the safety of operating activities, and systematically monitors and assesses operating experience feedback. The nuclear safety department will also be responsible for defining and maintaining the operational limits and conditions (OLC) of the plant.

The planned number of personnel for the nuclear safety department is 35–45 people.

Quality department

The quality department will be responsible for the quality management and quality assurance of the nuclear power plant, the maintenance and development of Fennovoima's management system, and the management of plant documentation and environmental matters. Supplier

Table 2B-1. Estimated number of Fennovoima's personnel in the operating phase.

Organization department	Operating phase
Operation	220–240
Plant engineering	40–50
Nuclear safety	35–45
Quality	15–25
Human resources	10–15
Legal and administration	10–15
Finance and control	20–25
Communications	10–15

evaluations and the management of deviations will also be included in its tasks. In addition, the quality department will ensure the proper coordination of occupational health and safety operations. The planned number of personnel for the quality department is 15–25 people.

Human resources department

Fennovoima's human resources department will be responsible for personnel and employment relationships as well as competence development. It will also coordinate the training of the personnel and maintain competence development programs. The planned number of personnel for the human resources department is 10–15 people.

Legal matters and administration

The department of legal matters and administration will be responsible for legal services, labor market considerations and assistant services. The planned number of personnel for the department of legal matters and administration is 10–15 people.

Financial department

The financial department will be responsible for Fennovoima's financial administration and information management. The planned number of personnel for the financial department is 20–25 people.

Communications department

The communications department will be responsible for communications, connections to stakeholders, and visitor operations. The planned number of personnel for the communications department is 10–15 people.

Persons in charge

For the purposes of the operating phase, persons in charge and their deputies, subject to STUK's approval, will be appointed for the organization: responsible manager and persons in charge of security arrangements, emergency preparedness and the nuclear safeguards.

Fennovoima will train the adequate number of nuclear power plant operators approved by STUK (shift supervisors, reactor operators and turbine operators) for operating shifts and for other tasks in which the same level of competence is required. Such tasks include those of the operating engineer, who will be the immediate supervisor of shift supervisors, and the chief simulator trainer, other simulator trainers and on-call safety engineers.

Renewal of operating license

During the operating phase, overall safety of the plant is evaluated at intervals of no more than ten years in connection with a periodic safety review or the renewal of the operating license. The work load required by the operating license renewal and periodic safety review will not essentially differ from the work load required for the first operating license application. Operating license renewals and periodic safety reviews will be carried out as separate projects during the operating phase.

Decommissioning

The operating personnel of the nuclear power plant will also manage the decommissioning of the plant. At the final stage of commercial operation, the operating organization will transform into a decommissioning organization. This will ensure the availability of in-depth knowledge of the plant during decommissioning. The decommissioning of the plant is described in more detail in Appendix 5B of this application.

Nuclear power plant site
Appendix 3A

An account of the environmental impacts of the construction and operation of the nuclear power plant, as well as of measures to prevent and mitigate the adverse impacts

Summary

As required by section 32, paragraph 7 of the Nuclear Energy Decree (161/1988), this appendix includes a description of the nuclear facility's environmental impacts and the design criteria adopted by the applicant to avoid environmental damage and to restrict the burden on the environment. The information provided in this description is mainly based on the data presented in Fennovoima's environmental impact assessment report, published in February 2014, and in the environmental permit application for the nuclear power plant and the back-up power production system, submitted in December 2014.

The nuclear power plant will be built at a visible location in the central and northern parts of the Hanhikivi headland reaching out into the open sea, and the construction of the plant will change the landscape considerably. Some of the forests and seashores on the Hanhikivi headland will become built areas, which means that some of the flora and fauna in the area disappear or change. The endangered seashore meadows as well as the habitats of the endangered and strictly protected plants found in the headland are located outside the construction areas. The preservation of the protected moor frog among the headland's fauna is also not expected to be at risk. During hydraulic engineering work, fishing in the immediate area will not be possible, and the work will drive the fish away from an extensive area. Other environmental impacts of the construction phase will be temporary and localized.

The most significant environmental impact occurring during the operation of the power plant will be the spread of warm cooling water to the surrounding sea area, and its impacts on the water system and the fishing industry. The heat load will lead to some increase in the production of phytoplankton in the area. Seashore meadows found on the eastern coast of the headland may suffer from the increased temperature of the seawater. Warming and the lack of ice may, over the long term, accelerate the overgrowing of seashore meadows on the eastern coast of the headland, deteriorating the habitats of the Siberian primrose that grows in these meadows. Overgrowing of the seashore meadows can, however, be prevented through maintenance measures. The heat load discharged into the sea will be decreased by designing the plant to operate in an energy-efficient manner. The objective is to maximize electricity production and to minimize the waste heat to be discharged.

The warm cooling water will have adverse impacts on professional and recreational fishing in the areas near the power plant. Fishing will be prevented or rendered difficult, and changes will take place in the species distribution and fry production. The impact will be strongest in the immediate vicinity of the cooling water discharge channel, and gradually decrease with the distance from the Hanhikivi headland. Professional fishermen will be compensated for the adverse impact on fishing. A fishery fee will also be paid.

Radioactive substances are generated during the operation of a nuclear power plant. These substances are isolated from the living environment using several successive barriers. Very low levels of radioactive substances will be able to reach the environment via the ventilation channels, for example. All potential emission pathways are monitored, and they can be closed and the radioactive emissions recovered. The radiation exposure from radioactive emissions is only a fraction of the exposure from natural background radiation, and the emissions will have no impact on nature even in the Hanhikivi headland.

Other environmental emissions or discharges resulting from nuclear power plant operations are low, and their environmental impacts have been assessed to be minor.

Construction and operation of the nuclear power plant and the nuclear facilities required for its operation are not expected to have any significant adverse impact on the habitats or species that form the conservation criteria of the Parhalahti–Syölätinlahti and Heinikarinlampi Natura 2000 area, or on the integrity of the area.

The environmental impacts of the construction and operation of the nuclear power plant and the nuclear facilities required for its operation have been carefully assessed, and are well known. The construction and operation activities will have no such adverse environmental impacts that are unacceptable or could not be mitigated to an acceptable level.

An account of the environmental impacts of the construction and operation of the nuclear power plant, as well as of measures to prevent and mitigate the adverse impacts

Environmental management system

Fennovoima is committed to continuous improvement of environmental management, and will define clear environmental objectives and targets for its operations, as well as programs to achieve these objectives and targets. For the purposes of the environmental management, Fennovoima will prepare an environmental management system for the nuclear power plant in accordance with the ISO 14001 standard. The environmental management system will be an integral part of the company's management system. The environmental management system will be certified and adopted before power production operations begin.

Fennovoima will also prepare a separate environmental management system for the construction phase of the nuclear power plant to ensure that the environmental impacts of the construction phase are properly managed and remain as low as possible. The environmental management system will be continuously developed to correspond to any changes in conditions at the construction site.

Fennovoima commits to the continuous improvement of energy efficiency and will integrate an energy efficiency system into its environmental system. Fennovoima will also join the national energy efficiency agreement scheme before beginning power production operations at the nuclear power plant. In its energy efficiency system, the company will commit to developing the efficiency of the energy conversion process, reducing internal consumption, promoting overall energy efficiency and ensuring the right attitudes.

Environmental impact assessment

Fennovoima carried out the environmental impact assessment (EIA) procedure in 2013–2014 to investigate the environmental impacts of the construction and operation of a nuclear power plant with an approximate power output of 1,200 MW. The facilities will be located on the Hanhikivi headland in the municipality of Pyhäjoki. The coordinating authority, the Ministry of Employment and the Economy, issued a statement on the EIA report on June 2, 2014 to conclude the EIA procedure. In its statement, the Ministry of Employment and the Economy found that the EIA report meets the requirements laid down in the EIA legislation, and that the statement issued by the coordinating authority regarding the EIA program had been taken into account in the report.

The coordinating authority also included in its EIA statement the requirement that Fennovoima shall carry out additional surveys of the marine environment and fishery, and attach their results to the construction license application. The additional surveys are included in this application as Appendix 3B.

The current state of the environment

The Hanhikivi headland area is low-lying land-uplift coast, the typical features of which include seashore meadows and overgrowing shallow bays. The natural forest succession series of the land uplift coast is the dominating habitat type in the headland, but without the oldest stages of the series.

The headland has several small gloe lakes and one flada, created as a result of land-uplift. A gloe lake is a pond that has been separated from the sea by land-uplift and that has no regular connection to the sea. A flada is a low water pool at the shoreline which still maintains a connection to the sea.

A Finnish Important Bird Area (FINIBA), several nature conservation areas, protected habitat types and other important sites are located in the immediate surroundings of the Hanhikivi headland (Figure 3A-1). The Parhalahti–Syölätinlahti and Heinikarinlampi Natura 2000 area is located approximately two kilometers to the south of the project site. The area is also a bird area of national significance, and it is included in the Finnish Waterfowl Habitats Conservation Programme.

Five endangered or otherwise protected vascular plants are or have been found in the headland area, of which the Siberian primrose appears in many places in the Hanhikivi east meadow and the Takaranta seashore meadow, among other places. The moor frog, which is among the species listed in Annex IV(a) to the Habitats Directive (92/43/EEC), is also found in the headland. No endangered plants grow in the areas where construction will take place, nor have any bat or Siberian flying squirrel nesting or resting sites been found there.

Due to its varied habitats, Hanhikivi has a wide range of nesting bird species and large bird populations. A wide variety of wetland birds nest in the area. Species of the meadow and reed bed habitats, as well as those of rough shores and beaches, are also found in the area. Species of mixed forests dominated by deciduous trees are found in the inner parts of the headland. The areas with the widest range of bird species are located outside the area included in land use plans, in the Takaranta, Heinikarinlampi, Hietakarinlahti, Parhalahti and Syölätinlahti areas.

The loose soil layer of the Hanhikivi headland mainly consists of moraine. The bedrock is mainly metaconglomerate. The headland area has been classified as a valuable area in terms

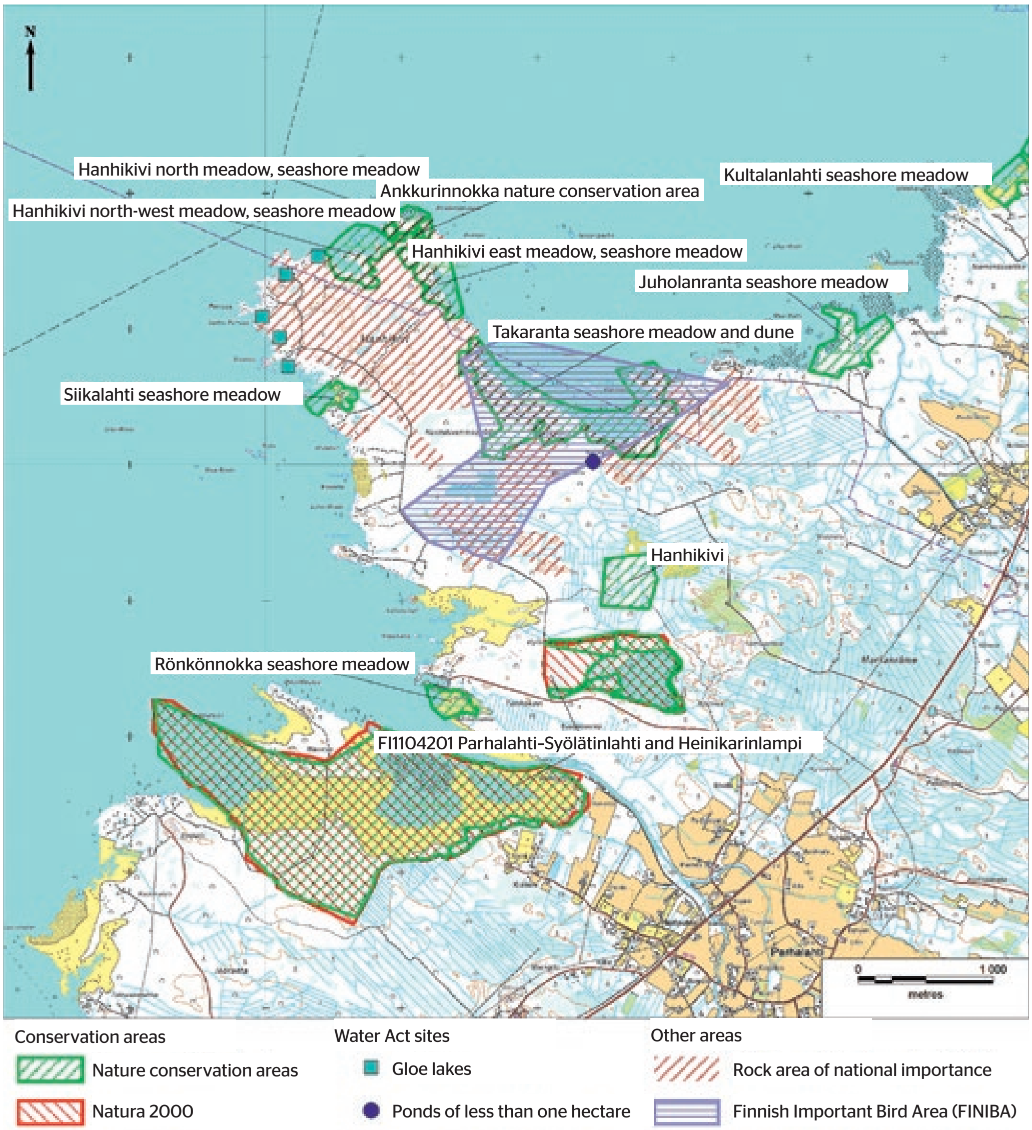


Figure 3A-1. Natura 2000 areas, nature conservation areas and other noteworthy areas in the Hanhikivi headland and the surrounding areas.

of natural and landscape conservation, and it is also a bedrock area of geological importance. The nearest classified groundwater catchment area is approximately ten kilometers from the headland.

In the northern parts of the headland, there is the Hanhikivi border stone, which is of historical importance. The stone is a fixed historical monument protected by the Antiquities Act (295/63) and an object of national value.

The coastline around the Hanhikivi headland is very open and windy, and water turnover in the area is efficient. The depth of the water increases very slowly, initially at a rate of one meter per 100 m distance. The sea water quality depends on the general state of the Bothnian Bay and is influenced by the water coming from the Pyhäjoki river as well as the currents running along the coast. Pyhäjoki empties approximately six kilometers from the plant site on the south side of the Hanhikivi headland. The quality of the seawater in the area corresponds to the average quality of water along the Bothnian Bay coast. In an ecological assessment of the Finnish environmental administration, the water quality of the sea in front of the Hanhikivi headland was classified as "satisfactory" near the shore and "good" farther away from the shore (at a distance of more than 300 meters). The state of the coastal waters is affected by eutrophication caused by nutrients carried by rivers, as well as the population centers and industries found in the coastal regions.

The shores of the Hanhikivi headland are gently sloping and open to waves. The most sheltered areas with the most diverse aquatic vegetation are found in the shallow coves of Takaranta and Kultalanlahti. Five endangered Baltic Sea habitat types are found on the shores of the Hanhikivi headland and in the waters around it, of which the bottom dominated by submerged macrophytes is classified as Vulnerable (VU) and the charophyte meadows as Endangered (EN). Bottom dominated by submerged macrophytes is most frequently found in the more sheltered parts of the coastline, such as the flada to the east of the planned cooling water discharge site, at the base of the headland on the Kultalanlahti side, and in the Juholanranta area. Charophyte meadows have been found on the east coast of the headland and, particularly, at the base of the headland on the Kultalanlahti side. All the Charophyta found were *Chara aspera*, which is not an endangered species. A total of 33 species of plants and algae were found in surveys, of which 20 were species of aquatic vegetation. No endangered species have been found in the headland area. For a more detailed description of the aquatic vegetation in the area, see Appendix 3B of this application.

The sea in front of the Hanhikivi headland is significant both in terms of the fish stock and in terms of fishery. The fish species typically found in the area are those typically found in the whole of the Bothnian Bay. Species of economic significance include the sea-spawning whitefish *Coregonus l. widegreni*, common (migrating) whitefish, perch, Baltic herring, vendace, sea trout, salmon, and pike. Spawning river lampreys can also be caught in the rivers emptying into the area. Furthermore, endangered graylings have been found in the sea. The surroundings of the Hanhikivi headland are an important spawning area for sea-spawning whitefish, Baltic herring, and vendace. Migration routes of whitefish and salmon exist in the headland area, but based on interviews with professional fishermen, the main migration routes to the rivers in the north are located fairly far away from the shoreline, in waters at least ten meters deep. A more detailed description of the fish stocks and fishing industry in the area, as well as migrating fish and their routes, is included in Appendix 3B of this application.

Environmental impacts of the construction phase and the prevention and mitigation of adverse impacts

The nuclear power plant will be built at a highly visible location in the central and northern parts of the Hanhikivi headland reaching out into the open sea. The plant will stand out from the environment in terms of size and character, and will bring about significant changes to the landscape. The role of the Takaranta seashore meadow of regional importance in the landscape will change, as will the role of the historic Hanhikivi border stone of national importance. Visitors will still be able to reach the Hanhikivi stone, but the route will change.

Fennovoima and the main contractor will prepare an environmental management system for the construction site to ensure that the adverse impacts of the construction phase are as minimal as possible. The construction site will be marked off with fences and signs during the construction phase. Access to the seashore areas of the construction site and other construction site areas existing protected species or habitats will be prevented with fences and signs. Employees will be provided with training and information on the restrictions that are in force with regard to activities in the natural environment and in nature conservation areas.

Bedrock, groundwater and surface waters

Excavation of the bedrock will reduce the geological value of the Hanhikivi headland, which has been classified as valuable. Part of the bedrock of geological value will, however, remain untouched, as excavation of the bedrock will mainly focus on the power plant site. As indicated by the land use plans, representative parts of the bedrock will be left exposed. The adverse impacts of the vibration generated by the excavation work will be mitigated by proper planning of the excavation work and by appropriate working methods.

The level and pressure of groundwater may decrease during the construction work, and its quality may undergo temporary deterioration as a result of blasting and grouting of the bedrock. Any changes will be limited to the construction area by using solutions such as water-tight support structures and sealing of bedrock. The impact on groundwater will remain local and minor.

Rainwater will be collected from the construction site in a controlled manner, purified appropriately and released into the sea. The rainwater is not expected to deteriorate the quality of the seawater. The quality of the collected rainwater will be managed using both centralized (retention basins) and distributed (catch basins) structures. Oil sumps and other water cleaning structures will be built as necessary. The condition and functionality of rainwater basins and structures will be monitored in accordance with a maintenance program.

Flora, fauna and nature conservation areas

Some of the forests and seashores on the Hanhikivi headland will become built areas, which means that some of the flora and fauna in the area disappear or change. The natural forest succession series of the land uplift coast habitat type represented by the headland will be partially fragmented, but a significant part of the habitat type will remain outside of the areas reserved for construction. Of the endangered habitat types, nearly all the seashore meadows are protected as nature conservation areas or as protected habitat types under the Nature Conservation Act, and are therefore excluded from the construction site.

The power plant area has some objects of the natural environment that have been indicated as items of particular importance for natural diversity within the area but that will be partially covered by constructions. Parts of the meadows and one small gloe lake will be covered by the harbor structures and the cooling water intake and discharge structures to be built at the tip of the headland. This impact cannot be considered significant, as similar objects are found in larger and more representative form in other parts of the Hanhikivi headland.

The habitats of endangered flora and the species of flora listed in Annex IV(b) to the Habitats Directive (92/43/EEC) found in the Hanhikivi headland are located outside the construction areas, and will not be subjected to any direct impact. A legally valid permit has been granted concerning the transfer of batches of yellow iris, which is among the species protected in North Ostrobothnia.

Two of the five habitats of the moor frog, listed as a species under strict protection in Annex IV(a) of the Habitats Directive, are located in the harbor area. These habitats will be lost. A legally valid permit has been granted concerning the transfer of the moor frogs and clearing out the spawning area. The most important spawning sites of the moor frog are, however, found outside the power plant area, and power plant operations will have no impact on these. The preservation of the moor frog among the fauna of the headland is not at risk. No nesting or resting sites of bats or the Siberian flying squirrel have been found in the areas where construction will take place.

The nuclear power plant and other construction operations related to it are mainly located in the inner parts of the Hanhikivi headland, where most of the birds are forest species. These populations will leave the area as a result of the construction operations. The shore areas of the harbor and the cooling water intake and discharge areas are not particularly valuable as bird habitats, which means that their impact on bird populations during the construction phase will remain minor. The noise during construction may temporarily disturb birds close to the power plant construction site and the road.

Construction operations are not expected to have any significant adverse impact on the habitats or species that form the conservation criteria of the Parhalahti–Syölätinlahti and Heinikarinlampi Natura 2000 area, or on the integrity of the area. The area influenced by noise during the construction phase will extend approximately one kilometer from the power plant site, which means that the project will not pose any harm, even temporary, to birdlife in the Natura 2000 areas. The dredging activity in the harbor and navigation channel will cause some turbidity, but it has not been estimated to reach the Natura 2000 areas.

Water systems and the fishing industry

Dredging during the construction of the navigation channel, the harbor area, an auxiliary cooling water inlet channel, and the cooling water discharge area, as well as the construction of protective piers, will cause temporary turbidity of the seawater. The seabed in the area to be dredged mainly consists of quickly settling rough-grained materials, such as sand and gravel. When such rough-grained materials are dredged, the turbidity will spread to approximately 10–100 meters from the dredging or deposit site, while the dredging of more fine-grained materials may cause turbidity of the water in an area extending up to two kilometers from the site. The dredging is not expected to cause any releases of nutrients or contaminants into the sea. There are charophyte meadows in the cooling water discharge structure area. These meadows will be lost. The area that will be changed by the construction activities is small, however.

Turbidity will be controlled or limited by utilizing continuously operating measuring buoys to gather data about turbidity levels and the prevailing flows. Continuously operating measuring buoys will also be used to monitor the turbidity resulting from any dumping of dredging soil material into the specific sea area.

Fishing in the construction areas and in their immediate vicinity will not be possible during the hydraulic construction work. The construction activities in the sea area may also drive away fish from a larger area and possibly influence their migration routes. Excavation, in particular, will cause powerful underwater noise that may drive away fish from an extensive area. The impact will most likely be significant in an area extending at least one kilometer from each blasting site. The construction activities in the sea will destroy some spawning areas of the sea-spawning whitefish and herring found in the dredging areas. The fishing activities in the area mainly focus on whitefish that come to the area to feed on herring spawn during the herring's spawning season. Thus, construction activities may have an adverse impact on the fishing of whitefish in the immediate vicinity of the headland.

The impacts of the construction phase on fishery and fish stocks will be monitored together with the appropriate authorities in accordance with the agreed fisheries monitoring program. The disadvantages caused to commercial fishermen will be compensated on a case-by-case basis.

Noise, waste, wastewater and emissions into the air

Excavation work, construction site traffic, and activities such as rock crushing will generate dust during the construction of the nuclear power plant. The dust will affect air quality mainly at the construction site. The volume of dust can be reduced by building asphalt roads or wetting the roads in the area, as well as by careful planning and execution of the rock crushing and excavation work. Dust collectors will be used to monitor the spread of dust outside the plant site.

The traffic emissions will increase significantly during the construction phase, particularly during the period of the heaviest construction activities. Traffic emissions will be reduced by establishing speed limits and by arranging shared transportation to the site. Since the air quality in the area is currently good and the period of heavy traffic will be limited in duration, the traffic emissions during construction will not have any significant impact on the air quality in the area.

During the noisiest construction phase, i.e. when excavation and rock crushing work is underway, the average daytime noise level will remain below the reference value of 45 dB(A) defined for holiday residences. According to the noise model, the noise level in the closest nature conservation areas (the north-west meadow and the Siikalahti seashore meadow) may be approximately 50–53 dB(A).

During the heaviest construction phase, the traffic noise of 55 dB(A) and 50 dB(A) from the road leading to the Hanhikivi headland will spread to fairly narrow zones, in which there are no residences. The zone where the noise will be approximately 45 dB(A) will extend a short distance into a protected seashore meadow and an important bird area adjacent to the road connection. The noise is not, however, estimated to significantly disturb the birdlife.

The impact of noise on people or the environment will be mitigated and prevented by the construction of noise barriers and by proper planning of the location of noisy activities. A detailed noise prevention plan will be prepared for the construction site. Noise from the traffic will be reduced by traffic control, scheduling and speed limits. Construction and traffic noise will be monitored using continuously operating sound level meters.

The handling of regular or hazardous waste at the construction site will not give rise to any environmental impacts. A waste management plan will be prepared for the construction site, and waste sorting and processing instructions will be given to everyone working at the site. Waste is sorted at the place where it is generated, and most of it will be reused or recycled as material or energy.

Excavation, quarrying and dredging masses will be used to construct breakwaters and embankments in the harbor area and at the cooling water discharge site. On land, masses will be used in filling and leveling operations in the construction areas. The handling, storage, and transportation of hazardous waste will be arranged in accordance with the regulations.

Sanitary wastewater will be conducted from the site to a municipal water treatment plant via a sewer network. The volume and quality of sanitary wastewater will be monitored in accordance with the agreement signed with the municipal sanitary services.

Environmental impacts of the operating phase and the prevention and mitigation of adverse impacts

According to section 8 of the Environmental Protection Act (527/2014), the operator shall prevent pollution of the environment by ensuring that best available techniques (BAT) are used. Fennovoima will adopt this principle in the design and operation of the nuclear power plant.

Cooling waters

The nuclear power plant will be designed for maximum electricity production and minimum discharge of waste heat into the sea with the cooling water. Appropriate technical solutions and correct dimensioning of the turbine plant will have a major impact on the plant's energy efficiency and the amount of waste heat discharged. Turbine extraction steam will be used for heating the power plant and other buildings at the plant site. In the case that a demand for the production of district heat arises in the vicinity of Pyhäjoki in the future, heat pumps will enable the recovery of waste heat.

Thermal load from the cooling water

The nuclear power plant uses approximately 45 m^3/s of cooling water. The cooling water will be taken from the dock basin located on the western shore of the Hanhikivi headland using an onshore intake system and discharged at the northern part of the headland. The temperature of the water will rise by 10–12 °C in the process.

The fact that the cooling water used at the power plant will be discharged into the sea will increase the temperature of the seawater close to the discharge site. The extent and direction of the spreading of warm cooling water has been investigated with the help of a three-dimensional flow model (Lauri 2013). Based on the model, the temperature of the seawater will increase by more than 5 °C in an area of approximately 0.7 km^2 in the immediate vicinity of the cooling water discharge site, and by 1 °C in an area of approximately 15 km^2. The thermal impact will be higher in the surface water (0–1 meters below the surface) and decrease at greater depths (Figure 3A-2). According to the modeling results, no temperature increase will occur at a depth of more than four meters.

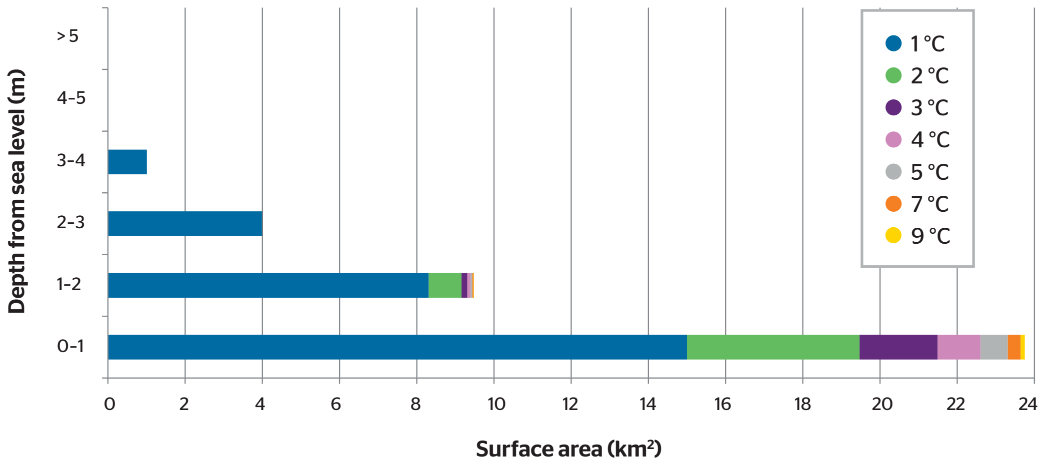


Figure 3A-2. Surface areas in which the temperature increase exceeds 1, 2, 3, 4, 5, 7, and 9 degrees Celsius in the June 2012 average temperature field.

The spreading of the warm cooling water in surface waters (0–1 m) in different years has been modelled in a period between July 15 and August 15 in 2009–2013, at which time the seawater is at its annual peak temperature and the impact of the cooling waters is at the highest level reached in the summer season. The largest increase of temperature (more than 9 °C) was observed within a limited area of 0.09–0.19 km^2 in the immediate vicinity of the cooling water discharge location. An increase of five degrees in the surface water temperature was limited to an area of 0.54–0.82 km^2, and an increase of one degree to an area of 8.0–13 km^2. An average surface water temperature increase of more than two degrees was limited to a distance of 2–3 kilometers from the cooling water discharge location in all situations. Brief periods may occur when the warm cooling water will be carried significantly further than in the average conditions presented here.

Under typical south-westerly winds, the thermal discharge will tend to accumulate in the Kultalanlahti bay on the north side of Hanhikivi. Warm water will, however, mix reasonably well with the current that flows along the coast. When temperature layers exist in the seawater and northerly winds prevail, upwelling will occur as the wind pushes warm surface water to the open sea and cold water rises from the bottom to the surface layer. In these conditions, the power plant's thermal discharge is efficiently diluted in the rising cold water.

In the winter, the thermal load from the cooling water will keep the discharge site unfrozen and cause the ice to be thinner, mainly to the north and east of the Hanhikivi headland. During the early winter, the scope of the open water area and the area where the ice is thinner will largely depend on the prevailing temperatures. According to the modeling results, the annual differences in the thickness of the ice will even out further into the winter months, as the ice becomes thicker overall, and the open water area will be 2.4–4.5 km^2 by February–March. At this time of the year, the open water area will extend approximately 2–5 kilometers from the discharge site and the area with thinner ice approximately 0.5–2 kilometers further.

Continuously operating meters will be used to monitor the intake and discharge temperature of the cooling water. Measurement sensors are planned to be installed in two circular arrangements in the sea area, with the sensor located in the immediate vicinity of the discharge location acting as the center point of the circles. The inner circle, located one kilometer from the discharge location, will have sensors used to monitor the average increase of seawater temperature in the area. The outer circle will be placed at a distance of two kilometers from the discharge location, enabling the monitoring of cooling water temperatures further afield. A total of 13 measurement points are planned to be installed into the sea area in the first stage, plus one in the cooling water discharge channel. Measurement will begin one year before the commissioning of the plant, allowing the gathering of reference data for all measurement locations. After commissioning, measurements will continue for three years. In the fourth year, the location and number of measurement points will be reviewed based on operating experience.

In the winter, the thermal load from the cooling water will keep the discharge site unfrozen and cause the ice to be thinner, mainly to the north and east of the Hanhikivi headland. Ice conditions in the discharge area (thickness and extent of unfrozen area) will be monitored at intervals of 1–3 weeks, depending on the conditions. Warnings of thin ice will be given, for example on warning boards along the roads to the area.

Impacts on water systems

Apart from the increase in temperature, the quality of cooling water will not change as it flows through the power plant. The operation of the power plant is not estimated to have impact on the oxygen conditions in the sea area, as there are no basins susceptible to oxygen depletion near Hanhikivi. Based on measurements and water analysis, the oxygen conditions in the Hanhikivi sea area have also been found to be good even in deeper water layers; the area has no particular load of organic materials which could, together with the warm cooling water, lead to oxygen depletion.

In the Bothnian Bay, the production of phytoplankton is particularly limited by the short open sea period. The warm cooling water will extend the open sea period and therefore the growth period. The summer season chlorophyll content and biomass measured in phytoplankton samples reflect the typically low nutrient levels of the Hanhikivi sea area. The thermal load from cooling water is estimated to lead to some increase in the production of phytoplankton in the discharge area. There may also be changes in the species distribution, also between seasons. The operation of the power plant is not estimated to have detrimental impacts on zooplankton.

Blooming of cyanobacteria typically occurs in eutrophic sea areas particularly in late summer, when nitrogen is the limiting nutrient. In the Hanhikivi sea area, phosphorus is the primary limiting nutrient for primary production, making cyanobacteria blooms fairly unlikely.

Benthic fauna in the Hanhikivi sea area mainly consists of species which are able to live on hard bottom surfaces. The potential impacts of cooling water on benthic fauna are mainly indirect and mostly due to changes in primary plankton production. Since no major changes to the primary production levels are expected, and the amount of organic matter accumulated on the seabed is expected to remain low, the temperature increase is not expected to cause any major impact on the benthic fauna, and any impacts that occur will remain local.

Charophyte meadows found on the eastern coast of the Hanhikivi headland and in the Kultalanlahti bay may suffer from the temperature increase. Decreased growth is most likely to take place on the eastern coast of the headland, and the impact is expected to be more subdued in Kultalanlahti. It has been estimated that the conditions required by bottom dominated by submerged macrophytes may even improve around the Hanhikivi headland, but the species distribution in this habitat type may change. A more detailed description of the impacts of cooling water discharge on aquatic vegetation is included in Appendix 3B of this application.

The impact of the thermal load on the quality of water and the water fauna will be regularly monitored in accordance with a program approved by the North Ostrobothnia Centre for Economic Development, Transport and the Environment. The monitoring results will be compared with the current status of the environment; comprehensive data on the current status is available due to the surveys and advance monitoring carried out. As defined in the program, the physical and chemical monitoring will consist of taking water samples from eight sampling points. The biological monitoring system will include, for example, monitoring of plankton production and species distribution, monitoring of aquatic plant species and their abundance, and monitoring of benthic fauna species and their volumes.

Impacts on fishery

The operation of the nuclear power plant will have adverse impacts on professional and recreational fishing in the spreading area of warm cooling water. Fishing will be prevented or rendered difficult, and changes will take place in the species distribution and fry production. The impact will be strongest in the immediate vicinity of the cooling water discharge channel, and gradually decrease with the distance from the Hanhikivi headland. The impact on fishing will be mainly negative, but positive impacts such as improved growth of the fish can also be found. Ice fishing is expected to end in the ice fishing area around the Hanhikivi headland and in the Kultalanlahti bay. In more distant areas, thinning of ice will prevent ice fishing from time to time.

The fish pulled into the cooling water intake channel will be mostly small, young individuals and small species moving in schools. Newly hatched fry drifting with water columns are particularly susceptible to ending up in the water intake channel. The impact of the lost fry on the fish stocks and catch in the area is expected to remain minor and local. A more detailed description of the impact of cooling water intake and discharge on the fish stocks and fishery as well as migration routes is included in Appendix 3B of this application.

Fishery impacts will be monitored in accordance with the monitoring program approved by the appropriate fishing authority. Monitoring will be distributed into three sectors: (1) monitoring of fishing activities (professional and recreational fishing), (2) monitoring of species distribution and growth, and (3) monitoring of fry production. In addition, a three-year monitoring period is being planned to investigate the species, numbers and sizes of fish pulled into the cooling water intake by taking samples at different times of the year. The outcome of the three-year monitoring program will be used to assess the need for further monitoring. The disadvantages caused to professional fishermen will be compensated on a case-by-case basis.

Impacts on nature conservation areas and birdlife

Under typical south-westerly winds, the warm cooling water will tend to gather in the Kultalanlahti bay on the north side of the Hanhikivi headland, off the Takaranta seashore meadow. According to the water system modelling, the average water temperature will increase by more than two degrees Celsius in front of the seashore meadows in the north-east and east parts of the headland, defined as protected habitat types under the Nature Conservation Act. Warming of the seawater and the lack of ice may lead to local increase of primary production and thus the growing over of seashore meadows over the long term. The lack of ice may also accelerate overgrowth as ice no longer causes erosion at the shoreline. Overgrowth of seashore meadows in the Hanhikivi east meadow and at Takaranta may deteriorate the habitats of the Siberian primrose. Seashore meadows do experience natural overgrowth due to the lack of traditional use as pasture and sources of hay. If overgrowth of the meadows accelerates, their protection value will deteriorate faster than the current development if no maintenance is carried out.

The impact of warm cooling water on seashore meadows will be monitored in accordance with a separate monitoring program to be approved by the Centre for Economic Development, Transport and the Environment. Based on the outcome of the program, maintenance of the meadows will take place according to a separate plan when necessary. Primary maintenance measures include mowing and use as pasture, both of which generally improve the condition of seashore meadows.

In 2009, Fennovoima carried out a Natura assessment concerning the impact of the construction (including the construction of power line connections) and operation of the nuclear power plant on the protected habitat types and species of the Parhalahti–Syölätinlahti and Heinikarinlampi Natura 2000 area (Pöyry Environment Oy 2009). In its statement on the Natura assessment, the North Ostrobothnia Centre for Economic Development, Transport and the Environment (PPO-2009-L-683-255, POPELY/15/07.04/2010) stated that the project seemed to have no direct impacts that would significantly deteriorate the protected habitat types and species. The North Ostrobothnia Centre for Economic Development, Transport and the Environment did, however, stated that the possible long-term risks of the project are such that their potential impacts cannot be completely excluded based on the completed Natura assessment. The statement refers to potential long-term impacts on the Siberian primrose and the bird populations, as well as the possible reflection of hydrological changes of the Hanhikivi headland on the state of the Natura area.

The 2014 investigation of the need for a Natura assessment (Sito Oy 2014) included a consideration of the potential long-term impacts of the power plant's cooling water on the Takaranta area, not included in the Natura area, and further potential consequences of these impacts to the nature values based on which the Natura area has been protected, as well as a consideration of the significance of hydrological impacts on Heinikarinlampi. The conclusion of this investigation states that the operation of the nuclear power plant will have no significant adverse impacts on the Natura area over the short or the long term. The nuclear power plant is not located within the Natura 2000 area, nor is the thermal load from the cooling water targeted at the Natura area or its immediate vicinity. Based on these considerations, the nature values based on which the area is protected are subject to no direct adverse impacts.

Indirect adverse impacts on the habitat types and bird populations of the Natura area are not assessed to be caused by the power plant operations either.

The cooling water would only have a minor adverse impact on the Siberian primrose population of the Natura area, even over the long term, if the populations were to disappear from the Takaranta area. Monitoring of the Takaranta seashore meadows and active maintenance when necessary will secure the preservation of the Siberian primrose in the Takaranta and Hanhikivi areas. No adverse hydrological impacts on the development of Heinikarinlampi or any other section of the Natura area could be found.

The North Ostrobothnia Centre for Economic Development, Transport and the Environment has reviewed the report on the investigation of the need for Natura assessment, and it issued a statement on January 29, 2015 (POPELY/2670/2014). The Centre for Economic Development, Transport and the Environment finds that based on the investigation, it can be concluded that the project is not likely to cause significant adverse impacts or indirect long-term impacts on the nature values based on which the area has been defined as a Natura area. The Centre for Economic Development, Transport and the Environment also states that the avoidance of such impacts will be ensured by the monitoring and maintenance measures presented in the report as mitigating action.

Migrating waterfowls may use the unfrozen area in front of the cooling water discharge location as a resting and feeding site. Some of the migrating birds may stay in the unfrozen area longer than usual, or return earlier in the spring. The transfer of the edge of the ice further away from the shore may move the early spring migration of gulls to the outer sea. This is not, however, assessed to have significant impacts on the migration behavior of gulls. Species that feed on fish, such as common tern and Arctic tern, may have better feeding opportunities, and waterfowls and birds that nest on the shore may begin their nesting period earlier. However, the timing of the nesting season will also depend on other environmental conditions.

Wastewater, rainwater and groundwater

Waste water

The nuclear power plant will generate approximately 50,000–70,000 m^3 of purified process water and wastewater per year. Of this annual volume, 80–90% will be generated during the annual maintenance outage. The phosphorus load to the sea from the process water and wastewater (annual maximum of 15 kg) will be very low compared to the phosphorus load reaching the sea via rivers, for example. After purification, the plant's process water and wastewater will be discharged into the sea via the cooling water discharge tunnel. The process water and wastewater will mix with the cooling water and flow to the open sea. Even with the seawater temperature increase in the discharge area caused by the cooling water, the wastewater load from the power plant is not estimated to cause detectable or harmful changes to the eutrophication levels, oxygen saturation, vegetation or fishery.

The boron carried into the sea with the wastewater (approximately 100 kg annually) will be effectively diluted in the immediate vicinity of the discharge channel. The addition to the boron content of seawater will be too low to have any impact on the seawater quality or water fauna. The process water will also contain salts generated in the neutralization process. These salts are naturally found in the seawater and have no adverse impact on the marine ecosystem.

The acidic and alkaline wastewater generated in process water production (demineralization) will be led into the neutralizing tank. After neutralization, the water will be led into the cooling water discharge channel. The liquid waste treatment plant will process the controlled area wastewater that may contain radioactive substances. Different types of wastewater will be conducted and treated separately, and the treatment method will depend on the quality and radioactivity level of the wastewater. Possible treatment methods include separators, ion exchangers, distillation and, when required, evaporation. One of the purposes of the waste water treatment that contains radioactive substances is to concentrate the radioactivity in a smaller volume.

The total volume of treated process wastewater and the concentrations of radioactive substances from the liquid waste treatment system will be measured before the wastewater is led into the cooling water discharge channel. The concentrations of radionuclides and total phosphorus as well as emissions will be measured and determined from the collecting samples. Other loading factors will not be monitored, as no other discharges generate into water system.

The non-radioactive wastewater generated at the nuclear power plant will be kept separate and treated in the appropriate manner. The drain water and preserving solutions from conventional auxiliary systems as well as the filter rinsing and decantation water will be led to chemical processing in which hydrogen peroxide and a catalyst will be mixed into the wastewater. Wastewater containing chemicals will also be treated at the liquid waste treatment plant and the non-radioactive wastewater treatment system, depending on whether the wastewater has been generated within or outside the controlled area of the power plant.

Floor drain and washing water will be led into the sewage system via oil separators. Any solids carried by the water will be separated. When necessary, the wastewater to be pumped out will be neutralized with sodium hydroxide or sulfuric acid. After treatment, the wastewater will be discharged into the cooling water discharge channel. The volume of non-radioactive wastewater will be calculated based on the plant's water consumption. These wastewater types do not contain substances that increase the load to water bodies, and their quality will therefore not be monitored.

The power plant's sanitary wastewater (water from restrooms and showers, wastewater from the cafeteria and the kitchen facilities of offices) will be conducted from the power plant site via the sewer network to be treated at the wastewater treatment plant of the municipal water utility (Pyhäjokisuun Vesi Oy). The sanitary wastewater will be monitored in accordance with the agreement signed with the municipal sanitary services.

Algae, fish and other solids entering the facility with cooling water will be removed using screens and filters and treated as biowaste. Solids attached to the cleaning equipment will be rinsed off with seawater and led to the treatment plant where the solids will be separated from water. The water will then return to the sea via the cooling water discharge channel.

Rainwater

Rainwater will be collected from the plant site in a controlled manner, purified using the appropriate structures, and released into the sea. The rainwater is not estimated to cause any contamination of groundwater or the soil. The quality of the rainwater collected will be managed using both centralized and distributed structures. As centralized management structures, retention basins will be built to the plant area. Retention basins will balance overflow and reduce the risk of erosion in the discharge routes. In addition, solids will sediment in the retention basins. As distributed rainwater management structures, catch basins will be built to the plant area to gather solids from the rainwater. Structures will also be built to separate floating litter. Oil sumps and other water cleaning structures will be built as necessary.

The condition and functionality of rainwater basins and structures will be monitored in accordance with a maintenance program. After the separation of sand and oil, the rainwater will not contain any contaminants that would require chemical monitoring.

Groundwater

The formation of groundwater will decrease as a result of watertight surfaces and the draining of rainwater. This may lower the surface level or pressure of groundwater in the headland area. The Hanhikivi headland is not classified as a groundwater area, and the lowered surface level or pressure of groundwater will have no significant impact on the water supply in the region.

A lower groundwater level may lead to changes in the groundwater's direction of flow in such a manner that seawater is able to mix with the groundwater, which will alter the chemical composition of the groundwater. The concrete structures that come into contact with the groundwater in the soil or bedrock may also increase the pH value of the groundwater. The impact will, however, be limited to the immediate vicinity of the structures, and the changes in the chemical composition of the groundwater will not be significant.

Chemicals and flammable substances

The majority of the chemicals used at the nuclear power plant will be various acids and bases used in the production of power plant process water and the control of acidity and chemical reactions in the plant's water circulation systems. Chemicals will also be used for cleaning the steam cycle equipment and pipelines and preventing corrosion.

The emergency diesel generators and auxiliary steam boilers will be fueled with light fuel oil. Gases to be used include the hydrogen used for cooling the turbine plant generator, and the nitrogen used as the motive power in certain equipment. Lubricating oils will be used to lubricate rotating machines (including the turbine and generator bearings and pumps). Additionally, the transformer will contain a large amount of oil for cooling purposes.

Storage of chemicals, fuels and oils is not estimated to cause contamination of groundwater or the soil. The prevention of various leakage and accident situations will be taken into account in the design of the chemical and fuel systems. Risk analyses will be carried out to support the design. The chemical offloading locations, storage tanks and facilities, and the chemical dosing systems will be constructed in accordance with the legislation governing the safe storage and handling of hazardous chemicals and fuels, the Finnish Safety and Chemicals Agency (TUKES) guidelines pursuant to the legislation, and SFS standards. In the event of leaks, all premises that contain chemical tanks or storage facilities will be drained to shielding pools, sludge and oil separation wells and the neutralization pool. The volume of the protective basins for flammable liquid storage containers will be a minimum of 110% of the volume of the storage container. The chemical and fuel offloading locations will also be equipped with basins.

Air emissions, noise and vibration

Air emissions

During the operation of the nuclear power plant, emissions into the air will be generated in the production of back-up energy. The primary purpose of the emergency diesel generators is to guarantee power supply to the functions critical to nuclear safety under all operating conditions, for example if the connection to the external power supply network is lost. During normal operation, the use of emergency diesel generators will be limited to monthly test runs. The maximum running time of each emergency diesel generator will be 50 hours per year. Auxiliary steam boilers are normally only used during the start-up and shutdown of the nuclear power plant. The auxiliary steam boilers will be in operation a maximum of 120 hours per year. Two boilers will be running simultaneously, with the third one acting as a back-up boiler.

The emergency diesel generators and auxiliary steam boilers will be fueled with low-sulfur light fuel oil. Other emissions into the air will be controlled with combustion technology. The annual emissions from the back-up power generation will be very low during normal operation, and will have no impact on air quality at the plant site.

Noise and vibration

Noise from the nuclear power plant operations will remain below the reference values set for residential areas and areas including holiday residences (Government Decision on Noise Level Guide Values 993/1992). The average sound level on the closest holiday residence plots will remain below 30 dB(A). The maximum noise level at the Siikalahti seashore meadow and the Hanhikivi north-west meadow will be 35–40 dB(A). According to the noise simulation, the reference values for noise will not be exceeded in the nearest nature conservation area (Ankkurinnokka).

The noise from road traffic to the plant will remain below the reference values for day and night time (55 dB(A) at 50 dB(A)) at the nearest residences. In the area between Hietakarinlahti and the Takaranta seashore meadow, the maximum noise level in the vicinity of the road will be approximately 45 dB(A). The noise is not estimated to cause any significant harm to birds during plant operation.

The primary sources of noise will include the turbine, the generator, pumps, compressors, coolers and fans. They will make a steady, low humming noise. The noise will be reduced by covering the noise sources and installing sound-absorbing wall structures. Traffic noise will be reduced by establishing a speed limit for the road to the plant, for example.

Noise measurements will be carried out during the first full operating year to survey the noise level in the plant environment. The measurement locations will be established in the measurement plan to be prepared before measurements begin. After the commissioning of the plant, noise measurements will be repeated in connection with any significant operating changes that have an impact on noise levels.

The operation of the nuclear power plant will cause no significant vibration. Traffic to the power plant will mostly consist of passenger traffic that will only cause minor vibration limited to the immediate vicinity of the road. There will be no permanent vibration sources at the nuclear power plant.

Radioactive substances

Radioactive substances are found at natural low concentrations everywhere in the environment. Most of the radioactive substances in the environment originate from natural sources such as cosmic radiation or uranium found in the soil, and less than 1% originate from man-made sources. The radioactivity found in Finnish nature that originates from man-made sources mainly comes from nuclear weapons testing and the Chernobyl accident.

The atomic nuclei of a radioactive substance decay into lighter nuclei, emitting ionizing radiation. Depending on the type of decay, this radiation can be either particle radiation or electromagnetic radiation. The health effects of radiation are illustrated using the concept of radiation dose, measured in sieverts (Sv). The sievert is a large unit, and in practical applications, millisieverts (one thousandth of a sievert, mSv) or microsieverts (one millionth, µSv) are nearly always used.

According to calculations by the Radiation and Nuclear Safety Authority (STUK 2014), the average annual radiation dose of a person living in Finland is approximately 3.2 mSv. The most important source of this radiation is the radon found in indoor air, which accounts for approximately half of the annual radiation dose, while man-made radioactive substances in the environment only account for 0.02 mSv. The factors contributing to the annual average radiation dose are specified in Figure 3A-3.

Radioactivity in a nuclear power plant

The majority of the radioactive substances in a nuclear power plant are found in the spent nuclear fuel. Fresh fuel consists of uranium dioxide (UO_2), which only contains oxygen and uranium. In addition, a small quantity of gadolinium has been added to part of the fuel. Gadolinium, like oxygen, is a stable element. The uranium in the fresh fuel is only weakly radioactive, and causes no radiation hazard.

In a nuclear reactor, heat is generated in nuclear reactions that take place within the fuel. Neutrons collide with uranium nuclei and split them into lighter elements called fission products. Instead of splitting in two, some uranium nuclei capture the neutron to create transuranic elements, which are heavier than uranium. The majority of fission products and all transuranic elements are radioactive. Therefore, spent fuel is highly radioactive and must be handled with particular care. The most important safety requirement in the entire nuclear power process is to keep the radioactive substances from the spent fuel isolated from the living environment.

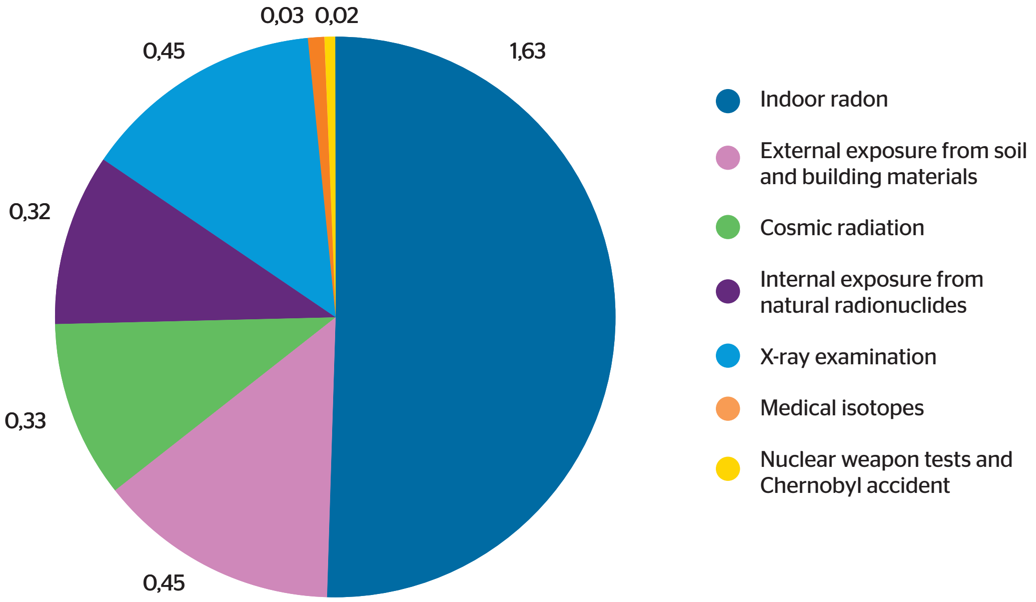


Figure 3A-3. The average annual radiation dose to a person living in Finland is approximately 3.2 mSv (STUK 2014).

A considerably lower portion of the radioactivity found in a nuclear power plant is located in the primary cooling circuit of the reactor, and other systems connected to it, such as the purification systems. Small amounts of radioactivity may also be released from the fuel elements into the cooling water. The water of the primary circuit is continuously purified, and radioactive substances will be captured by the ion exchange resin used in the purification systems. The ion exchange resin will be treated as radioactive reactor waste, processed appropriately and safely disposed of in the operating waste repository on the Hanhikivi headland. For a more detailed account of the processing of radioactive waste, see Appendix 5B of this application.

Limits for radiation exposure from operating nuclear power plant

The license holder of a nuclear power plant is obligated to set limits for radioactive emissions that ensure that the limit for the dose of an individual in the population, laid down in the Government Decree on the Safety of Nuclear Power Plants (717/2013), will not be exceeded. According to the Decree, the annual dose for an individual in the population arising from the normal operation of a nuclear power plant must not exceed 0.1 mSv; furthermore, an anticipated operational occurrence must not cause an addition to the annual dose of an individual in the population that exceeds 0.1 mSv.

Nuclear power plant accidents are divided into three categories, and limits for the annual dose for an individual in the population have been defined for each of these. The limit is 1 mSv for class 1 accidents, 5 mSv for class 2 accidents and 20 mSv for a design extension condition; a higher dose thus may arise from a less probable accident. For a more detailed account of the probabilities of the different accident types, see Appendix 4B of this application. The dose arising from an accident may be compared to a chest X-ray, which will typically cause a dose of 0.1 mSv, or a CT scan of the abdomen, which will cause a dose of 12 mSv.

The Hanhikivi nuclear power plant will be designed so that the dose arising to the population will remain with certainty below the limits. In addition, Fennovoima will define emission targets for radioactive substances in accordance with the ALARA (As Low As Reasonably Achievable) principle. These emission targets will be considerably lower than those defined in the Government Decree. Current radioactive emissions from Finnish nuclear power plants are typically less than 1 percent of the limits set in the Government Decree. Fennovoima aims to limit radioactive emissions from the Hanhikivi nuclear power plant to the level of the nuclear power plants currently operational in Finland, or lower. Emission levels can be influenced by design and through various measures during operation.

The strict limits and monitoring of emissions will keep radioactive emissions very low, and the impact of the radiation on the environment will be very low when compared to the impact of natural radioactive substances found in the environment.

Containment of radioactivity

Containment of radioactive substances is based on the functional and structural implementation of the defense-in-depth principle, including several successive and redundant structures and functions. The structural defense-in-depth principle refers to four successive barriers that are able to reliably isolate the radioactivity of the fuel from the environment. These barriers are: the ceramic fuel, the fuel cladding, the primary circuit and the containment. The structural defense-in-depth principle is illustrated in Figure 3A-4.

1. The nuclear fuel is the first level of the structural defense-in-depth principle. The fuel consists of a solid ceramic material from which radioactive substances are released at a slow rate. Thus, only a minor portion of the radioactive substances migrate out of the fuel material. During normal operation mainly gaseous and volatile fission products, such as inert gases, iodine and cesium, are released inside the cladding.
2. The fuel cladding is the second level of the structural defense-in-depth principle. The fuel is packed into a gas-tight one-millimeter-thick cladding manufactured from zirconium-niobium alloy. A fuel rod is approximately four meters long with a diameter of one centimeter. The reactor holds approximately 50,000 fuel rods. Despite strict quality requirements, minor leaks may occur in individual fuel rods. Measures will be planned to manage leaking rods to prevent the spread of radioactivity from causing any harm.
3. The third level consists of the primary circuit designed to contain any radioactive substances found in the coolant. The primary circuit consists of the reactor pressure vessel, the pressurizer and four separate cooling circuits, each equipped with a steam generator and a reactor coolant pump. Steam generators are heat exchangers in which heat is transferred from the primary circuit to the secondary circuit with no mixing of the water from each circuit. This prevents radioactive substances from reaching the water in the secondary circuit.

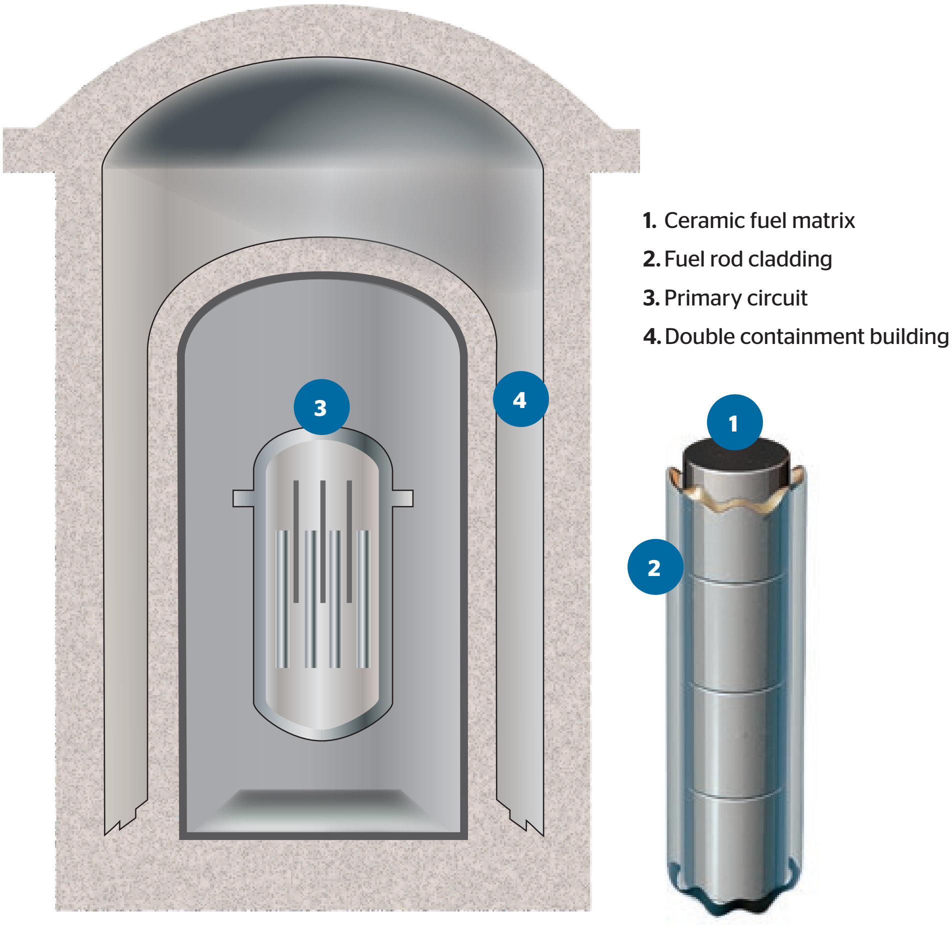


Figure 3A-4. The levels of the structural defense-in-depth principle.

4. The outermost level is the double containment, which contains nearly all radioactivity found at the facility: the reactor core, the entire primary circuit, and the spent fuel storage pools. The inner shell of the containment consists of a pre-stressed reinforced concrete structure with a gas-tight steel lining that functions as a release barrier. The outer shell of the containment is a massive reinforced concrete structure designed to withstand a large passenger aircraft crash. The containment has efficient pressure relief and heat removal systems that will ensure the integrity of the containment even in accident conditions.

For a more detailed description of the technical operating principles of the AES-2006 nuclear power plant, see Appendix 4A of this application. The implementation of the functional defense-in-depth principle at the nuclear power plant is described in Appendix 4B.

Limiting and control of emissions

The controlled area of a nuclear power plant includes the parts of the plant in which radioactivity may exist in systems or rooms. The release routes in the controlled area (ventilation, wastewater, waste, equipment, tools and employees) are continuously monitored to ensure that any releases into the environment remain negligible. If activity levels above normal are observed, emissions can be limited using systems designed for the purpose.

Gases that contain radioactive substances are led into a cleaning system where radioactive substances are removed from the gas using, for example, activated carbon filters. The cleaned gases will be released into the atmosphere via the vent stack. Radioactive emissions into the air will be monitored and measured at the various stages of the gas treatment systems, and finally at the vent stack.

Radioactive liquids from the controlled area will be led to the liquid waste treatment plant, where they will be cleaned so that their activity level falls well below the limit values set for emissions before they are released into the sea. The level of radioactivity in the water released into the sea will be determined using a representative sample and by conducting measurements at the outlet line before the water is released into the cooling water discharge tunnel. The goal is to minimize the volume of emissions by, for example, recycling the process and pool water and by minimizing the generation of wastewater. Best available technologies will be used to limit both gaseous and liquid emissions.

The tools and equipment leaving the controlled area will be inspected for radioactivity and cleaned when necessary. People leaving the controlled area will also be subjected to personal contamination monitoring to ensure that no radioactive substances are present on the employees' clothes or skin.

Any radioactive substances found in inspections will be separated from release flows and permanently disposed of in the repository for low and intermediate level waste to be built within the plant site. The procedure ensures the reliable isolation of waste from the living environment until the radioactivity has reduced to a negligible level.

Environmental radiation monitoring

The radioactivity levels in the environment around the nuclear power plant are monitored to reveal any changes during the entire operating life of the power plant from the design phase to the completion of decommissioning. Fennovoima has already begun surveying the initial condition of the environment at the plant site and the naturally occurring radioactivity to facilitate reliable observation of any changes brought about by the power plant and its construction operations.

During plant operation, radiation levels will be measured in the plant environment precisely and with good coverage using systems such as the automatic radiation monitoring network, which will reach an approximate distance of five kilometers from the plant. The plant's impact on the level of background radiation will be too low to be reliably observed using dose rate meters for external radiation. The most important method of environmental monitoring will be the determination of levels of radioactive substances found in samples gathered from the environment. Samples will be taken to cover various migration routes and stages of food chains. Samples will be taken from plants, fungi, animals, rainwater and air, for example.

Emissions under exceptional conditions

The Hanhikivi nuclear power plant will not, even during a severe reactor accident, release a quantity of emissions that would require civil defense measures outside the areas close to the plant, or long-term restrictions on the use of extensive land and water areas. The actual analyses to prove that emissions from the plant will be, in all accident conditions, lower than the limits defined in the Government Decree on the Safety of Nuclear Power Plants will be submitted to STUK as part of the materials related to the construction license application.

Emergency preparedness arrangements will be planned for accident situations to ensure that the plant will be able to reach a safe state and to minimize any consequences for people of any radioactive releases. These consequences can be reduced, for example, by seeking shelter indoors, evacuating the area and taking iodine tablets. Regular drills will be organized to improve cooperation between Fennovoima personnel and the authorities. In accordance with the Nuclear Liability Act (484/1972), Fennovoima will also be responsible for the post-processing of a potential accident.

Waste

Reactor waste and spent nuclear fuel

The estimated volumes of reactor waste and spent nuclear fuel, as well as the plans and procedures related to their handling, processing, storage and final disposal, are presented in Appendix 5B of this application. The treatment and storage of reactor waste will be carried out in the treatment and storage facilities located in connection with the power plant. The facilities will be equipped with systems that allow safe processing and transfer of the waste, as well as monitoring of the quantity and quality of radioactive substances. The processing and storage of the waste will cause no risks to the environment. The final disposal of reactor waste will be carried out so that the radioactive waste will be isolated from the living environment, ensuring that the safety of the environment is not compromised at any stage of the process.

The interim storage facility of the spent nuclear fuel will be equipped with ventilation and filtering systems that will prevent any radioactive releases occurring in exceptional situations from escaping into the environment. In normal conditions, the processing and storage of spent nuclear fuel will not have any impact on the environment, and the statutory limits will not be exceeded.

Conventional waste and hazardous waste

Similarly to other energy production plants or industrial facilities, a nuclear power plant generates both conventional waste and hazardous waste. The primary objective of waste management at the power plant will be to generate as little waste as possible. Sorting and gathering of waste will be carried out in accordance with the waste management guidelines, and the quality, quantity, and treatment of waste will be continuously recorded, as required by the Waste Act. Conventional waste will be utilized as far as possible. The objective is to utilize and recycle 80% of all waste. There will be no landfill at the plant site.

Waste volumes will vary from year to year depending on factors such as the length of the annual outage and the maintenance measures included in it. Waste generated at the plant will include scrap iron and metal, wood, paper, and cardboard waste, biowaste, and energy waste (combustible waste). Hazardous waste will consist of, for example, waste oil and oil-contaminated waste, fluorescent tubes, solvents and chemical waste, as well as discarded electrical and electronic equipment. The estimated annual volumes of conventional waste and hazardous waste will be 400 tonnes and 40 tonnes, respectively.

Solid matter will be carried with the cooling water intake, generating screenings that will be separated at their own treatment facility. The screenings will be pre-processed to reduce their volume and to make interim storage easier. The processing of screenings is not expected to generate disturbing odors or other harm. After pre-processing, the screenings will be packed and transported from the power plant site to be processed as biowaste. The total annual volume of solid screenings is estimated at 5–15 tonnes.

Minor quantities of ash will be generated by the auxiliary steam boilers and emergency diesel generators that burn light fuel oil, and chimney cleaning waste will be generated from boiler maintenance work. The ash and cleaning waste will be stored at the power plant in closed containers to prevent the spread of dust from them. The quantity of ash generated will mostly depend on the ash content of the fuel. The ash content of light fuel oil is low. Hazardous waste such as oily waste will be gathered in separate containers and stored in the hazardous waste storage facility. Ash, chimney cleaning waste and hazardous waste will be delivered to appropriately licensed operators for further processing and final disposal.

Environmental and water permits

Permits pursuant to the Environmental Protection Act

On December 23, 2014, Fennovoima submitted a permit application pursuant to the Environmental Protection Act (527/2014) to the Regional State Administrative Agency of Northern Finland. The application concerns actions during the operation of the nuclear power plant, and the emergency diesel generators and auxiliary steam boilers to be installed in the nuclear power plant area (PSAVI/3877/2014). The same permit application was also used to apply for a permit pursuant to the Water Act (587/2011) for the intake of seawater and its use as cooling water at the plant. The environmental permit application included an assessment of the environmental impacts of the nuclear power plant during operation.

Permits pursuant to the Water Act

Fennovoima filed the permit applications pursuant to the Water Act (587/2011) with the Regional State Administrative Agency of Northern Finland on February 12, 2013. There are three applications, the most extensive of which concerns the construction of a pier and the harbor area, cooling water intake structures, and a navigation channel (PSAVI/20/04.09/2013). The second permit application concerns the cooling water discharge structures (PSAVI/21/04.09/2013), and the third the marine spoil disposal area (PSAVI/22/04.09/2013). Processing of the permits at the Regional State Administrative Agency has proceeded, and decisions are expected to be issued in 2015.

Permits pursuant to the Water Act, applied by Fennovoima, concern hydraulic construction work and structures in water bodies. The water permit applications include an assessment of the environmental impact of the hydraulic construction works.

References

Lauri, H. 2013. Virtausmalli Pyhäjoen edustalle lämpöpäästöjen leviämisen arviointiin. Suomen YVA Oy. In Finnish.

Pöyry Environment Oy 2009. Pyhäjoen Hanhikiven ydinvoimalaitoshanke, Natura-arviointi. In Finnish.

Sito Oy 2014. Selvitys Natura-arvioinnin tarpeesta Pyhäjoen Hanhikiven niemen ydinvoimalaitoksen toiminnan pitkäaikaisvaikutusten osalta. In Finnish.

STUK 2014. Surveillance of Environmental Radiation in Finland. Annual Report 2013, ed. Pia Vesterbacka. http://www.stuk.fi/julkaisut_maaraykset/en_GB/valvontaraportit (Accessed January 7, 2015).

Nuclear power plant site
Appendix 3B

Additional surveys required by the Ministry of Employment and the Economy on the impacts of the nuclear power plant on the marine environment and fishery during operation

Summary

Fennovoima carried out an environmental impact assessment (EIA) procedure in 2013 and 2014 concerning a 1,200 MW nuclear power plant to be constructed on the Hanhikivi headland located in the municipality of Pyhäjoki. The coordinating authority, the Ministry of Employment and the Economy, issued a statement on the EIA report on June 2, 2014 (TEM/1965/08.04.01/2013) to conclude the EIA procedure. The Ministry of Employment and the Economy also included in its EIA statement the requirement that Fennovoima shall carry out additional surveys of the marine environment and fishery, and attach their results to the construction license application. As required by section 32, paragraph 15 of the Nuclear Energy Decree (161/1988), this appendix includes an account of the additional surveys required by the Ministry of Employment and the Economy.

The additional surveys aimed to assess the impact of the nuclear power plant operation on the spread of non-indigenous species, the migration of seals and their staying in the Pyhäjoki sea area, fishery and migrating fish species, and the habitat types of bottom dominated by submerged macrophytes, and of charophyte meadows. In addition, the survey report presents the objectives of the Finnish Marine Strategy that have the essential significance for the nuclear power plant, and the impacts of power plant operation on these objectives.

Non-indigenous species are not expected to spread as a result of the operation of the nuclear power plant. An increase in the temperature of the seawater may, however, help new fish species adapt to the region. The overall impact of the unfrozen area at the cooling water discharge location on seal populations and the reproductive process of seals is estimated to remain low.

Fishing in the vicinity of the Hanhikivi headland is estimated to be prevented or rendered more difficult due to the impact of the warm cooling water to be discharged. The adverse impact on fishing will be most pronounced in the immediate vicinity of the warm cooling water discharge channel, and will gradually reduce as the distance from the Hanhikivi headland increases. Changes will probably take place in the fish stocks and the species distribution. Local changes may be large, but in the scale of the entire Bothnian Bay, the impact is estimated to remain very low. Power plant operations are not expected to have a significant impact on the routes of migrating fish, or their access to spawning rivers.

The charophyte meadows on the eastern coast of the Hanhikivi headland may suffer from the increased seawater temperature, but bottom dominated by submerged macrophytes may even benefit from the change.

Operation of the nuclear power plant in the Hanhikivi headland is not estimated to compromise the general objective of the Finnish Marine Strategy to protect, preserve and, when necessary, restore the Baltic Sea so that it is biologically diverse, dynamic, clean, healthy and productive.

Additional surveys required by the Ministry of Employment and the Economy on the impacts of the nuclear power plant on the marine environment and fishery during operation

Survival and spread of non-indigenous species in the Pyhäjoki sea area

Non-indigenous species are new species that were not previously part of the original ecosystem, but have spread to an ecosystem as a result of human activity. A total of 34 non-indigenous species have been found in Finnish territorial waters, of which 27 are well established. These figures also include mammals and birds. Most of the non-indigenous species observed in Finnish territorial waters are found in the Gulf of Finland. The second most important area for non-indigenous species is the Archipelago Sea (Ministry of the Environment 2012). The conditions prevailing in the Bothnian Bay, such as the low salinity and temperature of the water, constitute a more challenging environment for non-indigenous species. Still, more than ten indigenous species are also found in the most northern parts of the Baltic Sea (VL1 Itämeren vieraslajit, May 7, 2013).

Non-indigenous species can be classified into harmful, potentially harmful and other non-indigenous species. The detrimental impact of harmful non-indigenous species may be ecological, economic or social, or related to health. Potentially harmful non-indigenous species are species found in Finland that may become harmful if conditions change. Other non-indigenous species are either species that have been found to have no detrimental impact, or species of which little is currently known. Four harmful or potentially harmful non-indigenous species are currently known to exist in the Bothnian Bay: the red-gilled mud worm , the freshwater hydroid, Canadian waterweed, and the Chinese mitten crab. (VL1 Itämeren vieraslajit, taustatiedot, May 7, 2013, Ministry of Agriculture and Forestry 2012, Vieraslajiportaali 2014a).

The red-gilled mud worm (*Marenzelleria viridis*) is found in all Finnish sea areas. The species spreads rapidly and efficiently and is able to survive in a variety of water depths and environmental conditions. The red-gilled mud worm has significantly changed the species distribution of soft sea bottoms. The worm is found off the Hanhikivi headland, and the discharge of cooling waters may result in local growth of populations in the water area where the temperature increases. Growing populations have, however, been already observed over the entire Baltic Sea. (Katajisto et al. 2014a.) The thermal load from cooling waters is not expected to have an impact on the spread of the species in the Bothnian Bay as a whole.

The sea walnut (*Mnemiopsis leidyi*) has not so far been found in the Bothnian Bay. Its spread has probably been limited by the small volume of zooplankton and possibly the low salinity combined with other environmental factors such as low temperatures. The warming impact of cooling waters is focused on the immediate vicinity of the shore as well as the surface layer, whereas the sea walnut only exists in deep waters in the Baltic Sea. Warm cooling waters have also not been found to have much impact on zooplankton communities. (Vieraslajiportaali 2014a.) As a result, power plant operation is not expected to have such impact on the appearance of the sea walnut population that could be distinguished from general changes in the state of the Baltic Sea.

Non-indigenous species currently found in the Baltic Sea also include the zebra mussel (*Dreissena polymorpha*) and dark false mussel (*Mytilopsis leucophaeta*), both of which belong to zebra mussels. Neither of the species are known to appear in the Bothnian Bay area (Laine et al. 2006). The discharge of the power plant's cooling waters could create a water area where the temperature and other conditions were favorable for zebra mussels. However, the coldness of the Bothnian Bay restricts the spread of zebra mussels outside the warmed area, i.e. the cooling water intake area or the Bothnian Bay in general. The low salinity may also limit the spread of mussels. Power plants use mechanical and chemical means to prevent mussels from affecting their safety and production operations.

Canadian waterweed (*Elodea canadensis*) is an underwater plant native to North America, found along Finnish coasts and in inland water bodies. This resilient species spreads rapidly and particularly thrives in shallow, alkaline, nutrient-rich lakes and bays, as well as rivers and ditches with slow water flow. There is no efficient way to exterminate Canadian waterweed. (Vieraslajiportaali 2014b.) Canadian waterweed will grow from pieces of the plant that may travel within water bodies to great distances. The species favors nutrient-rich, sheltered environments. The nutrient load from the power plant during operation will not increase the nutrient levels in the sea area; operation of the power plant is thus not expected to promote the spread of Canadian waterweed into the area.

Freshwater hydroid (*Cordylophora caspia*) is found in large colonies attached to aquatic vegetation, rocks and various man-made structures. The species is native to the Black Sea and Caspian Sea region, and spread to the Baltic Sea in the early 1800s. Freshwater hydroid thrives in brackish water and can tolerate a wide salinity range, from freshwater to 15‰ salinity (Raita 2006). It originates in warm waters, but has resting periods that make it able to winter in cold waters. The species is found along the entire Finnish coast, most frequently in archipelagos and bays. (Vieraslajiportaali 2014c.)

Freshwater hydroid affects the operation of power plants, particularly when the colonies grow in the power plant's cooling water system. They deteriorate the heat transfer capacity of heat exchangers and increase corrosion (Raita 2006). The species has been found to form extensive populations at the Olkiluoto nuclear power plant, for example (Pöyry Energy Oy 2008). Freshwater hydroid competes for living space with the common mussel and other species able to attach to hard surfaces. It also competes for food with other animals, such as fish, that feed on plankton and small invertebrates. (Vieraslajiportaali 2014c.) Freshwater hydroid can be controlled mechanically, for example, by cleaning the cooling channel walls. Plant operations do not promote the spread of the species to the area.

The Chinese mitten crab (*Eriocheir sinensis*) is a crab native to East Asia. It spread to the Baltic Sea in the 1920s and 1930s. The Chinese mitten crab is a migratory species. It reproduces in the sea and migrates to rivers and lakes to grow. The species is not able to reproduce in the Baltic Sea due to the low salinity, but crabs, most likely carried with ships, are observed every year. The species has been found in all Finnish sea areas, but the occurrences are too sporadic to cause any harm. According to the non-indigenous species observation register (Vieraslajihavaintorekisteri 2014), one Chinese mitten crab was found in Raahe in 2012. In countries such as Germany, on the other hand, the Chinese mitten crab is considered to have caused significant costs through broken fishing nets and by feeding on fish that have been caught by the nets or are being farmed in pools. The species causes particular harm during mass migration, blocking water intake pipes in industrial facilities and irrigation systems and digging into dams and river banks, accelerating erosion. They also compete for resources with native crab species. (Katajisto et al. 2014b.) The operation of the nuclear power plant will not increase the risk of the species being found in the Pyhäjoki sea area.

Two new fish species have become established in Finland as a result of climate change and increased ship traffic, **the round goby** (*Neogobius melanostomus*) and **the Prussian carp** (*Carassius gibelio*), and their numbers are likely to grow. The round goby has been introduced in the ballast water of ships from the Black Sea and Caspian Sea area. The Prussian carp, native to Asia, became implanted in inland water bodies in the Baltic countries in the mid-1900s. After accessing the Baltic Sea, it has spread to the northern parts of the Gulf of Finland. (Urho 2011.)

The increase in seawater temperature resulting from the operation of the nuclear power plant may help new fish species adjust to the conditions in the vicinity of the nuclear power plant. The risk of new fish species spreading to nearby rivers also exists. The impact increases with climate change, as the round goby and the Prussian carp have been observed to benefit from the warming of seawater. (Urho 2011.)

According to the non-indigenous species observation register (Vieraslajihavaintorekisteri 2014), two round gobys have been found in Raahe (in 2011 and 2012). There was also one later observation of a round goby that has not yet been recorded in the register. The increased harbor traffic may advance the spread of the species, as they may be carried in the ballast water of ships or attach to the bottom of boats or ships (Karppinen et al. 2014).

Increasing populations of new species may either improve or deteriorate the conditions for native species. It seems that both the round goby and the Prussian carp are in suitable conditions able to replace native species (Urho 2011). In addition to new fish species, the non-indigenous species may be species that fish feed on (benthic fauna, plankton).

Populations and migration of seals

Seal populations

Information about the populations of the ringed seal and the gray seal in the Hanhikivi region has been received from a professional fisherman. For several years, the fisherman has been involved in a project by the Finnish Game and Fisheries Research Institute to catch ringed seals in the Hanhikivi sea area to carry out GPS tracking.

There is a year-round population of ringed seal in the Bothnian Bay. The ringed seal is also able to live in areas covered by fast ice by maintaining a network of breathing holes. Gray seals do not make breathing holes like ringed seals do, and must change their living environment as ice conditions change. When the sea is covered with ice, the gray seals move towards the south where there is no ice, or further away from the coast to the open sea.

In the early 1900s, the ringed seal population of the Baltic Sea comprised several hundred thousand seals. The populations collapsed as a result of hunting rewards and the difficulty of breeding due to high levels of environmental toxins. Currently, the ringed seal population in the Baltic Sea is estimated at 10,000 specimens, most of them in the Bothnian Bay. A total of 6,500 ringed seals have been sighted in Finnish and Swedish surveys in recent years. (The Finnish Game and Fisheries Research Institute, releases 2010–2014.)

Ringed seal mothers and pups are typically found in the Hanhikivi sea area immediately after the ice has broken. The move to other regions for the summer and return in September to winter and nest in the area. Ringed seal populations in the Hanhikivi sea area are abundant; for example, approximately 20 ringed seals get caught in the fyke nets of a local commercial fisherman each year. Up to 40 ringed seals have been counted on a single floe.

The counted population of the gray seal, or the number of gray seal sighted in surveys, has increased from the 10,000 found in the early 2000s to the current number of nearly 30,000 seals. During the season when the gray seal grow new fur, their core habitat is at the northern edge of the main body of the Baltic Sea, in the archipelago of central Sweden and the south-eastern Finnish archipelago. The counted population in the archipelago of central Sweden has shown steady growth in the 21st century so far, while the increase halted in Finland in the middle of the last decade. In 2013 surveys, the number of gray seals counted in the Bothnian Bay and Kvarken was 300, in the Bothnian Sea approximately 700, in the south-eastern Finnish archipelago more than 9,000, and in the Gulf of Finland 400. In the 2010s, the population counted in the Bothnian Bay and Kvarken has varied between 300 and 700 seals. (Finnish Game and Fisheries Research Institute, releases 2010–2014.)

The gray seal migrates to the north in the spring as the edge of the ice retreats, but does not yet come to the shores of Hanhikivi at that time. Hunting of the gray seal takes place in late winter out in the still-frozen sea. Gray seal typically come to the shore near Hanhikivi in September or October, and leave the area when the sea freezes. The movements of the seal and the period they stay in the area depend on the development of the ice conditions. Gray seal mostly nest on floes at the edge of fast ice, and sometimes on land. There are no gray seal nesting near the Hanhikivi headland. Gray seal populations in the Hanhikivi sea area are fairly abundant; for example, approximately 10 gray seals get caught in the fyke nets of a local commercial fisherman each year.

Impacts on the migration and staying of seals

The sea area kept unfrozen by the cooling water will extend at most to a distance of a few kilometers from the Hanhikivi headland, and its overall impact on seal populations is estimated to remain low. The ringed seal will not be able to nest in the unfrozen area, but the overall impact on the ringed seal population will be small. The ringed seal has adapted to living in frozen seas during the winter, so the unfrozen area is not expected to particularly attract ringed seals. Ringed seals may, however, use the unfrozen area as a feeding ground in the winter.

The better availability of food may attract gray seals into the area, influenced by the warm cooling waters. Signs of this have been observed in the cooling water discharge area of the Olkiluoto nuclear power plant, at the mouth of the Eurajoki river (Lehtonen et al. 2012). As the sea freezes, the gray seal migrate towards the south. In practice, the period in which gray seals stay in the Hanhikivi region depends on the rate at which fast ice forms. Gray seals swim great distances every day, sensing the progress of the edge of fast ice, and will leave the region by the time that the sea south of Hanhikivi freezes. Gray seals are not expected to remain in the unfrozen area to winter. The unfrozen area will have no impact on the reproduction of gray seals.

Fish and fishing industry

The sea area in front of the Hanhikivi headland is a significant area for fish stocks and the fishing industry, and fish species typical to the Bothnian Bay are common there. This section presents research results concerning the fish stocks and spawning areas as well as professional and recreational fishing activities in the sea area around the Hanhikivi headland. This section contains an impact assessment of the nuclear power plant's cooling water intake and discharge on the fish stocks and fishery in the area.

Current fish stocks and fishing activities

Fish stocks

Fish stocks and fishing activities in the Hanhikivi sea area have been surveyed in recent years by fishing with nets, catching fry, and fishing surveys (Haikonen et al. 2012, Vatanen and Haikonen 2012, Vatanen et al. 2013, Haikonen et al. 2014, Karppinen and Vatanen 2014, Karppinen et al. 2014).

Various research methods have yielded catches with an approximate total of 30 different fish species. In the fishing with nets carried out in July and August in 2012 and 2014, the most abundant species were ruffe and perch (Figure 3B-1). Fishing with nets was carried out in three separate areas (1) the water intake area, 2) the cooling water discharge area, and 3) the cooling water impact area). The catches in all three area were fairly similar. Variation was observed between the years mostly in the proportion of Cyprinidae (black clams). A significantly greater number of them were caught in 2012 than in 2014. The distribution of different species over various depths was fairly similar in the fishing with nets of 2012 and 2014.

Based on fry surveys, the area has significance for the fry production of sea-spawning whitefish, vendace and Baltic herring. Sea-spawning whitefish and vendace spawn in the shallows in October and November. Baltic herring mainly spawn between the middle of June and the middle of July.

The most important spawning areas of sea-spawning whitefish and Baltic herring can be found on the northern side of the Hanhikivi headland very close to it, and in the Maanahkiainen and Lipinä shallows located approximately 7–9 kilometers to the north of Hanhikivi (Figure 3B-2). In the outer sea, significant spawning areas of Baltic herring and sea-spawning whitefish include the shallows of Matti and Sumu, and Ulkonahkiainen. Vendace also spawn in the same

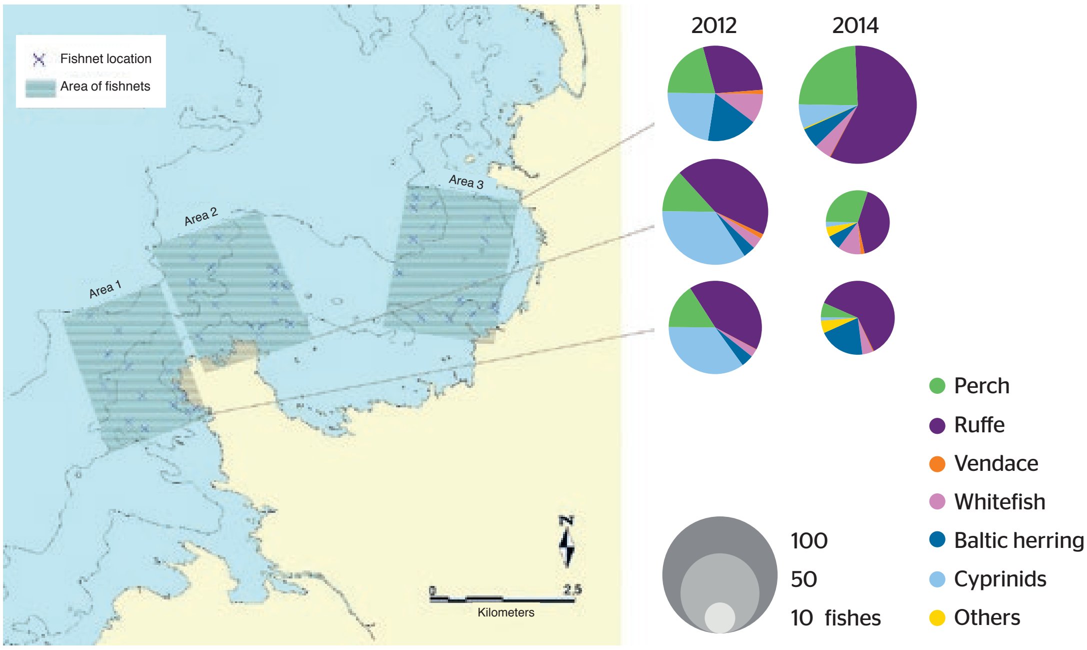


Figure 3B-1. The number of fish caught by fishing with nets in three areas around the Hanhikivi headland in July and August 2012 and 2014. The size of the diagram describes the size of the catch. Proportions of different fish species are indicated by colors. (Karppinen et al. 2014.)

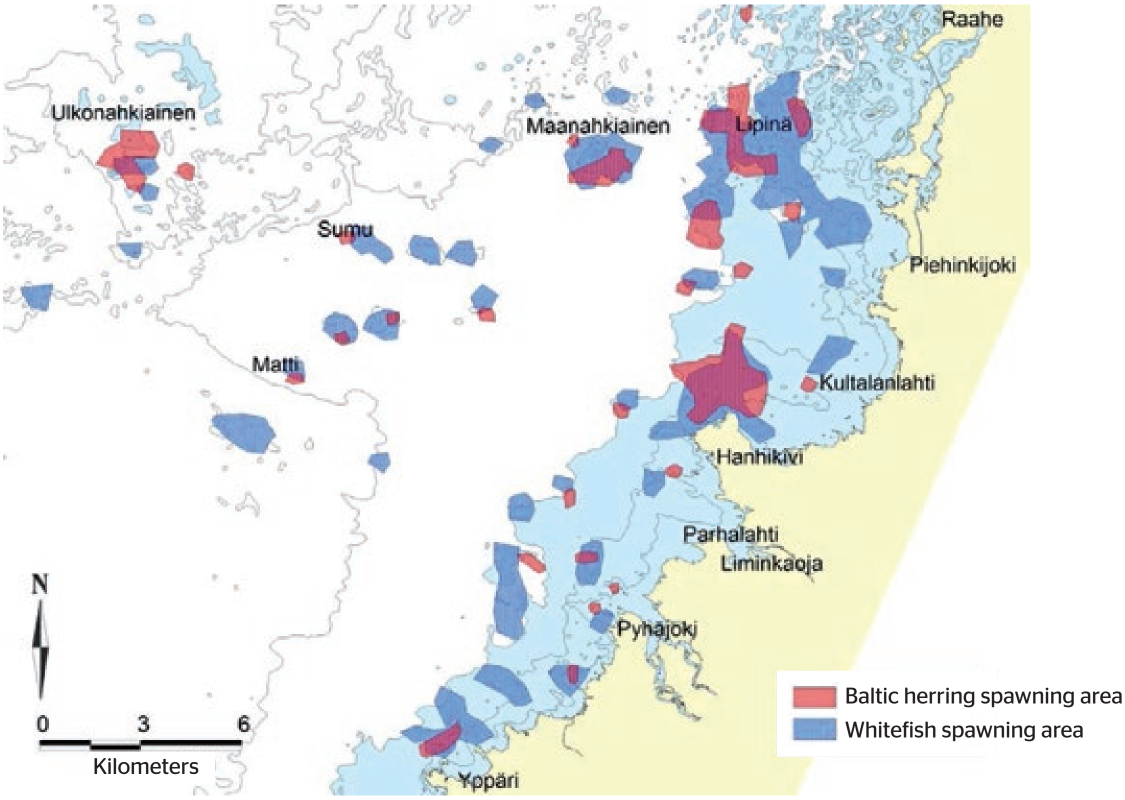


Figure 3B-2. Spawning areas of sea-spawning whitefish and Baltic herring as reported by commercial fishermen (Karppinen and Vatanen 2014).

shallows as sea-spawning whitefish and Baltic herring. Test fishing in the water intake area in October 2014 revealed a large number of vendace nearly ready to spawn.

In the fry surveys of 2014, the number of newly hatched Baltic herring fry was considerably lower than in previous years. It seems that there is large annual variation in the spawning of Baltic herring in the Hanhikivi headland sea area.

Table 3B-1 presents the fish species found in the sea area of the Hanhikivi headland and estimates of their reproduction, as well as the fry and fish counts in the water intake area.

Professional fishing

According to a survey targeted on the year 2013, a total of 23 professional fisherman households operate in the surveyed area (Karppinen and Vatanen 2014). Three of the fishermen were of professional fisherman category 1, two of category 2 and the rest of category 3, some of which carry out professional fishing on a very small scale. For example, some of the category 3 fishermen operating to the north of the surveyed area, off the town of Raahe, described their operations as domestic fishing (Salo 2012). On the other hand, there were fishermen among them who regularly deliver fish to market (Oikarinen 2012).

The most frequently used fishing gear in the sea area of Pyhäjoki and Raahe was a bottom-set net with a mesh size of less than 45 mm. A total of 125,800 of these were used in 2013 in the area. Bottom-set nets with a mesh size over 45 mm were also popular, with approximately 38,000 units in use. Other generally used fishing gear included surface-set nets (2,860 units) and fyke nets for whitefish and salmon (620 units). Less popular fishing gear included vendace and herring nets and various fyke net and hook gear. Trawling does not take place in the area. (Karppinen and Vatanen 2014.)

Fishing takes place in the surveyed area round the year, but is considerably more intense between May and October. Fishing with nets takes place throughout nearly the entire surveyed area, mostly close to the coastline and near shallows in the outer sea, also in winter (Figure 3B-3). Fishing with nets was very frequent in the spawning areas of whitefish and Baltic herring. Fyke nets were used in four areas: Lipinä, Kultalanlahti, the Hanhikivi headland, and the area between Pyhäjoki and Yppäri. Winter fishing focused on areas near the coastline, and mostly took place to the north of the Hanhikivi headland.

Table 3B-1. Fish species in the sea area of the Hanhikivi headland; fry and adult fish. The estimate of the numbers of fish species and the periods when they are typically found in the area is based on data collected in 2009, 2012 and 2014, as well as an interview with a local commercial fisherman. (Haikonen et al. 2014.)

Species	Spawning period	Population frequency in the vicinity of the project site			
		Spawning in the area	Fry stage	Juvenile stage	Aged over one year
Perch	May–June	not significant		abundant	abundant
Pike	May	not significant		improbable	abundant
Cyprinids	May–July	not significant		abundant	abundant
Pikeperch	May–June	improbable			rarely observed
Ruffe	May–July	probable		abundant	abundant
Ten-spined stickleback and three-spined stickleback	June–July	common		abundant	abundant
Smelt	May	improbable			abundant
Whitefish and vendace	October–November	common	abundant	abundant	abundant
Baltic herring	May–July	common	abundant	abundant	abundant
Fall-spawning Baltic herring	inadequate data		observed in the area		
Common sand eel	May–July	probable, inadequate data		abundant	abundant
Sprat	June–August	no		not observed	sporadic
Fourhorn sculpin	December–January	probable, inadequate data			observed in the area
Burbot	January–February	spawns in rivers	inadequate data		common
Eelpout	August–September	probable, inadequate data			observed in the area
Minnow	June–July	common		abundant	abundant
Gobies	May–July	common			abundant
Bullhead	May–June	probable, inadequate data			observed in the area

In 2013, the total catch of professional fishermen in the surveyed area was approximately 44,000 kg (Table 3B-2). Whitefish, mostly of the sea-spawning variety, accounted for nearly 60% of this volume. The catch of carp bream (12.6%) and perch (11%) was also fairly abundant. Other species of commercial significance were the Baltic herring, vendace, sea trout, and salmon.

Domestic and recreational fishing

Domestic and recreational fishing in the Pyhäjoki and Raahe sea areas in 2011 has been surveyed (Vatanen and Haikonen 2012). The survey was carried out as three contact rounds of interviews based on census register data.

Of the households that responded, approximately 10% reported that they had been fishing in the surveyed area. Of these, 94% reported that they had caught fish. A total of 737 households had been fishing in the area. The average size of a fishing household was three persons, of whom two participated in the fishing activities.

A total of 26,000 days of fishing activities took place in the Raahe and Pyhäjoki sea area. Most of the fishing took place between June and August. The least active periods were the late fall and mid-winter.

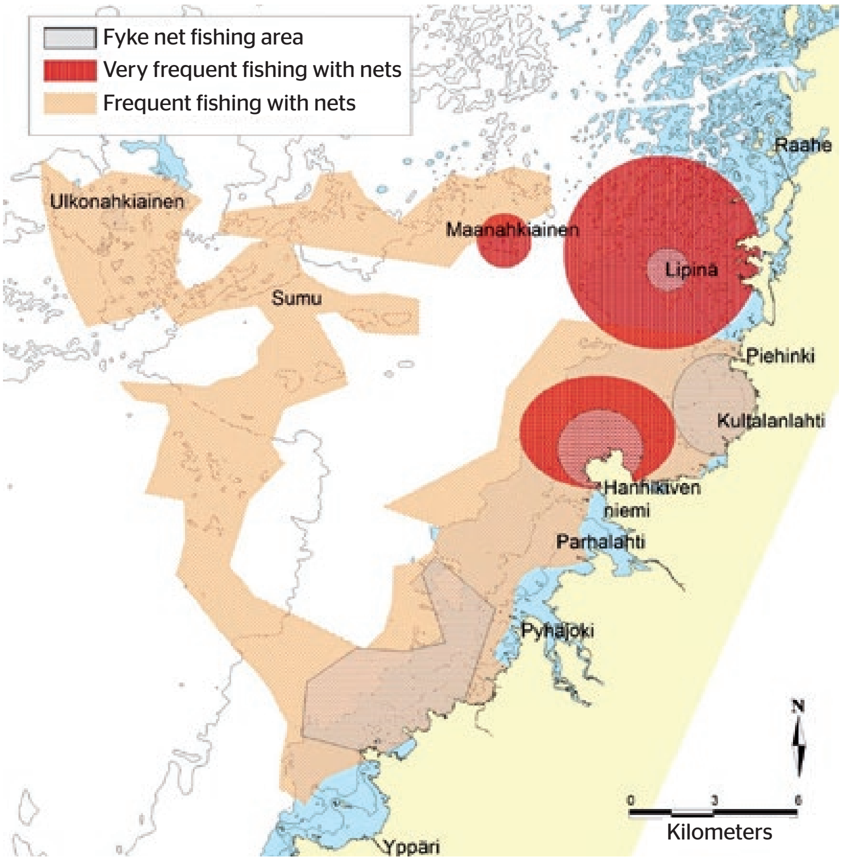


Figure 3B-3. Typical net and fyke fishing with nets areas of professional fishermen in the surveyed area (Karppinen and Vatanen 2014).

Table 3B-2. Catch reported by professional fishermen in 2013 (Karppinen and Vatanen 2014).

Species	Catch, kg
Perch	4,846
Pike	672
Pikeperch	29
Burbot	146
Baltic herring	1,924
Vendace	1,017
Salmon	761
Sea trout	1,031
Sea-spawning whitefish	21,108
Common whitefish	4,741
Grayling	4
Carp bream	5,535
Roach	1,262
Other (smelt, bullhead, river lamprey, ide)	868
Total	**43,944**

The most popular fishing gear was a bottom-set net with a mesh size below 40 mm. These were used by 42% of the fishing households. Other popular fishing gear and methods included bait casting and trolling (30%), angling (27%), vendace or herring nets (27%), ice fishing (23%) and bottom-set nets of with a mesh size of more than 40 mm (22%). Approximately 40% of the fishing households carried out winter fishing. Forms of winter fishing included nets and ice fishing with bait or lure.

The average catch per household was 102 kg and the total catch approximately 75,000 kg. The most frequent species of fish caught were sea-spawning whitefish (34%) and common whitefish (14%), which together accounted for nearly 50% of the total catch. Other common species were pike, perch and Baltic herring.

Impacts of cooling water intake

The impacts of the power plant operation on fishery have been assessed by Kala- ja vesitutkimus Oy in 2014. The impacts of cooling water intake on fish stocks and fishery, presented in this section, are based on the impact assessment report (Karppinen et al. 2014).

The fish pulled into the cooling water intake channel will be mostly small, young individuals and small species moving in schools. Newly hatched fry drifting with water columns are particularly susceptible to ending up in the water intake channel. All the fish species found in the area usually get drawn into the water intake structures of power plants, and the number of fish generally increases with the increase of water volumes. In the Swedish nuclear power plants around the Baltic Sea, 14–29 million fish (25,000–51,000 kg) are annually drawn into water intake channels. At the Finnish Olkiluoto nuclear power plant, the volumes have been lower, approximately 6 million fish (11,000 kg) per year. This means 3.3–8.3 fish per 1,000 m^3 of cooling water. The size of the fish ending up in the intake channels is similar at all the plants, and the majority of the fish are very small. The number of fish seems to increase as the regional plankton production increases, towards the south. Based on these considerations, the volume of fish expected to be drawn into the cooling system of the Hanhikivi nuclear power plant has been estimated to remain considerably lower than at power plants in southern Sweden, and somewhat lower than at Olkiluoto (3.3 fish / 1,000 m^3). If the number of fish in the cooling water channel of the Hanhikivi nuclear power plant were, for example, two fish per 1, 000 m^3 of cooling water, the annual fish volume would be approximately 2.8 million fish (4,800 kg).

Species that undergo a pelagial juvenile phase are at particular risk of being drawn into the water intake channel. These species include many of those common in the Pyhäjoki sea area, such as Baltic herring, whitefish, vendace, lesser sand eel, and gobies. Adult fish and small species also get drawn into the cooling water channel. The fish species most commonly found in the water intake channel at the nuclear power plants mentioned above has been the three-spined stickleback. Large amounts of Baltic herring and smelt also end up in the plants. Other common species include ninespine stickleback, perch, straightnose pipefish, and ruffe. All these are likely to get into the water intake channel also at Hanhikivi. Most of the fish drawn into water intake channels are small fish living in large schools, and small fry that have a high natural death rate. The impact of the lost fry on the fish stocks and catch in the area is assumed to remain minor and local.

Impacts of cooling water discharge

The impacts of cooling water discharge on fish stocks and fishery, presented in this chapter, are mainly based on the impact assessment report of Kala- ja vesitutkimus Oy (Karppinen et al. 2014).

Impacts on fish

The tolerance of fish to temperatures and temperature variations differs between species and stages of growth. Adult fish and juveniles above the fry stage tolerate temperature changes better and may move to other locations if the temperature rises too high. Smaller juveniles and newly hatched fry and eggs in particular are more sensitive to the temperature and are not able to avoid the direct impact of warm discharge water. The changed conditions will probably benefit those species that are able to tolerate temperature changes. The detrimental impact will be largest for those species that have adjusted to cold waters and whose eggs develop in cold waters during the winter. The season, weather conditions and wind direction have a significant impact on the spread of cooling water around the Hanhikivi headland. According to simulations (Lauri 2013), the impact of warm water will be greatest, and reach the most extensive area, in the surface layer of the water (0–1 m). Temperature increases are not commonly observed at the depth of more than four meters.

The total scope of the cooling water impact area was estimated in the fishery impact assessment by combining the surface area data and spread maps of the simulation report (Lauri 2013) and by dividing the area into three zones based on the intensity of the impact. At the mouth of the discharge channel, in an area of 0.03–0.19 km² (3–19 ha), the temperature will be fairly consistently approximately 10 °C higher than in the surrounding area (intense thermal impact). Within this area, fish are mostly repelled due to the high temperature, particularly in the summer season. Procreation of fish in this area is not likely to succeed.

A temperature increase of 3 °C or more in the surface layer (0–1 m) will be observed in an area of 4 km² (high thermal impact). Fish move in this area regularly, but are likely to be repelled at least during the warmest summer season. The increased temperatures and temperature variation may cause problems in the procreation of sensitive species and kill eggs. The procreation of whitefish and vendace, for example, is likely to be disturbed in this area.

The size of the total impact area where a minimum summertime temperature increase of 1 °C can be observed in the surface layer at least part of the time will be approximately 40 km² (low thermal impact). The area in which the temperature of the surface layer has increased by at least 1 °C will, however, always be smaller than the total impact area, and will vary between 5–19 km² in size within the total impact area. The shape, location and surface area of the warmed water area, as well as the intensity of the thermal impact (temperature increase) will vary continuously depending on the weather conditions and the time of the year.

The spreading and cooling of the warm water will generally be efficient around the Hanhikivi headland due to the open, windy sea and the good water turnover rate. However, there are extensive, very shallow coastal waters favored by fry in the area, and the impact of warm waters in these will be intense. Based on the typical winds prevailing in the sea area of the Hanhikivi headland, the warm cooling water will mostly spread to the north and east into Kultalanlahti, where good growth conditions for fry and even adult fish may be created under favorable weather conditions. However, the temperature of water in the shallow coastal waters of Kultalanlahti may rise too high for fish in hot summer weather.

Eutrophication caused by the heat increase will probably remain slight around the Hanhikivi headland due to the low nutrient levels and poor primary production in the area. Increased primary production may, however, have a positive impact on the food volumes available to fish as benthic fauna production improves over a more extensive area. On the other hand, nutrient loads enter the area from the catchment area of the Pyhäjoki river, for example, and as the primary production increases, these nutrients will be recycled more efficiently in the local ecosystem. This may lead to intensifying eutrophication, particularly in shallow areas near the coastline at which the thermal impact is regularly targeted. The species most likely to benefit from the changed conditions via faster growth will be perch and various black clams, and the pike that feed on these fish. Fish species that may experience increased populations in the area include pike-perch, which is currently not very common in the area. Baltic herring can reproduce in the cooling water impact area, but there is a high risk of increased mortality of fry that hatch too early in the spring if spawning happens early due to the increased temperatures. The impact of cooling water is likely to be stronger for whitefish and vendace, which have adjusted to cold waters and spawn in the fall. Their fry production is likely to suffer. The warm cooling waters are likely to cause changes to local fish stocks and the species distribution in the area. Local changes may be large, but in the scale of the entire Bothnian Bay, the impact is expected to remain very low.

Impacts on fishery

The operation of the nuclear power plant will have several different impacts on both professional and recreational fishing. Fishing may be prevented or rendered more difficult, and the species distribution and fry production may change. As a whole, the impact on fishing activities is estimated to be large in the area where the thermal impact of cooling water will be high. The impact will gradually reduce as the distance from the Hanhikivi headland increases. The impact on fishing will mainly be negative, but positive impacts such as improved growth of fish can also be found.

Access to the area around the nuclear power plant will be prohibited. Due to the prohibition, fishing in the net and fyke net areas along the Hanhikivi shoreline will end. Recreational fishing from the shore will also be prevented.

As a result of the discharge of cooling water, the immediate water area around the discharge location at the tip of the Hanhikivi headland will remain unfrozen. Based on simulations, there will be strong annual variation in the size of the unfrozen area and the area where ice will be thin. However, ice fishing in the winter fishing areas off the Hanhikivi headland and Kultalanlahti is expected to end. Similarly, thinning of ice will prevent ice fishing from time to time in more distant areas (Figure 3B-4). Fishing in the unfrozen area is also likely to be impossible after the sea has frozen, as boats cannot easily access the area. Because winter fishing will be prevented, fish that may be attracted by the warm water will most likely not be fully utilized.

The impact of the establishment of an access prohibition area and the deterioration of the ice cover is estimated to be high. The access prohibition area will have an impact on some professional fishermen operating in the vicinity of the Hanhikivi headland, as well as recreational fishermen. Limitations to winter fishing, on the other hand, will have an impact in a more extensive area and on a larger number of both professional and recreational fishermen.

The thermal load to be discharged into the sea will increase eutrophication near the Hanhikivi headland, which may increase the accumulation of slime in various types of netted fishing gear. Increased accumulation of slime will require more frequent cleaning of the gear. This will have an impact on the amount of work required for fishing operations, and thus the profitability of fishing. It is also possible that as eutrophication increases, the portion of unwanted fish species (e.g. black clams and ruffe) in the catch will increase. Increase in unwanted catch volumes will add to the workload of fishermen and thus weaken the profitability of fishing operations.

Fishing may also be rendered more difficult by the potential changes to the living areas and migration routes of the fish, brought on by changing conditions. It is possible that traditional fishing areas will no longer yield a sufficient catch, or that fish will be found in these areas at

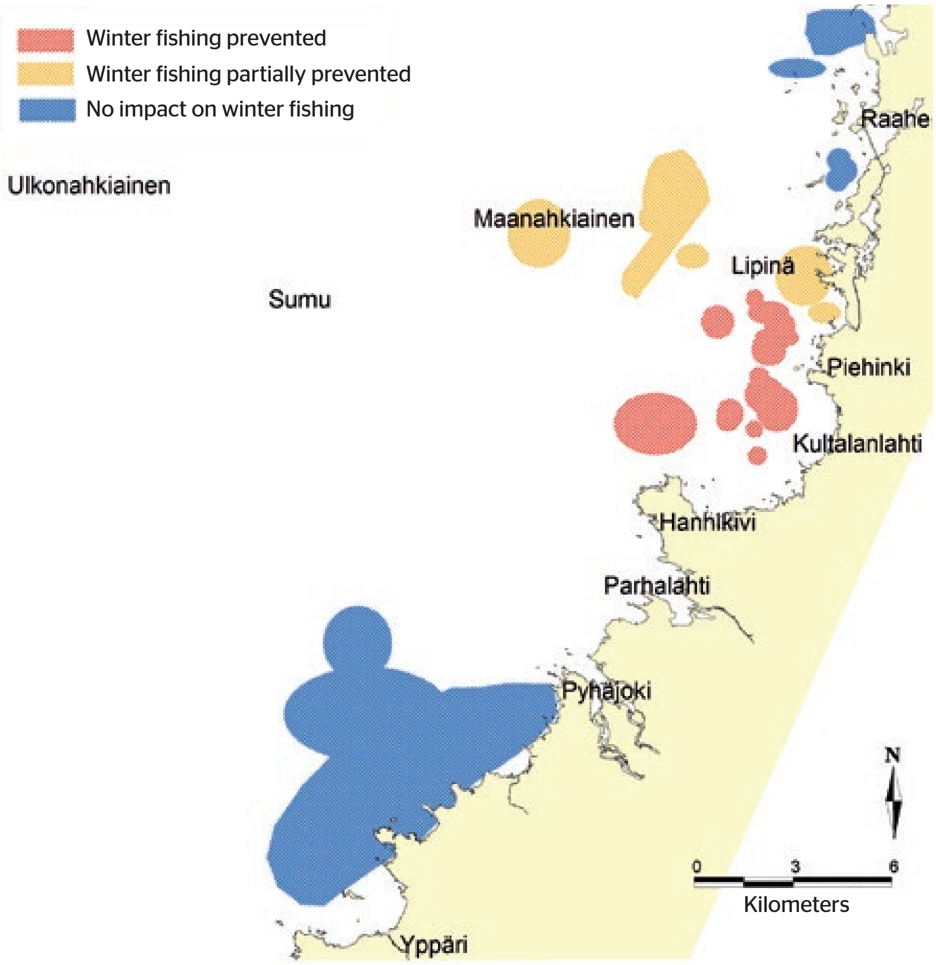


Figure 3B-4. The winter fishing areas reported in the professional fishing surveys of 2011 and 2013, and the impact of cooling water discharge on winter fishing (Karppinen et al. 2014).

untypical times, making it necessary to find new fishing areas or change fishing schedules. Getting new fishing areas is often a challenge. Permits may be difficult to acquire, and typically the distances will get longer, which will be reflected in fuel costs and working hours.

The impact of changes to the living areas of fish and the difficulties in acquiring new fishing areas is estimated to be moderate or high. The impact of the increased need to clean fishing gear is estimated to be low. The impacts will be targeted at an area extending to several kilometers' distance from the Hanhikivi headland. The impact will gradually decrease as distance from the headland increases. The impacts will affect several professional fishermen as well as recreational fishermen.

Changes will take place in the distribution of fish species within the cooling water impact area. Changes in species distribution are generally diverse and complicated processes that happen over a long period of time. The intensity of changes will vary between different parts of the impact area. As a general tendency, it can be stated that perciforms and black clams will benefit from the warming of waters, and that cold water species will suffer. The total catch in the cooling water impact area will probably increase, but the portion of the currently important species will decrease.

The most important species for current commercial fishing are the cold water species, such as sea-spawning whitefish and common whitefish, which together form 60–70% of the professional fishermen's catch. Whitefish are sensitive to changes and likely to react strongly to disturbances and the warming of waters. Fishing for whitefish with fyke nets will end at the area of the strongest impact, at the tip of the Hanhikivi headland, but fishing with nets will probably move to new areas at an increased distance of the cooling water discharge area.

Fishing of perch is likely to increase in the area. As a consequence of the warmer water, perch will grow faster and are also likely to become more abundant in the area. It is also possible that the population of the pike-perch in the area, currently small, will become larger. The impacts listed above are mainly positive. On the other hand, the increase in black calm populations in the area would render fishing more difficult.

The operation of the nuclear power plant would also have an impact on the fry production of various fish species (cooling water discharge) and the mortality of fry (cooling water intake and discharge). The negative impact of the changes in fish populations on fishing is estimated to be high. The positive impact is estimated to be moderate. The impacts will be targeted at an area extending to several kilometers' distance from the Hanhikivi headland. The impact will gradually decrease as distance from the headland increases. The impacts will affect several commercial fishermen as well as recreational fishermen.

Routes of migrating fish and the access of fish into spawning rivers

Routes of migrating fish in the Bothnian Bay

Migrating fish found in the Bothnian Bay include sea-spawning whitefish, salmon, trout and river lamprey. This section contains a description of their populations in the Hanhikivi headland sea area and the timing of their migration, as well as an assessment of the impact of power plant operation on their routes and access to their spawning rivers.

River-spawning **common whitefish** are found in the Hanhikivi headland sea area. Common whitefish are generally larger than sea-spawning whitefish.

In the Bothnian Bay area, common whitefish are found in several rivers, particularly in the Kiiminkijoki, Simojoki and Tornionjoki rivers. In the lower sections of the Pyhäjoki river, adult whitefish that come to the river to spawn yield a good catch every year. Plenty of newly hatched common whitefish fry are released into the Pyhäjoki river and the sea area near it. Natural reproduction may also take place in the Pyhäjoki river. (Karppinen et al. 2014.)

Common whitefish fry leave the river to migrate to the sea soon after hatching, when they are a few centimeters long, in the early summer or during the summer (Leskelä et al. 1991, Lehtonen and Himberg 1992). According to Leskelä (2006), migration of the fry to the sea takes place in shallow coastal waters. The common whitefish stocks of rivers emptying into the Bothnian Bay may migrate further into the Gulf of Bothnia or even to the Archipelago Sea to feed, and then return to their reproduction or planting areas (Lehtonen and Himberg 1992). Some common whitefish only migrate within the Bothnian Bay.

Common whitefish males achieve sexual maturity at the age of four or five, and females at the age of five or six. They then migrate from feeding areas towards their spawning rivers (Leskelä 2006). Migration of the common whitefish to various spawning rivers takes place at different times. Migration into the big rivers emptying into the Gulf of Bothnia, such as the Tornionjoki river, mainly occurs between the end of July and October (Lehtonen and Himberg 1992). Migration into smaller rivers, such as the Kiiminkijoki and Simojoki rivers, takes place in September and October.

In the sea area off the Hanhikivi headland, the common whitefish are either planted common whitefish or whitefish that naturally reproduce in the rivers in the area. According to a professional fisherman operating in the area (Karppinen et al 2014), common whitefish migrate into the area starting from the end of June.

Earlier, when the use of drift nets was still allowed in whitefish fishing, fishing with drift nets took place off Yppäri, approximately 10 kilometers from the coast. The net haulers followed the whitefish schools to Maanahkiainen. Migrating fish passed the Hanhikivi headland in the surface layer of water areas more than ten meters deep. Based on this, it can be assumed that whitefish coming from rivers in the north migrate along routes located 5–10 km from the Hanhikivi headland (Figure 3B-5). (Karppinen et al. 2014.)

The most important Finnish spawning rivers of **wild salmon** are Tornionjoki and Simojoki. Some natural reproduction of salmon may also occur in the Pyhäjoki river.

Salmon spawn in September and October on gravel bottoms in locations with a strong current. Salmon fry spend an average of two to four years in rivers and then migrate to the sea to feed (Haikonen et al. 2006). Salmon hatched in the rivers emptying into the Bothnian Bay migrate to the sea between the end of May and early July (Jutila et al. 2005).

Salmon migrating to spawn are found in the Bothnian Bay starting from May. The main migration in the sea area takes place in June, but significant numbers of fish also migrate in July and August (Niva 2001, Siira et al 2008). In the Tornionjoki river, the migration peak is in late June, around Midsummer, but migration continues until the end of summer. Some salmon are caught in the sea even in September, during whitefish fishing (Siira et al. 2008).

Migration of salmon back to their hatching rivers takes place in the warm water layer close to the surface, at a depth of 2–3 meters (Karlsson et al. 1999). Migration has been observed to occur in a narrow strip parallel to the coastline (Westerberg et al. 1999). There is annual variation in migration routes, and migration is regulated by the water temperature and the prevailing winds

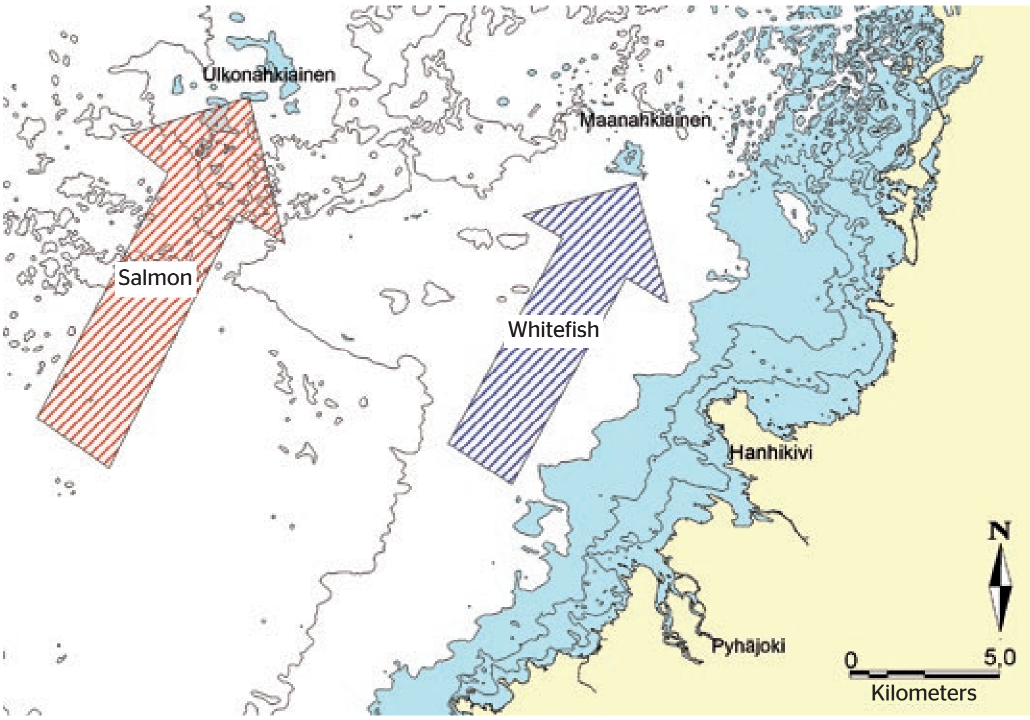


Figure 3B-5. According to interviews with professional fishermen, the main migration routes of whitefish and salmon to the rivers in the north are located fairly far from the shoreline, in waters at least 10 m deep, close to the surface (Karppinen et al. 2014).

(Westerberg et al. 1999). In the Bothnian Bay, salmon generally prefer to migrate along the shallower Finnish coast, which will warm up more quickly. However, migration also takes place along the Swedish coast if the water is warm enough. During weak or northerly winds, salmon have been observed to migrate further from the Finnish coastline.

According to professional fishermen, salmon migrate both in the outer sea and close to the Hanhikivi headland (Vatanen and Haikonen 2012). Most of the salmon in the Hanhikivi headland area migrate towards the north, but not close to the shore where the fyke nets are placed (Taskila 2009). The salmon catch in the area is therefore rather small. Very few Carlin tags of salmon are returned from the Pyhäjoki area (Finnish Game and Fisheries Research Institute, fish tagging register), and the tag returns are mostly from fish planted in the Pyhäjoki river. Salmon planted in northern rivers have represented a small minority in the tag returns from the Pyhäjoki area in the last 20 years.

There is hardly any research-based information about smolt migrating in the sea area. According to Ikonen (2006), young salmon migrating in the sea, post-smolt, travel southwards along both Finnish and Swedish coastlines, as the water near the coast warms up more quickly than in the deep sea area. South of Kvarken, migration of post-smolt mainly takes place along the Swedish coast. A very small portion of Carlin tag returns (11 returns) of post-smolt have come from the surveyed area in the last 20 years, and all the returned tags have been from fish planted in the Pyhäjoki river (Finnish Game and Fisheries Research Institute, fish tagging register). In trawling surveys carried out in summer 2014, two smolts, most likely hatched from natural spawning, were caught off the Hanhikivi headland (Haikonen et al. 2014). Based on information recorded in the survey fishing register, some minor natural reproduction of salmon has been observed in the Pyhäjoki river. The smolts that have been found may, however, have come from other salmon rivers that empty into the Bothnian Bay.

Sea trout, like salmon, reproduce in strong currents and migrate to the sea after spending an average of 3–5 years in the river (Haikonen et al. 2006). The trout usually stay close to the shore and do not migrate to such great distances as salmon do (Lovikka et al. 2006). Sea trout from the Bothnian Bay have been observed as far as the Archipelago Sea, but most of them remain in the Bothnian Bay. The sea migration of sea trout normally takes 1–4 years, after which it returns to its hatching river to spawn (Haikonen et al 2006).

Few of the sea trout in the Bothnian Bay originate from natural spawning. For example, only 18,000 naturally spawned juvenile sea trout left the Tornionjoki water system to migrate into the sea in 2011, while the number of salmon leaving in the same year was approximately 1.5 million (Vähä et al 2014). Plenty of sea trout fry were, however, planted in the Bothnian Bay area, also resulting in large sea trout catches in the sea area near the Pyhäjoki river. Based on Carlin tags (Finnish Game and Fisheries Research Institute, fish tagging register), plenty of fish planted further away, mostly in rivers in Ostrobothnia and northern Finland, are caught in Pyhäjoki. Trout come closer to the shore than salmon in the Pyhäjoki sea area, and trout are caught around the year.

The spawning of **river lamprey** takes place in May and June. Sexually mature river lampreys usually already rise into rivers between August and October of the previous year, but migration takes place later as well. (RKTL Kala-atlas.) Soon after spawning, the river lamprey will die. The eggs of river lamprey develop inside gravel for two to three weeks.

River lamprey larvae, or fry (ammocoetes), spend their first years in the sand and mud bottoms of riverbanks. The fry stage will last from four to seven years. Migration of river lamprey into the sea occurs during spring floods. The sea stage has been estimated to usually last from the spring to the fall in the next year, but based on tagging, some river lamprey seem to rise back to the rivers to spawn already in fall of the same year. In the first summer in the sea, young river lampreys move widely in the river. There is little information of how river lampreys move in the sea otherwise. In the sea, river lampreys eat, for example, bottom fauna and fish. Suction marks left by river lampreys have been observed on fish such as Baltic herring, sprat, smelt and vendace. (RKTL Kala-atlas.)

Within the surveyed area, river lampreys reproduce in at least the Pyhäjoki and Liminkaoja rivers. Pyhäjoki river has been classified as a very important river lamprey spawning river (Oikarinen 2012). In addition to the Pyhäjoki river, fishing of river lamprey takes place in the lower section of Liminkaoja. The largest catches of river lamprey come from the Pyhäjoki river in September and October. There is no information of the migration of river lamprey around the Hanhikivi headland.

Table 3B-3 is a summary of the migration timing of salmon, trout, whitefish and river lamprey, and their populations in the sea area off the Hanhikivi headland.

Table 3B-3. Timing of the various stages of migrating fish found in the surveyed area (edited from Karppinen et al. 2014).

Species	Spawning period	Spawning in the area	Timing of juvenile migration	Spawning migration	Population frequency in the area
Salmon	October	Pyhäjoki (minor)	May–June	June–August	in connection with migration, fairly common
Sea trout	October	Pyhäjoki (minor)	May–June	June–August	around the year after the juvenile river stage, common
Common whitefish	October–November	inadequate data, possibly Pyhäjoki	May–June, planted in large numbers in spring	June–August	in connection with migration
River lamprey	May	Liminkaoja, Pyhäjoki	probably in the spring, inadequate data	August–November, probably also in the winter	found, little data about life in the sea

Impact on the routes of migrating fish and on their access to spawning rivers

There are no significant salmon or trout spawning rivers in the surveyed area, but reproduction on a small scale may take place in rivers such as Pyhäjoki or Liminkaoja. Migration routes of common whitefish, salmon and sea trout run along the coastline. Large numbers of common whitefish are planted in the Pyhäjoki river and the sea area near the Hanhikivi headland. Fishing of common whitefish, salmon and sea trout takes place in the surveyed area, including the immediate vicinity of the project location. (Karppinen et al. 2014.)

Trout thrive in cool waters, and generally avoid temperatures over 20 °C. The migration of trout and salmon in rivers has been observed to come to a total standstill when the water temperature exceeds 20 °C. Salmons have also been observed to go around the warm waters on their migration route and then continue the migration. The spread of warmed cooling water in the sea area off the Hanhikivi headland may thus slow down the migration of fish passing through the area on their way towards the spawning rivers in the Bothnian Bay. Most of the northbound migration routes of salmon and whitefish are, however, located at a greater distance from the shoreline of the Hanhikivi headland. Thus, the project is not expected to have a significant impact on the migration of fish towards the north. It can also be assumed that the project will have no impact on the migration of post-smolt, with the exception of any fish possibly coming from the Pyhäjoki river, some of which could be drawn into the water intake channel. Operation of the nuclear power plant may have an impact on the feeding behavior of sea trout and whitefish feeding in the vicinity of the Hanhikivi headland. Salmon, on the other hand, do not feed during their spawning migration. (Karppinen et al. 2014.)

Bottom dominated by submerged macrophytes, and charophyte meadows

Aquatic vegetation in the Hanhikivi headland area has been surveyed in 2012 and 2009 (Leinikki et al. 2012, Ilmarinen et al. 2009). Surveying methods have included scuba diving and on-foot surveys of shallow areas. In an extensive survey in 2014, aquatic vegetation was mapped in 15 locations in the area between the Hanhikivi headland and Lännennokka, as well as in five locations in a reference area in Ulko-Harmi of Yppäri (Figure 3B-6). The research results and impact assessment presented in this chapter are mainly based on the 2014 research report (Syväranta and Leinikki 2014).

The Yppäri reference area is located approximately 13 kilometers from the Hanhikivi headland to the south, and has a similar seabed and open environment as the Hanhikivi headland.

Extensive brackish water bays open on the east side of both headlands, allowing comparison of vegetation. The survey paid particular attention to endangered species and habitat types, the most probable of these being charophyte meadows.

Aquatic vegetation was mapped using a main zone line method. The main zone line method is based on lines five meters wide in which vegetation is mapped from the flood limit to the limit depth after which it is no longer found. In this method, vegetation is divided into main categories such as helophytes, elodeids, and isoetids. Start and end distances are defined for the zones from the beginning of the line. Start and end depths are also recorded. Frequency and coverage on the line are estimated only once for each plant species. Frequency is calculated by dividing the line into hundred sections and then estimating the number of sections where the species is found. As coverage, the average percentage coverage is given.

The impacts of the spread of warm cooling water on aquatic vegetation were assessed utilizing a model created by Suomen YVA Oy (Lauri 2013) and, in particular, a model that studies the changes in seawater temperatures at various depths, as Charophyta are mainly found at depths of less than two meters (Tolstoy and Österlund 2003). Ice conditions modeled by Suomen YVA Oy in March 2013 (Lauri 2013) were used in the assessment of changes in the ice cover.

Charophyte meadows and bottom dominated by submerged macrophytes in the area

A total of 33 species of plants and algae were found in the survey lines of the aquatic vegetation survey, of which 20 were actual aquatic vegetation and 13 were coastal vegetation. Rough stonewort (*Chara aspera*) and clasping-leaf pondweed (*Potamogeton perfoliatus*) were clearly the most abundant species. Other common plants in the area included horned pondweed (*Zannichellia palustris*), lesser pondweed (*Potamogeton pusillus*), slender-leave pondweed (*Potamogeton filiformis*) and fennel pondweed (*Potamogeton pectinatus*). Watermilfoils (*Myriophyllum*) in shallow bays were considerably fewer in number than pondweeds. Only one species of hard seabed algae was observed, (*Cladophora glomerata*), and only at one location. The results were in line with earlier surveys carried out in the area (Leinikki et al. 2012, Ilmarinen et al. 2009).

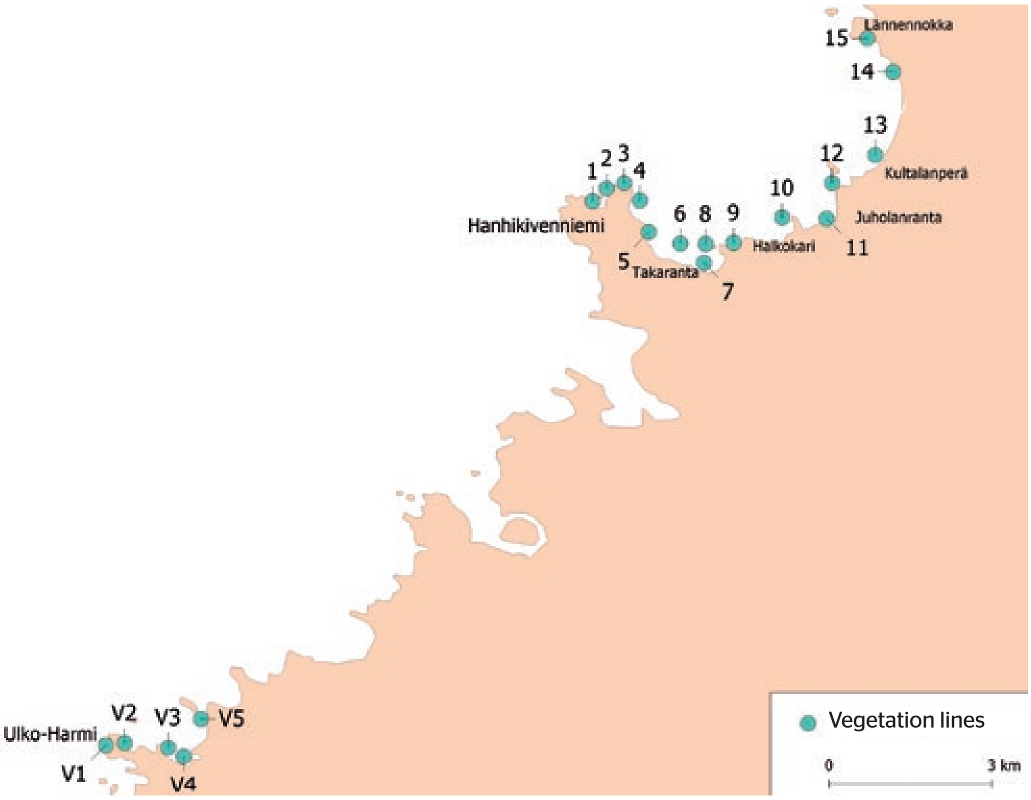


Figure 3B-6. Aquatic vegetation survey lines 1–15 between the Hanhikivi headland and Lännennokka, and reference lines V1–V5 in Yppäri (Syväranta and Leinikki 2014).

No endangered species were found in the area between the Hanhikivi headland and Lännennokka. Endangered species were only found in line V5 of the Yppäri reference area, where a small number of long-beaked water feather-moss (*Rhynchostegium riparioides*) was growing. The species is classified in category NT (Near Threatened).

The habitat type of bottom dominated by submerged macrophytes, common in the Hanhikivi headland area, has been classified as Vulnerable (VU) on a national scale, but as DD (Data Deficient) in the Bothnian Bay. Based on surveys carried out in the area, the habitat type is mostly limited by the openness of the shores. In the lines surveyed in summer 2014 (Figure 3B-6), this habitat type was found in the flada located in the northern part of the headland (line 1), in the eastern shore areas of the headland (lines 3–7) and in the Juholanranta area (line 11). In earlier surveys (Leinikki et al. 2012, Ilmarinen et al. 2009), bottom dominated by submerged macrophytes was found over the entire area from the Hanhikivi headland to the northern part of Kultalanlahti.

Of the 15 lines surveyed between the Hanhikivi headland and Lännennokka (Figure 3B-6), charophyte meadows were found in 13 lines. In the Yppäri reference area, Charophyta were found in all five survey lines. The most abundant Charophyta populations were observed in lines 6–8 in Kultalanlahti and in line 4 of the Yppäri reference area. All the Charophyta found were rough stonewort (*Chara aspera*). It is not an endangered species. As a habitat type, Charophyta meadows are classified as EN (Endangered). The classification considers the habitat types on a national scale. On a regional scale, the data is mostly deficient. In Kvarken, the classification is VU (Vulnerable).

Line-specific frequency and coverage of Charophyta in the Hanhikivi headland sea area and the Yppäri reference area are presented in Table 3B-4.

Table 3B-4. Frequency and coverage of charophyte meadows (*Chara aspera*) in the Hanhikivi headland sea area (lines 1-15) and the Yppäri reference area (lines V1-V5) (Syväranta and Leinikki 2014).

Line	Date	Frequency (%)	Coverage (%)	Lat	Long
1	8/18/2014	25	10	64.535	24.259
2	8/18/2014	60	17	64.535	24.259
3	8/19/2014	50	20	64.538	24.271
4	8/19/2014	45	30	64.535	24.277
5	8/19/2014	70	25	64.530	24.281
6	8/19/2014	90	50	64.529	24.293
7	8/19/2014	60	70	64.526	24.303
8	8/19/2014	95	65	64.529	24.303
9	8/19/2014	95	30	64.529	24.314
10	8/20/2014	95	40	64.534	24.332
11	8/20/2014	0	0	64.534	24.349
12	8/20/2014	15	5	64.540	24.351
13	8/20/2014	30	2	64.545	24.367
14	8/20/2014	0	0	64.559	24.372
15	8/20/2014	40	30	64.564	24.362
V1	8/21/2014	3	2	64.441	24.082
V2	8/21/2014	60	15	64.442	24.089
V3	8/21/2014	50	5	64.442	24.106
V4	8/21/2014	80	60	64.440	24.112
V5	8/21/2014	80	35	64.447	24.118

Data has been gathered on the distribution and frequency of aquatic vegetation in the Finnish Inventory Programme for the Underwater Marine Environment (VELMU). Based on the data, charophyte meadows are found in the Bothnian Bay in the Rahja islands in Kalajoki, the sea area to the south of Hailuoto, Varjakka in Lumijoki, the Krunni islands of Ii, Kraaseli in Oulu, and the Perämeri National Park in Kemi, among other places. VELMU data shows that charophyte meadows are found in approximately one out of three of the observation locations where the water depth is 0–2 meters. Charophyta are considered to be found in an area if their coverage is at least 10%. The observations confirm that Charophyta are not found in extremely open locations, such as the west side of Hailuoto, where water depths suitable for Charophyta are frequently observed. The sheltered location is therefore estimated to account for the extensive coverage of Charophyta in lines 6–8.

Impact on charophyte meadows and bottom dominated by submerged macrophytes

Aquatic vegetation to the north and east of the Hanhikivi headland mainly consists of various pondweeds and Charophyta. The two dominant species are clasping-leaf pondweed (*Potamogeton perfoliatus*) and rough stonewort (*Chara aspera*). Extensive charophyte meadows grow between the Hanhikivi headland and Halkokari. The most abundant populations were found in lines 6–8 in the shore section of the Takaranta seashore meadows (Figure 3B-6).

Watermilfoils (*Myriophyllum*) and other vascular plants will benefit from the temperature increase. Their populations are likely to grow between the Hanhikivi headland and Halkokari. Pondweeds will also benefit from the temperature change and are expected to become more abundant. A long period of frozen sea is typical in the Bothnian Bay. If the erosive impact of pack ice on vegetation decreases in the Kultalanlahti area, perennial aquatic mosses may become more abundant in shallow water. Eutrophication, dredging and water construction works are considered to be the reasons why bottom dominated by submerged macrophytes has become an endangered habitat type (Raunio et al. 2008). Water construction works and dredging destroy seabed plants directly and via increased turbidity, or the habitat may deteriorate as water depth increases. Eutrophication accelerates the growth of filamentous algae, which attach to submerged vegetation, prevent light from reaching them, and thus slow down their growth. Floating mats of filamentous algae also destroy benthic fauna.

The thermal load discharged from the nuclear power plant will cause mild eutrophication, but no aggressive growth of filamentous algae is expected to occur. Rather, the mild eutrophication and longer growth season are likely to increase submerged plant populations. The dredging and water construction work for the nuclear power plant project will cause at most limited and temporary damage to submerged plant populations. It has been estimated that the conditions required by bottom dominated submerged macrophytes will improve around the Hanhikivi headland as the temperature of the seawater increases, but the species distribution in the habitat type may change.

Threats to charophyte meadows include eutrophication and the overgrowth of habitats (Raunio et al. 2008). Temperature increases are known to have impacts similar to those of eutrophication (Løvendahl Raun 2013). The increased seawater temperature may thus have a similar impact on charophyte meadows. Charophyte meadows are most likely to suffer in the area between the north tip of the Hanhikivi headland and Takaranta, in vegetation survey lines 1–6 (Figure 3B-6). To the east of Takaranta, in lines 7–15, the impact will be more limited, as the surface water temperature increase in these areas will be between one and two degrees. This could be obscured by normal annual variation, and may not have any negative impact on the frequency of charophyte meadows. A small temperature increase may even improve the growth conditions for Charophyta, as they are naturally found in sheltered bays where the water turnover rate may be low in the summer, and temperatures higher than in the surrounding sea areas. If the temperature increase is too high, however, competition with vascular plants may limit the growth of Charophyta. Charophyte meadows may therefore either suffer or benefit from the temperature increase.

In the Bothnian Bay, vegetation is typically covered by a layer of diatoms. If the temperature increase leads to increased diatom populations, photosynthesis may become difficult for the Charophyta. In addition, warm water will bind less soluble oxygen than cold water does. High temperature and the low oxygen content of the water column may weaken the formation of the roots and leaves of aquatic vegetation.

The extensive Charophyta populations found in the Takaranta area are representative. VELMU data shows that the Bothnian Bay has a fairly large number of shallow seashores well suited for Charophyta, but a more limited number of suitable sheltered habitats. The regional significance of the Takaranta Charophyta meadows cannot be assessed before the models generated within the VELMU project become available.

The targets and implementation of the Finnish Marine Strategy

The target of Marine Strategy is to achieve and maintain the good condition of the Baltic Sea by 2020. The Finnish Marine Strategy is based on the European Union Marine Strategy Framework Directive (2008/56/EC), implemented in Finland by the Act on the Management of Water Resources and the Marine Environment (1299/2004, amended by 272/2011) and the Government Decree on the Organization of Marine Management (980/2011).

The Marine Strategy has three parts, and it covers Finnish territorial waters and the exclusive economic zone. The first part (Ministry of the Environment 2012) contains an initial assessment of the current state of the marine environment, definitions of a good state of a marine environment, and an account of the environmental targets and the related indicators. The second part (Ministry of the Environment 2014) is a monitoring program, and the third part is an action program. The Government issued a decision on the first part in 2012 and on the second part in 2014. The third part, the action program, is currently under development and will be completed by the end of 2015.

The first part of the Marine Strategy (Ministry of the Environment 2012) defined the general targets concerning the good state of the marine environment. The purpose of the targets is to define the human originated systems used to improve the state of the marine environment and to ensure the long-term functionality and productivity of the ecosystem. The general target is to protect, preserve and, when necessary, to restore the Baltic Sea to retain its biological diversity and to keep it dynamic, clean, healthy and productive.

In its environmental permit application filed in 2015, Fennovoima has defined the targets of the Marine Strategy that are of particular importance for the nuclear power plant. The following includes an account of these targets and an assessment of how the targets will be fulfilled during the operation of the nuclear power plant:

Target 1. Eutrophication will not damage the Baltic Sea environment.

> *"The target is to achieve the nutrient release reductions defined in the water management plans for the Finnish water resources management regions, and to reduce the phosphorus and nitrogen loads from various sources so that they remain below the maximum values allowed in the HELCOM Baltic Sea Action Plan."*

The very low nutrient load emerging from the power plant to the sea will not affect the total regional load volumes. The phosphorus load from the power plant (approximately 15 kg annually), put in proportion with the load from the Pyhäjoki river alone, remains negligible. The operation of the nuclear power plant will not be in conflict with the nutrient load reduction target.

Target 2. Hazardous substances shall not disturb the marine ecosystem or the use of fish or game for human consumption.

> *"The target is to conform to the environmental quality standards for hazardous substances, or the quality standards set for fish and game used for human consumption. Management of the risks related to hazardous substances, as well as the quality and quantity of data available for the hazardous substances, shall also be improved."*

Substances hazardous or detrimental to the aquatic environment, listed in Annexes 1A, B or C of the Government Decree (868/2010), will not be released to the aquatic environment from the power plant during operation. The operation of the nuclear power plant will not be in conflict with the target, as the operation will not lead to releases of detrimental substances hazardous to the aquatic environment, and quality standards shall thus not be exceeded.

Target 3. The conservation status of all species naturally found in the Baltic Sea is favourable, and their long-term preservation is ensured.

> *"The target is to ensure the natural diversity and functionality of species, habitat types and ecosystems, and to minimize the impact on non-indigenous species. The functional prerequisites of the seabed food webs, as well as the structure and functions of the seabed ecosystems, shall also be protected."*

The operation of the power plant will have a local impact on the marine environment within the cooling water impact area. In this area, primary production may increase. The operation of the nuclear power plant will not risk the maintenance and achievement of the favourable conservation status of species or habitat types. The impact of the nuclear power plant operation will not compromise the target of ensuring the functional prerequisites of the food webs of the sea. The structure or functions of the seabed ecosystems shall also not be compromised. Changes are possible at a local level.

The Hanhikivi nuclear power plant will not compromise the general target of the Marine Strategy to protect, preserve and, when necessary, to restore the Baltic Sea to retain its biological diversity and to keep it dynamic, clean, healthy and productive.

References

Finnish Game and Fisheries Research Institute, releases 2010–2014. http://www.rktl.fi/tiedotteet (Accessed September 1, 2014). In Finnish.

Finnish Game and Fisheries Research Institute, fish tagging register. http://www.rktl.fi//kala/kalavarat/kalamerkinta (Accessed September 1, 2014). In Finnish.

Haikonen, A., Romakkaniemi, A., Ankkuriniemi, M., Keinänen, M., Mäntyniemi, S., Pulkkinen, K. and Vihtakari, M. 2006. Lohi- ja meritaimenkantojen seuranta Tornionjoessa vuonna 2005. Kala- ja riistaraportteja nro 379. Finnish Game and Fisheries Research Institute. In Finnish.

Haikonen, A., Vatanen, S., Kervinen, J. and Karppinen, P. 2012. Kalasto ja poikastuotanto Pyhäjoen edustan merialueella vuonna 2012. Kala- ja vesimonisteita nro 85. Kala- ja vesitutkimus Oy. In Finnish.

Haikonen, A., Helminen, J., Karppinen, P., Kervinen, J. and Vatanen, S. 2014. Fennovoiman ydinvoimahankkeen vedenotto- ja lauhdeveden purkualueen kalastoselvitykset vuonna 2014. Kala- ja vesimonisteita nro 150. Kala- ja vesitutkimus Oy. In Finnish.

Ikonen, E. 2006. The role of the feeding migration and diet of Atlantic salmon (Salmo salar L.) in yolk-sac fry mortality (M74) in the Baltic Sea. Doctoral thesis. University of Helsinki, Faculty of Biological Sciences, Department of Biological and Environmental Sciences; and Finnish Game and Fisheries Research Institute.

Ilmarinen, K., Leinikki, J. and Oulasvirta, P. 2009. Fennovoima Oy, ydinvoimalaitoshanke. Vedenalaisen luonnon nykytilan kuvaus. Alleco Oy. In Finnish.

Jutila, E., Jokikokko, E. and Julkunen, M. 2005. The smolt run and postsmolt survival of Atlantic salmon, Salmo salar L., in relation to early summer water temperatures in the northern Baltic Sea. Ecology of Freshwater Fish 14: 69–78.

Karlsson, L., Ikonen, E., Westerberg, H. and Sturlaugsson, J. 1999. Data storage tag study of salmon (Salmo salar) migration in the Baltic: The spawning migration of wild and hatchery-reared fish and a comparison of tagging methods. ICES C.M. 1999/AA:5.

Karppinen, P. and Vatanen, S. 2014. Ammattikalastus Pyhäjoen ja Raahen edustan merialueella vuonna 2013. Kala- ja vesimonisteita nro 142. Kala- ja vesitutkimus Oy. In Finnish.

Karppinen, P., Vatanen, S., Haikonen, A., Helminen, J. and Kervinen, J. 2014. Fennovoiman ydinvoimalaitoksen käytöstä aiheutuvat kalataloudelliset vaikutukset. Kalatalousarvio. Kala- ja vesimonisteita nro 160. Kala- ja vesitutkimus Oy. In Finnish.

Katajisto, T., Lehtiniemi, M. and Setälä, O. 2014a. Vieraslajiportaali, Liejuputkimadot. http://www.vieraslajit.fi/lajit/MX.52874/show (Accessed August 28, 2014). In Finnish.

Katajisto, T., Lehtiniemi, M. and Setälä, O. 2014b. Vieraslajiportaali, Villasaksirapu. http://vieraslajit.fi/lajit/MX.53038/show (Accessed August 28, 2014). In Finnish.

Laine, A., Mattila, J. and Lehikoinen, A. 2006. First record of the brackish water dreissenid bivalve Mytilopsis leucophaeata in the northern Baltic Sea. Aquatic Invasions 1, 1: 38-41. In Finnish.

Lauri, H. 2013. Virtausmalli Pyhäjoen edustalle lämpöpäästöjen leviämisen arviointiin. Suomen YVA Oy. In Finnish.

Lehtonen, H. and Himberg, M. K.-J. 1992. Baltic Sea migration patterns of anadromous Coregonus lavaretus (L.) s.str. and sea-spawning European whitefish C.l. widegreni Malmgren. In: T. N. Todd and M. Luczynski (ed.) Biology and management of Goregonid Fishes. Pol. Arch. Hydrobiol. 39 (3,4): 463–472.

Lehtonen, E., Oksanen, S., Aalto, N., Lappalainen, A. Peuhkuri, N. and Kunnasranta, M. 2012. Rysillä Selkämereltä pyydystettyjen hallien satelliittiseuranta vuosina 2008–2009. Tutkimuksia ja selvityksiä 2/2012. Finnish Game and Fisheries Research Institute. In Finnish.

Leinikki, J., Syväranta, J. and Ilus, E. 2012. Selvitys säteilymittauksiin soveltuvien kasvi- ja eläinlajien esiintymisestä Hanhikiven merialueella. Raportti 7/2012. Alleco Oy. In Finnish.

Leskelä, A. 2006. Marking one-summer-old whitefish with fluorescent pigment spraying method and results of whitefish stockings in the Gulf of Bothnia. Doctoral thesis. University of Helsinki, Faculty of Biological Sciences, Department of Biological and Environmental Sciences; and Finnish Game and Fisheries Research Institute.

Leskelä, A., Hudd, R., Lehtonen, H., Huhmarniemi, A. and Sandström, O. 1991. Habitats of whitefish (Coregonus lavaretus L. s.l.) larvae in the Gulf of Bothnia. Aqua Fennica 21, 2:145–151.

Lovikka, T., Hiltunen, M. and Partanen, L. 2006. Iijoen merialueen kalakantojen velvoitehoidon tarkkailutulokset vuosina 2001–2005. Moniste. Voimalohi Oy. In Finnish.

Løvendahl Raun, A. 2013. Effects of eutrophication and temperature on submersed rooted plants. Faculty of science, University of Copenhagen.

Ministry of Agriculture and Forestry 2012. A national strategy to combat invasive alien species. http://www.mmm.fi/fi/index/etusivu/ymparisto/luonnonmonimuotoisuus/vieraslajit.html (Accessed January 12, 2015).

Ministry of the Environment 2012. Valtioneuvoston päätös meren nykytilan ja hyvän tilan arvioimisesta sekä ympäristötavoitteiden ja indikaattorien asettamisesta; Suomen merenhoitosuunnitelman ensimmäinen osa. Issued December 13, 2012. In Finnish.

Ministry of the Environment 2014. Valtioneuvoston päätös merenhoitosuunnitelman seurantaohjelmasta vuosille 2014–2020. Suomen merenhoitosuunnitelman toinen osa. Issued August 21, 2014. In Finnish.

Niva, T. 2001. Perämeren ja sen jokien lohi-istutusten tuloksellisuus vuosina 1959–1999. Kalatutkimuksia 179. Finnish Game and Fisheries Research Institute. In Finnish.

Oikarinen, J. 2012. Pyhäjoen edustan merialueen kalataloudellinen merkitys. Raportti. Perämeren Kalatalousyhteisöjen Liitto Ry, Raahe. In Finnish.

Pöyry Energy Oy 2008. Environmental Impact Assessment Report for a Nuclear Power Plant. Fennovoima Oy.

Raita, A. 2006. Tilannekatsaus fouling-eliöstöstä Suomen lämpövoimalaitosten jäähdytysvesijärjestelmissä. Finnish Energy Industries. In Finnish.

Raunio, A., Schulman, A. and Kontula, T. 2008. Suomen Luontotyyppien uhanalaisuus – osa 2: Luontotyyppien kuvaukset. Suomen ympäristö 8/2008 Osa 2. In Finnish.

RKTL Kala-atlas. http://www.rktl.fi/kala/tietoa_kalalajeista (Accessed September 1, 2014). Finnish Game and Fisheries Research Institute. In Finnish.

Salo, J. 2012. Raahen edustan velvoitetarkkailu. Kalataloustarkkailun raportti vuodelta 2011. Lapin vesitutkimus. In Finnish.

Siira, A., Suuronen, P., Erkinaro, J. and Jounela, P. 2008. Run timing routes of returning Atlantic salmon in the Northern Baltic Sea; implications for fisheries management. Manuscript.

Syväranta, J. and Leinikki, J. 2014. Pyhäjoen Hanhikivenniemen vesikasvillisuustarkkailu ja ydinvoimalaitoksen käytönaikaisten vaikutusten arviointi. Raportti 9/2014. Alleco Oy. In Finnish.

Taskila, E. 2009. Paikanvalintaa edeltävät vesistöselvitykset ydinvoimalaitoshankkeessa – kalataloudellisia selvityksiä. Raportti. Pöyry. In Finnish.

Tolstoy, A. and Österlund, K. 2003. Alger vid Sveriges östersjökust – en fotoflora. ArtDatabanken & Swedish University of Agricultural Sciences & WWF, Uppsala. In Swedish.

Urho, L. 2011. Kalasto- ja kalakantamuutokset ja vieraslajit ilmaston muuttuessa. Työraportti 6/2011. Finnish Game and Fisheries Research Institute. In Finnish.

Vatanen, S. and Haikonen, A. 2012. Ammatti- ja vapaa-ajankalastus Pyhäjoen ja Raahen edustan merialueella vuonna 2011. Kala- ja vesimonisteita nro 83. Kala- ja vesitutkimus Oy. In Finnish.

Vatanen, S., Haikonen, A. and Karppinen, P. 2013. Fennovoiman ydinvoimalaitoksen vesistörakennustöiden kalatalousvaikutusarvio. Kala- ja vesimonisteita nro 92. Kala- ja vesitutkimus Oy. In Finnish.

Vieraslajihavaintorekisteri 2014. http://www.riistakala.info/vieraslajit (Accessed November 24, 2014). In Finnish.

Vieraslajiportaali 2014a. Itämeren lajit. http://vieraslajit.fi/lajit/HBE.MG4/list (Accessed August 28, 2014). In Finnish.

Vieraslajiportaali 2014b. Kanadanvesirutto. http://www.vieraslajit.fi/lajit/MX.40119/show (Accessed August 28, 2014). In Finnish.

Vieraslajiportaali 2014c. Kaspianpolyyppi. http://vieraslajit.fi/lajit/MX.52871/show (Accessed August 28, 2014). In Finnish.

VL1 Itämeren vieraslajit, May 7, 2013 (updated). http://www.luonnontila.fi/fi/indikaattorit/vieraslajit/vl1-itameren-vieraslajit (Accessed August 28, 2014). In Finnish.

VL1 Itämeren vieraslajit, taustatiedot May 7, 2013 (updated). http://www.luonnontila.fi/ext/fi/data-pages/vl1-taustatiedot.html (Accessed August 28, 2014). In Finnish.

Vähä, V., Romakkaniemi, A., Pulkkinen, K., Ankkuriniemi, M., Keinänen, M., Lilja, J. and Leminen, M. 2014. Lohi- ja meritaimenkantojen seuranta Tornionjoen vesistössä vuonna 2013. Riista- ja kalatalous. Tutkimuksia ja selvityksiä 2/2014. Finnish Game and Fisheries Research Institute. In Finnish.

Westerberg, H., Sturlaugsson, J., Ikonen, E and Karlsson, L. 1999. Datastorage tag study of salmon (Salmo salar) migration in the Baltic: Behaviour and the migration route as reconstructed from SST data. ICES CM 1999/AA:06.

Nuclear power plant site
Appendix 3C

A description of the plant site in Hanhikivi, Pyhäjoki, and Fennovoima's right to use the planned site

Summary

As required by section 32, paragraphs 1 and 2 of the Nuclear Energy Decree (161/1988), this appendix includes proof of the applicant's right to use the site planned for the nuclear facility, and a description of settlement and other activities and planning arrangements at the planned nuclear facility site and in its immediate vicinity.

Fennovoima's nuclear power plant will be built in the central and northern parts of the Hanhikivi headland located in Pyhäjoki, Northern Ostrobothnia. The Hanhikivi headland is located in the coast of the Gulf of Bothnia, approximately 100 km south from Oulu, and it is divided between the municipalities of Pyhäjoki and Raahe. Most of the Hanhikivi headland is located in the municipality of Pyhäjoki, less than seven kilometers from the municipal center. The northeastern part of the headland reaches into the area of the Town of Raahe, around 20 kilometers from the center of the town.

In its statement regarding the decision-in-principle granted to Fennovoima, as well as in the statement regarding the supplement to the decision-in-principle, the Radiation and Nuclear Safety Authority (STUK) found that there are no factors with an impact on the design, construction or safety of a nuclear power plant in the Hanhikivi headland or its immediate vicinity that would prevent the use of the area as a nuclear power plant site. There is no existing industrial infrastructure in the planned plant area to limit Fennovoima's possibilities of constructing a nuclear power plant complete with all the necessary functions. There are also no such population centers or functions in the immediate surroundings of the Hanhikivi headland that would prevent the planning and execution of effective emergency response and rescue arrangements to limit potential nuclear damage.

Land use in the Hanhikivi headland is prescribed by the Hanhikivi regional land use plan for nuclear power, and the Raahe and Pyhäjoki component master plans and local detailed plans for the nuclear power plant area. The land use planning for the nuclear power plant is now legally valid at all three levels of planning.

Fennovoima controls all the areas required for the nuclear power plant and its support functions either via direct ownership or based on the power of eminent domain and the right to take possession. Fennovoima owns a total of 397.3 hectares of land and water areas in the Hanhikivi headland. On December 11, 2014 the Finnish Government issued a decision to grant Fennovoima the permit to exercise the power of eminent domain to purchase the areas reserved for the Hanhikivi nuclear power plant project and its support functions in the land use plans of the municipality of Pyhäjoki and the town of Raahe. In the same decision, the Government granted Fennovoima the right to take possession of the land and water areas subject to eminent domain proceedings, a total of approximately 108 hectares, before the time referred to in section 57, subsection 1 of the Act on the Redemption of Immoveable Property and Special Rights (603/1977). Since the granting of the power of eminent domain, Fennovoima has completed voluntary real estate transactions on two properties subject to the power of eminent domain. Two other areas subject to the power of eminent domain were taken possession of via eminent domain proceedings on March 25, 2015.

A description of the plant site in Hanhikivi, Pyhäjoki, and Fennovoima's right to use the planned site

Hanhikivi headland in Pyhäjoki as a nuclear power plant site

Fennovoima's nuclear power plant will be built in the Hanhikivi headland in the municipality of Pyhäjoki, which is a new nuclear power plant location. The Hanhikivi headland is located in the coast of the Gulf of Bothnia, in Northern Ostrobothnia, and it is divided between the municipalities of Pyhäjoki and Raahe. Most of the headland is located in the municipality of Pyhäjoki, less than seven kilometers from the municipal center (Figure 3C-1). The northeastern shoreline of the Hanhikivi headland extends beyond the border of Raahe. The distance from the plant site to the center of Raahe is about 20 kilometers.

Pyhäjoki is part of Oulu region, and it is located in the south-western part of Northern Ostrobothnia, on the coast of the Gulf of Bothnia. The municipality of Pyhäjoki, located approximately 100 kilometers to the south from Oulu, had 3,290 inhabitants at the end of 2014 (Statistics Finland, December 31, 2014). The neighboring municipalities of Pyhäjoki are Raahe, Kalajoki, Merijärvi, Alavieska, Oulainen and Siikajoki. These seven municipalities form the Raahe economic zone, which has a combined population of 59,000. The center of the economic zone is the town of Raahe, which has a population of 25,400 (Statistics Finland, December 31, 2014). Raahe is the second largest town in Northern Ostrobothnia next to Oulu, and the third largest town in the Oulu region.

Figure 3C-1. Location of the Hanhikivi headland in Pyhäjoki.

The plant area and buildings

The nuclear power plant buildings will be located in the central and northern parts of the Hanhikivi headland, in the energy management area indicated in the Pyhäjoki local detailed plan for the nuclear power plant. The size of the block area is 134.6 hectares, and it forms a site area where movement and sojourn is restricted, as referred to in Government Decree on Emergency Response Arrangements at Nuclear Power Plants (716/2013). All the major operations of the nuclear power plant will be located in this block area. In the Pyhäjoki and Raahe local detailed plans for the nuclear power plant area, areas are also allocated for buildings required for the support operations, construction activities and maintenance of the nuclear power plant.

The planned layout of the plant area is presented in Figure 3C-2. The primary buildings of the nuclear power plant are indicated by numbers 1–11 in the figure.

Settlements in the immediate region

Permanent settlements

There is no permanent settlement in the Hanhikivi headland, and the immediate region is sparsely populated. A protective zone extending to approximately five kilometers' distance from the facility has been defined around the power plant site. The village of Parhalahti, located slightly more than five kilometers from the facility, is included in the protective zone. A total of 458 people permanently lived within the protective zone at the end of 2014, 23 of them within the radius of five kilometers from the facility (Statistics Finland, December 31, 2014).

A total of 11,384 people lived within a radius of 20 kilometers from the nuclear power plant, the area defined as the emergency planning zone. Population centers within in the 20-kilometer radius include the center of the municipality of Pyhäjoki, which is located approximately seven kilometers from the facility, and the Raahe town center, located at a distance of approximately 20 kilometers. Figure 3C-3 illustrates the distribution of the population in the immediate region

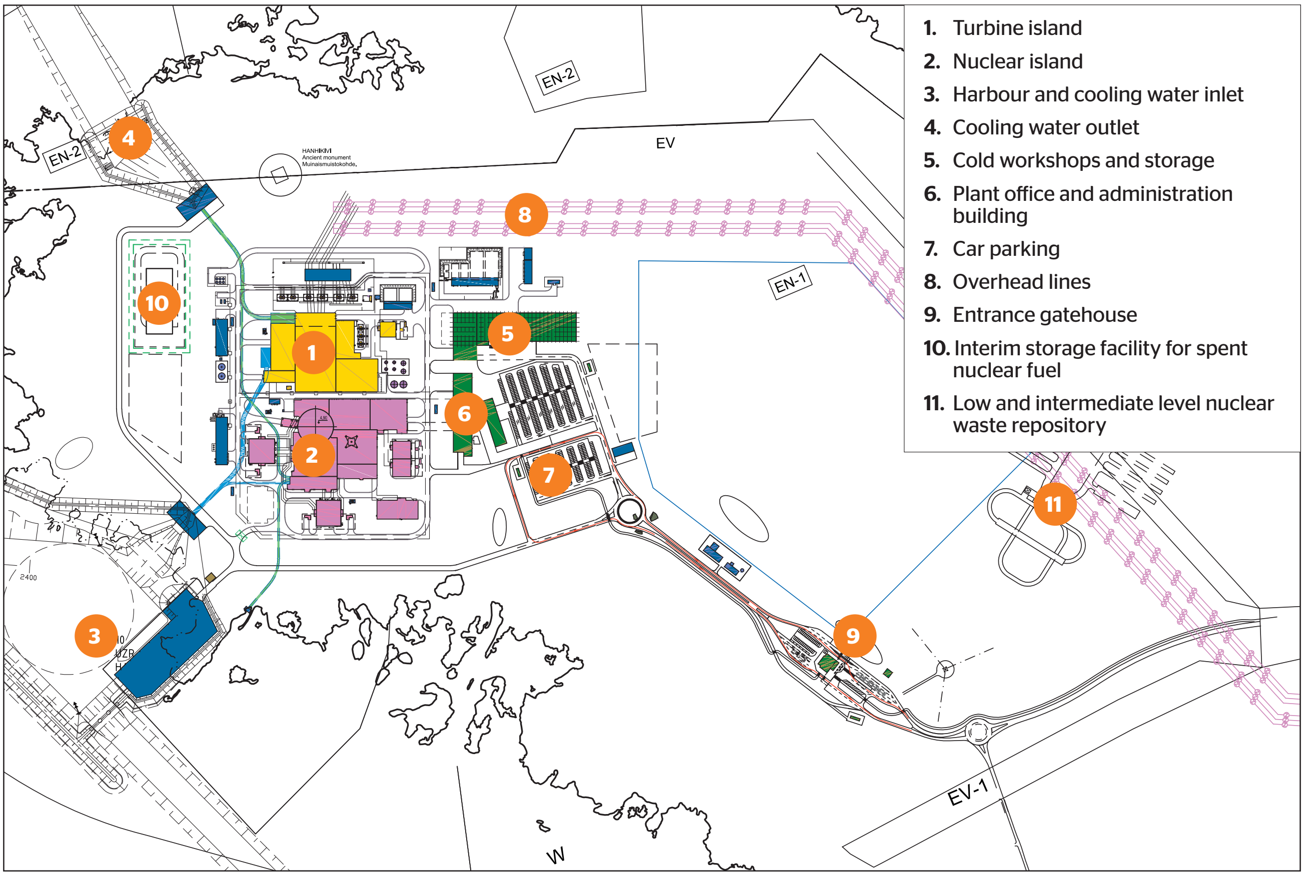
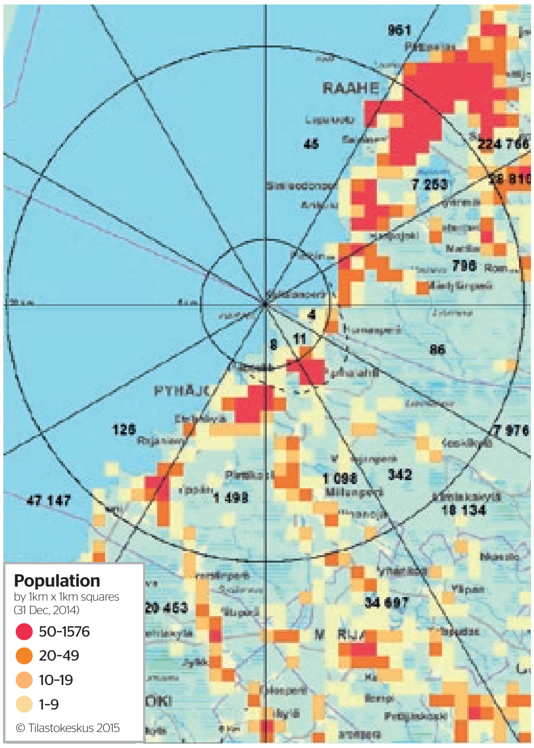


Figure 3C-2. Planned layout of the nuclear power plant site.

Figure 3C-3. Distribution of the population in the immediate region of the project site, within 5 and 20 kilometers from the nuclear power plant and within the protective zone at the end of 2014 (Statistics Finland, December 31, 2014).



of the project site, within 5 and 20 kilometers from the nuclear power plant and within the protective zone at the end of 2014 (Statistics Finland, December 31, 2014).

Holiday homes

No holiday homes will remain within the Hanhikivi nuclear power plant site. A few hundred holiday homes will be located within a 20-kilometer radius from the nuclear power plant, mainly in the shore areas on the northern and southern side of the Hanhikivi headland. Buildings and constructions intended for recreational use by Fennovoima's employees during the construction and operation of the nuclear power plant can be built in the areas reserved for the nuclear power plant in the land use plan.

Current and projected population

Population projections for the Raahe economic zone do not take into account any migration that are likely to result from the nuclear power plant project. The Raahe economic zone includes seven municipalities: Pyhäjoki, Raahe, Kalajoki, Merijärvi, Alavieska, Oulainen and Siikajoki. A total of 59,000 people live in the Raahe economic zone. According to the population projections of Statistics Finland, the population of the municipalities within the Raahe economic zone will decrease by approximately 1,000 people by 2040 (Table 3C-1). The population of the municipality of Pyhäjoki is estimated to decrease by 213 people between 2015 and 2040.

Principal activities in the area

With the exception of the area reserved in land use plans for the nuclear power plant and its support functions, the primary forms of land use in the immediate region of the Hanhikivi headland are forestry and outdoor activities. Near to the tip of the headland, on the border between Pyhäjoki and Raahe, there is Hanhikivi border stone of national importance, protected under the Antiquities Act (295/1963). The historical Hanhikivi borderline, believed to be part of the borderline defined in the Treaty of Nöteborg, also marks the current municipal border between Pyhäjoki and Raahe. The historical monument will remain intact, and will receive a new permanent connection from the new Hanhikivi road.

There are no industrial activities in the immediate region of the Hanhikivi headland that could have a detrimental impact on the operation of the nuclear power plant. The nearest

Table 3C-1. Population projection for the Raahe economic zone from 2015 to 2040 (Statistics Finland 2013).

	2015	2020	2025	2030	2035	2040
Pyhäjoki	3,292	3,253	3,224	3,183	3,131	3,079
Alavieska	2,707	2,692	2,684	2,680	2,676	2,669
Kalajoki	12,821	13,101	13,333	13,507	13,614	13,655
Merijärvi	1,173	1,148	1,132	1,122	1,116	1,106
Oulainen	7,735	7,580	7,477	7,394	7,317	7,224
Raahe	25,605	25,578	25,525	25,351	25,114	24,853
Siikajoki	5,554	5,500	5,463	5,436	5,407	5,376
Total	**58,887**	**58,852**	**58,838**	**58,673**	**58,375**	**57,962**

industrial activities are found approximately 10 kilometers from the power plant site, in the municipality of Pyhäjoki, and include engineering industry, for example. In the town of Raahe, some 15 kilometers from the Hanhikivi headland, on the coast of the Gulf of Bothnia, there are SSAB's steelworks, Oy Polargas Ab's atmospheric gas plant, and liquid gas storage facilities, among others. To the south of the municipality of Pyhäjoki, more than 20 kilometers from the Hanhikivi headland, there are restricted military areas of the Finnish Defence Forces' Lohtaja firing range and military practice site.

Main road 8 passes the nuclear power plant site to the east of the Hanhikivi headland, at an approximate distance of five kilometers. A local road leads to the Hanhikivi headland along its shoreline from the village of Parhalahti. The Tankokarinnokka fishing port to the south of the headland can also be reached via the road. A new connection road will be built from main road 8 to the power plant site by the end of October 2015. A bicycle and pedestrian connection will also be built alongside with the two-lane road. The new road and the bicycle and pedestrian connection will join main road 8 in Pyhäjoki, near the municipal border between Pyhäjoki and Raahe. The old local road, Puustellintie, will undergo renovation during Fennovoima's project. Puustellintie will be used an alternative exit road together with the new road.

The protective zone and the emergency planning zone

A protective zone and emergency planning zone as referred to in section 2 of the Government Decree on Emergency Response Arrangements at Nuclear Power Plants have been established around the nuclear power plant. The radius of the protective zone is approximately 5 kilometers and that of the emergency planning zone 20 kilometers from the power plant. The purpose of these areas is to ensure that the location of the nuclear power plant is taken into account in land use planning and rescue planning in the area.

The protective zone is subject to restrictions on land use and permitted functions, which prevent densely populated residence areas within the zone. The number of permanent inhabitants as well as any recreational activities in the protective zone should be kept such that an appropriate rescue plan can be drawn up for the area. In addition to residential areas, the restrictions particularly apply to schools, nursing homes, hospitals and employment areas. The protective zone for the nuclear power plant has been defined in the currently valid Hanhikivi regional land use plan for nuclear power.

The protection measure defined for the protective zone is the rapid evacuation of the entire protective zone. The number of people permanently living within the protective zone was 458 at the end of 2014. Case-specific protection measures of varying degrees will be used within the emergency planning zone outside of the protective zone; potential measures include taking shelter indoors, taking iodine tablets, and evacuation. The number of people permanently living within the emergency planning zone was 11,384 at the end of 2014. In a situation involving a nuclear threat, measures will be instigated in the part of the emergency planning zone that would be affected by any emission based on the prevailing weather conditions.

Fennovoima will submit a preliminary emergency response plan to STUK during the construction license application process. STUK will review the plan, which will then be delivered to the regional rescue department, among other recipients. The regional rescue authority will prepare an external rescue plan for the protective zone and emergency planning zone together with Fennovoima. Fennovoima, the rescue authorities, STUK and other authorities will together carry out rescue drills at the minimum intervals of three years.

Planning required by the project

The land use planning required for the execution of the Hanhikivi nuclear power plant project is in force at all three levels: the regional land use plan for nuclear power became legally valid in fall 2011, and the local master and detailed plans for Pyhäjoki and Raahe in summer 2013. Procedures pursuant to the Land Use and Building Act (132/1999) have been followed to prepare the land use plans of all levels as required by the project. The land use plans allow the construction of a nuclear power plant on the Hanhikivi headland. For a more detailed description of the preparation of the land use planning processes and the draft plan phases, see Fennovoima's application for a supplement to the decision-in-principle (Application for a Supplement to Government Decision-In-Principle M 4/2010 vp pursuant to Section 11 of the Nuclear Energy Act (990/1987), granted on May 6, 2010).

Regional land use plan

Hanhikivi regional land use plan for nuclear power

The Hanhikivi regional land use plan for nuclear power, established for the Hanhikivi headland, became legally valid in fall 2011. The Hanhikivi plant area is included in the regional land use plan for nuclear power in its entirety (Figure 3C-4). The Hanhikivi regional land use plan for nuclear power constitutes a general representation of the project's preconditions with regard to land use. The area for which a new land use plan was drafted is comprised of the planned nuclear power plant area and adjacent areas. The land use plan defines a protective zone in accordance with the Government Decree on Emergency Response Arrangements at Nuclear Power Plants, and covers land use issues related to safety and rescue operations. Furthermore, the regional land use plan indicates a road connection leading to the nuclear power plant, harbor functions, and the connections required for the 400 kV and 110 kV power lines.

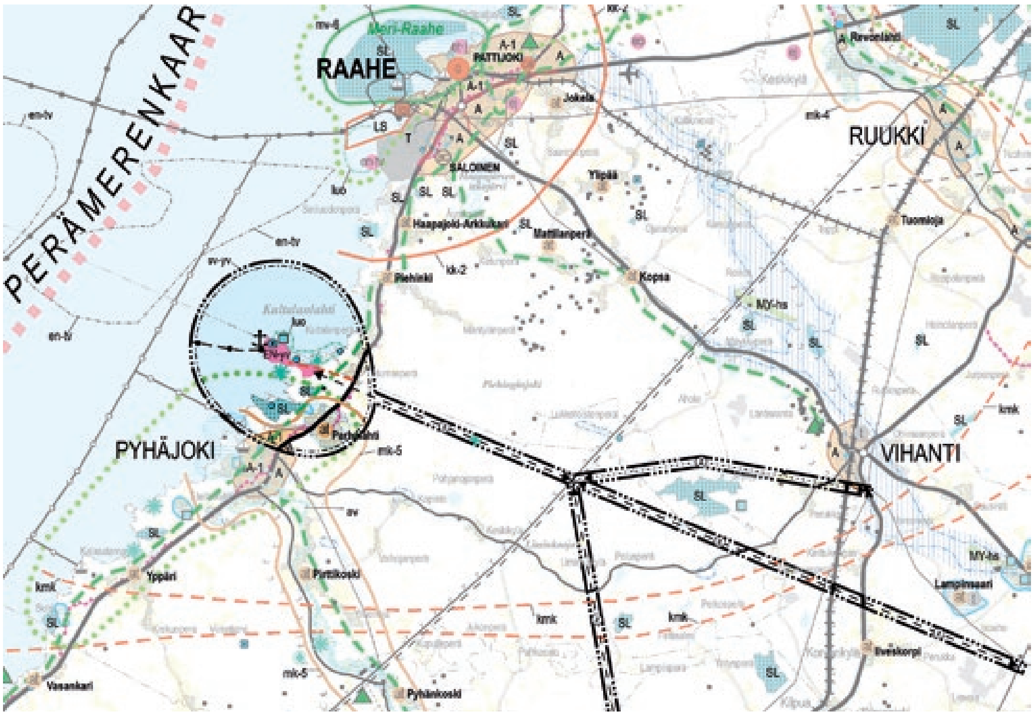


Figure 3C-4. The Hanhikivi area as defined by the Hanhikivi regional land use plan for nuclear power (2010).

Revision of the Northern Ostrobothnia regional land use plan, regional land use plan of the first stage

The Assembly of the Northern Ostrobothnia Regional Council approved the regional land use plan of the first stage in spring 2013.

The first stage approved by the Assembly of the Regional Council (Figure 3C-5) defines three nature conservation areas on the Hanhikivi headland. The following restriction applies to any land use planning for these areas: the land use of the area and its environment must be planned and implemented so that the purpose for which the area has been protected is not subjected to any risk; instead, the natural diversity and ecological connections between areas must be protected. The restriction also requires that a statement from the Centre for Economic Development, Transport and the Environment, as specified in section 133 of the Land Use and Building Act, must be requested on the building permit application. Fennovoima's nuclear power plant project's construction operations are not targeted at the nature conservation areas.

Rocks important for the landscape (ge-1) are found on the southern and northern shores of the Hanhikivi headland. The ge-1 indication marks geological formations of national importance in terms of nature and landscape conservation. According to the planning restriction, the land use in the area must be planned so that the landscape is not ruined, elements of significant aesthetic value or special natural formations are not destroyed, and no major or extensive harmful changes are caused to the natural environment.

A preliminary reservation for a 400 kV power line has been made close to the Pyhäjoki and Raahe municipal border, and for a 110 kV power line to the south of it.

A need for a bicycle and pedestrian connection has been indicated for main road 8.

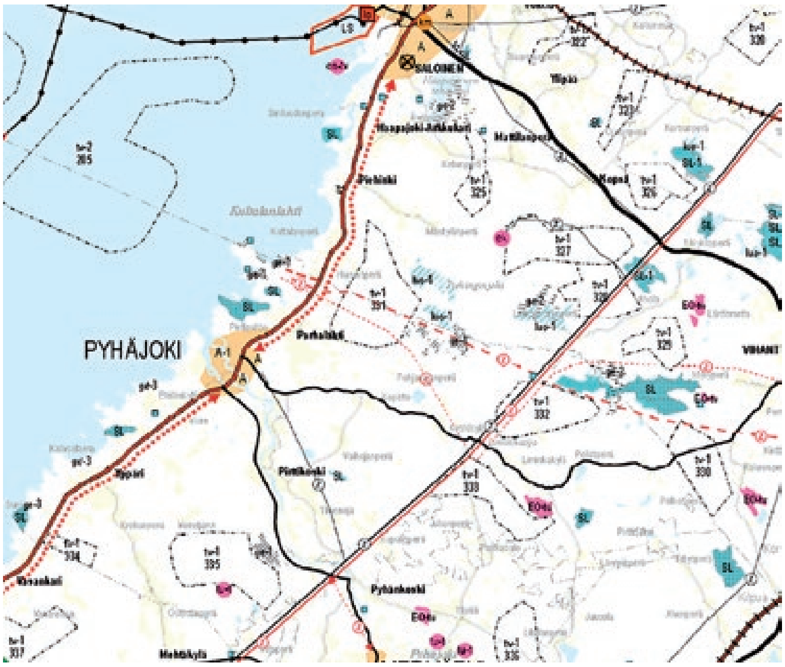


Figure 3C-5. The Hanhikivi headland in the North Ostrobothnia regional land use plan of the 1st stage (2013).

Master plans

Component master plans for the Hanhikivi nuclear power plant area in the municipality of Pyhäjoki and the Town of Raahe apply to the Hanhikivi area. The component master plans entered into force in summer 2013 after public notice.

The component master plan (Figure 3C-6) includes reservations for the nuclear power plant (EN-1) and its support and maintenance areas (EN-2). The land use plan also includes an area for work site functions (TP-1). The land use plan indicates that areas are to remain in agricultural and forestry use (M-1) along the Hanhikivi road connection which leads to the power plant area from main road 8. Some of the shore and water zone included in the energy management area and located at a distance of approximately 200 meters from the shoreline is indicated as W-1, a zone that can be used for the purposes of the power plant, such as the construction of docks and

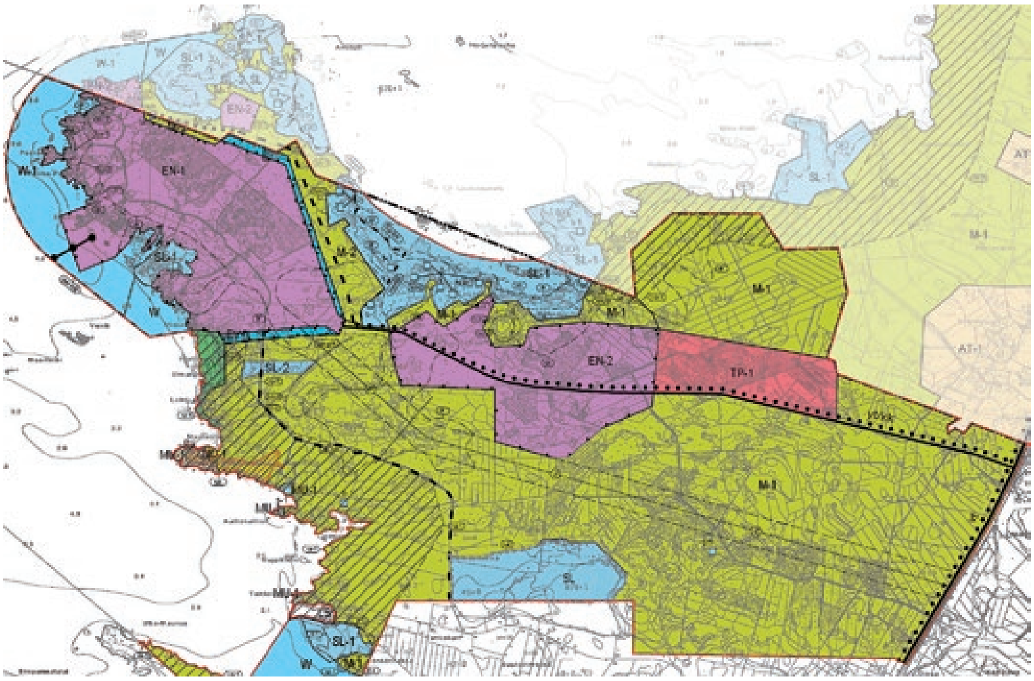


Figure 3C-6. Excerpt from the Pyhäjoki component master plan for the Hanhikivi nuclear power plant area (2010). The Raahe component master plan for the nuclear power plant area is printed with grayed out colors.

other structures and equipment required for the power plant. The construction must be carried out in compliance with the Water Act. The nature conservation areas (SL, SL-1, SL-2) and green protective zones (EV, EV-1) are also indicated in the component master plan.

The land use plan area is included in the nuclear power plant's protective zone in accordance with the general stipulation of the component master plan.

Local detailed plans

Local detailed plans for the Hanhikivi nuclear power plant area in the municipality of Pyhäjoki and the Town of Raahe apply to the Hanhikivi area. The local detailed plans entered into force in summer 2013 after public notice.

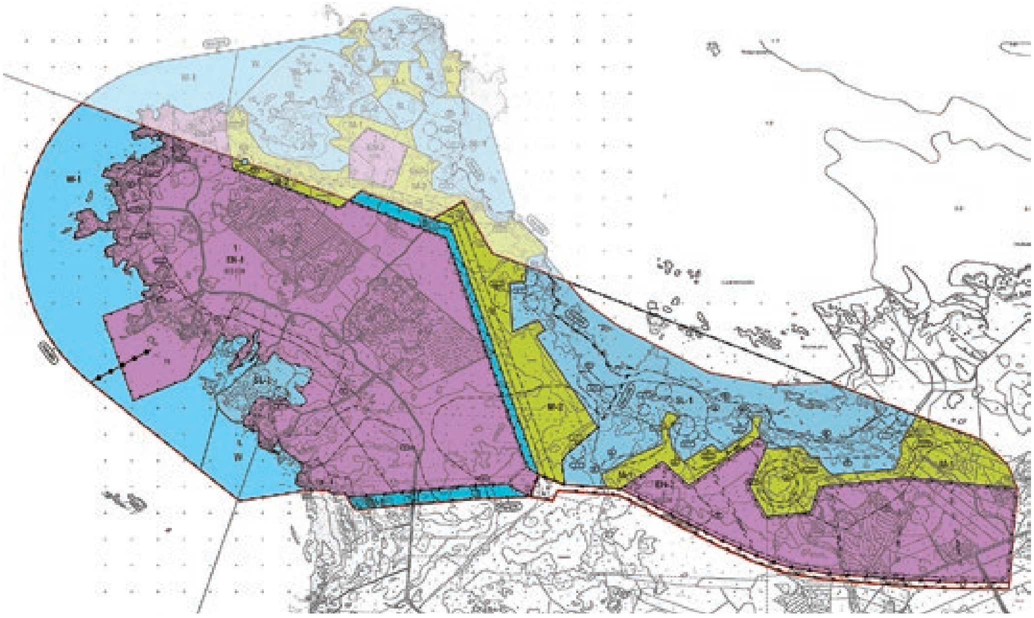


Figure 3C-7. The Pyhäjoki local detailed plan for the Hanhikivi nuclear power plant area (2010).

The local detailed plan for the Hanhikivi nuclear power plant area (Figure 3C-7) established in the municipality of Pyhäjoki indicates an energy management area that will be used for building the nuclear power plant. The local detailed plan also indicates other necessary facilities required for the power plant: an area for temporary housing, other support function areas, the necessary traffic areas and a preliminary reservation for a navigation channel. Furthermore, the local detailed plan indicates the locations of nature conservation areas and a protected historical monument, the Hanhikivi border stone. Passage to these areas is routed through the agricultural and forestry areas.

The entire tip of the Hanhikivi headland is largely reserved as an energy management area under two different indications (EN-1 and EN-2). A nuclear power plant with one or two plant units can be built in the EN-1 area. Temporary storage facilities for spent nuclear fuel and final disposal facilities for low and intermediate level nuclear waste can also be built in the area.

The water area that can be used for the purposes of the power plant and in which special areas have been defined for the construction of docks and other structures and equipment within the stipulations of the Water Act has been indicated as W-1. Other water areas have been indicated as W.

The total permitted building volume is 300,000 m^2 for EN-1 and 96,000 m^2 for EN-2.

The local detailed plan for the Hanhikivi power plant area (Figure 3C-8) established in the Town of Raahe indicates the areas in which support facilities for the nuclear power plant as well as housing and other facilities for construction and maintenance personnel can be built (EN-2).

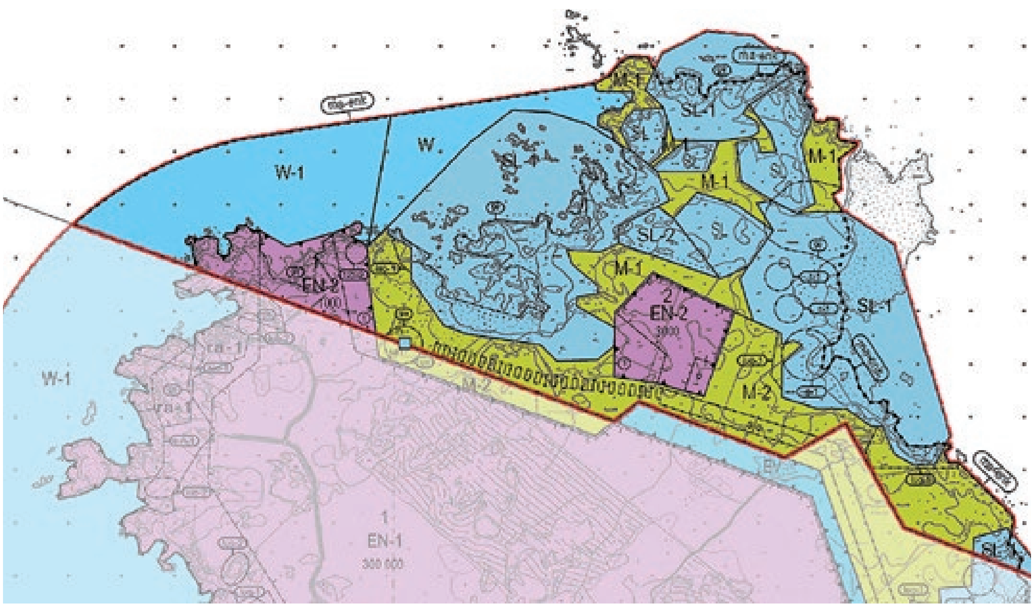


Figure 3C-8. The Raahe local detailed plan for the Hanhikivi nuclear power plant area (2010).

The local detailed plan also indicates the locations of nature conservation areas and the protected Hanhikivi border stone. Preliminary passage to these areas is routed through the agricultural and forestry areas. The water area that can be used for the purposes of the power plant and in which special areas have been defined for the construction of docks and other structures and equipment within the stipulations of the Water Act has been indicated as W-1. The total permitted building floor area indicated in the local detailed plan for EN-2 areas is 4,000 m^2.

In addition to the local detailed plans for the nuclear power plant area, the Hanhikivi headland has a separate local detailed plan for the workplace area, and a separate energy management area for the nuclear power plant's support functions and facilities for construction and maintenance operations. Both are located along the Hanhikivi road connection that leads to the power plant area from main road 8, and belong to the area covered by the component master plan for the nuclear power plant area.

The local detailed plan for the workplace area (Figure 3C-9), or the extension of the local detailed plan for the Hanhikivi nuclear power plant area in blocks 2, 4, 5 and 6, was approved by the Pyhäjoki Municipal Council on May 22, 2013 and entered into force via public notice on February 26, 2015.

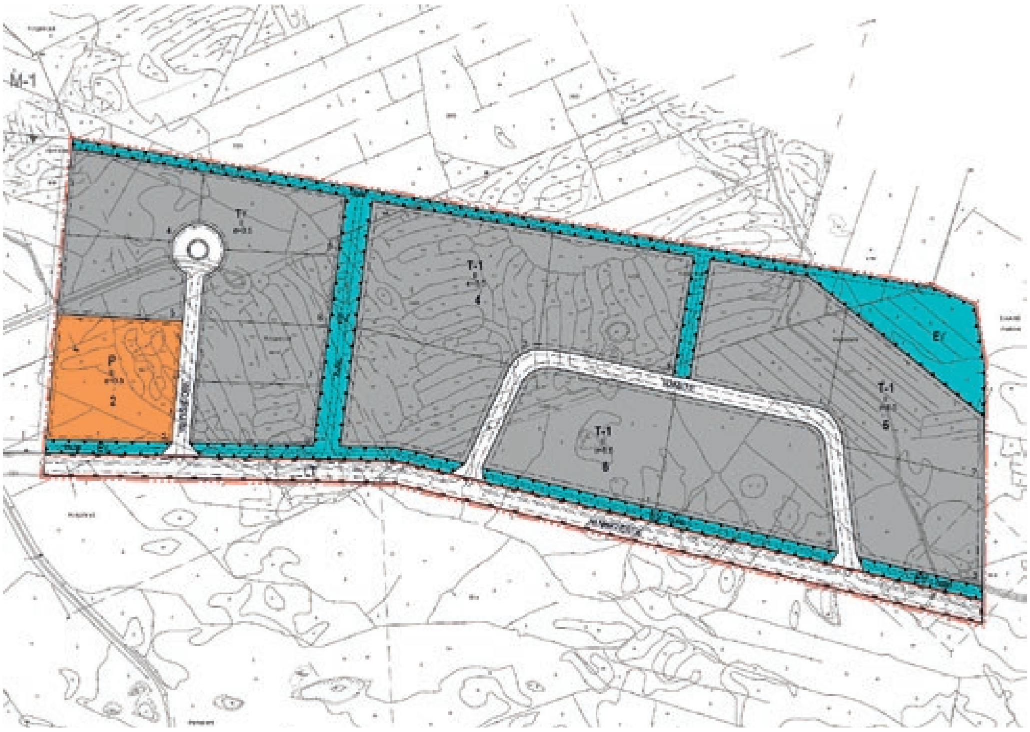


Figure 3C-9. The extension of the local detailed plan for the Hanhikivi nuclear power plant area in blocks 2, 4, 5 and 6 (2013).

The local detailed plan for the workplace area indicates blocks of workplace and industrial functions in the immediate vicinity of the Hanhikivi nuclear power area. The plan indicates service building areas (P) and industrial and warehouse areas (T-1 and TY). The necessary traffic areas and green protective zones are also indicated (EV). The permitted building volume of the plan area has been defined using the ratio (e) of building volume to the surface area of the plot or building site.

Extension II of the local detailed plan of the Hanhikivi nuclear power plant area in block 3 has been approved by the Pyhäjoki Municipal Council on March 26, 2014 (Figure 3C-10). The surface area of the extension is 33.6 hectares, and the total permitted building volume is 5,000 m^2. The area is on the south side of the road connection from main road 8. On the north side, the land use plan extension area is limited by the currently valid local detailed plan of the Hanhikivi nuclear power plant area.

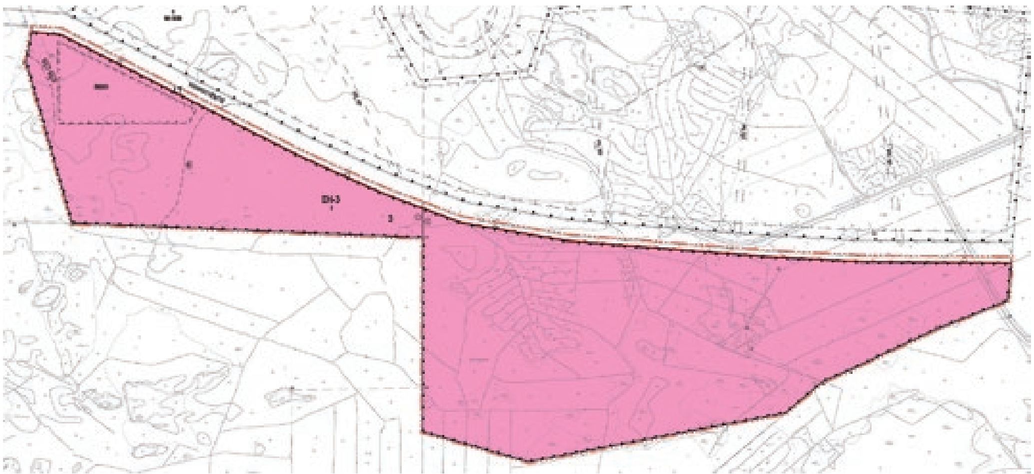


Figure 3C-10. Extension II of the local detailed plan of the Hanhikivi nuclear power plant area in block 3 (2014).

The land use plan defines an energy management area in block 3 in accordance with the principles presented in the component local master plan for the Hanhikivi nuclear power plant area prepared earlier. Block 3 will have nuclear power plant support functions and functions related to construction and maintenance operations.

Extension II in block 3 of the local detailed plan has been approved by the Pyhäjoki Municipal Council, but it is not yet in force. A complaint concerning the decision of the Municipal Council has been filed with the Administrative Court of Northern Finland. Extension II in block 3 of the local detailed plan is expected to reach validity by the end of 2015.

Local and national grid connections of the nuclear power plant

The Hanhikivi nuclear power plant will be connected to the Finnish national grid so that the grid connection enables, for its part, the safe and planned operation of the nuclear power plant, as well as the transmission of the electrical energy produced at the power plant to the grid in the planned manner under all grid conditions.

Local connection cables approximately 20 km long will be used to connect the nuclear power plant to the national grid. The local connection points will be located at substations to be built in Hanhela and Valkeus. The local connection of the nuclear power plant has been planned to use two 400 kV power lines and two 110 kV power lines. In the area covered by the component master plan for the Hanhikivi nuclear power plant, the power lines are built in a shared right of way. To secure the safety of the nuclear power plant, the 400 kV and 110 kV power lines from the power plant will be separated in areas that remain outside the component master plan for the nuclear power plant.

The connection of the nuclear power plant to the national grid will be carried out in cooperation with Fingrid Oyj. Fennovoima will be responsible for the plant's local connection, and Fingrid will be responsible for the national grid connection.

For the revision of the Northern Ostrobothnia regional land use plan (1st stage), Fingrid Oy has prepared for Fennovoima a preliminary description of the local connection and necessary substations for Hanhikivi 1. The cable routes indicated in the regional plan help ensure that the routes remain feasible.

Ownership of the nuclear power plant site

A total of 504 hectares of land and water areas belonging to the Hanhikivi headland were under the management of Fennovoima at the beginning of June 2015 (June 1, 2015) (Figure 3C-11). Fennovoima is the direct owner of most of the land and water areas required for the nuclear power plant. Fennovoima has acquired the area it currently owns, 397.3 hectares, through voluntary real estate transactions. The area in Fennovoima's ownership is comprised of a total of 45 properties registered in the cadastral registry. In some cases, Fennovoima has purchased a parcel of land, and in others the entire registered property.

In a decision issued on December 11, 2014, the Government has granted Fennovoima the permit to exercise the power of eminent domain based on the Act on the Redemption of Immoveable Property and Special Rights (603/1977). In its decision, the Government stated that Fennovoima's project is rendered necessary by public need, and that the power of eminent domain is necessary for the implementation of the project. For this reason, the Government found it justified to grant to Fennovoima the permit to exercise the power of eminent domain in accordance with the application and the attached map to acquire the areas required for the Hanhikivi nuclear power plant project, located in the municipality of Pyhäjoki and the Town of Raahe. According to the decision, any special rights concerning the areas to be acquired, such as land leases signed with third parties, will be terminated. In the same decision, the Government granted Fennovoima the right to take possession of the property before the time referred to in section 57, subsection 1 of the Act on the Redemption of Immoveable Property and Special Rights. The power of eminent domain applies to land and water areas that are currently part of four properties, totaling around 108 hectares. Around 107 hectares of the area to which the power of eminent domain applies are land and water areas owned by a single partnership. A complaint has been filed regarding the power of eminent domain with the Supreme Administrative Court, but the complaint procedure will not prevent taking possession of the areas based on the right to take possession granted to Fennovoima.

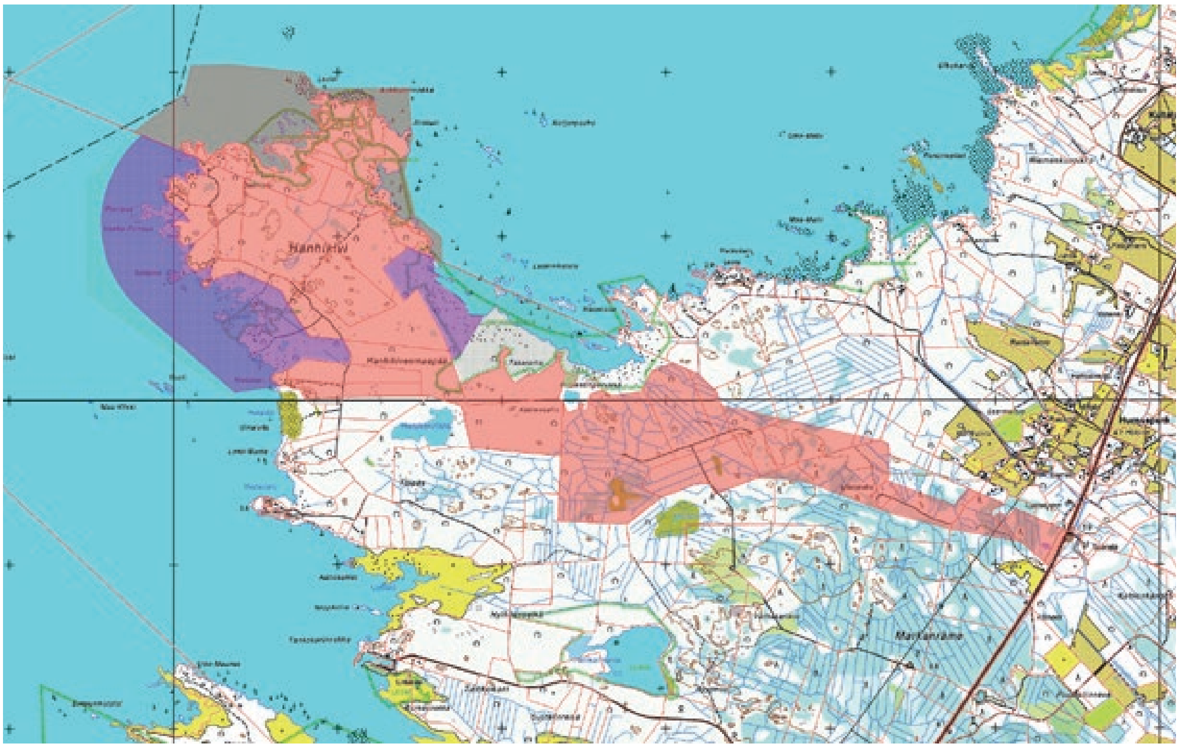
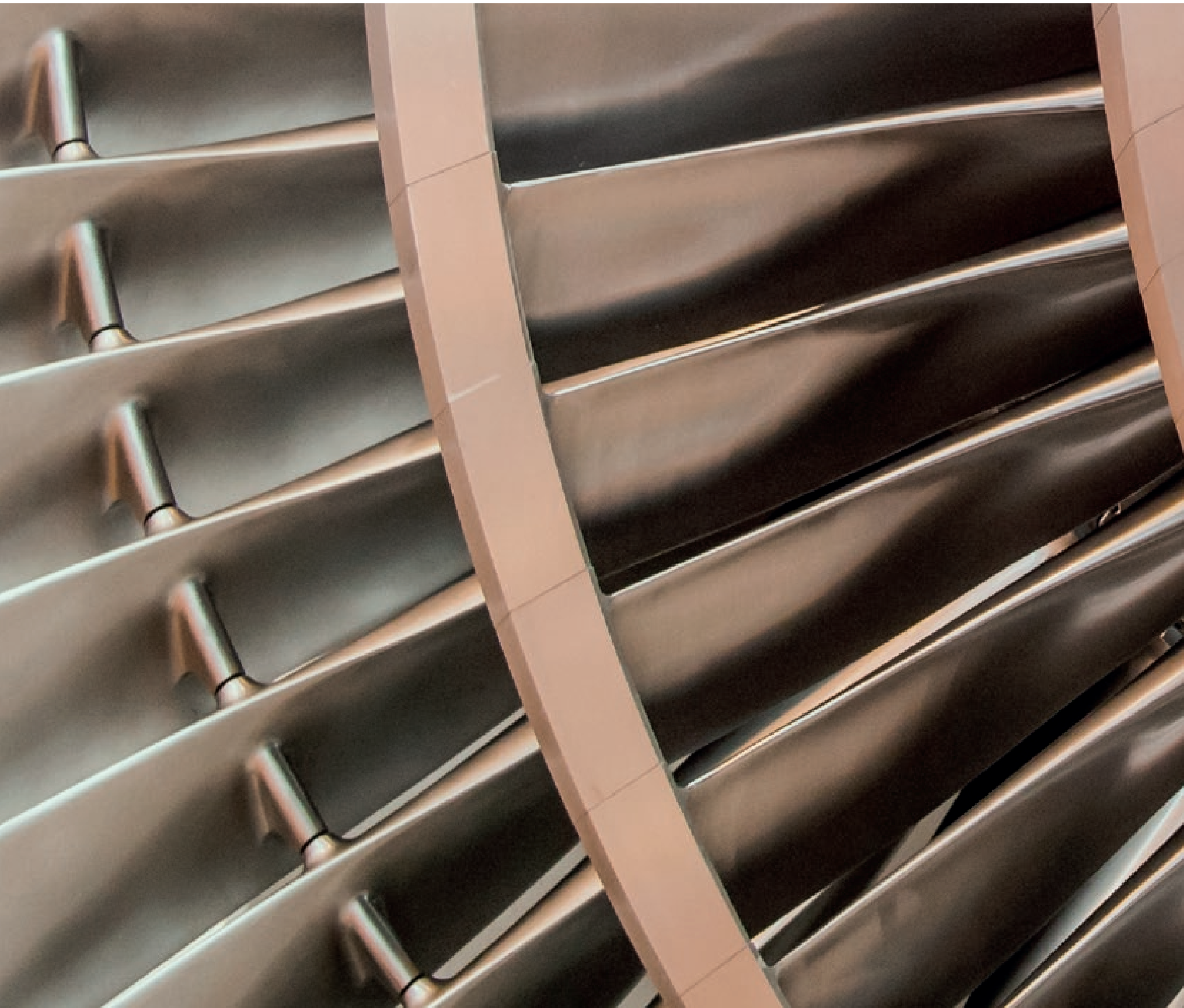


Figure 3C-11. Areas managed by Fennovoima on the Hanhikivi headland. The areas subject to the power of eminent domain and the right to take possession of are indicated in violet.

Since the granting of the power of eminent domain, Fennovoima has completed voluntary real estate transactions on two properties subject to the power of eminent domain. Two other areas subject to the power of eminent domain were taken possession of via eminent domain proceedings on March 25, 2015 (entry 2014–494430, MMLm/29405/33/2014).

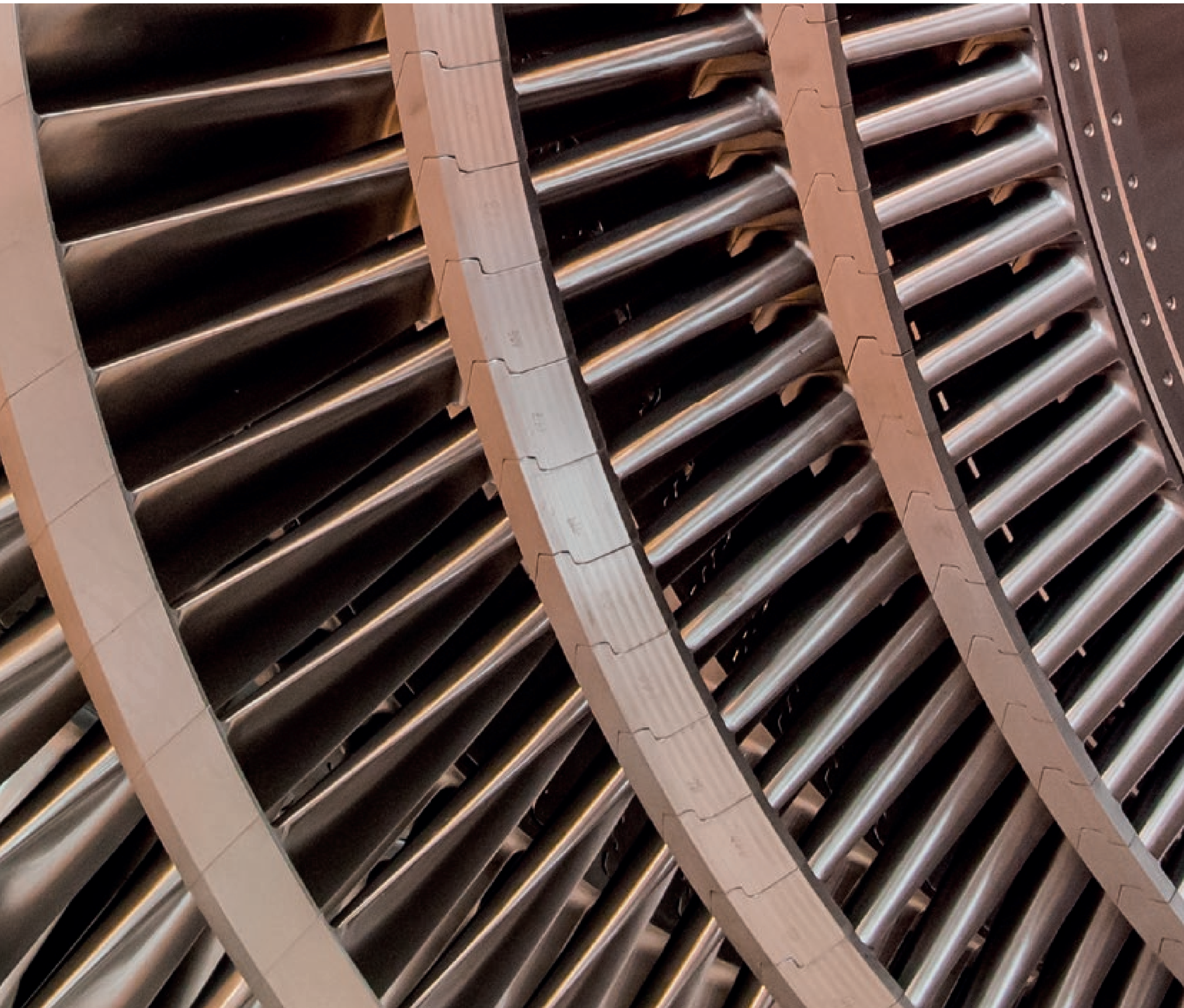
Fennovoima has the right to use the site planned for the nuclear facility. Fennovoima controls all the areas required for the nuclear power plant and its support functions either via direct ownership or based on the power of eminent domain and the right to take possession.



Safety of the nuclear power plant

Appendix 4A

A description of the type and technical principles of the nuclear facility to be constructed, and the planned suppliers of the essential parts



Summary

As required by section 32, paragraph 3 of the Nuclear Energy Decree (161/1988), this appendix includes a description of the type of the nuclear facility to be constructed, and the planned suppliers of the essential parts, as well as an outline of the technical operating principles and features and other arrangements which are used to ensure the safety of the nuclear facility, in accordance with paragraph 5 of the same section. A description of the safety principles that the applicant intends to observe, and the license applicant's evaluation of the fulfillment of the principles is included in Appendix 4B of this application. A description of the selected plant site is included in Appendix 3C. For an overall plan for nuclear waste management of the Hanhikivi 1 power plant, see Appendix 5B.

Fennovoima's nuclear power plant unit will be supplied by RAOS Project Oy, and the plant type to be constructed will be AES-2006 pressurized water reactor. The AES-2006, developed by the Rosatom Group, is a third-generation pressurized water reactor with an approximate power output of 1,200 MW. The reactor is based on the VVER (Vodo-Vodyanoi Energetichesky Reaktor, or water-cooled water-moderated energy reactor) nuclear power plant type developed by Rosatom Group. The safety solutions of the plant represent the best available technology.

Due to the long history of modern pressurized water reactors such as the AES-2006, the reactors of all plant suppliers closely resemble each other, and the major safety features such as power control, reactor cooling and preventing the spread of radioactive substances are based on similar solutions. The technical functionality and safety solutions of the AES-2006 thus represent well-established technology. Among the most important features of the AES-2006 that represent new technology are the extensive utilization of passive cooling systems, the core catcher used in the management of severe reactor accidents, the programmable automation system, and the reactor containment able to withstand the impact of a collision of a large passenger airplane.

Fennovoima has reviewed the operating and safety principles of Rosatom's AES-2006 and found that the plant can be designed and constructed to meet the safety requirements set by Finnish authorities, and any other requirements set by Fennovoima for the nuclear power plant. The Radiation and Nuclear Safety Authority (STUK) also stated in its preliminary safety assessment that the AES-2006 plant alternative, chosen by Fennovoima, can be built to fulfill Finnish nuclear and radiation safety requirements with certain design modifications and through additional analysis and qualification procedures.

The main designer of the Hanhikivi 1 plant will be JSC Atomproekt, and the primary circuit will be designed by JSC OKB Gidropress. The procurement of primary circuit equipment and the turbine generator will be managed by JSC Atomenergomash. The turbine will be based on Alstom's Arabelle technology. The project supervisor will be CJSC Concern Titan-2. The automation integrator will be JSC VNIIAES. Safety-classified automation systems. which are important for nuclear safety, will be supplied by Rolls-Royce or Schneider Electric. As a fuel supplier, Fennovoima has chosen JSC TVEL.

A description of the type and technical principles of the nuclear facility to be constructed, and the planned suppliers of the essential parts

Technology and safety of Rosatom's AES-2006 nuclear power plant

History

Rosatom's AES-2006 is a modern, third-generation nuclear power plant, which has two reference versions: the AES-2006/V392M and the AES-2006/V491. Fennovoima's Hanhikivi 1 nuclear power plant will be based on the latter. The most important technical information of the AES-2006 are presented in Table 4A-1.

Rosatom has operated and developed VVER nuclear power plants for more than 40 years. In June 2015, a total of 56 VVER nuclear power plants were in operation in different countries, and 13 were under construction. The plant type has been developed further with new technical improvements while retaining proven solutions. AES-2006 plants are based on proven VVER technology.

VVER-440 nuclear power plants were among the first VVER reactors to be used for commercial energy production, and plant units of this type have been safely operated in Loviisa for more than 30 years. The next major development after the VVER-440 was the VVER-1000, which had a higher thermal output and considerably more advanced safety features. The primary safety systems of the VVER-1000 have four-fold redundancy; they consist of four independent, parallel entities which would be able to perform the necessary safety function even if one or more of the entities were not operational.

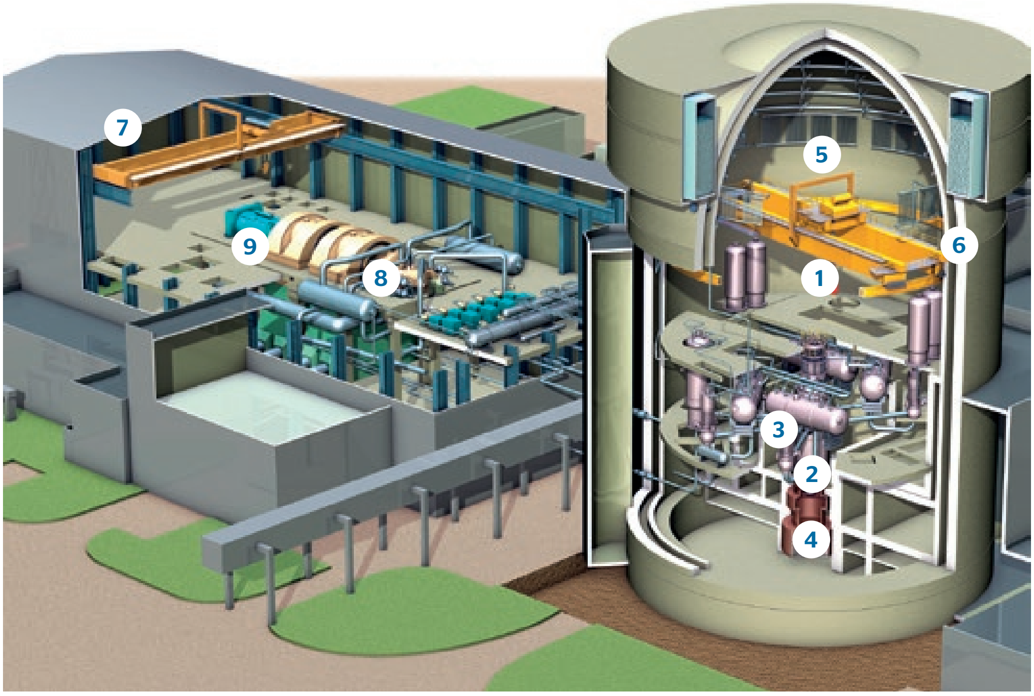
Important safety features of the AES-2006 that were not found in earlier models include passive cooling systems that can be used in addition to the active cooling systems. Passive cooling systems are driven by natural circulation and gravity, and require no electricity supply or other external power to function.

From the start, the safety design of the AES-2006 has aimed to comply with International Atomic Energy Agency's (IAEA) safety guidelines and standards, European Utility Requirements (EUR), and the Russian national regulations and requirements.

The Leningrad II-1 (V491) plant unit under construction since 2008 in Sosnovy Bor, Russia, is used as a reference plant for Hanhikivi 1. Figure 4A-1 is an approximate representation of an AES-2006/V491 nuclear power plant.

Table 4A-1. Technical information of Rosatom's AES-2006 nuclear power plant.

	Rosatom AES-2006
Manufacturer, country (of origin)	Rosatom, Russia
Thermal power MW	approx. 3,220
Electricity output MW	approx. 1,200
Reactor type	Pressurized Water Reactor (PWR)
Primary safety systems	Active and passive
Reference plant, country	Leningrad II-1, Russia



1. Reactor building
2. Reactor pressure vessel
3. Steam generator
4. Core catcher
5. Passive containment heat removal system
6. Inner and outer containment building
7. Turbine building
8. Steam turbine
9. Generator

Figure 4A-1. Rosatom AES-2006/V491.

In a preliminary safety assessment carried out in connection with the processing of the supplement to Fennovoima's decision-in-principle application, the Radiation and Nuclear Safety Authority (STUK) has evaluated the safety of Rosatom's AES-2006, and the fulfillment of Finnish safety requirements. The plant did not fulfill Finnish safety requirements concerning functions such as the primary circuit pressure relief system used during severe reactor accidents, the ability of the containment to withstand an aircraft crash, and the isolation of emergency diesel generators. Based on these observations and other technical requirements set by Fennovoima for its nuclear power plant, modifications will be made to the AES-2006 nuclear power plant to be delivered to Fennovoima to ensure that it meets the safety requirements set by Finnish authorities. Fennovoima will submit the design documentation concerning these design modifications to STUK together with other design documentation during the construction license application process. The design documentation will show how the AES-2006 being designed for Fennovoima will meet the requirements of Finnish authorities. A brief description of the solutions is given in the following sections.

Basic technology, the reactor pressure vessel and the primary circuit

The primary circuit consists of the reactor pressure vessel, four coolant lines attached to it, and the pressurizer. Each coolant line includes a horizontal steam generator, an electric reactor coolant pump, and the pipeline connecting these. The pressurizer designed for adjusting the pressure within the primary circuit is connected to the primary circuit via a surge pipe.

Figure 4A-2 is a simplified process diagram of the AES-2006 that shows an approximate representation of one primary circuit coolant line and its connection to the secondary circuit.

The reactor pressure vessel, primary circuit and the components connected to it will be manufactured from carefully selected materials, using the best modern manufacturing techniques. The components of the primary circuit are designed for a minimum operating life of 60 years.

Neutron irradiation embrittlement of the reactor pressure vessel will be limited by designing a reactor pressure vessel that is larger than in previous VVER nuclear power plants. The larger reactor pressure vessel will allow more cooling water between the pressure vessel wall and the fuel. The water will slow down fast neutrons and thus protect the pressure vessel. There is more than 30 years of operating experience in managing radiation embrittlement in VVER plants, and appropriate monitoring programs are in place.

The pipelines of the AES-2006 primary circuit will be designed and manufactured in accordance with the leak-before-break principle. This means that the pipes have no identified failure mechanisms that would cause a full and abrupt break. Instead of a full and abrupt break, any damage to the primary circuit pipes will appear as a minor leak that can be easily detected. Repairs can then be carried out before an accident occurs. The rooms that contain primary circuit pipelines will be equipped with complete leak detection systems.

Reactor core

The reactor core of the AES-2006 has 163 nuclear fuel elements and 121 control rods. The fuel elements have a hexagonal cross-section, and each of them contains 312 fuel rods. One quarter of all fuel assemblies are replaced in the annual maintenance outage, and the remaining fuel assemblies are repositioned to ensure safety margins and optimal fuel burnup. Figure 4A-3 shows an example of the fuel layout in the reactor core of an AES-2006 nuclear power plant. Nuclear fuel management at the Hanhikivi 1 nuclear power plant is described in more detail in Appendix 5A of this application.

The large number of control rods aims to ensure that the reactor will remain subcritical even at low temperatures, requiring no other control system in addition to the control rods. The control rods are finger-type control rods typical of pressurized water reactors. During power operation, electromagnets hold the control rods in the top section of the reactor core or completely out of the reactor core.

The reactor core is designed so that the natural reactor power feedback will restrain power variations. For example, when the core temperature increases, the reactor power decreases, which will keep the reactor stable at all operating conditions. In addition, the safety margins related to heat transfer of the nuclear fuel are large in transient conditions.

Control rods are used as the primary means to shut down the reactor and to make rapid adjustments to its power output. Emergency shutdown of the reactor is carried out by cutting power to the electromagnets that hold the control rods up. As a result, the control rods will drop into the reactor core within seconds. The control rods will be designed so that the reactor will shut down and remain subcritical even if the most significant control rod stays completely out of

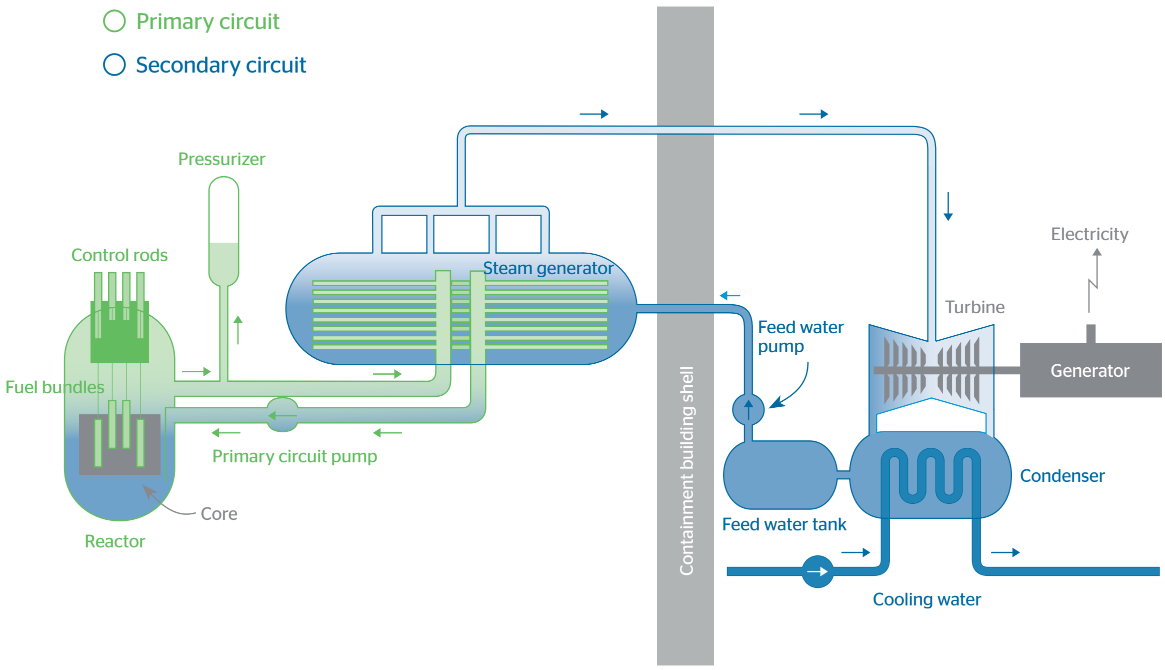


Figure 4A-2. Primary circuit and secondary circuit of the AES-2006 nuclear power plant.

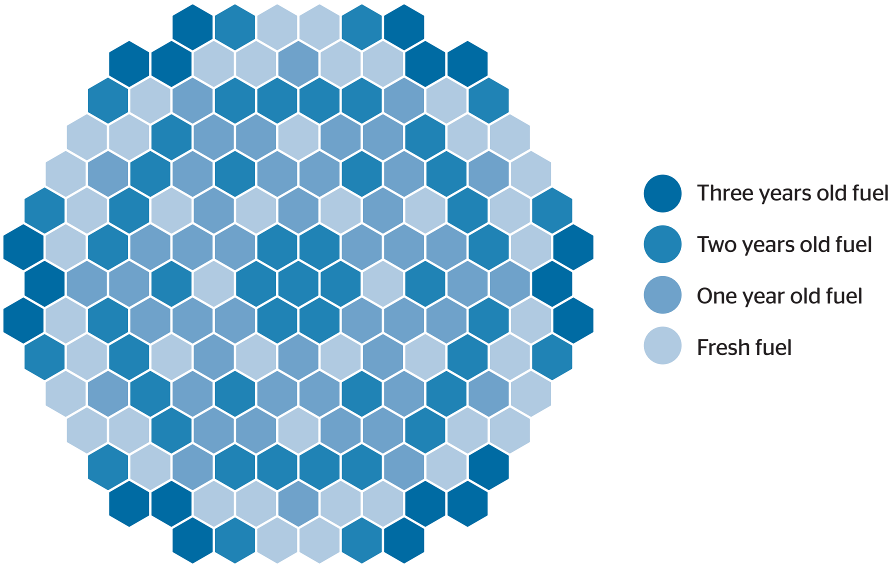


Figure 4A-3. An example of the fuel layout in the reactor core of an AES-2006 plant.

the reactor due to a failure. To adjust the power distribution, the position of control rods can also be changed with electronic motor control capable of precision operation.

If the movement of the control rods is completely prevented for any reason, the reactor can be shut down by an automatic system that will pump borated water into the primary circuit from dedicated storage tanks located in the reactor building. The boron solution pumping system consists of four redundancies of 50% capacity, which means that the system meets the single failure criterion set out in section 14 of the Government Decree on the Safety of Nuclear Power Plants. With a total system capacity of 4 × 50%, that is, four subsystems each capable of handling 50% of the required total capacity, the system will be able to carry out the required safety function when any two subsystems are operational.

Defense-in-depth

According to the defense-in-depth principle, the safety of a nuclear facility must be secured with successive and independent protections. The principle encompasses both structural and functional plant safety. For a more detailed description of the functional defense-in-depth principle, see Appendix 4B of this application. For a description of the use of successive barriers to prevent the spread of radioactivity in accordance with the structural defense-in-depth principle, see Appendix 3A of this application.

The main safety features of the AES-2006, such as emergency core cooling systems, are implemented using both active and passive safety systems. Safety systems follow the redundancy principle by being built as four parallel subsystems that will be able to perform the necessary safety function even if one of the subsystems was not operational.

The redundancies are located in separate facilities to comply with the separation principle. The active safety systems of the AES-2006 will be designed to comply with the diversity principle by using a minimum number of common factors that could result in the failure of several redundancies at the same time.

Containment

The primary circuit components of the AES-2006 are protected by a double containment. The inner containment is designed to withstand the energy discharged into the containment in accident conditions. The inner containment is a massive, cylindrical, pre-tensioned reinforced concrete structure with a steel lining.

The inner containment is protected by an outer containment. The outer containment of the AES-2006 designed for Fennovoima will be the outer wall of the cylindrical reactor building, and it will be designed to withstand a collision of a large passenger airplane in accordance with Finnish safety requirements. During normal operation of the power plant, the pressure in the annular space between the outer and inner containment will be kept below atmospheric pressure to allow monitoring of the leak-tightness of the containment and to ensure that any leaks only occur through filtering systems.

The pipes and channels that pass through the containment wall will be equipped with isolation valves on both sides of the wall. In the case of a transient or accident, the valves are closed or they close automatically, unless the valve in question is used to control the situation as a part of a safety system. To secure the isolation function, the inner and outer isolation valves are different from each other. All systems have two isolation valves, with the exception of the emergency core cooling system suction lines, which only have one isolation valve because the flow route must be open during accident conditions.

Reactor cooling and residual heat removal

In AES-2006 nuclear power plants, residual heat is primarily transferred into the ultimate heat sink via steam generators. The ultimate heat sink will be either the atmosphere or the sea.

In normal conditions, the heat generated in the reactor transfers from the primary circuit to the secondary circuit via the steam generators located in the reactor building (Figure 4A-2). In the steam generators, the high-pressure hot water of the primary circuit heats up the water that flows on the secondary side of the steam generator. The secondary side water will convert into high-pressure steam that flows in the pipelines into the turbine located in the turbine building. In the turbine, the steam expands and part of the energy contained in the steam converts into mechanical energy in turbine rotation. The turbine turns the generator that will, in turn, convert the mechanical energy into electrical energy. The low-pressure steam that has passed through the turbine converts into water in the seawater-cooled condenser. The water then flows back into the steam generator via the secondary circuit pipeline.

In transients and accident conditions, the cooling and residual heat removal of the AES-2006 nuclear power plant can be carried out by active or passive systems.

During operational occurrences that are not of a serious nature, cooling may be carried out in a manner very similar to the method used in normal conditions, via the steam generators by leading steam from the secondary side either into the turbine plant condenser or into the atmosphere through the steam generators' relief valves. In such situations, adequate water mass of the steam generators is maintained by an emergency feedwater system.

If steam generators are not available, the primary circuit can be cooled by feeding water into the reactor from the high-pressure emergency core cooling system and by letting water out from the pressurizer relief valves. Direct cooling of the primary circuit in low-pressure conditions is possible by using a low-pressure emergency core cooling system with residual heat removal settings. The system consists of four full-capacity redundancies (4 × 100%), which means that the system exceeds the failure criteria of a random single failure of one redundancy combined with one redundancy being under maintenance.

During accidents, primary circuit leaks in particular, both high-pressure and low-pressure emergency core cooling systems will be used to cool the reactor. In addition to the active emergency core cooling systems, there are passive systems based on nitrogen-pressurized accumulators that connect to the reactor pressure vessel via non-return valves. The accumulators discharge automatically with no control measures required when the pressure of the primary circuit falls below the gas pressure of the tanks.

The high-pressure and low-pressure emergency core cooling systems both have four redundancies. The pumping capacity of each redundancy is adequate for performing the emergency cooling function, which means that the emergency core cooling systems meet the failure criteria set for a primary safety function. The pressure produced by the high-pressure emergency core cooling system pumps is selected to be lower than the opening pressure of the steam generator safety valves. This prevents the release of primary circuit coolant into the environment in a situation that involves a leak from the primary circuit to the secondary side (turbine side) of the steam generators.

High-pressure and low-pressure emergency core cooling systems take water from a boron water tank located in the lower part of the containment. Water that leaks into the containment from the primary circuit will flow into the same tank via sump strainers. To maintain system functionality, the sump strainers of emergency core cooling systems are designed to strain any insulation materials and other impurities broken loose by the leak with no major pressure loss.

The high-pressure and low-pressure emergency core cooling systems function as mutual back-up systems. If the high-pressure emergency core cooling system is not operational, the pressure of the primary circuit is lowered so that the cooling capacity of the low-pressure emergency core cooling system is adequate. The pressure of the primary circuit can be lowered either by steam generator relief valves, primary circuit relief valves, or both. The capacity of the high-pressure emergency core cooling system, on the other hand, is adequate to fill the reactor and maintain an adequate cooling level with no separate pressure relief. Overpressure protection of the primary circuit is carried out using three safety valves connected to the pressurizer and controlled by spring-loaded control valves.

In cases involving a complete loss of power supply to the plant, steam generators can be cooled down using a passive steam generator cooling system that requires no external power supply to transfer the heat from steam generators into water pools located outside the top section of the containment.

Safety systems

Next to the reactor building, there is a safety system building where each redundant subsystem of the safety systems is located in its own compartment so that the failure of the equipment in one subsystem due to a flood or fire, for example, will not prevent the functionality of other subsystems. The safety system building also contains the automation and auxiliary systems required for the control of safety systems. Like the containment, the safety system building of the Hanhikivi 1 nuclear power plant will be designed to withstand a collision of a large passenger airplane.

Monitoring and control of safety systems will primarily be carried out using programmable instrumentation and control systems. The reactor protection system consists of four redundancies so that at least four times the necessary number of measuring instruments required for starting up the major safety functions exist, ensuring that each redundancy has all the necessary instrumentation. The safety function is launched when two out of four measuring instruments indicate that the start-up criteria are met. This operating method has been chosen for its ability to allow the testing of an individual redundancy even during the operation of the plant; even if one redundancy is being tested and another fails, the safety function is still able to launch, but it will not be triggered unnecessarily.

The AES-2006 has two reactor protection system redundancies which have differing operating principles. To back up programmable systems for cases of common cause failure, the plant has a hardwired back-up system that operates independent of any computer-based systems.

Normally, safety systems get their power supply from the plant generator or from the national grid via separate transformers. For back-up power, the plant has emergency diesel generators, designed to be able to maintain all the necessary safety systems during design basis accidents. Each diesel generator serves all the loads included in its own redundancy, such as pumps, fans, valve actuators, and monitoring and control systems.

The Hanhikivi 1 nuclear power plant will also have diesel generators dedicated for design extension conditions and severe reactor accidents. These diesel generators will be separate from the emergency diesel generators and improve the electricity self-sufficiency of the plant; power supply to the most critical systems of the plant can be arranged even in accident conditions which involve the loss of external power supply and the primary emergency diesel generators.

In addition, one non-classified diesel power plant will be built in the Hanhikivi headland. With special arrangements, this power plant will be able to supply the equipment backed up by the safety classified diesel units. The primary purpose of this diesel unit is to maintain the operation of the infrastructure around the plant when their external power supply is disrupted.

Management of severe reactor accidents

The severe reactor accident management strategy of the AES-2006 is based on four safety functions: depressurization of the primary circuit, cooling of the molten core in the core catcher at the bottom of the reactor pit, hydrogen control (prevention of hydrogen explosions), and residual heat removal from the containment. These protections will ensure the integrity and leak-tightness of the containment so that the emission limits set for severe reactor accidents will not be exceeded.

Depressurization of the primary circuit

Depressurization of the primary circuit is a primary function in the severe reactor accident management strategy. The purpose of the function is to prevent the loss of integrity of the primary circuit, and the spreading of a radioactive release into the containment. According to a requirement set out in YVL Guide B.1 of STUK, the systems intended for controlling severe reactor accidents shall be both functionally and physically separated from the systems intended for normal operation and anticipated operational occurrences and for controlling postulated accidents and design extension conditions. This means that systems dedicated and designed for severe reactor accidents must be in place for the safety systems included in the severe reactor accident management strategy.

In Rosatom's AES-2006, depressurization of the primary circuit is carried out via a pressure relief line used in postulated accidents, design extension conditions and severe reactor accidents. Pursuant to the requirement mentioned above, depressurization of the primary circuit at the AES-2006 nuclear power plant unit being designed for Fennovoima will be carried out using a special pressure relief line designed for severe reactor accidents. This pressure relief line will be designed to meet Finnish safety requirements, and their fulfillment will be demonstrated in the design documentation that will be submitted to STUK during the construction license application process.

Cooling of molten core

The core catcher of the AES-2006 is the result of long-term research and development. In the AES-2006, cooling of a molten core in case of a severe reactor accident is arranged to take place in the core catcher, which is located below the reactor pressure vessel. Cooling water will flow onto the outer surface of the core catcher of AES-2006 from a boron water tank located inside the containment, and from the shaft used for the inspection of reactor internals. The molten core will be cooled directly within the core catcher and indirectly from the outside. The sacrificial ceramic material of the core catcher contains iron and aluminum oxides, and will react with the molten core and thus lower its melting point. This will keep the molten core liquid for longer and help it spread evenly within the core catcher, which will improve the coolability of the molten core.

The steam generated in the core catcher will condense on the surfaces of the containment and in the heat exchangers of the residual heat removal system. From these, the coolant will flow via the boron water tank back to the core catcher. The core catcher will prevent the uncontrolled spreading of the hot molten core in the containment.

Hydrogen control

Hydrogen is released during a severe reactor accident, when the zirconium cladding of the nuclear fuel, as well as other metals, reacts with the steam and oxidize.

Generation of an explosive mixture of hydrogen and air is prevented in the AES-2006 by equipping the facility with passive recombiners which turn hydrogen and oxygen into water through a catalytic process. The catalytic oxidization of hydrogen in the recombiners begins spontaneously at a very low hydrogen concentration, before the concentration increases to a level where the hydrogen-air mixture in the containment would be able to ignite. Recombiners will be placed in the sections of the containment where any hydrogen generated within the primary circuit is assumed to be first released. The number of recombiners will be determined so as to rule out any practical possibility of an explosive hydrogen-air mixture being created.

Removal of residual heat from the containment

As a result of a severe reactor accident, part of the residual heat generated within a damaged reactor will be released directly into the containment atmosphere, which will, over the long term, increase the internal pressure of the containment. To prevent this, the residual heat released into the containment must be removed in a reliable manner and conducted safely into the ultimate heat sink.

In an AES-2006 nuclear power plant, the containment can be directly cooled with two different systems: a sprinkler system with active pumps, or a passive containment cooling system driven by natural circulation based on differences of water density.

The water sprayed into the containment by the sprinkler system will flow via sump strainers to heat exchangers that will transfer the heat from the containment into the intermediate circuit and further into the sea.

The passive containment cooling system will use heat exchangers installed on the inside of the containment wall to condense steam that has been released into the containment atmosphere. From the heat exchangers, the heat is carried by steam in pipes to the water pools located outside the top section of the containment. In the water pools, the steam condenses back into water and is returned to the heat exchangers by gravity. The heat will be released from the pools to the atmosphere, which will act as the ultimate heat sink of the system. The passive containment cooling system has four subsystems, each able to handle one third of the required total capacity (4 x 33%). The system is driven by natural circulation and gravity, and thus needs no electricity or other external power sources to maintain operation. The system will be able to function autonomously without any actual control measures or addition of water for a minimum of 24 hours, and up to 72 hours with the water reserves available in the plant area.

Severe reactor accidents occurring during annual outages

A severe reactor accident occurring during a plant outage will be managed similarly to an accident that occurs during power operation, with the difference that provision must be made for closing the access openings of the containment fast enough, if they have been opened for maintenance work. In addition, some of the severe reactor accident management systems may be temporarily disabled due to maintenance work, in which case provision must be made for returning their functionality.

Turbine building

The turbine building contains systems, equipment and auxiliary systems required for the generation of electricity. The turbines, the generator, moisture separators/reheaters, condensers, condensate preheaters, feedwater tank and feedwater preheaters with their pipelines, pumps and related auxiliary systems are all located in the turbine building.

The systems in the turbine building belong to the secondary circuit, and contain no radioactive substances. The systems have been designed so as to ensure that any disturbance or damage occurring in them will not directly lead to compromised nuclear safety or a release of radioactive substances or radiation into the environment.

The risk from internal threats in the turbine building (such as missiles from broken turbine blades or ruptured high-energy pressure vessels) will be analyzed to ensure that the probability of such events is sufficiently low. The design and analyses do, however, take into account the fact that if such an extremely improbable event were to occur, its impact would be absorbed by protective barriers (the turbine containment) or structures, or the design of the equipment support would prevent uncontrolled missiles. Furthermore, if the missiles succeeded in piercing the barriers listed above, no systems that have an impact on nuclear safety would be located on their impact route. For this reason, the reactor building, safety system building, steam cell and turbine building of the AES-2006 are all placed in longitudinal orientation with regard to the turbine shaft. This ensures that any turbine blade or piece of rotor to break off the steam turbine due to a failure cannot hit any safety-critical constructions. The planned layout of the Hanhikivi 1 nuclear power plant is presented in Appendix 3C of this application.

Even though the systems within the turbine building have no nuclear safety classification, they will be designed in compliance with strict safety principles to achieve high availability of the power plant and to avoid any operational occurrences. The two separate, independent overspeed protections of the turbine required by Fennovoima are an example of this. The reliable operation of the turbine overspeed protection essentially reduces the risk of blade ruptures, and thus the probability of turbine missiles. Other examples of turbine plant safety design include the double redundancy of the condenser vacuum pumps to ensure that if one pump should fail, the other would still be able to generate a vacuum in the condenser to keep primary cooling with seawater operating, without the need to use secondary cooling.

Provision for external hazards

The plant design will take into account any external hazards such as extreme weather conditions, climate change, earthquakes, chemical transportation accidents that may occur in the vicinity of the plant, and illegal activities, including an intentional collision of a large passenger airplane.

Fennovoima has defined a design basis for the plant. This design basis is, with fair certainty, much more stringent than any conditions that can be assumed to exist during the service life of the plant. The design takes into account conditions that can be estimated to occur with an expected frequency of occurrence lower than once in a 100,000 years. Provision will also be made for conditions that exceed the design basis. Probabilities of external phenomena in Hanhikivi have been estimated by specialists, the Finnish Meteorological Institute in particular. The expertise and measurement data of the Swedish Meteorological and Hydrological Institute (SMHI) has also been utilized in estimates concerning phenomena such as earthquakes and heavy rains. The estimates take into account the increased frequency of extreme weather conditions, caused by climate change, and the estimated impact of rising sea levels until the end of the current century. The estimates are based on the forecasts of the Intergovernmental Panel on Climate Change (IPCC) working under the UN, as well as climate models. The AES-2006 specifically designed for Fennovoima will be dimensioned to withstand external hazards so that it can be operated at the Pyhäjoki site until the end of its useful life with sufficient safety margins.

Various structural and organizational safety arrangements will be used to protect against illegal activities. For example, the collision of a large passenger airplane will be taken into account in the design of safety-critical structures, as described earlier in this appendix. The containment's ability to withstand collisions will be shown in the documentation that will be submitted to STUK during the construction license application process. For a more detailed description of security arrangements, see Appendix 4B of this application.

Suppliers of essential components

In December 2013, Fennovoima signed a plant supply contract with JSC Rusatom Overseas on the supply of an AES-2006 nuclear power plant to the Hanhikivi plant site. In April 2015, the plant supply contract was transferred to RAOS Project Oy, a Finnish subsidiary fully owned by JSC Rusatom Overseas. The plant supply contract with all responsibilities has been assigned to the new company. RAOS Project Oy will be the supplier of the Hanhikivi 1 nuclear power plant. The transfer of the plant supply contract will not affect Rosatom Groups's responsibility for the fulfillment of the contract.

Most of the resources allocated for the Hanhikivi 1 project by JSC Rusatom Overseas, such as employees, will go over to the new company. The new company will have main offices in St. Petersburg, Helsinki and Pyhäjoki. All subcontracting and consultancy contracts will also be assigned to the new company. The existing management system of JSC Rusatom Overseas will be utilized in the new company as applicable, and the management system solutions established for the Hanhikivi 1 project will be adopted by RAOS Project Oy. The transfer of the plant supply contract will not affect the requirements set for the plant supplier. Fennovoima will ensure that the competencies and management system of the new company meet the Finnish requirements, and will deliver to STUK the necessary materials to demonstrate this during the construction license application process.

As a Finnish company, the plant supplier will be able to cooperate with Finnish subcontractors and authorities, for example, more efficiently. Closer project management cooperation will also become possible. The transfer of the plant supply contract is also expected to simplify the import operations and the customs, currency and tax formalities within the EU in particular.

Fennovoima's contract partner RAOS Project Oy will be responsible for the Hanhikivi 1 project as the main supplier. Other RAOS Project Oy's subcontractors will be responsible for the design and construction of the nuclear power plant within their scopes of work.

The main designer of the Hanhikivi 1 plant will be JSC Atomproekt, and the primary circuit will be designed by JSC OKB Gidropress. The equipment and components of the reactor island, including the primary circuit and the reactor pressure vessel, will be supplied by JSC Atomenergomash. JSC Atomenergomash will also be responsible for the acquisition of the turbine generator. The turbine of the Hanhikivi 1 nuclear power plant will be based on Alstom's Arabelle technology, and the main components of the turbine will be manufactured at Alstom's facilities.

The main contractor responsible for on-site power plant construction work will be CJSC Concern Titan-2, which is also the main contractor of the reference power plant of Hanhikivi 1. The main contractor is responsible for having the primary nuclear power plant buildings, such as the reactor and turbine building, built. Titan-2 will also manage preparatory work such as earth-moving.

The automation integrator will be JSC VNIIAES. Safety-classified automation systems. which are important for nuclear safety, will be supplied by Rolls-Royce or Schneider Electric.

As a fuel supplier, Fennovoima has chosen JSC TVEL. The fuel contract covers the uranium required for the fuel as well as the manufacturing of the nuclear fuel for the first operating cycle of the nuclear power plant, and reload batches for the following eight years. Fennovoima will also maintain a reserve stockpile of approximately two reload batches at the plant. The fuel will be designed by JSC OKB Gidropress, which is a subsidiary of JSC TVEL, and manufactured by JSC MSZ and JSC NCCP, both subsidiaries of JSC TVEL. After the expiry of the contract period, Fennovoima will be able to freely tender its fuel supply.

Safety of the nuclear power plant
Appendix 4B

Description of safety principles to be observed at the nuclear power plant and an assessment of their fulfillment

Summary

As required by section 32, paragraph 6 of the Nuclear Energy Decree (161/1988), this appendix includes an overall description of the safety principles to be observed at the nuclear power plant, and the applicant's assessment of their fulfillment. For a description of the safety principles, see Chapters 2 and 2 a of the Nuclear Energy Act (990/1987).

Nuclear power production is characterized by the radioactive materials used and generated in the power production process. Nuclear power plant safety therefore primarily involves designing, building, operating and decommissioning the plant in a way that ensures that the releases and impact of radioactive materials are kept as low as practically achievable.

The Government grants the license to construct and operate a nuclear power plant. As the licensee, Fennovoima will be responsible for compliance with safety principles and requirements during the entire life cycle of the nuclear power plant.

Continuous observation of safety principles is a fundamental precondition for the safe construction, operation and decommissioning of Fennovoima's nuclear power plant. Detailed regulations governing the observance of safety principles are given in government decrees and in the regulatory guides for nuclear safety: the YVL Guides issued by the Radiation and Nuclear Safety Authority (STUK). Fennovoima executes its project in accordance with valid laws, decrees, official requirements and guidelines, and will not authorize any solutions that are in conflict with the safety principles presented in this appendix.

The authorities have means backed by legislation at their disposal for ensuring the safe use of nuclear energy in all phases of operations and for intervening if any actions are suspected of being in conflict with the set requirements.

The technical operating principles of the selected plant type are presented in more detail in Appendix 4A of this application. A description of the selected plant site is included as Appendix 3C. For an overall plan for nuclear waste management of the Hanhikivi 1 power plant, see Appendix 5B.

Description of safety principles to be observed at the nuclear power plant and an assessment of their fulfillment

General principles of nuclear energy use

This section includes an account of the general safety principles provided in Chapter 2 of the Nuclear Energy Act. As the construction license applicant, Fennovoima will comply with these principles.

According to section 5 of the Nuclear Energy Act, the use of nuclear energy, taking into account its various effects, shall be in line with the overall good of society. The objective of the requirement concerning the overall good of society is to allow wide-scale consideration of the impact of nuclear energy on society, particularly when processing an application for a decision-in-principle. This will ensure that nuclear power capacities will only be taken into use if the benefit to the society exceeds any potential harm.

The decision-in-principle granted by the Government on May 6, 2010 states that Fennovoima's project is in line with the overall good of society. The decision-in-principle granted on September 18, 2014 based on the application for a supplement to the earlier decision-in principle confirms that, considering the changes having taken place in Fennovoima's project since the previous decision-in-principle, the project still meets this condition.

Safety

According to section 6 of the Nuclear Energy Act, the use of nuclear energy must be safe and must not cause injury to people, or damage to the environment or property.

The use of nuclear energy in Finland is subject to a license, and the construction and operating licenses are granted by the Government. Section 9 of the Nuclear Energy Act unambiguously states that the licensee of a nuclear facility has the obligation to ensure the safe use of nuclear energy at all stages of operations, and cannot transfer this responsibility to other parties. All nuclear energy use must be continuously in accordance with the general principles of the Nuclear Energy Act.

Fennovoima will be responsible for the safety and safe operation of the nuclear power plant at all phases of its life cycle. Fennovoima will also be responsible for the safe implementation of the safeguards to prevent nuclear proliferation, and safe nuclear waste management.

In Fennovoima's project, safety takes precedence over all other objectives. The design, construction, commissioning, operation and decommissioning of Fennovoima's nuclear power plant will be carried out in accordance with the requirements set out in legislation and the regulations stipulated by the authorities. The applicable requirements are included in the Nuclear Energy Act and in general safety regulations that provide more detailed provisions for the areas referred to in the Nuclear Energy Act. The general safety regulations are included in the Nuclear Energy Decree and in the following government decrees:

- Government Decree on the Safety of Nuclear Power Plants (717/2013)
- Government Decree on the Security in the Use of Nuclear Energy (734/2008)
- Government Decree on Emergency Response Arrangements at Nuclear Power Plants (716/2013)
- Government Decree on the Safety of Disposal of Nuclear Waste (736/2008)

In addition, Radiation and Nuclear Safety Authority (STUK) has defined detailed safety requirements for the implementation of the safety level required by the Nuclear Energy Act. The requirements are included in the YVL Guides (regulatory guides on nuclear safety) published by STUK. As the license applicant, and later as the licensee, Fennovoima must fulfill the safety requirements defined in the YVL Guides.

Assessment of the safety of the nuclear power plant in the construction license phase means a detailed review of the plant design to ensure that the plant will be designed to meet Finnish regulations. The design documentation with the most importance for the safety assessment are compiled into the Preliminary Safety Analysis Report (PSAR) and submitted to STUK. The structure and content of the PSAR are defined based on general international practices. As the project proceeds, the design documentation included in the PSAR will be used as the basis for compiling the more extensive Final Safety Analysis Report (FSAR), which will be submitted to STUK in connection with the operating license application process. The FSAR will be kept up to date.

The plant supplier models transient and accident conditions using analysis software for which plenty of experience exists and which has been validated for the purpose for which it will be used. The PSAR will include a list of computing codes used in the analyses, and of the conditions for which they have been used. It will also include a list of the analyzed transients and accidents, the most important results of the analyses, the uncertainties included in the results, and an account of how each analyzed event fulfills the required acceptance criteria.

The plant supplier will prepare a Probabilistic Risk Assessment (PRA) that fulfills Finnish requirements and is based on the PRA of the reference facility as well as the PRA models and documentation of other AES-2006 nuclear power plant units currently under construction. The PRA will be supplemented and developed in the construction license phase to fulfill Finnish requirements concerning various initiating events (flood, fire, external, seismic), for example. The design solutions used for the Hanhikivi facility will also be taken into account where they differ from those used for the reference facility, together with factors related to the plant site. According to the PRA of the reference facility, the probability of an accident leading to core damage as a result of different initiating events in the AES-2006 fulfills Finnish requirements with a sufficient safety margin. However, the fulfillment of requirements for Hanhikivi 1 can only be proven reliably when the PRA model has been modified to meet Finnish requirements.

For the sections of plant safety that cannot be comprehensively covered by analytical methods alone, tests that illustrate plant functions must also be carried out. Typical subjects of testing include various management systems for severe reactor accidents, and the structure of sump sump strainers of emergency cooling systems. The plant supplier has executed several test programs to investigate the operation of systems such as the passive residual heat removal systems, the core catcher, and sump strainers. The tests have been utilized in reviewing the plant's system design and in the development and validation of the analytical methods applied by the supplier. The description and result of each test program will be presented as subject-specific reports submitted to STUK during the construction license application process.

The environmental impact of the construction and operation of the Hanhikivi 1 nuclear power plant has been assessed in the environmental impact assessment report prepared in compliance with the requirements set out in the Act on Environmental Impact Assessment (468/1994) and the Government Decree on Environmental Impact Assessment Procedure (713/2006). The EIA report was submitted to the Ministry of Employment and the Economy on February 13, 2014. No adverse environmental impacts that are unacceptable or that could not be mitigated to an acceptable level were identified during the environmental impact assessment of the project. In addition to areas being covered by the nuclear power plant's auxiliary buildings, the most important environmental impact of the project is the impact on the marine environment of the discharged cooling water. This impact, however, will be limited to a small area. Furthermore, the project will have positive environmental impacts, such as the increased CO_2-free energy production capacity.

During the construction license application process, Fennovoima will submit to STUK the documents listed in section 35 of the Nuclear Energy Decree. These documents will demonstrate that the Hanhikivi 1 nuclear power plant will fulfill all the requirements mentioned above, that it will be operated safely, and that it will not cause injury to people or damage to property or the environment.

Based on what has been stated above, Fennovoima considers that the general safety principle set out in section 6 of the Nuclear Energy Act will be fulfilled.

Nuclear waste management

Section 6 a of the Nuclear Energy Act requires that nuclear waste generated in Finland in connection with or as a result of nuclear energy use must be handled, stored and permanently disposed of in Finland. Furthermore, section 6 b of the Nuclear Energy Act requires that nuclear waste generated in connection with or as a result of the use of nuclear energy elsewhere than in Finland, shall not be handled, stored or permanently disposed of in Finland.

Fennovoima will only handle, store and dispose of nuclear waste generated in connection with its own operations.

Fennovoima will observe the nuclear waste management requirements set out in the Nuclear Energy Act in all phases of the project. Handling and final disposal of the low and intermediate level operating waste generated at Fennovoima's nuclear power plant will be managed on site as detailed in Appendix 5B of this application.

The spent nuclear fuel generated during the operation of Fennovoima's nuclear power plant will be placed in an interim storage at the nuclear power plant site and is planned to be disposed of in a final disposal facility to be built in Finnish bedrock. The suitability of various interim storage methods for Fennovoima's final disposal alternatives, as well as the financial feasibility of the methods, require further investigation. For this reason, Fennovoima is now applying for a construction license for both the dry storage and the pool storage methods, and will supplement the construction license application materials to be submitted to STUK with a requirement specification for both methods, as well as an account of the fulfillment of the safety requirements related to interim storage operations. The supplementary materials will be submitted to STUK by the end of 2015. In addition, Fennovoima will submit an interim storage facility licensing plan to STUK for information, also by the end of 2015. The dry storage and pool storage methods are described in Appendix 5B of this application.

Furthermore, Fennovoima will supplement Appendix 5B of this application (an overall plan for nuclear waste management) with a report on the final disposal of spent nuclear fuel to fulfill the condition set in the government decision-in-principle by the end of June 2016.

Fennovoima's nuclear waste management plans are essentially based on proven and safe methods. The nuclear waste management for Fennovoima's nuclear power plant can be arranged in a safe manner and in compliance with the applicable requirements. To secure the financial resources for nuclear waste management, Fennovoima is obligated under section 35 of the Nuclear Energy Act to make financial provision for all costs to be incurred in the nuclear waste management for the nuclear power plant in the future.

Based on what has been stated above, Fennovoima considers that the nuclear waste management principles set out in sections 6 a and 6 b of the Nuclear Energy Act will be fulfilled.

Security and emergency response arrangements and other comparable arrangements

According to section 7 of the Nuclear Energy Act, sufficient physical protection and emergency planning, as well as other arrangements for limiting nuclear damage and for protecting nuclear energy against illegal activities, shall be a prerequisite for the use of nuclear energy. According to section 2 of the Nuclear Energy Act, this prerequisite applies to both the construction and operation of a nuclear facility. Section 35 of the Nuclear Energy Decree states that when applying for a construction license, the applicant must submit to STUK the preliminary plans for the nuclear facility's security and emergency response arrangements.

The purpose of security arrangements at the nuclear power plant is to prevent any illegal activity that could compromise nuclear safety at the nuclear power plant and its immediate vicinity.

The emergency response arrangements of the nuclear power plant are plans that prevent and restrict damage that could take place in the environment of the nuclear power plant in any emergency conditions.

The selection criteria for Fennovoima's plant location, the Hanhikivi headland, included the physical protection and emergency planning considerations mentioned in section 7 of the Nuclear Energy Act.

Fennovoima will own sufficient areas on the Hanhikivi headland to implement appropriate security arrangements. On June 3, 2015, Fennovoima filed a request that restrictions to movement and sojourns in the nuclear power plant area are established, based on Chapter 9, section 8 of the Police Act (872/2011), in order to maintain the clarity of the security arrangements and the related legal authorization.

The Northern Ostrobothnia regional land use plan for nuclear power indicates the protective zone required for emergency response operations. The land use plan has been used to establish appropriate limitations to land use to ensure that the prerequisites for the required emergency response and rescue operations exist during the entire operational life of the plant. The access routes to the power plant, required for emergency response operations, are backed up using two parallel road connections. Adequate routes for rescue operations will also be established at the plant site. For a more detailed description of the selected plant site, see Appendix 3C of this application.

The security and emergency response arrangements of the Fennovoima nuclear power plant will be planned and implemented in cooperation with STUK, the police and the local rescue authorities to ensure effective containment of the effects of illegal activities that compromise nuclear safety, and any nuclear damage caused by the operations of Fennovoima's nuclear power plant, to the extent required by the law. During the construction license application process, Fennovoima will submit to STUK the preliminary plans for the nuclear facility's security and emergency preparedness, as required by section 35 of the Nuclear Energy Decree. As the project proceeds, the final plans for the nuclear facility's security and emergency response arrangements will be prepared and submitted to STUK during the operating license application process.

Based on what has been stated above, Fennovoima considers that the principle set out in section 7 of the Nuclear Energy Act concerning the physical protection and emergency planning and other arrangements will be fulfilled.

Safety requirements

This section includes an account of the essential safety requirements provided in Chapter 2 a of the Nuclear Energy Act. As the construction license applicant, Fennovoima will fulfill these requirements.

Guiding principles

Section 7 a of the Nuclear Energy Act requires that the safety of nuclear energy use is maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience and safety research and advances in science and technology. Safety requirements and measures to ensure safety must be designed and targeted relative to the risks of nuclear energy.

The essential components of the AES-2006 plant type are based on proven technology, and the experience gained in the construction and operation of previous generations of nuclear power plants, as well as advances in science and technology, have been taken into account in its development. For a more detailed description of the development and technical operating principles of the AES-2006 plant type, see Appendix 4A of this application.

During the construction license application process, Fennovoima will submit to STUK the preliminary safety analysis report for the nuclear power plant and the probabilistic risk assessment for the design phase in accordance with section 35 of the Nuclear Energy Decree. These documents prove the fulfillment of the safety requirements defined in legislation and official requirements during the entire life cycle of the nuclear power plant.

In addition, when applying for the operating license and when renewing it at a later time, Fennovoima will prove the fulfillment of the continuous improvement requirement by showing that it has implemented the safety modifications and improvements that are considered justified considering operating experience and safety research as well as advances in science and technology.

Assessment and root cause analysis of operating events taking place at the plant unit are included in the normal operation of a nuclear power plant. During the project, Fennovoima will develop procedures to monitor operating events. Fennovoima will use domestic and international networks to monitor the operating experience of nuclear power plants. Fennovoima actively participates in the monitoring, evaluation and support of safety research within the Finnish Research Programme on Nuclear Power Plant Safety (SAFIR), and it has representatives in each of the support groups within the program. In addition to funding SAFIR via the National Nuclear Waste Management Fund, Fennovoima has provided financial assistance for the operations of the YTERA Doctoral Programme for Nuclear Engineering and Radiochemistry and the GEN4FIN network (Finnish Research Network for Generation Four Nuclear Energy Systems), for example.

If operating experience or safety research reveal targets for development at Fennovoima's nuclear power plant, the improvements will be implemented in accordance with the SAHARA principle (Safety as High as Reasonably Achievable) to the extent and within the schedule that can be reasonably achieved.

Fennovoima will pay attention to the continuous improvement of the safety of its nuclear power plant during its entire life cycle. The continuous improvement of safety at Fennovoima's facility will include modifications based on technological advances and development of the plant's operating procedures based on the results of new safety analyses. The impact of these improvements on nuclear safety can be assessed quantitatively using the probabilistic risk assessment, which will be kept up to date.

Based on what has been stated above, Fennovoima considers that the guiding principles set out in section 7 a of the Nuclear Energy Act will be fulfilled.

Defense in depth

One of the essential safety requirements set out in the Nuclear Energy Act is the defense-in-depth principle defined in section 7 b. According to the defense-in-depth principle, the safety of a nuclear facility must be secured with successive and independent protections. The principle encompasses both structural and functional plant safety.

Functional implementation of the defense-in-depth safety principle is based on safety functions defined for the nuclear power plant. The plant's principal safety functions are reactor shutdown, removing residual heat from the reactor, and ensuring the integrity of the containment. The safety functions are successive, so that a failure of a single function will not be able to cause injury to people or damage to the environment (Figure 4B-1).

The defense-in-depth principle illustrated in Figure 4B-1 is comprised of five levels of defense:

1. The first level of defense aims to prevent the occurrence of initiating events. The reliable and undisturbed operation of the plant is based on inherent safety features, control systems and the reliability of the components included in safety systems. As a result of inherent safety features, increased temperature of the reactor coolant or fuel, for example, decrease

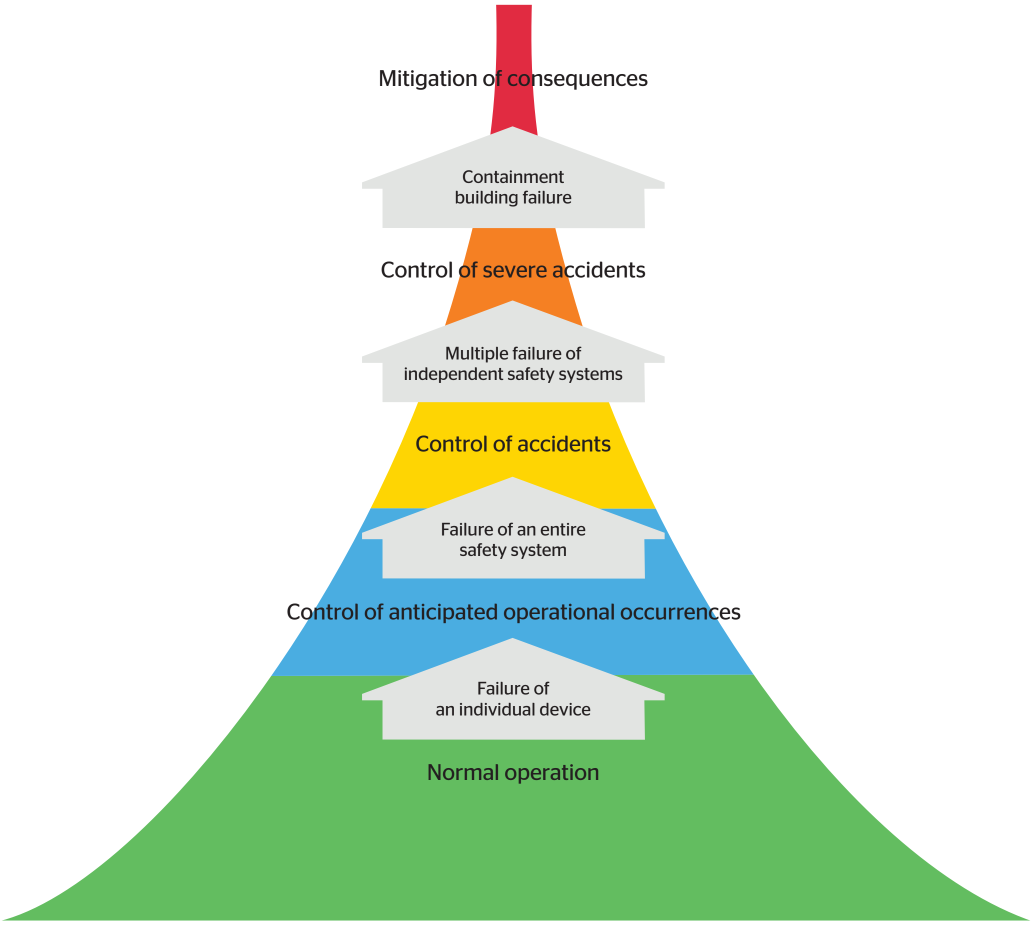


Figure 4B-1. Levels of defense-in-depth protection.

the reactivity level and restrain the power increase. The plant control system must allow safe power operation of the plant in cases where deviations occur in process variables. This is done by adjusting the reactor power and water level, temperature and pressure in various parts of the process. The reliability of safety system components is maintained through maintenance measures and appropriate design.

2. An initiating event may lead to an operational occurrence at a nuclear power plant. The second level of the defense-in-depth principle aims to prevent the escalation of operational occurrences into accidents. Initiating events include failures of single pieces of plant equipment, for example. The purpose of systems such as the emergency shutdown and cooling systems that are designed to limit the impact of operational occurrences is to prevent the escalation of operational occurrences into accidents by bringing the plant to a controlled state where the cooling of the fuel is secured with a sufficient safety margin.
3. The third level of defense aims to prevent core damage. Control of accidents and design extension conditions is carried out using reliable automatic protection systems and emergency cooling systems. Accident control can also be carried out manually.
4. The fourth level of defense aims to contain any radioactive release from a damaged core within the plant. Containment of a release takes place using severe reactor accident management systems and procedures.
5. The fifth level of defense aims to mitigate the radiation dose caused to the population as a result of a release. Mitigation of the consequences in the plant environment has already been taken into account when selecting a plant location, and included in the emergency response plan prepared for accidents.

The reliable operation of the nuclear power plant is guaranteed by appropriate plant design and the proper maintenance and operation of the plant. The primary objective of plant design is to prevent any operational occurrences from arising during normal operation of the plant. Fennovoima will apply strict quality requirements to the design, manufacture, installation and maintenance of equipment, and to the plant operating activities that aim to ensure these. The structures and equipment will be designed to include adequate safety margins, their condition will be monitored during operation, and they will be operated and maintained in accordance with appropriate procedures.

The procedures and systems used to implement protection levels 1–5 will be designed to be independent of each other. The measures needed to control an operational occurrence or accident, or to prevent radiation injuries, will be designed in accordance with the defense-in-depth principle. For an overall description of the primary safety functions used to implement the defense-in-depth principle at the AES-2006 nuclear power plant, see Appendix 4A of this application. For a description of the use of successive barriers to prevent the spread of radioactivity in accordance with the structural defense-in-depth principle, see Appendix 3A of this application.

Within Fennovoima's project, the implementation of the defense-in-depth principle is evaluated using both deterministic and probabilistic safety analyses. The analyses have so far been used to model the ability of the key safety functions of the AES-2006 reference power plant to control various operational occurrences, accidents and their combinations.

During the construction license application process, Fennovoima will submit to STUK a preliminary safety assessment report as required by section 35 of the Nuclear Energy Decree. The report will include a presentation of the safety analyses carried out for the Hanhikivi 1 nuclear power plant, as well as the results of the analyses, which demonstrate the implementation of the defense-in-depth principle.

Based on what has been stated above, Fennovoima considers that the defense-in-depth principle set out in section 7 b of the Nuclear Energy Act will be fulfilled.

Maximum values for radiation exposure

Pursuant to section 7 c of the Nuclear Energy Act, radioactive material emissions arising from nuclear energy use must be restricted in accordance with the principle prescribed in section 2, paragraph 2 of the Radiation Act (592/1991), which states that emission-related radiation exposure must remain as low as practically possible. The maximum values for radiation exposure of individuals arising from the operation of the nuclear facility or from other nuclear energy use are prescribed in the Government Decree on the Safety of Nuclear Power Plants.

Section 2 of the Radiation Act requires that to be acceptable, the use of radiation and practices involving exposure to radiation must meet the following criteria:

- Principle of justification: the benefits derived from the practice shall exceed the detriment it causes.
- Principle of optimization: the practice shall be arranged so that the resulting exposure to radiation hazardous to health is kept as low as is reasonably achievable (the ALARA principle).
- Principle of limitation: no person shall be exposed to radiation exceeding the maximum values prescribed by the Decree.

Section 8 of the Government Decree on the Safety of Nuclear Power Plants defines the limit for the annual dose of an individual in the population, arising from the normal operation of a nuclear power plant, at 0.1 mSv (millisieverts). The limit can be compared to the average annual dose of 3.2 mSv that a Finn receives from other sources. The limit is independent of the number of nuclear power plant units or other nuclear facilities of the nuclear power plant. The maximum individual dose commitment and incident frequency per incident category are presented in Table 4B-1.

Section 3 of the Radiation Decree (1512/1991) defines the maximum dose caused to employees: the effective dose caused to a worker by radiation work shall not exceed an average of 20 mSv per year reckoned over a period of five years, nor 50 mSv in any one year.

As the decision-in-principle established that Fennovoima's project is in line with the overall good of society, the acceptability criteria set for the use of radiation in section 2 of the Radiation Act is fulfilled. In the decision-in-principle, the government stated that the detriment caused by the operation of Fennovoima's Hanhikivi 1 nuclear power plant will be small compared to the benefits derived from the operation. The benefits and detriments of the implementation

Table 4B-1. The maximum individual dose commitment and incident frequency per incident category.

Incident category Government Decree (717/2013)	**Annual dose commitment limit** Government Decree (717/2013)	**Likelihood of occurrence** Guide YVL B.3
Normal operation	0.1 mSv	-
Abnormal operation (anticipated operational occurence)	0.1 mSv	More than once per 100 years
Category 1 postulated accident	1 mSv	Less than once per 100 years
Reference value	*The Finnish average individual annual dose commitment is approximately 3.2 mSv*	
Category 2 postulated accidents	5 mSv	Less than once per 1,000 years
Extension of postulated accidents	20 mSv	Less than once per 10,000 years*
	Requirements Government Decree (717/2013)	**Design objective** Guide YVL A.7
Severe accident	No extensive civil defence measures required No long-term restrictions on the use of extensive geographical and aquatic areas Atmospheric release of cesium-137 under 100 TBq	Less than once per 100,000 years
Very severe accident	Selection of plant site Mitigation of radiation hazard	Less than once per 2,000,000 years

* Incident frequency is indicative; extension of postulated accidents is not specified in Regulatory Guide YVL.

and non-implementation of the project have been comprehensively assessed in Fennovoima's environmental impact assessment report published in 2014.

The Hanhikivi 1 nuclear power plant will be designed so that any releases during normal operation will not cause a radiation dose that exceeds the limit defined for an individual of the population in the decree. In addition, the design and operation of the power plant will be carried out in accordance with the principle of optimization, which will retain exposure to radiation at a level that is considerably lower than the limit. The exposure to population from Finnish nuclear power plants has typically remained at approximately 1 percent of the allowed dose. Fennovoima aims to achieve the same level or remain below it.

In the operational limits and conditions of the nuclear facilities included in the scope of its nuclear power plant (including the operating waste repository), Fennovoima will define nuclide-specific emission limits so that the annual dose to an individual in the population from the various nuclear facilities at the plant site will remain below 0.1 mSv. Fennovoima will submit the operational limits and conditions to STUK for approval.

Fennovoima will ensure through appropriate plant design and work planning that the radiation exposure to workers will remain below the annual dose limits prescribed in the legislation. The principle of optimization will be applied to the design of the Hanhikivi 1 nuclear power plant, and Fennovoima will ensure that the effective dose caused to a worker at the nuclear power plant will not exceed 5 mSv per year. The same design basis will also be applied to nuclear waste management at the plant.

According to the YVL Guides, the collective annual dose of the personnel of a plant unit must not exceed 0.5 manSv (man-sievert) per 1 GW of net electric power during normal operation averaged over the plant's design service life. In the design of the Hanhikivi 1 nuclear power plant, the target for the maximum collective annual dose of the personnel during the plant's service life will be 0.5 manSv (0.42 manSv / net electric power of 1 GW). The extensive operating experience and research results accrued from VVER facilities have been taken into account in the plant design to minimize radiation doses. The design of the equipment, systems and facilities of Hanhikivi 1, as well as the planning of operation and maintenance, will be carried out so that the radiation exposure of workers will remain as low as is reasonably achievable.

The plant alternative selected by Fennovoima utilizes the best available technology to limit the radiation impact from normal operation. The plant will have a continuously operating radiation measurement system that will be used to monitor the access routes of all radioactive substances into the environment, among other things. The radioactivity levels in the environment of the nuclear power plant are monitored to reveal any changes during the entire life cycle of the power plant. When applying for an operating license, Fennovoima will submit to STUK the program for radiation monitoring in the environment of the nuclear facility referred to in section 36, paragraph 10 of the Nuclear Energy Decree. Fennovoima has already begun surveying the basic condition of the radioactive substances that naturally occur in the plant environment to facilitate reliable observation of any changes brought about by the operation of the power plant. For a more extensive discussion of radioactivity at the nuclear power plant, see Appendix 3A of this application.

Based on what has been stated above, Fennovoima considers that the principle set out in section 7 c of the Nuclear Energy Act, concerning the limitation of releases of radioactive materials caused by the use of nuclear energy, will be fulfilled.

Preparation for operational occurrences and accidents

Section 7 d of the Nuclear Energy Act stipulates that the design of a nuclear facility shall provide for the possibility of operational occurrences and accidents. The probability of an accident must be lower, the more severe the consequences of such an accident would prove for people, the environment or property. While the primary objective in the safety design is the prevention of accidents, practical measures necessary for the management of accidents and the mitigation of their consequences must also be implemented.

The maximum values for radiation exposure that will be used as the basis of safety design to provide for operational occurrences and accidents are prescribed in the Government Decree on the Safety of Nuclear Power Plants (Table 4B-1).

The fuel rods of the AES-2006 reactor have been designed so that the probability of fuel damage is very low in normal operating conditions as well as during design basis accidents. To minimize damage caused by foreign bodies, the fuel assemblies are equipped with screens. During operational occurrences, fuel damage is prevented, for example, by the utilization of flywheel masses of main coolant pumps to slow down the weakening of the reactor coolant flow. The purpose of the flywheel masses is to rotate the pump during power outages until the emergency power supply is brought online. In addition to the technical systems designed for the management of accidents and the mitigation of their consequences, Fennovoima also makes provisions through the coaching of the operating personnel of the nuclear facility, and by providing appropriate procedures and guidelines.

Various spread and dose calculation tools have been used to assess the radiation exposure to the population resulting from potential releases of radioactive substances during Fennovoima's project. The preliminary safety analysis report of Fennovoima's Hanhikivi 1 nuclear power plant demonstrates that the AES-2006 can be built so that the radiation exposure and probabilities of incidents remain below the limits and values presented in Table 4B-1.

For a more detailed description of the ability of the key safety functions of the AES-2006 to control various operational occurrences and accidents, see Appendix 4A of this application.

During the construction license application process, Fennovoima will submit to STUK the preliminary safety analysis report in accordance with section 35 of the Nuclear Energy Decree. The report will describe the provisions made by Fennovoima for the possibility of operational occurrences and accidents referred to in section 7 d of the Nuclear Energy Act.

Based on what has been stated above, Fennovoima considers that the principle of making provisions for the possibility of operational occurrences and accidents, set out in section 7 d of the Nuclear Energy Act, will be fulfilled.

Verification and assessment of safety

According to Section 7e of the Nuclear Energy Act, compliance with requirements concerning the safety of a nuclear facility must be reliably proven. The overall safety of the facility must be assessed at regular intervals.

As Fennovoima's nuclear power plant project proceeds, the overall safety of the nuclear power plant will be assessed during the construction license and operating license application processes as well as at maximum intervals of ten years during the operation of the power plant, in connection with operating license renewals or periodic safety reviews. Evidence of the appropriate safety of nuclear facilities as well as the technical solutions within the safety systems must be based on testing and calculations.

Fennovoima uses assessment methods and tools approved by STUK for the assessment of safety. STUK will follow its own guidelines to monitor the safety of the construction and operation of the nuclear power plant. During the construction license application process, Fennovoima will submit to STUK the preliminary safety analysis report in accordance with section 35 of the Nuclear Energy Decree. The report will include, among other sections, the safety analyses that describe the behavior of the plant during accidents, and the probabilistic risk assessment for the design phase. Fennovoima will maintain the analyses and provide additional detail to them with attention to operating experience, the results of experiments, plant modifications and the development taking place in calculation methods.

When applying for an operating license for the nuclear power plant, Fennovoima will finalize the plant's final safety analysis report and submit it to STUK for approval. The final safety analysis report will then be kept up to date.

Based on what has been stated above, Fennovoima considers that the principle concerning the verification and assessment of safety set out in section 7 e of the Nuclear Energy Act will be fulfilled.

Construction and operation

Section 7 f of the Nuclear Energy Act requires that safety shall take priority during the construction and operation of a nuclear facility. The Nuclear Energy Act also states that the licensee is responsible for plant safety. The condition of the plant and the operating experience accrued must be systematically monitored and assessed.

An overall assessment of the safety of the nuclear power plant's design solutions will take place during the construction licensing phase. In the construction licensing phase, Fennovoima will review the design materials of the Hanhikivi 1 nuclear power plant, and ensure the safety of the plant's design solutions. After the review by Fennovoima, the materials are sent to STUK for approval. STUK will then provide a safety assessment for Fennovoima's nuclear power plant based on these materials.

Fennovoima will only deliver to STUK materials that, according to Fennovoima's estimate, can be used as the basis for constructing the nuclear power plant in a safe manner, and for granting a construction license for the plant. Some of the structures and equipment that are important for nuclear safety, such as the reactor pressure vessel, require very long manufacturing schedules. Before a construction license is granted, Fennovoima may request that STUK review and approve the design of these structures and equipment under section 55 of the Nuclear Energy Act. The approval of STUK can then be used as a basis for beginning the manufacture of equipment and structures that require a very long manufacturing schedule before a construction license is granted. However, section 55 of the Nuclear Energy Act states that no work on structures with an impact on nuclear safety shall begin at the plant site before a construction license is granted.

During the construction phase, Fennovoima and STUK will supervise the construction of the nuclear power plant and its safety at all stages of the work. As the holder of the construction license, Fennovoima will ensure that the plant will be constructed in accordance with safety requirements, using accepted plans and procedures. Fennovoima will also ensure that the plant supplier and the subcontractors that produce services and products important to safety operate in accordance with the safety requirements and understand the importance of the requirements. Fennovoima will ensure that only suppliers who possess the prerequisites for operations that meet the requirements, and who use clear quality management and assurance procedures, may take part in deliveries that have safety significance. Fennovoima has established procedures for the assessment, approval, supervising and steering of the suppliers of products that have safety significance. The procedures cover the entire supply chain and all the phases in the life cycle of the product. Fennovoima will submit the operational models for quality management and assurance, as well as the construction supervision plan, to STUK during the construction license application process.

An overall assessment of the safety of the completed nuclear power plant will take place during the operating license phase. The operation of the nuclear power plant must not begin until STUK has established that Fennovoima's nuclear power plant and operating organization meet the set safety requirements. For a more detailed description of the expertise available to Fennovoima and its organization in the licensing and construction phases, see Appendix 2A of this application. For an outline of the planned operating organization, see Appendix 2B. The nuclear power plant will be operated in accordance with the operational limits and conditions approved by STUK. Based on what has been stated above, Fennovoima considers that the principle concerning the priority of safety, set out in section 7 f of the Nuclear Energy Act, will be fulfilled.

Decommissioning

According to section 7 g of the Nuclear Energy Act, the design of a nuclear facility shall provide for the facility's decommissioning. The decommissioning plan must be kept up to date as provided in section 28 of the Nuclear Energy Act. When the operation of a nuclear facility has been terminated, the facility shall be decommissioned in accordance with a plan approved by STUK. Dismantling the facility and other measures taken for the decommissioning of the facility may not be postponed without due cause.

Decommissioning of the Hanhikivi 1 nuclear power plant will be taken into account already in the design phase of the plant. Appropriate design of the plant can reduce the volume of decommissioning waste that will require final disposal, as well as the radiation exposure of decommissioning workers. It can also efficiently prevent radioactive substances from escaping into the environment. In accordance with its financial provision obligation, Fennovoima will pay the funds required for the decommissioning of the nuclear power plant into the National Nuclear Waste Management Fund in advance as required by the nuclear energy legislation and the guides provided by the authorities. Fennovoima's financial provision obligation begins with the granting of the operating license for the nuclear power plant, after which Fennovoima will pay into the National Nuclear Waste Management Fund the annual fee intended for the decommissioning of the nuclear power plant.

During the construction license application process, Fennovoima will submit to STUK a plan for the decommissioning of the nuclear power plant, as required by section 35 of the Nuclear Energy Decree. Fennovoima will prepare the plan together with the plant supplier and keep it up to date as the project proceeds, as required by section 28 of the Nuclear Energy Act.

Based on what has been stated above, Fennovoima considers that the principle concerning the provision for the decommissioning of the plant set out in section 7 g of the Nuclear Energy Act will be fulfilled.

Nuclear material and nuclear waste

Section 7 h of the Nuclear Energy Act requires the nuclear power plant to have sufficient facilities, equipment and other arrangements in place to ensure the safe handling, treatment and storage of the nuclear materials needed by the plant and of any nuclear waste generated by its operations. Nuclear waste must be managed so that after disposal of the waste no radiation exposure is caused which would exceed the level considered acceptable at the time the final disposal is carried out. The disposal of nuclear waste in a manner intended as permanent shall be planned so that ensuring long-term safety does not require continuous surveillance of the final disposal site.

Appropriate facilities will be designed and built at the Fennovoima nuclear power plant for the safe handling and storage of fresh fuel, other nuclear materials and the nuclear waste generated at the plant.

Fresh nuclear fuel can be stored at the AES-2006 nuclear power plant at a dry storage facility for fresh fuel, located in the plant area, or in water-filled pools within the reactor building. The dry storage facility for fresh fuel will have room for approximately 200 fuel assemblies. During plant operation, the dry storage facility can be used to store the required nuclear fuel for four operating years, when necessary.

Spent nuclear fuel will be placed in racks in water pools in the reactor hall for storage. The planned storage capacity of the pools roughly corresponds to the fuel that will be used during ten years of operation. After this, the fuel will be transferred into the interim storage facility. To ensure the continued subcriticality of the fuel, the fuel racks will be manufactured from boron steel. The water in the pool and the concrete structures will act as radiation shields.

For an overall plan for nuclear waste management of Fennovoima's Hanhikivi 1 power plant, see Appendix 5B of this application. For an account of Fennovoima's plans for organizing the nuclear fuel management at the nuclear power plant, see Appendix 5A. As the project proceeds, Fennovoima will keep the nuclear waste management plans up to date as required by section 28 of the Nuclear Energy Act.

Based on what has been stated above, Fennovoima considers that the principle concerning nuclear material and nuclear waste set out in section 7 h of the Nuclear Energy Act will be fulfilled.

Personnel

Pursuant to section 7 i of the Nuclear Energy Act, the holder of the license granting the right to use nuclear energy (the licensee) must have a sufficient number of qualified personnel suitable for the related tasks. The licensee shall appoint persons responsible for ensuring emergency response arrangements, security arrangements and the control of nuclear material. Only persons approved by STUK specifically for each position can be appointed as the person responsible or the deputy. The appointment of responsible personnel is discussed in this appendix in section Responsible manager. The licensee must organize adequate training for maintaining and developing the expertise and skills of the personnel responsible for nuclear safety-related tasks.

The structure, management relationships and responsibilities of Fennovoima's organization are described in an organization manual that will be regularly updated. At an individual level, each employee will have a personal job description. The impact of any significant changes in the organization are assessed as specified in the organization manual.

Fennovoima will carry out recruitment, induction training and other training operations to ensure that it will have the appropriate organization for each phase of the project, and the adequate expertise to ensure safety, and that all employees working in various positions in the organization are aware of the safety significance of their work. Fennovoima will strongly increase the size of its organization in 2014 and 2016, when specialists are needed for steering and reviewing the design of the plant. Fennovoima particularly recruits experienced professionals from the nuclear energy industry and other industries.

Through induction training and continuous training of the personnel, Fennovoima will ensure that the personnel is familiar with the requirements of the nuclear energy field, and adopts and maintains a high safety culture. Fennovoima has developed procedures for the development of its personnel's competencies as required by the Nuclear Energy Act and the YVL Guides from STUK. Expertise within the organization is continuously developed in accordance with the personnel development plan and training plan. The adequate number and continuous development of the personnel who perform safety-critical tasks is regularly reviewed. During the construction license application process, Fennovoima will submit to STUK a resource plan that describes the required competencies and human resources by competence area. The resource plan will also include an account of how Fennovoima will acquire these resources.

For a more detailed description of Fennovoima's organization and the available expertise in the licensing phase, see Appendix 2A of this application.

Based on what has been stated above, Fennovoima considers that the principles concerning the licensee's personnel set out in section 7 i of the Nuclear Energy Act will be fulfilled.

Management system

Section 7 j of the Nuclear Energy Act requires that the management system of a nuclear facility shall pay particular attention to the impact that the safety-related opinions and attitudes of the management and personnel have on the maintenance and development of safety, alongside systematic operating methods and their regular assessment and development procedures.

Section 35 of the Nuclear Energy Decree requires that during the construction license application process, the applicant submits to STUK an account of quality management operations during the construction of the nuclear power plant. The document must include a presentation of the systematic procedures followed by the organizations participating in the design and construction of the nuclear power plant in any operations that influence quality. In addition, YVL Guide A.1 requires that the license applicant's quality manual for the construction stage describing the license applicant's management system procedures related to the control of safety and quality management shall be submitted to STUK for approval. The general requirements defined for the management system regarding the management of quality and safety are presented in YVL Guide A.3 from STUK.

Fennovoima's management system includes the procedures used in the assurance of nuclear and radiation safety, and in quality management. The management system establishes the processes and procedures that Fennovoima uses to define its safety and quality policies, targets of operations, and procedures for achieving those targets. One of the objectives of the management system is to develop and maintain a high level of safety culture. Responsibilities, the priority of safety, and the significance of openness are established, for example, in the nuclear safety policy included in Fennovoima's management system.

An appropriate safety culture means that safety takes precedence in all decision-making within the company, that the quality management requirements set for a function correspond to the safety significance of the function, and that project planning and project management are based on best practices and solid experience. In an appropriate safety culture, each employee has a good command of his or her own work and understands the importance of the safety culture for safety. Observed deviations and faults will be corrected. In its safety culture, Fennovoima emphasizes commitment, awareness, openness and continuous improvement. Maintenance of the management system includes the management team's review of the state and appropriate functionality of the system, carried out every six months or more frequently.

During the construction license application process, Fennovoima will submit to STUK the descriptions of quality management during construction and the procedures included in the management system in accordance with section 35 of the Nuclear Energy Decree and YVL Guide A.1.

Based on what has been stated above, Fennovoima considers that the principles concerning the management system set out in section 7 j of the Nuclear Energy Act will be fulfilled.

Responsible manager

Section 7 k of the Nuclear Energy Act states that the licensee must appoint a responsible manager and his or her deputy for the construction and operation of the nuclear facility. A person who has consented to occupy the position and who has been approved for the role by STUK can be appointed as responsible manager. It is the responsible manager's task to ensure that the provisions, license conditions and STUK regulations concerning the safe use of nuclear energy, the arrangements for security and emergencies, and the control of nuclear materials are complied with.

Fennovoima defines the position and authority of the responsible manager so that the appointed person has the actual authority to match the responsibilities. Other responsible persons will be able to report directly to the responsible manager.

During the construction license application process, Fennovoima will appoint a responsible manager for the construction phase as referred to in section 7 k of the Nuclear Energy Act, as well as the persons responsible for security and emergency arrangements and the control of nuclear material, and their deputies. To ensure fulfillment of the requirements set out in YVL Guide A.4, Fennovoima will prepare induction programs for each of these persons.

Fennovoima will appoint the responsible persons for the construction phase and subject them for STUK's approval before a construction license is granted. Similarly, Fennovoima will appoint the persons responsible during the operating phase and apply for STUK's approval for them before an operating license is granted. To verify the appropriate competence of the candidates for these positions, STUK will organize an evaluation event to assess the performance of a single candidate named by Fennovoima.

Based on what has been stated above, Fennovoima considers that the principles concerning the responsible manager, set out in section 7 k of the Nuclear Energy Act, will be fulfilled.

Security arrangements

Based on section 7 l of the Nuclear Energy Act, arrangements for security during the use of nuclear energy shall be based on threat scenarios involved, and analyses of the need for protection. A nuclear facility shall have an adequate number of security personnel trained in the planning and implementation of arrangements for security, and for securing the transport and storage of nuclear material and nuclear waste (security organization). The tasks and training requirements of the security organization and security personnel shall be defined and they shall have monitoring equipment, communication equipment, protective equipment and forcible means equipment available as required for their tasks. This forcible means equipment shall be proportioned to the threat scenarios and protection needs involved, so that it is suitable for the purpose. Measures belonging to the regular security control of a nuclear facility shall be appropriately communicated to the employees of the nuclear facility and other people transacting business within the nuclear facility site.

In addition to section 7 l of the Nuclear Energy Act, more detailed requirements set for security arrangements have been defined in sections 7 m (security control), 7 n (preparation for prevention of unlawful action) and 7 o (use of forcible means) of the same Act.

For a more detailed description of Fennovoima's security arrangements, see section Security and emergency response arrangements and other comparable arrangements in this appendix.

During the construction license application process, Fennovoima will submit to STUK the preliminary plans for the nuclear facility's security arrangements, as required by section 35 of the Nuclear Energy Decree. Fennovoima will also submit to STUK an account of the security arrangements to be used during the nuclear power plant's construction phase. The account will include the descriptions of the security organization and the principles of security arrangements. Instructions for the implementation of security arrangements will be attached to the document. As the project proceeds, Fennovoima will update the security arrangement documentation as required by the Government Decree on the Security in the Use of Nuclear Energy.

Based on what has been stated above, Fennovoima considers that the principles concerning security arrangements set out in section 7 l of the Nuclear Energy Act will be fulfilled.

Emergency response arrangements

Section 7 p of the Nuclear Energy Act requires that the planning of emergency response arrangements for the use of nuclear energy is based on analyses of operational occurrence and accident conditions, and the consequences assessed on the basis of these analyses. The emergency response arrangements of the nuclear power plant mean Fennovoima's plans to prevent and restrict damage that could take place in the environment of the nuclear power plant in any emergency conditions. The nuclear facility shall have persons trained in the planning of emergency response arrangements and emergencies (emergency response organization), whose duties shall be specified and who shall have access to the facilities, equipment and communication systems required for their duties. Emergency response arrangements shall be consistent with the rescue and preparedness plans drawn up by the authorities, considering the provisions laid down in section 9 of the Rescue Act (468/2003).

For a more detailed description of Fennovoima's emergency response arrangements, see section Security and emergency response arrangements and other comparable arrangements in this appendix.

During the construction license application process, Fennovoima will submit to STUK the preliminary plans for the nuclear facility's emergency response arrangements, as required by section 35 of the Nuclear Energy Decree. Fennovoima will also prepare the emergency response plan required by section 36 of the Nuclear Energy Decree, as well as practical procedures and other documents, guidelines and support materials related to operations during an emergency response situation. As the project proceeds, Fennovoima will update the documentation for emergency response arrangements as required by the Government Decree on Emergency Response Arrangements at Nuclear Power Plants.

Based on what has been stated above, Fennovoima considers that the principles concerning emergency response arrangements set out in section 7 p of the Nuclear Energy Act will be fulfilled.

Nuclear fuel and nuclear waste management at the nuclear power plant
Appendix 5A

Nuclear fuel management plan

Summary

As required by section 32, paragraph 9 of the Nuclear Energy Decree (161/1988), this appendix includes a description of the applicant's plans for arranging nuclear fuel management.

In December 2013, Fennovoima signed a fuel supply contract with JSC TVEL, which is a part of the Rosatom Group. The fuel supply will cover the delivery of uranium and the manufacture of fuel. In addition to the initial core loading, the contract also covers reload batches for the following eight fuel cycles. Furthermore, the contract includes a safety stock of nuclear fuel adequate for two reload batches. Fennovoima has made a preliminary decision to use reprocessed uranium at its nuclear power plant for the first operating years. Reprocessed uranium is not essentially different from natural uranium, and its operating characteristics are similar to those of fuel manufactured from natural uranium.

According to the fuel supply contract signed in December 2013, Fennovoima may also test alternative fuel assemblies in its reactor during the contract period. After the expiration of the contract, Fennovoima will be able to tender its fuel supply. Euratom Supply Agency, the European Union's nuclear fuel agency, approved the fuel supply contract between Fennovoima and TVEL in April 2014.

Nuclear fuel management plan

Nuclear fuel procurement and security of supply

Procurement of nuclear fuel

Nuclear fuel management at a nuclear power plant must be arranged so that the supply of nuclear fuel to the nuclear power plant is ensured throughout the planned service life of the plant, and so that the design, production, transportation and storage of nuclear fuel is properly controlled to ensure appropriate quality and safety.

In connection with the plant supply contract signed in December 2013, Fennovoima also signed a contract with JSC TVEL, a part of the Rosatom Group, on the delivery of nuclear fuel to the power plant. The fuel contract covers fuel deliveries for the plant's first fuel cycle as well as reload batches for the following eight years. The contract also includes a safety stock adequate for two reload batches. The fuel delivery will be an integrated delivery, which means that it covers the manufacture of fuel assemblies, delivery of uranium, and related services. Fennovoima has made a preliminary decision to use reprocessed uranium fuel during the first operating years. The contract signed provides Fennovoima with the option of choosing to use natural uranium instead of reprocessed uranium. Euratom Supply Agency, the European Union's nuclear fuel agency, approved the fuel supply contract between Fennovoima and TVEL in April 2014.

The current contract allows Fennovoima to test alternative fuel assemblies in its reactor during the contract period. The testing will enable Fennovoima to carry out full tender process on nuclear fuel deliveries after the contract expires.

Integrated fuel deliveries may then continue, in which case one supplier will manage both the procurement of uranium and the manufacture of the fuel assemblies, or separate contracts may be signed with different suppliers for fuel fabrication, enrichment and conversion services as well as the procurement of uranium.

Fuel manufacturing services for Rosatom's plant types are currently available in Russia and Sweden. Raw uranium is mined in Asia, Australia, Africa and North America. Fuel from secondary sources is also available, such as the reprocessed uranium currently chosen by Fennovoima. Isotopic enrichment services are available in Europe, Russia and North America.

Globally, there are both sufficient nuclear fuel raw materials and enough service providers available for Fennovoima to secure fuel deliveries to the nuclear power plant throughout its entire service life.

As the price of the nuclear fuel plays a minor role in the total production costs of electricity, typically comprising around 10% of the total costs, any changes in uranium prices, which constitute approximately 70% of the fuel costs, have no major significance for the overall nuclear power production costs or the profitability of nuclear power plant projects. Changes in the cost of fuel assembly manufacturing will have an even smaller impact.

Fennovoima will carry out the appropriate procedures to ensure that the necessary safeguards to prevent nuclear proliferation are implemented in accordance with Finnish legislation and international agreements.

Security of supply

Nuclear power plants usually stock enough fuel for one year's operation. When required for reasons of security of supply, nuclear fuel can easily be stocked for longer periods of operation. To ensure continued power production during any fuel supply disturbances, Fennovoima plans to maintain a safety stock adequate for two reload batches for at least the first operating years of the nuclear power plant. After stable operating routines have been established, the safety stock may be reduced to the recommended level, currently corresponding to approximately seven months' production operation.

Structure of the fuel assembly

The Rosatom AES-2006 pressurized water reactor uses uranium oxide fuel with a maximum enrichment of 5%. Fuel pellets are packed into zirconium rods, which are bundled into fuel assemblies. One fuel assembly contains 312 fuel rods. The reactor core contains a total of 163 fuel assemblies and 121 control rods. One quarter of all fuel assemblies are replaced in the annual maintenance outage. The AES-2006 reactor uses hexagonal fuel assemblies (Figure 5A-1). For a more detailed description of the technology of the AES-2006 nuclear power plant, see Appendix 4A of this application.

Figure 5A-1. A fuel assembly of the AES-2006 nuclear power plant.

Uranium requirement

The nuclear fuel has been enriched from the natural uranium content of 0.7% to 3–5% of isotope U-235. The annual fuel consumption of a nuclear power plant with an electrical output of 1,200 MW is in the range of 20–40 tonnes of enriched uranium. To produce the required amount of fuel, an annual supply of 200–350 tonnes of natural uranium would be required.

The global production volume of natural uranium was approximately 56,000 tonnes in 2014. The top uranium-producing countries included Kazakhstan, Canada and Australia, which together produced two thirds of all uranium available on the global market. The global need for uranium for nuclear power plants is expected to be approximately 67,000 tonnes in 2015. The uranium market is expected to increase significantly in the next ten years (WNA 2015a, 2015b).

There are sufficient known global uranium resources to satisfy the needs of nuclear power plants based on current light water reactor technology for at least the next 90 years. Estimated additional resources are also significant. As an alternative to natural uranium, fuel can be manufactured using secondary sources such as reprocessed uranium. In addition to Russia, reprocessed uranium is also produced in France, for example, and it is available on the global market in minor quantities.

Transportation and storage of nuclear fuel

The annual fuel consumption of nuclear power plants is very low in terms of mass compared to the fuel consumption of power plants based on other fuels. For example, a coal-fired condensing power plant consumes around 100,000 times more fuel mass per unit of electrical power generated than a nuclear power plant. Correspondingly, the volumes of nuclear fuel transported to power plants are very low.

All the intermediate products in the nuclear fuel production chain, from uranium ore to nuclear fuel assemblies, are very weakly radioactive. Nuclear fuel is transported by specialized transportation companies with the required skills, appropriate equipment and permits issued by the authorities supervising the operations.

The fuel supplier will manage the transportation of fuel assemblies to the plant location. Annual fuel transportations will take place by air, road, rail or sea, or as a combination of these. The transportation arrangements and the design of the transportation containers will comply with Finnish legislation and international recommendations (such as the recommendations of the IAEA). The purpose of the regulations is to protect people and the environment from radiation during the transport of radioactive materials. Fennovoima will acquire the necessary permits and approvals for the import and transportation of nuclear fuel. The transportations will be covered by nuclear liability insurance.

Fresh nuclear fuel can be stored at the AES-2006 plant at a dry storage facility for fresh fuel, located in the plant area, or in water-filled pools within the reactor building. The dry storage facility will have room for approximately 200 fuel assemblies. During plant operation, the dry storage facility can be used to store the required nuclear fuel for four operating years, when necessary.

For a more detailed description of the management of spent nuclear fuel, see Appendix 5B of this application.

Quality control of nuclear fuel management and minimization of the environmental impact

Quality management and control

The fuel supply contract signed by Fennovoima requires that the nuclear fuel supplier meets the requirements set out in Finnish legislation (Nuclear Energy Decree 161/1988) and the YVL Guides from the Radiation and Nuclear Safety Authority (STUK). The fuel supplier's quality system must be certified according to the ISO 9001:2008, ISO 14001:2004 and ISO 14004:2004 standards, as well as the OHSAS 18001:2007 standard, and it must be under continuous development. In addition, the fuel supplier must fulfill the requirements of IAEA safety standard GS-R-3 (The Management System for Facilities and Activities: Safety Requirements). The fuel supplier shall ensure that all the subcontractors used in the fuel manufacturing and transportation chain fulfill the quality and safety requirements listed above.

Quality assurance operations related to the manufacture of nuclear fuel are based on audits and quality supervision performed by external specialists and Fennovoima, including the monitoring of testing and inspection results. Fennovoima shall perform the applicable audits of the entire fuel manufacturing chain, monitor the manufacture of the fuel, and ensure that the quality requirements defined for the final product are fulfilled. The nuclear fuel manufacturing process must also meet the requirements set by the national safety authority of the country where the manufacture takes place.

Minimization of the environmental impact

Fennovoima will take into account the environmental impact of the entire nuclear fuel management process. Fennovoima requires companies operating within the nuclear fuel manufacturing chain to implement a certified environmental management system or other verifiable indication that the environmental impact of their operations is monitored and remains at an acceptable level.

For a more detailed description of the environmental impact of the various phases of nuclear fuel management, as well as an account of the means to limit the environmental stress, see the project's environmental impact assessment report.

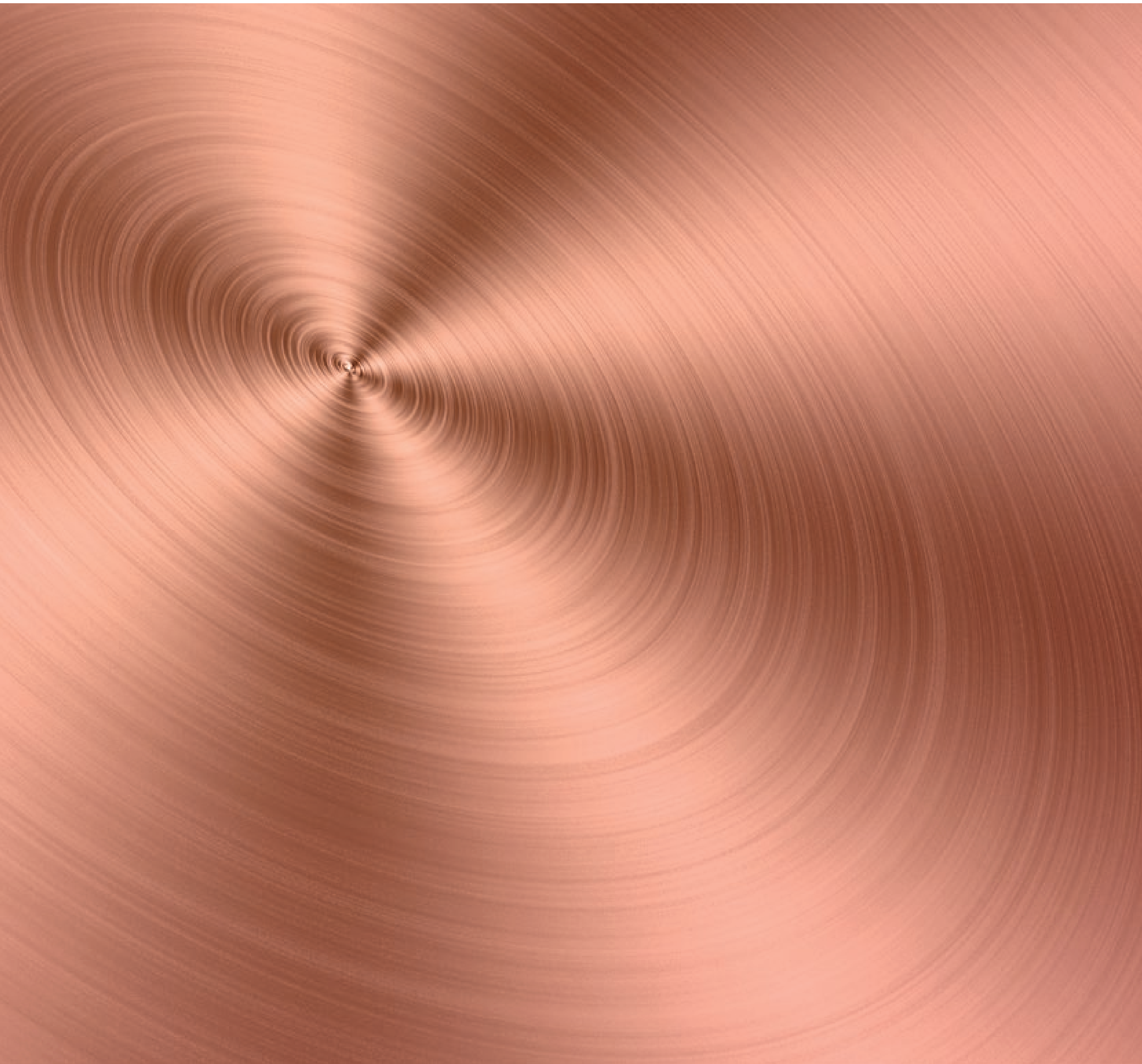
References

WNA 2015a. World Uranium Mining Production. World Nuclear Association. http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Mining-of-Uranium/World-Uranium-Mining-Production (Accessed May 22, 2015).

WNA 2015b. Uranium Markets. World Nuclear Assosiaction, helmikuu 2015. http://www.world-nuclear.org/info/nuclear-fuel-cycle/uranium-resources/uranium-markets (Accessed May 22, 2015).

Nuclear fuel and nuclear waste management at the nuclear power plant
Appendix 5B

Overall nuclear waste management plan



Summary

As required by section 32, paragraph 10 of the Nuclear Energy Decree (161/1988), this appendix includes a description of the applicant's plans and available methods for arranging nuclear fuel management, including the decommissioning of the nuclear facility and the disposal of nuclear waste, and a description of the timetable of nuclear waste management and its estimated costs. This appendix also constitutes a response to the requirement presented in the decision-in-principle granted on May 6, 2010 that Fennovoima must submit a further specification of its nuclear waste management plans in connection with the construction license application.

Fennovoima estimates that during its 60 years of service life, the Fennovoima nuclear power plant will generate approximately 5,400 m^3 of low and intermediate level reactor waste packaged for final disposal, 17,000 m^3 of decommissioning waste, and spent nuclear fuel equivalent to between 1,200 and 1,800 tonnes of uranium.

Sufficient facilities, equipment and other arrangements will be planned and constructed to ensure the safe handling, treatment and storage of the nuclear materials needed by the plant and of the nuclear waste generated by its operations. Low and intermediate level reactor waste and the low and intermediate level decommissioning waste will be treated, stored and finally disposed of at the plant site on the Hanhikivi headland in Pyhäjoki. The spent nuclear fuel generated during the operation of the plant will also be placed in interim storage at the plant site.

The final repository for low and intermediate level reactor waste to be built in the plant area for the final disposal of the reactor waste and decommissioning waste will consist of an underground final repository and the related facilities, and a near surface landfill repository for very low level waste. According to preliminary geological investigations ordered by Fennovoima in 2014, no such factors have been revealed at the plant site that would prevent the construction of a final repository for low and intermediate level reactor waste.

The landfill repository will begin operations approximately two years after the commissioning of the power plant. Construction and operating licenses for the underground reactor waste repository, the VLJ repository, will be applied for separately, and the facility is estimated to begin operations in 2035.

The spent nuclear fuel generated during plant operations will be stored in water pools in the reactor building for 3–10 years after removal from the reactor. After this, the spent nuclear fuel will be transferred to an interim storage facility within the power plant area for several decades. The facility may be either a pool storage or a dry storage facility. Fennovoima is now applying for a construction license for both interim storage methods. The interim storage facility is expected to be commissioned in 2030.

The spent nuclear fuel generated at Hanhikivi 1 will be disposed of in Finnish bedrock using the KBS-3 method developed in Sweden and Finland. As required by the decision-in-principle granted in 2010, Fennovoima must either present an agreement of nuclear waste management cooperation or launch an environmental impact assessment procedure for its own final disposal facility by the end of June 2016. According to current plans, final disposal of spent nuclear fuel will begin in the 2090s. The final disposal schedule will, however, be further specified once the final disposal solution has been established.

The decommissioning of the nuclear power plant is planned to be carried out in accordance with the immediate dismantling strategy. It has been estimated that the nuclear power plant will be decommissioned and completely dismantled by 2100. After this, the part of the plant site in which the nuclear power plant and its auxiliary buildings were located can be released from control by the Radiation and Nuclear Safety Authority (STUK).

Fennovoima's waste management plans are based on methods proven to be safe and appropriate for nuclear waste management in Finland.

Overall nuclear waste management plan

Management of low and intermediate level nuclear waste

Low and intermediate level nuclear waste, known as reactor waste or operating waste, is generated during the operation and dismantling of a nuclear power plant. Reactor waste includes the radioactive waste accumulated during the plant's service life, excluding spent nuclear fuel, decommissioning waste or highly activated metal waste such as reactor internals. Operating waste is generated during the normal operation of the plant in tasks such as the handling of radioactive liquids and gases, and maintenance and repair work carried out in the controlled area. The controlled area refers to the area within the nuclear power plant where special safety regulations are enforced with respect to radiation protection and prevention of the spread of radioactive contamination. Access to the area is controlled.

Reactor waste is divided into very low level, low level and intermediate level waste based on the radioactivity concentration, in accordance with the Nuclear Energy Decree (161/1988) and YVL Guide (regulatory guide on nuclear safety) D.4. The very low and low level waste mainly consists of insulation material, paper, old protective clothing, machine parts, plastic and oil, i.e. regular maintenance waste. Intermediate level waste mainly consists of ion exchange resin from process water purification systems and evaporation waste created in sewage water treatment. Table 5B-1 contains the classification of waste based on average radioactivity concentration.

A 1,200 MW AES-2006 power plant is estimated to produce approximately 5,300 m^3 of very low, low and intermediate level reactor waste during its 60 years of service life. In addition to its radioactivity classification, reactor waste is classified into dry and wet waste based on its physical characteristics. Dry waste is further classified into compressible and non-compressible waste. Table 5B-2 presents an estimate of the division of the waste volume into various waste types.

Treatment and storage of reactor waste

According to section 7(h) of the Nuclear Energy Act (990/1987), a nuclear facility shall have the facilities required for the handling and storage of radioactive waste. The reactor waste treatment and storage facilities will be located in the power plant area and in connection with the power plant. Their licensing will be carried out as part of the power plant licensing procedure. For treatment and storage, reactor waste is divided into solid and wet waste.

Whenever possible, solid radioactive waste generated at the power plant will be sorted at the location of generation. Sorted waste will be removed from the location of generation without

Table 5B-1. Classification of reactor waste based on average radioactivity concentration.

Category	Average activity concentration	Required radiation protection
Very low-level waste	under 0.1 MBq/kg	Can be handled without special radiation protection
Low-level waste	under 1 MBq/kg	Can be handled without special radiation protection
Intermediate level waste	under 10 GBq/kg	Handling requires effective radiation protection

Table 5B-2. An estimate of the volumes of very low, low and intermediate level waste generated by the AES-2006 annually and over the operating life of 60 years (after treatment and packing).

Dry waste	[m³/year]	[m³/60 years]
Compressible		
Very low-level	4.9	294
Low-level	8.4	504
Intermediate level	4	240
Incompressible		
Very low-level	4.8	288
Low-level	10.5	630
Intermediate level	3.6	216
Total (dry waste)	**36.2**	**2,172**
Wet waste	**[m³/year]**	**[m³/60 years]**
Ion-exchange masses		
Very low-level	-	-
Low-level	25.7	1,542
Intermediate level	27.1	1,626
Total (wet waste)	**52.8**	**3,168**
Total (all)	**89**	**5,340**

delay. The solid waste collection, treatment and storage facilities are designed with attention to the radioactivity level of the waste and the appropriate treating methods.

Solid waste

The solid waste treatment facility will have a dedicated clean facility for the clearance of waste from regulatory control. Waste that does not need to be treated, stored and finally disposed of as radioactive waste in accordance with radiation safety principles can be released from control. The basic radiation safety requirement observed in the clearance procedure is that the annual dose from the materials cleared from one nuclear power plant to the general population or the personnel working at the waste processing site does not exceed 10 μSv. For example, some of the resins generated in the water treatment processes have such low activity levels that they can be dried and released from control. Waste released from control will no longer be considered reactor waste, and it can be disposed of or re-used as raw material or an energy source like ordinary waste.

For storage or final disposal, solid low and intermediate level reactor waste will be packed in 200-liter drums which facilitate the transfer of the waste, prevent the spread of radioactive contamination, and reduce the risk of fire. Very low level waste is baled or, alternatively, packed in suitable containers such as drums or freight containers. Before waste is packed in the storage or disposal vessels, its volume will be decreased by compaction or mechanical or thermal cutting.

Compaction typically reduces the volume of the waste to half or even one tenth of the original volume. The tight packing will improve the characteristics of the waste with respect to final disposal. The spreading of contamination will be prevented by equipping the processing equipment with suction or filtering for exhaust air, or by using a processing method that does not generate dust. Packed solid waste will be stored in a solid waste storage facility within the power plant area before being transferred to the low and intermediate level waste repository to be constructed at the plant site. Very low level waste will be disposed of in a landfill repository.

Wet waste

Wet and liquid radioactive waste, such as ion exchange resins, sludge materials, and concentrates will be processed by drying. Wet waste will be solidified by mixing it with a binding agent such as cement to create hard units that can be safely handled and disposed of. Dried or solidified wet waste will be packed in 200-liter drums for storage and final disposal. The packed drums will be stored in the low and intermediate level waste storage facility before being disposed of in the low and intermediate level waste repository.

Storage process

The low and intermediate level waste storage facility will have separate areas for low and intermediate level waste. Packed waste will be stored under supervision in a solid waste storage building within the plant area. The storage building will be located in the immediate vicinity of the waste processing facilities. According to current plans and waste volume estimates, storage capacity will be adequate for approximately ten years, after which the final disposal of reactor waste must begin at the latest.

Final disposal of reactor waste

A repository for low and intermediate level waste will be built at the nuclear power plant site in accordance with the decision-in-principle. The total activity of the nuclear waste to be disposed of in the repository will exceed 1 TBq (terabecquerel), which makes it extensive final disposal of nuclear waste as referred to in section 6 of the Nuclear Energy Decree. In accordance with the Nuclear Energy Act, the reactor waste repository will be a separate nuclear facility for which separate construction and operating licenses shall be applied in the 2020s and 2030s.

The low and intermediate level waste repository will consist of an underground final disposal facility and the auxiliary facilities, buildings and structures closely related with the operations of the repository. Based on section 22 of the Government Decree on the Safety of Disposal of Nuclear Waste (736/2008), very low level waste can be disposed of in a landfill repository constructed in the soil instead of the bedrock.

Landfill type repository for very low level waste

Fennovoima will construct a landfill repository to surface for very low level waste (average activity concentration < 100 kBq/kg). Based on estimated waste volumes, the capacity of the landfill repository will be approximately 1,500 m^3, requiring an area of approximately 400 m^2. The landfill repository will be later expanded to accommodate for the very low level decommissioning waste. An action permit for constructing a surface repository will be applied from STUK in 2024, and the facility will be commissioned in 2026. At a later stage, the landfill repository will be included in the construction and operating license of the low and intermediate level waste repository.

A landfill repository is an above-ground structure in which the waste is loaded on a concrete slab. Any leakage water is recovered from the surface of the slab. Alternatively, the surface repository can be constructed on a well-insulated base which admits the flow of leakage water, while the release barrier retains contaminants. In either case, the landfill repository will be completely or nearly completely insulated by means of waterproof surface layers (clay or geotextile layers). Releases are thus prevented by the concrete slab or a release barrier installed beneath the base.

The repository will be ready for operation when the base layer is ready and the construction of transportation access ways and systems (e.g. the groundwater measuring system) is completed. Following the final sealing of the repository, it will be actively monitored until the radioactivity of the disposed waste has been reduced to an insignificant level. According to a preliminary estimate, this will occur some 50–60 years after the final sealing of the facility.

After the end of the active monitoring period, the monitoring of the area will be continued, and the preservation of the information concerning the repository, the guard fences, and outdoor identification signs will be ensured (passive monitoring).

Final disposal of low and intermediate level waste

For the final disposal of low and intermediate level waste, Fennovoima will build a repository (VLJ repository) in the bedrock at the plant site, at a depth of approximately 60–100 meters. The final depth of the repository will be confirmed based on the geological characteristics of the bedrock and it may be either a rock silo or a tunnel. Of these two alternatives, the most likely solution is a tunnel-type repository where waste is transported via a vehicle access tunnel. Bedrock will function as the primary release barrier of radionuclides. If necessary, the waste canister and the cement used as a binding agent in the solidification process will also function as release barriers. Other technical release barriers, such as concrete structures, may also be used, particularly in the intermediate level waste repository.

Fennovoima carried out the preliminary geological investigations for the low and intermediate level waste repository site alternatives in the Hanhikivi headland in 2014. The results of the investigations reveal no factors that would preclude the construction of a repository in the Hanhikivi headland. Based on the estimated waste volumes, the total capacity of the repository will be approximately 3,200 m^3 of low level waste and approximately 2,700 m^3 of intermediate level waste. The respective tunnel volumes will be 5,200 m3 and 6,900 m^3. The repository for low and intermediate level waste will also be designed to accommodate the nuclear power plant decommissioning waste. According to preliminary estimates, the volume of the decommissioning waste facilities will be approximately 17,000 m^3.

The area reservation for the low and intermediate level waste repository has been entered into the land use plans for the nuclear power plant area. Land use plans for the nuclear power plant are described in Appendix 3C (Figure 3C-2). A first draft of the operating waste repository layout plan has also been prepared (Figure 5B-1) based on preliminary investigations results.

According to Fennovoima's estimate, a construction license as referred to in the Nuclear Energy Act will be sought for the low and intermediate level waste repository in 2028. The construction of the repository would thus begin in 2030 and operation in 2035. In the years preceding the construction license application, detailed bedrock investigations shall be carried out at the repository site, and the layout and detailed planning of the repository will be completed. The safety assessment documentation required for the construction license application will also be prepared, as well as a research and monitoring program for the construction period.

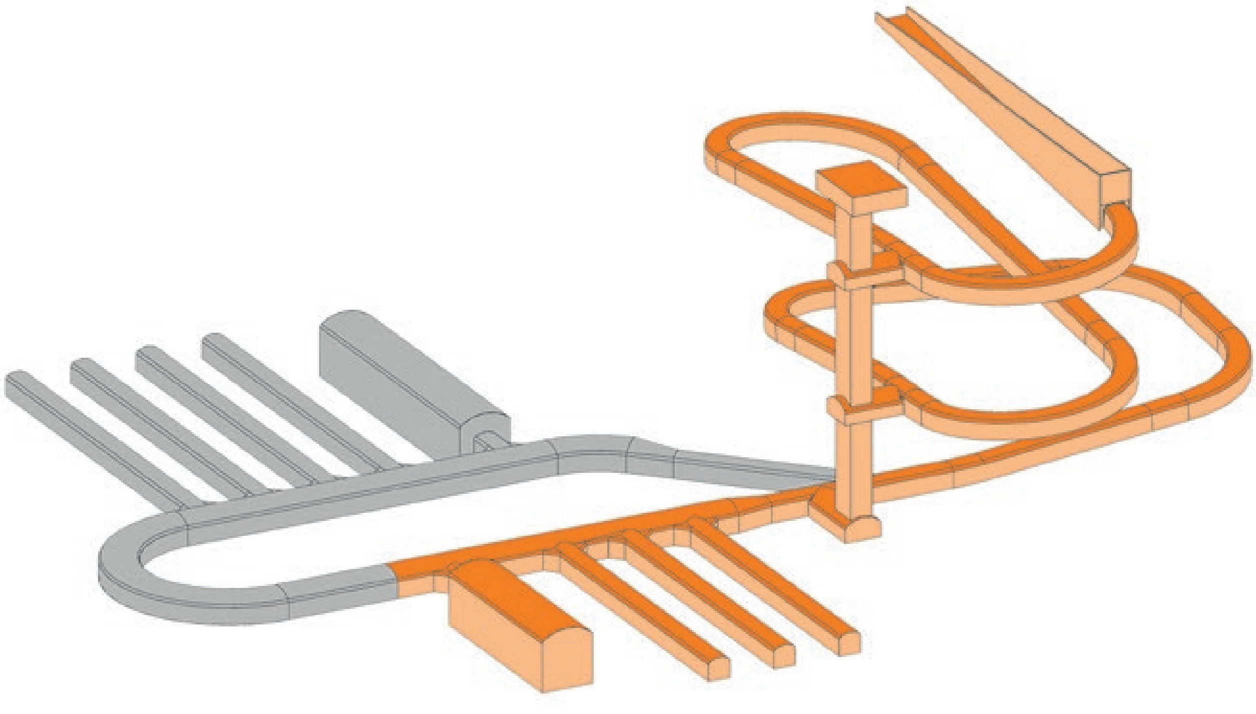


Figure 5B-1. Preliminary layout for the low and intermediate level repository. The operating waste facilities are indicated in orange and the decommissioning waste facilities to be excavated at a later stage in gray.

Management of spent nuclear fuel

The thermal output of Fennovoima's AES-2006 nuclear power plant will be approximately 3,220 MW. About 20–30 tonnes of spent fuel will be removed from the reactor of the nuclear power plant each year. During the 60 years of operation of the nuclear power plant, spent nuclear fuel equivalent to between 1,200 and 1,800 tonnes of uranium will be generated.

Treatment and interim storage of spent nuclear fuel

Following removal from the reactor, the spent fuel assemblies will be transferred to the reactor hall water pools, where they will be allowed to cool for 3–10 years. The radioactivity and, simultaneously, heat production of the fuel will decrease rapidly during the first year after removal from the reactor. From the reactor hall, the spent fuel will be taken in transport containers to interim storage for spent nuclear fuel, where it will remain for several decades prior to final disposal. During the interim storage period, the activity and heat generation of the spent fuel will continue to decrease significantly.

In its decision-in-principle application, Fennovoima stated that it will carry out the interim storage of spent nuclear fuel using either the pool storage or the dry storage method. Both storage methods can be constructed to meet Finnish safety regulations. Fennovoima has carried out investigations concerning the volume of waste requiring interim storage, the length of the interim storage period, the expansion capacity of the storage facilities, safety and financial feasibility, aimed at the selection of an interim storage method.

The suitability of various interim storage methods for Fennovoima's final disposal alternatives, as well as the financial feasibility of the methods, require further investigation. For this reason, Fennovoima is now applying for a construction license for both interim storage methods, and will supplement the construction license application materials, to be submitted to STUK, by the end of 2015 with a requirement specification for both methods, as well as an account of the fulfillment of the safety requirements related to interim storage operations. In addition, Fennovoima will submit an interim storage facility licensing plan to STUK for information, also by the end of 2015.

Based on preliminary investigations, the reprocessed fuel chosen by Fennovoima will require a slightly longer cooling period than conventional nuclear fuel manufactured from raw uranium. This must be taken into account when selecting, designing and using an interim storage method.

The detailed technical design documents for the interim storage facility for spent nuclear fuel will be submitted to STUK for approval no earlier than in 2020. Independent of the storage method selected, the construction of the on-site interim storage facility will begin around 2025. The interim storage facility will be built to the same elevation as the nuclear power plant, and the construction will take 3–6 years depending on the storage concept selected. The location of the interim storage facility is presented in Appendix 3C of this application.

An operating license for the interim storage facility for spent nuclear fuel will be applied for together with the operating license of the nuclear power plant, and the facility is estimated to be commissioned around 2030.

Wet interim storage facility

Wet-pool-type interim storage facilities have been in operation for more than 30 years in several countries. In Finland, this storage type is used at both Olkiluoto and Loviisa nuclear power plants. There are several alternative design options for interim storage pools, but all share the feature of storing spent fuel in water-filled pools in vertical orientation, supported by racks. The temperature of the water is normally kept below 40 °C. The water quality is monitored, and chemical impurities and radioactivity are continuously removed.

Fuel racks are usually manufactured from boron steel. The purpose of the boron steel and the structure of the fuel rack is to ensure the subcriticality, integrity and efficient cooling of the fuel. Furthermore, the purpose of the fuel racks is to prevent fuel assemblies from coming into contact with materials that could cause galvanic corrosion. The racks shall be designed to withstand design basis accidents such as earthquakes.

The water in the interim storage pools acts as a coolant and radiation shield. The heat from the fuel assemblies transfers into the ion-exchanged cooling water, which is in direct contact with both the fuel assemblies and heat exchangers. Air or a large water source such as the sea acts as the heat sink. Cooling of the pools may be passive, with heat transfer based on natural circulation, or active, with forced heat transfer from the water to the final heat sink using, for example, pumps.

Radiation protection in the pool-type interim storage facility is based on all fuel handling, inspection and transfer operations taking place under water. Fuel assemblies are covered by several meters of water, which will provide adequate radiation protection for operating personnel. The activity level in the interim storage facility will be monitored by continuous measurements.

The pool-type interim storage facility for spent nuclear fuel is a nuclear facility, and it must be designed in accordance with the same safety principles as nuclear power plants. The safety concept is based on the application of several consecutive barriers. The adequacy of the barriers shall be ensured during the design phase. Similarly to a nuclear power plant, the availability of cooling water in all possible operating and abnormal conditions shall be secured using independent methods. A pool-type interim storage facility is a structure closely connected with the nuclear power plant, and typically receives its process water from the nuclear power plant. It also requires actively operating process systems such as water purification systems.

Dry interim storage facility

Dry interim storage technology has been significantly developed during the last 25–30 years. Several different methods are currently being used in many countries, but not yet in Finland. The storage casks used in dry storage can be filled with air, nitrogen or inert gas. To avoid oxidization of the cladding, its temperature must not rise above 150 °C when using air storage. In inert gas, the temperature of the cladding must not rise above 350–400 °C to avoid oxidization as well as creep damage.

Of the available dry interim storage methods, Fennovoima is primarily considering the construction of a dry cask storage facility. In a dry cask storage facility, fuel assemblies are packed into commercially available interim storage casks that will be stored in a vertical position in a separate storage building. Some of the commercially available interim storage casks are also suitable for transportation, which will reduce the necessary fuel handling stages compared with the pool storage method. Interim storage casks act as the necessary radiation barrier and are able to withstand an aircraft crash. Cooling of the fuel is based on natural air circulation, and no process systems are required to secure cooling. Subcriticality of the fuel is ensured by the use of appropriate materials and the structure of the storage cask. The storage building must be equipped with continuously operating radiation measurements.

Similarly to a pool-type interim storage facility, dry storage must also be designed with attention to the design basis of a nuclear facility, and its safety must be based on the multiple barrier principle. A dry storage facility can be constructed as a fully independent structure, with no connection to the nuclear power plant process systems.

Transportation to the final disposal site

After the interim storage period, spent nuclear fuel is transported to the final disposal location in a transport cask. As transportation alternatives, sea, road and rail transportation or a combination of these are viable, depending on the location of the final disposal facility. Transportation of spent nuclear fuel will begin no earlier than in the 2090s, and will continue regularly until the end of the disposal operations. Permit procedures described in the YVL Guides published by STUK will be applied to the transportation of spent nuclear fuel.

Final disposal

The Government included in its 2010 decision-in-principle the condition that Fennovoima must develop its plan for the final disposal of spent nuclear fuel to the effect that by the end of June 2016, it will either have signed an agreement for the final disposal of spent nuclear fuel with the parties currently under the nuclear waste management obligation, or it will have prepared an environmental impact assessment program as referred to in the Act on Environmental Impact Assessment (468/1994) concerning its own final disposal facility for spent nuclear fuel.

Spent nuclear fuel from Fennovoima's nuclear power plant will be deposited in Finnish crystalline bedrock using the KBS-3 method developed in Finland and Sweden. In final disposal solutions according to the KBS-3 concept, the spent fuel is inserted into copper canisters at an encapsulation plant, surrounded with bentonite clay, and placed in deposition holes drilled deep in the bedrock. The final disposal schedule will be planned to allow the optimization of both the safety and the financial feasibility of the operations.

According to the overall plan for the final disposal of spent nuclear fuel, prepared after the decision-in-principle was granted, the optimal solution will be to carry out final disposal within a brief period of time. Fennovoima has estimated that spent nuclear fuel can be disposed of within approximately ten years, assuming that the encapsulation plant is able to complete an average of 100 copper canisters per year. The final repository will be open for as brief a period of time as possible, and its impact on the natural characteristics of the bedrock, and through them on the long-term safety of the repository, will remain as low as possible. In addition, this method will minimize the operating costs from final disposal operations.

Due to the factors mentioned above, Fennovoima has further specified its estimate of when the final disposal operations will begin. According to the current estimate, final disposal operations will not begin earlier than in the 2090s. Final disposal of spent nuclear fuel from the Hanhikivi 1 nuclear power plant will be completed around 2105, after which the repository will be sealed.

As Fennovoima may still carry out final disposal of spent nuclear fuel in cooperation with the parties currently under the nuclear waste management obligation, independently by constructing its own final repository, or as a combination of these two alternatives, the final disposal schedule presented above shall be further specified after the final disposal solution is established before the end of June 2016, and at later stages in connection with the final disposal licensing procedure.

Final disposal cooperation with current operators

In March 2012, the Ministry of Employment and the Economy appointed a working group to control the joint studies of Finnish nuclear power companies on the available alternatives for storing spent nuclear fuel. The final report of the working group was published in January 2013. The working group stated that the most expedient and cost-effective way to proceed would be to utilize the expertise and experience accumulated in the final disposal project of the nuclear waste management company Posiva, and to aim for an optimal solution in the provision for future final disposal operations.

Fennovoima's primary objective is to negotiate an agreement concerning the final disposal of spent nuclear fuel with Posiva Oy's owners, Industrial Power Corporation (TVO) and Fortum Corporation, by the end of June 2016, thus securing the utilization of Posiva Oy's expertise in the implementation of Fennovoima's spent nuclear fuel disposal project.

If a final disposal cooperation agreement can be reached, the schedule and actions of Fennovoima's spent nuclear fuel disposal project will be updated together with Posiva Oy. If this alternative materializes, Fennovoima will supplement this construction license application with a cooperation contract on the final disposal of spent nuclear fuel by the end of June 2016.

Environmental impact assessment program for Fennovoima's own final repository for spent nuclear fuel

Fennovoima has begun preparations for an environmental impact assessment program for its own final disposal facility for spent nuclear fuel. Based on the investigations, a number of potential areas are to be selected as possible locations for Fennovoima's own final repository. Based on how the negotiations on final disposal cooperation with other operators proceed, a decision will be made on whether an environmental impact assessment program (EIA program) should be submitted.

If no agreement can be reached through negotiations on final disposal cooperation within the established period, Fennovoima will supplement this construction license application with an EIA program for its own final repository by the end of June 2016. The submission of the program will initiate a research phase of several years, during which the geological characteristics of the alternative repository locations will be surveyed and their suitability for final disposal operations investigated. The EIA report would be completed no earlier than in 2035. Fennovoima has set the objective of being able to select a location for the repository in the 2040s.

Decommissioning of the nuclear power plant

The decommissioning of the nuclear power plant is planned to be carried out in accordance with the immediate dismantling strategy. During the construction license application process, Fennovoima will submit the decommissioning plan required by section 35, paragraph 10 of the Nuclear Energy Decree (161/1988) to STUK. The plan will be updated during the construction and operation of the plant so that when operation of the plant ends, measures leading to decommissioning can be launched with no delay.

The preparations for the decommissioning of the Hanhikivi 1 nuclear power plant will begin immediately after commercial operation ends. According to current plans, this will take place in 2085. During the preparatory stage of the decommissioning procedure, spent fuel will be transferred into interim storage, and radioactive waste accumulated at the plant will be packed and taken to storage or directly to the appropriate disposal facility. Decontamination of systems and structures, that is, removal of radioactive impurities, will also begin, and preparations will be made for actual demolition work including the construction of working areas and reserving the necessary equipment for them. During this stage, demolition of systems that are free of radioactivity, such as the turbine plant systems, may begin. According to preliminary estimates, the preparatory phase will take 5–10 years. After the preparatory phase, decontamination and demolition of the nuclear island will begin. The demolition of the nuclear island is estimated to take approximately ten years.

During the decommissioning, all radioactive nuclear power plant systems, structures and constructions will be removed from the plant site. The plant site will be cleaned so that it can be released from STUK's control. Buildings free of radioactivity, such as the turbine plant, office facilities and other auxiliary buildings, can be left in place for other industrial activities. The decommissioning of the nuclear power plant is expected to be completed in 2100.

After the dismantling of the nuclear power plant, operations subject to STUK's control will still remain in the Hanhikivi headland, such as the interim storage facility for spent nuclear fuel and the operating waste repository. Their operations are estimated to end in the 2110s.

Approximately 17,000 m^3 of very low level, low level and intermediate level dismantling waste is estimated to be generated during the decommissioning of the nuclear power plant. These will be disposed of in the surface repository and operating waste repository located at the plant site. The waste is processed and packed using methods developed during nuclear power plant operation. Large components, such as the reactor pressure vessel and the steam generators, can be removed from the nuclear power plant and finally disposed of either in pieces or as whole assemblies.

Overall nuclear waste management schedule

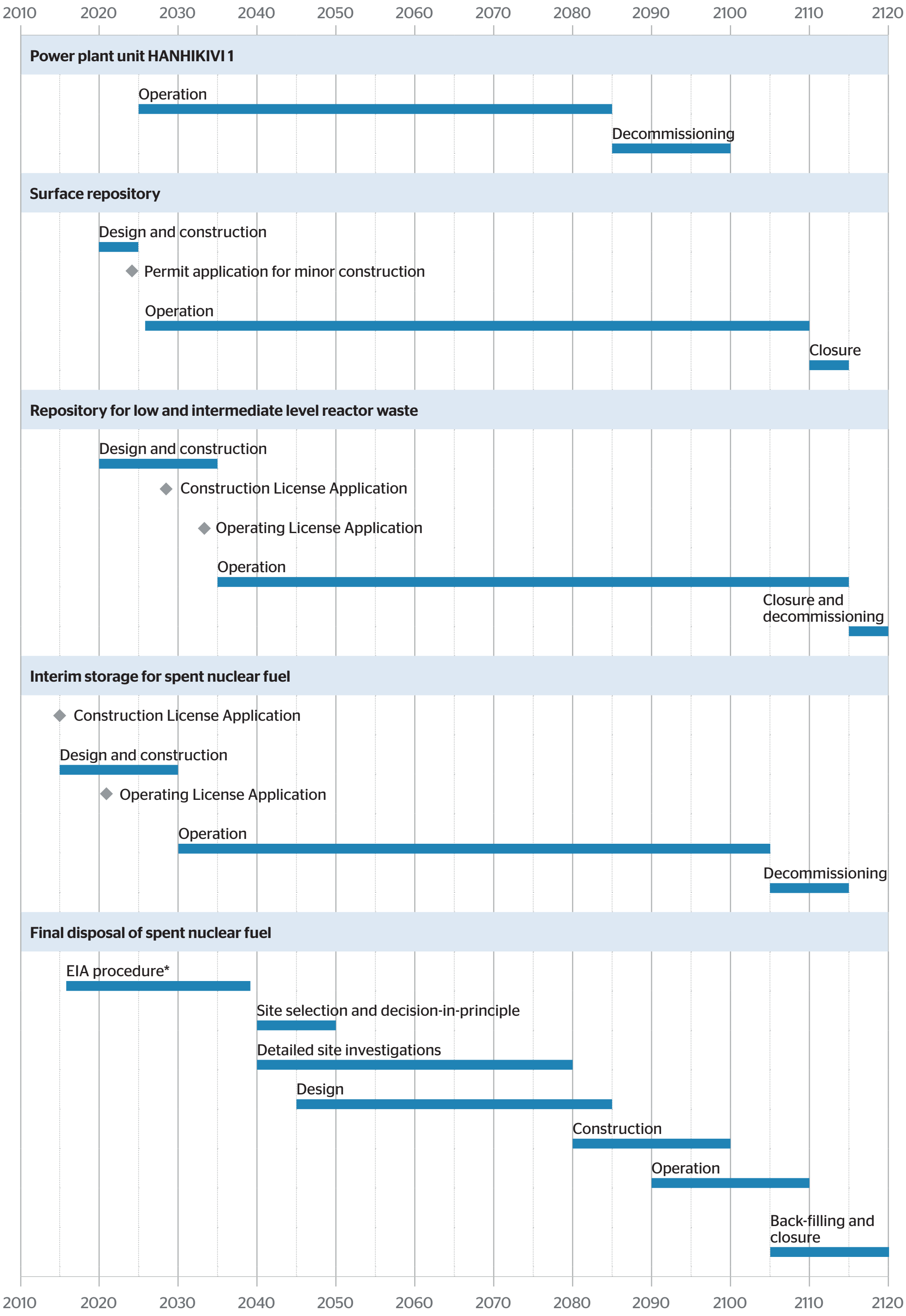
The overall nuclear waste management schedule (Figure 5B-2) has been prepared based on the plan to begin the commercial operation of the Hanhikivi 1 nuclear power plant in 2024, and to keep it operating for 60 years. If the construction schedule were to change significantly for any reason, the nuclear waste management schedule would be updated accordingly. Nuclear power plant design solutions such as the capacity of storage facilities and operating measures, including the generated waste volumes, define the appropriate scheduling of various nuclear waste management actions.

Total costs of nuclear waste management

Fennovoima has prepared an estimate of the total costs of nuclear waste management over the entire lifecycle of the project. The total costs of nuclear waste management include the processing, storage and final disposal of reactor waste, interim storage and final disposal of spent nuclear fuel, the necessary transportation and decommissioning costs, and the processing and final disposal of waste generated during the decommissioning phase.

Fennovoima estimates the total costs of the nuclear waste management to be approximately EUR 3/MWh during the plant's 60 years of service life, using the 2015 price level.

When the nuclear power plant has received an operating license, Fennovoima will fulfill the financial provision obligation set out in Chapter 7 of the Nuclear Energy Act by paying annual National Nuclear Waste Management Fund contributions and by supplying the State with the required collateral securities.



* If EIA procedure starts in June 2016

Figure 5B-2. Overall nuclear waste management schedule.

www.fennovoima.fi