Application for a supplement to the Decision-in-Principle M 2/2010 vp concerning the construction of the Olkiluoto 4 nuclear power plant unit

Application for a supplement to the Council of State's Decision-in-principle M 2/2010 vp concerning the construction of the Olkiluoto 4 nuclear power plant unit pursuant to section 11 of the Nuclear Energy Act, granted on May 6, 2010

This publication does not include the following documents enclosed:

- Extract from the Trade Register, Teollisuuden Voima Oyj	(Appendix 1)
- Copy of the company's Articles of Association and Register of Shareholder's	(Appendix 2)
- Annual Report 2013, Teollisuuden Voima Oyj	(Appendix 5.1)
- Environmental Impact Assesment Report, Extension of the Olkiluoto Nuclear Power Plant by a fourth unit	(Appendix 12.1)

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TO THE COUNCIL OF STATE

Application for a supplement to the Council of State's decision-in-principle M 2/2010 vp concerning the construction of the Olkiluoto 4 nuclear power plant unit pursuant to Section 11 of the Nuclear Energy Act, granted on May 6, 2010

APPLICANT

Teollisuuden Voima Oyj, hereinafter “TVO”.

APPLICATION

On the 25th of April, 2008, TVO requested for the Council of State’s decision-in-principle, referred to in Section 11 of the Nuclear Energy Act, for the construction of the Olkiluoto 4 nuclear power plant unit. The Finnish Council of State issued a favourable decision-in-principle (M 2/2010 vp) on the 6th of May, 2010, and it was ratified by the Parliament on the 1st of July, 2010.

With this application, TVO supplements the information concerning the scheduling of the Olkiluoto 4 project. Apart from the new timing, the project aimed at the construction of the Olkiluoto 4 nuclear power plant unit is essentially unchanged and in accordance with the project referred to in the Council of State's decision-in-principle M 2/2010 vp.

TVO requests the Council of State to set a new deadline for the submission of the construction licence application referred to in Section 18 of the Nuclear Energy Act.

TVO requests for the Council of State’s decision-in-principle referred to in Section 11 of the Nuclear Energy Act confirming that the construction of the Olkiluoto 4 nuclear power plant unit, described below in the section ‘Scope of the application’, as presented in this application for a supplement to the decision-in-principle M 2/2010 vp is still in line with the overall good of society.

SCOPE OF THE APPLICATION

The application concerns a nuclear power plant unit with a light water reactor of max. 4,600 MW thermal power and an electric power on the order of 1,000–1,800 MW that is to be located at the Olkiluoto power plant site owned by TVO.

Furthermore, the scope of the application includes the nuclear facilities associated with the operation of the Olkiluoto 4 nuclear power plant unit at the same site, required for the storage of fresh nuclear fuel, interim storage of spent nuclear fuel, as well as the processing, storage and disposal of low- and intermediate-level operating waste.

JUSTIFICATION FOR THE APPLICATION

The completion of the Olkiluoto 3 nuclear power plant unit has been delayed. In this situation, it is not possible for TVO to make the substantial decisions needed for the submittal of the construction licence application for the Olkiluoto 4 nuclear power plant unit within the present period of validity stated in the decision-in-principle.

Construction of a nuclear power plant unit is a socially significant investment, worth billions of euros, to Finland. Decisions for such investments have to be timed optimally taking into account the production capacity and the other factors affecting the operational environment.

The decision-in-principle issued by the Council of State and ratified by the Parliament in 2010 stated that the construction of the Olkiluoto 4 nuclear power plant unit is in line with the overall good of society. TVO sees that the Olkiluoto 4 project, aiming to build additional nuclear power to Olkiluoto as part of the required new base-load capacity free of carbon dioxide emissions, is still in line with the overall good of society, taking into account Finland’s climate and environmental objectives, the reliability of electricity supply, dependency on imports and a competitive and stable price of nuclear electricity.

The current nuclear power plant site at Olkiluoto is suitable for the Olkiluoto 4 plant unit. The fuel and nuclear waste management of the Olkiluoto 4 unit can be organised similarly to the fuel and nuclear waste management of the currently operating units and by relying on their arrangements.

Applicant

The applicant is TVO and its domicile is Helsinki. TVO is the owner and operator of the Olkiluoto nuclear power plant located in the municipality of Eurajoki. The combined production of the two plant units, Olkiluoto 1 and Olkiluoto 2, currently accounts for approximately one-sixth of all electric power required in Finland. In addition, at Olkiluoto there is the Olkiluoto 3 plant unit under construction.

TVO owns 60 per cent of Posiva Oy, whose task is to take care of the final disposal of spent nuclear fuel from the nuclear power plants of its shareholders in Finland. The remaining 40 per cent of Posiva Oy is held by Fortum Power and Heat Oy (“FPH”), which is the owner and operator of the Loviisa nuclear power plant.

More detailed information about TVO can be found in the appendices to this application. During the construction of the Olkiluoto 1 and Olkiluoto 2 plant units at Olkiluoto, during more than 35 years of their power operation, and during the construction of the Olkiluoto 3 plant unit, TVO’s personnel have gained significant expertise in the construction and operation of nuclear power.

The operating results of the current plant units at Olkiluoto have been at the top level in the world. Finland has been the leading country in the world for more than 20 years with regard to the annual capacity factor of nuclear power plants. The reliable operation of nuclear power plants is a proof of the high level of expertise in this field in Finland. The high utilisation degree also proves that there has been demand for TVO’s stable electricity production. Olkiluoto 3 has been one of the first nuclear power plant units under construction in the western countries for more than ten years. Its construction has significantly increased TVO’s expertise in the design, licensing, construction and equipment installation of the next generation’s plant units

TVO has studied the feasibility of several nuclear power plant alternatives to be constructed in Finland and has taken significant action to improve the licensability and constructability of the plant alternatives within the period of validity stated in the present decision-in-principle. In addition, TVO has started a competitive bidding process aiming at the procurement of the Olkiluoto 4 plant unit.

In TVO's view, nuclear power remains as a competitive alternative for the production of base-load power free of emissions. Therefore, TVO is willing to develop the investment prerequisites and continue the Olkiluoto 4 project, which has been stated to be in line with the overall good of society. The reliable power production of the Olkiluoto nuclear power plant units, TVO's competence, the existing infrastructure available at Olkiluoto as well as the strong support from the owners of TVO will help and advance the Olkiluoto 4 project.

General significance and necessity of the project

Electricity is a necessary basic commodity in society. Its uninterrupted and secured supply constitutes a prerequisite for the operations of society, including the functions serving well-being and production in households and workplaces. Sufficient and reasonable priced electricity means improved quality of living and is in the general interest of all Finnish people, regardless of the social and regional location.

The production structure of electric power in Finland is one of the most diversified in the world. The versatility of production forms for its part secures the supply and stable price development of electricity. The maintenance of the security and the economy of electricity production and the mitigation of climate and environmental impacts require that the versatility of electricity production is maintained without excluding any forms of production.

Alongside Finnish production, imports have accounted for about one-fifth of Finnish electricity supply on an annual basis. Finland is a net importer of electricity on the open Nordic electricity market where the supply and prices of electricity depend largely on the impact of rainfall for the availability of hydropower. During peak consumption, Finland's dependence on import of electricity is particularly significant.

A background report for the Finnish Government's National Energy and Climate Strategy, approved in 2013, estimates that the overall consumption of electricity will continue to grow in future by about one per cent per year. The non-industrial electricity consumption has increased by an average of two per cent per year in the 2000s. Regardless of increasing energy efficiency, it has been estimated that the electricity consumption by households and services will continue to grow. The industrial electricity consumption was about 40 terawatt-hours in 2013. That constitutes about 47 per cent of the total electricity consumption in Finland. Due to economic slowdown and industrial restructuring, industrial electricity consumption has decreased. It has been estimated that when the economy gets back on a growth path, the industrial electricity consumption will once again increase. The new production capacity will cover the deficit caused by the increasing demand for electricity, and by the reduction of old power plants and of imports.

European Commission presented in January 2014 a new climate and energy framework proposal for the period up to 2030. The most salient part of the framework proposal is a binding target to reduce the greenhouse gas emissions by 40 per cent by the year 2030.

Olkiluoto 4 nuclear power plant unit is needed so that Finland can achieve the binding target to reduce the emissions by 40 per cent by 2030. Construction of new nuclear power is the most powerful and cost-effective way to limit the carbon dioxide emissions caused by the electricity production in Finland.

TVO produces the base electric power, i.e. base-load, available at every moment of the day around the year. Nuclear power is well-suited for base-load production because its production is practically independent of any external factors and the share of operating costs in the production cost of electricity is small.

The share of fuel costs in the overall price of nuclear electricity and the share of natural uranium cost, in particular, is small, resulting in stable prices of nuclear electricity. A stable electricity price lays the ground for long-term investment decisions in Finland.

Schedule of the project

The completion of the Olkiluoto 3 nuclear power plant unit has been delayed. In this situation, it is not possible to make the substantial decisions needed for the submittal of the construction licence application for the Olkiluoto 4 nuclear power plant unit within the period of validity stated in the decision-in-principle that was ratified on July 1, 2010.

Based on TVO estimates, it is possible to start the construction work for the Olkiluoto 4 nuclear power plant unit when the Olkiluoto 3 nuclear power plant unit is in stable power operation and when the engineering and construction licence phases for the Olkiluoto 4 nuclear power plant unit have been finished. The timing of the definitive investment decision will take into account the prevailing prospects for shareholders' electricity needs and the development of the electricity market. The power production of the Olkiluoto 4 nuclear power plant unit is estimated to be started in the late 2020's.

TVO proposes that the period of validity of the present decision-in-principle concerning the construction of the Olkiluoto 4 nuclear power plant unit will be extended by five years. That is equivalent to the period of validity of the decision-in-principle granted in 2010.

Profitability and financing of the project

In the application for a decision-in-principle in 2008, TVO presented a preliminary cost estimate for the Olkiluoto 4 nuclear power plant unit. Since the favourable decision-in-principle concerning the construction of the Olkiluoto 4 nuclear power plant unit, ratified in 2010, TVO has started a competitive bidding process aiming at the procurement of the plant unit. TVO received the related bids in January 2013. At present, the cost estimate for the Olkiluoto 4 nuclear power plant unit is higher than the preliminary cost estimate presented in the application for a decision-in-principle in 2008. Due to the unfinished bidding process, it is not possible to release a more detailed cost estimate for the construction of the Olkiluoto 4 nuclear power plant unit.

In TVO's view, the Olkiluoto 4 project is still economically competitive. The competitiveness of nuclear power is based on the long operating phase, during which both the volume and the cost of the electricity production is stable. The reliable power production of the Olkiluoto power plants and the existing infrastructure available at the Olkiluoto site will work in favour of the realisation of the Olkiluoto 4 project.

TVO’s financial key figures and the ability to handle interest on loans and repayments will remain at a level satisfactory to financiers throughout the construction period of the Olkiluoto 4 nuclear power plant unit. Based on the studies conducted, the debt portion of the Olkiluoto 4 project can be financed on commercial terms.

Plant type and time of operation

The Olkiluoto 4 nuclear power plant unit referred to in the application will be equipped with a light water reactor. The majority of the world’s current power reactors are light water reactors. The Olkiluoto 4 unit can be either a boiling water or a pressurised water reactor plant. The Olkiluoto 1 and Olkiluoto 2 units are boiling water reactor plants and the Olkiluoto 3 unit is a pressurised water reactor plant.

The thermal power of the Olkiluoto 4 plant unit’s reactor will be a maximum of 4,600 MW which has been used as the plant unit’s maximum thermal power in its environmental impact assessment. The electric power of the plant unit will be approximately 1,000–1,800 MW.

TVO has carried out surveys on the feasibility of several nuclear power plant alternatives in Finland and has since the granting of the decision-in-principle taken several important steps to improve the licensability and constructability of the plant alternatives. The plant alternatives represent the latest developments in light water reactor technology with regard to their safety and economy-related properties and are, with reasonable changes, feasible to be built in Finland. In addition, plant alternatives other than those targeted by feasibility studies may be considered in the selection of the plant alternative to be implemented.

The planned technical operational lifetime of the Olkiluoto 4 plant unit is approximately 60 years.

Safety and environmental impacts

In accordance with the Nuclear Energy Act, the starting point for the design, construction and operation of the Olkiluoto 4 nuclear power plant is that the plant must be safe and it shall not cause injury to people or damage to the environment or to property.

Finnish nuclear power plants have had only a small number of incidents that have had safety implications or disturbed the use of plant units. None of these incidents has caused the allowed radiation doses for employees to be exceeded or any radiation hazard to the environment.

The Olkiluoto 4 nuclear power plant unit will be designed to meet the internationally strict safety requirements valid in Finland. In addition, the principles and instructions issued by the International Atomic Energy Agency (IAEA) and some other countries will be taken into account.

The direct and indirect impact of the Olkiluoto 4 nuclear power plant unit on people, nature, and the built environment has been assessed in accordance with the Act on Environmental Impact Assessment Procedure. During the environmental impact assessment process the environmental effects of the Olkiluoto 4 nuclear power plant unit have been evaluated in a versatile manner, taking into account combined effects of both present and planned operations at Olkiluoto. TVO submitted the environmental impact assessment report to the contact authority in February 2008. The contact authority issued its statement about the report in June 2008. Both the environmental impact assessment report and the statement by the contact authority were available to the Council of State when the Council of State on May 6, 2010, issued its favourable decision-in-principle, pursuant to Section 11 of the Nuclear Energy Act, concerning the construction of the Olkiluoto 4 nuclear power plant unit. In addition, a Natura assessment of the impact of the Olkiluoto power plants has been carried out. The power level of the Olkiluoto 4 nuclear power plant unit or the environmental impact of the plant have not changed. In addition, there have been no changes in the functions of the Olkiluoto power plant or in the vicinity of Olkiluoto plant site that would affect the results or conclusions of the environmental impact assessment carried out.

Nuclear fuel and nuclear waste management

Fuel management of the Olkiluoto 4 nuclear power plant unit can be implemented reliably in a diversified manner from several sources using similar arrangements as for the existing plant units. The main principle is to use long-term agreements and reserve stocks for fuel.

The intention is to use the same plans, methods and waste management facilities that are used for the existing nuclear power plant units. There are disposal facilities for low- and intermediate-level operating waste at Olkiluoto, and these can be expanded to accommodate the needs of the new unit as well.

Spent nuclear fuel is to be disposed of in the final disposal facility at Olkiluoto designed by Posiva Oy, which is owned by TVO and FPH. Posiva Oy's plans include the disposal of the spent fuel from the Olkiluoto 4 nuclear power plant unit. On the 1st of July, 2010, the Parliament ratified the Council of State's favourable decision-in-principle M 3/2010 vp regarding Posiva Oy's application to extend the final disposal facility to include the disposal of the spent nuclear fuel from the Olkiluoto 4 nuclear power plant unit. Posiva Oy will submit to the Council of State a separate application for a supplement to the Council of State's decision-in-principle M 3/2010 vp.

In accordance with Section 18 of the Nuclear Energy Act, Posiva Oy has submitted at the end of year 2012 a construction licence application for a final repository for spent nuclear fuel and other nuclear waste to the Council of State. The final repository for spent nuclear fuel and other nuclear waste is a facility complex consisting of an encapsulation plant and an underground final repository and it is to be built at the Olkiluoto site in the municipality of Eurajoki. This disposal facility involves also the disposal of the spent fuel from the Olkiluoto 4 nuclear power plant unit.

The information presented in this application and in its appendices has been updated to reflect the changes since the granting of the decision-in-principle in 2010.

Helsinki, 20 May 2014

TEOLLISUUDEN VOIMA OYJ

Jarmo Tanhua President and CEO	Janne Mokka Senior Vice President, OL4 Project

APPENDICES

Descriptions called for in Section 24 of the Nuclear Energy Decree:

1. Extract of the Trade Register
2. Copy of the company’s Articles of Association and register of shareholders
3. Description of the expertise available to the applicant
4. Description of the nuclear power plant project’s general significance and necessity considering domestic energy supply, in particular, and its significance considering the operation of other nuclear power plants in Finland and their waste management
5. Description of the applicant’s financial prerequisites for operations and economic viability of the nuclear power project
6. Overall financing plan for the nuclear facility project
7. Outline of the technical principles of the planned nuclear facility
8. Description of the safety principles observed
9. Outline of the ownership and occupation of the site planned for the nuclear facility
10. Description of settlement and other activities and planning arrangements at the planned nuclear facility site and in its immediate vicinity
11. Assessment of suitability of the planned site for its purpose taking into account the effect of local conditions on safety, security and emergency preparedness as well as the effect of the nuclear power plant on the immediate environment
12. Assessment report drawn up in accordance with the Act on Environmental Impact Assessment Procedure and the statement issued by the contact authority about the environmental impact assessment report as well as an account for the design criteria the applicant intends to apply in order to avoid environmental damage and to limit environmental burdens
13. Outline plan on nuclear fuel management
14. Outline of the applicant’s plans and the available methods for nuclear waste management

DESCRIPTION OF THE EXPERTISE AVAILABLE TO THE APPLICANT

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DESCRIPTION OF THE EXPERTISE AVAILABLE TO THE APPLICANT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

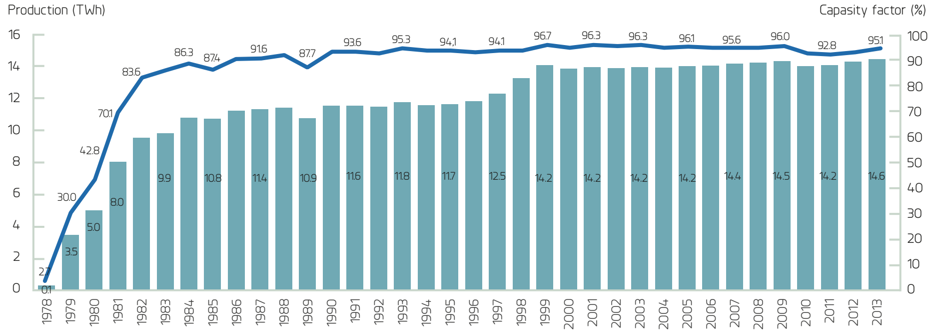
Since the favourable decision-in-principle, sustained in 2010 by the Parliament, concerning Nuclear Power Plant (NPP) unit OL4, the information and figures presented in this appendix have been updated to correspond the current situation.

1. GENERAL

TVO’s line of business is to construct and procure power plants and power transmission equipment and to produce, supply and transmit electricity primarily to its shareholders. The company has built and is operating two nuclear power plant units, OL1 and OL2, at Olkiluoto in the municipality of Eurajoki and is building the OL3 plant unit at Olkiluoto.

When the operation of the OL1 and OL2 plant units started, most of the technical personnel involved in the construction phase were transferred to tasks in support of the operation and maintenance of the plant units. TVO has accumulated the experience of over 35 years in the operation and maintenance of the plant units, including the efficient implementation of the maintenance outages. An indication of the company’s competence is that the high capacity factors of the Olkiluoto plant units have held the top positions in international comparisons for a long time.

Figure 3–1 *Total production and average capacity factor of Olkiluoto 1 and Olkiluoto 2 in 1978–2013.*



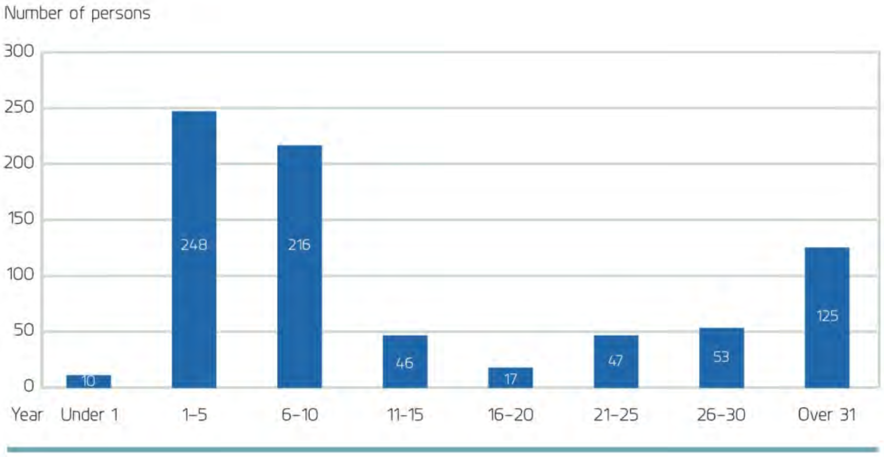
In addition, the company’s nuclear competence has been maintained and developed by the power upratings of the plant units and by their modernisation, by measures taken to manage severe accidents, the preparation of a probabilistic safety analysis (PSA), the use of the company's own training simulator, the construction of interim storage facilities for low and intermediate-level waste, the construction of an interim storage facility for spent fuel, the construction of a repository for operating waste, the development of the final disposal solution for spent fuel and the construction of OL3.

2. DEVELOPMENT OF COMPETENCE

Competence is manifested in people and in organizational routines. In TVO, the turnover of the personnel has been low and it has taken place mainly through the retirement. TVO has taken actions to retain the competence when employees retire.

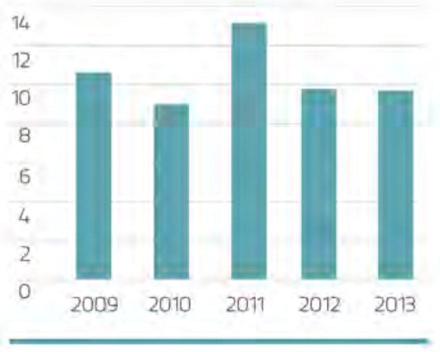
Nuclear power plant operations are typically well-documented. TVO has accumulated extensive material during its history concerning the plant's technical systems and the organisation's operations. TVO operational systems and information and their uses have been documented extensively and comprehensively. Numerous manuals, operating and maintenance manuals in particular the operations and maintenance manuals with their detailed instructions on operational and preventive maintenance procedures including operational and preventive maintenance instructions in particular, control the operations in great detail. Similarly, a good, regularly audited safety culture which has been cultivated at TVO is a significant part of the of TVO's organizational memory.

Figure 3–2 *The duration of employment for TVO's personnel*



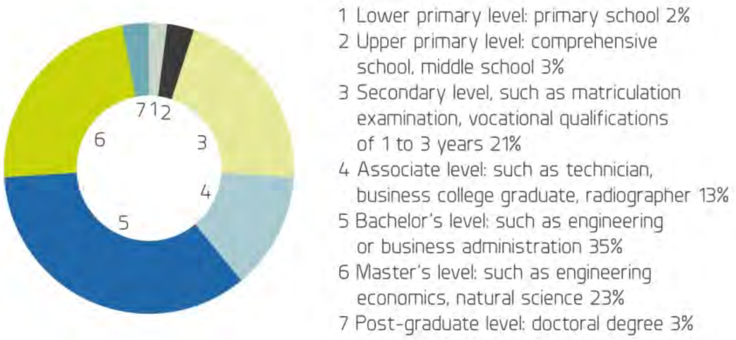
The development of personnel competence is a continuous process controlled by the key competence areas derived from the company strategy and by the competence requirements set for the personnel. The implementation of these requirements is monitored as part of supervisor operations in a coordinated manner at the company level. These operations are supported by the competence management data system. The regular number of personnel training days has annually been about 9–13 days/person.

Figure 3–3 *Training days for TVO personnel per person*



The company employs approximately 700 regular employees, 80 per cent of whom have technical or scientific educational backgrounds: there are 14 doctors, 6 licentiates, 141 Masters of Science in Engineering, 235 engineers, 73 technicians and 15 master mechanics. In addition to those with a technical or scientific degree, the company employs people with financial and legal expertise in the nuclear industry. The company supports its personnel's participation in different levels of post-graduate and continuing educational programmes.

Figure 3–4 *Education of TVO personnel divided by the level of education*



The company has taken proactive measures that will ensure that the accumulated know-how and the knowledge of plant units are transferred to new experts who have e.g. replaced retired personnel. The transfer of competence is supported by a good and comprehensive documentation that covers both the technology and the procedures.

3. COMPETENCE IN OPERATIONS

TVO has thirty years of experience in the operations of a nuclear power plant in Finland. An important part of operations is the management of the operating staff's competence (control room personnel). TVO is continuously monitoring the need to recruit personnel and when necessary, a new trainee team group with 4–8 persons is started. The latest trainee team, with six persons, has started in 2014. The members of a trainee team will become licensed operators after two years of training. TVO is continuously working on the development of the selection procedures of the operating personnel. There are sophisticated procedures for the training of the operating personnel: for example, the operating experience accumulated in

Olkiluoto and elsewhere is continuously utilised as a part of the basic and continuing training of the operating personnel. The operating personnel have yearly some 15 training days on the plant technology and procedures.

Part of the training takes place at the simulator, for the maintenance of which TVO has clear practices. TVO also has extensive experience in the utilisation of the simulator and wide competence in the special features of the didactics of simulator training. In addition to plant technology, the simulator is used to train procedures, such as control room communications. The operating personnel's competence management also includes the maintenance of licenses and different indications of work skills, for which TVO has standardised procedures. In addition to plant technology, the simulator is used to train procedures, such as control room communications. The operating personnel's competence management also includes the maintenance of licenses and different demonstration exams of work skills, for which TVO has standardised procedures. Operations constitute work in three shifts, including special requirements. Over the years, TVO has accumulated vast experience in manage the burden of shift work.

Figure 3–5 *Control room of the training simulator for plant units OL1 and OL2.*

Figure 3–6 *Control room of the training simulator for plant unit OL3.*

In the year 2013, the control room personnel received circa 9 simulator training days per person to maintain and develop their professional competence. In conjunction with the OL3 project, a wide-scale recruitment of new professionals has been conducted. The persons who have been employed at the OL3 project will mature in the work of the construction and commissioning phases for their tasks during the operational phase of the unit. The future control room personnel of OL3, some 35 people, were recruited in 2005 to be trained for these positions. The OL3 project has also widened the scope of international cooperation of the company's experts.

4. OUTSIDE EXPERTISE

TVO also uses outside contractors in its operations to the extent necessary. The principle has been to establish connections with institutions, companies and organisations representing the highest possible expertise in sectors related to the company's operations. The company has valid agreements on maintenance and expert services with several Finnish and foreign parties. TVO has long-term cooperation agreements with key plant, component and service suppliers. The expertise and competence of suppliers is inspected using regular assessments.

TVO has excellent long-term relationships with polytechnics and universities providing education in nuclear and energy technology. The company is taking active part in the institutes' research and development projects and supports students by offering trainee positions and possibilities to undertake a thesis project in TVO.

TVO has participated and is participating in a number of national and international nuclear power development programmes. This is a way to get information about the latest development in the field and to maintain functional connections to experts in the field. The company is actively involved in Finnish and international organisations in the field of energy and nuclear power.

The long operational experience and the OL3 project have provided TVO with extensive and fresh expertise and competence in the requirements of the design, construction and operations of nuclear power.

DESCRIPTION OF THE NUCLEAR POWER PLANT PROJECT'S GENERAL SIGNIFICANCE AND NECESSITY CONSIDERING DOMESTIC ENERGY SUPPLY, IN PARTICULAR, AND ITS SIGNIFICANCE CONSIDERING THE OPERATION OF OTHER NUCLEAR POWER PLANTS IN FINLAND AND THEIR WASTE MANAGEMENT

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DESCRIPTION OF THE NUCLEAR POWER PLANT PROJECT'S GENERAL SIGNIFICANCE AND NECESSITY CONSIDERING DOMESTIC ENERGY SUPPLY, IN PARTICULAR, AND ITS SIGNIFICANCE CONSIDERING THE OPERATION OF OTHER NUCLEAR POWER PLANTS IN FINLAND AND THEIR WASTE MANAGEMENT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

The construction of the Nuclear Power Plant (NPP) unit Olkiluoto 4 is still in accordance with the general interest of the society.

The economy and competitiveness of Finland and the rest of Europe have fundamentally declined. OL4 has concurrently become an even more important investment for the broad ownership of TVO and Finland as a whole.

The safeguarding of economic growth, employment and the welfare society requires industrial investment and domestic production. The significance of reasonably priced energy is underlined even more strongly as before.

In January 2014, the European Commission published a proposal for the 2030 goals of the energy and climate politics. The most important proposal is the commitment to the goal of decreasing greenhouse gas emissions by 40 per cent by the year 2030.

OL4 is needed for Finland to reach the binding obligation to cut emissions 40 per cent obligation by 2030.

According to the European Commission, households and industrial consumers are even more concerned of the rising energy prices. Especially the USA has obtained a major advantage by its cheap energy. In the EU, the household energy price has risen 18 per cent during the last five years, while the industry has experienced a 15 per cent price increase.

1. GENERAL SIGNIFICANCE OF THE PROJECT

A reliable and uninterrupted supply of electricity in all situations and self-sufficiency of its supply constitute starting points for social operations for each citizen, for industry, services and foreign trade. An uninterrupted supply of electricity at a reasonable price for private consumers and at a competitive price for business are prerequisites for the Finnish economy and well-being.

OL4 project primarily supports the reduction of carbon dioxide emissions in electricity production, the reduction of dependency on the import of electricity and fuels that are becoming ever more expensive. It also provides for the replacement of old production capacity, scheduled for dismantling, using an emission-free option. In addition, provisions shall be made to cover the increases electricity demand by using emission-free power plants.

The proposed NPP unit will be a part of a diversified Finnish energy mix. It will increase the self-sufficiency and reliability in the electricity supply, will reduce emissions and produce electricity at a competitive price. The significance of reasonably-priced Finnish electricity will be underlined in a situation where many European countries are more dependent on imported electricity and gas, resulting in more severe competition and stronger pressure to increase prices.

High-quality function of the energy system is particularly important in Finland. Despite the efficient use of energy, Finnish energy consumption per capita is one of the greatest in Western countries. This is caused by the high standard of living, energy intensive industry structure, the cold climate and long distances.

In order to maintain and secure stable economic growth and positive employment development, it is important that Finland has favourable operational conditions for investments. Even though the electronics and IT industries have increased their share in our industrial production, the energy-intensive forest, chemical and metal industries play a central role in exports which forms the backbone of our welfare state. Reliable electricity supply at a reasonable price is a prerequisite for the existence of these industries.

The mitigation of climate change is one of the biggest challenges for mankind. Through the decision issued in 2007, the European Union is committed to reduce greenhouse gas emissions by 20 per cent by 2020, compared to the level in 1990. The energy strategy has a central position in mitigating the climate change. The reduction of emissions takes place through the increase in the efficiency of energy use and the investment in low-and zero-emission energy forms, like renewable energy sources and nuclear power.

Even in the future, energy solutions must be carried out so that the reliability and reasonable prices of energy supply can be secured, while taking care of the environment particularly in preventing climate change. This requires investments in improved energy efficiency and versatile energy production without excluding any forms of production from the energy mix.

Electricity demand and the future outlook in Finland

Increased use of electricity has been and will be connected to the increase in the standard of living. The share of basic industry using plenty of electricity in the gross national product is high.

Due to the decline of the overall economy and the structural change in the industry, the industry power consumption has decreased. In 2013, the industry used about 40 TWh of electricity, which comprises about 47 per cent of the total Finnish electricity consumption. When the economy resumes growth, the industry power consumption is estimated to resume a growth also.

The power use by consumers other than industry has annually increased at a rate of circa two percent. Despite the improvements in energy efficiency, it has been estimated that the consumption of electricity by services and households will continue to grow.

According to a background report to the energy and climate strategy of the Finnish Government that was updated in 2013, the Finnish electricity consumption is estimated to increase in the future about one per cent per year.

Energy efficiency

The significance of energy efficiency has increased in recent years. The main reasons include increased energy expenses and the prevention of climate change, the significance and impacts of which have got more attention. The future of Finland’s energy efficiency is affected significantly by the energy efficiency decisions issued by the European Union, according to which energy efficiency should be improved by 20 per cent by 2020. In addition, the emissions trading sector, such as households, traffic, services and part of industry, is controlled by the Energy Services Directive which sets a binding 9 per cent energy saving target for these operators in 2008–2016.

In Finland energy efficiency is at a high level compared to the international situation. Finland is one of the world’s leading countries in energy efficient combined heat and power production. Central element in improving the efficiency of energy use is energy efficiency agreements between the state and operators.

The energy efficiency agreements have formed a wide scale system of voluntary compliance. According to Motiva, over half of the end use of energy in Finland was covered by the agreements at the beginning of year 2011.

The central parts of the agreements include the recognition of the potential to improve energy efficiency and the implementation of actions required for improved efficiency. In 1998–2006, the operators within the scope of the agreements improved the efficiency of their electricity use so that 1.7 TWh of electricity was saved every year compared to a situation where actions had not been implemented. During the years 2008–2012, the actions resulted in the savings of 1.3 TWh.

As the organisation responsible for the OL4 project, TVO does not have access to any energy conservation means that would allow replacement of the quantity of electricity produced by the new nuclear power plant unit while continuing the operations of the shareholders and other electricity consumers as planned.

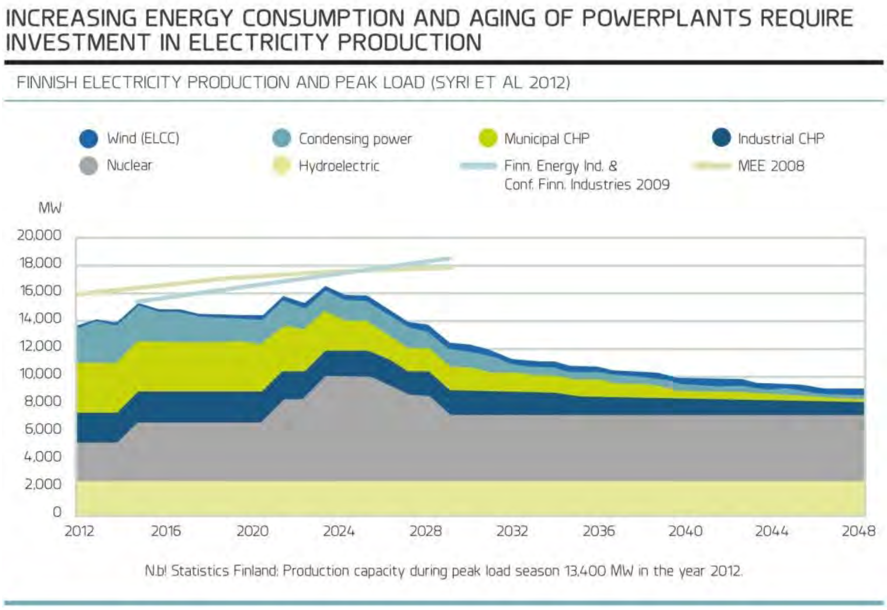
1.1. Current status of electricity supply and future outlook in Finland

Finland utilises different sources of energy in its electricity production in a versatile manner. The diversification supports maintenance of supply, competition on the open electricity market and, as a result, the availability of electricity as competitively as possible.

In 2013, 85.5 TWh of electricity was consumed in Finland. The combined heat and power production covered 28 % of this. The nuclear energy supplied somewhat over a quarter and other condensing power for 10 %. The import of electricity from Russia, Sweden, Norway and Estonia covered 19 per cent of the total electricity demand in the year 2013. The share of wind power was 0.9 %.

On the basis of the Electricity Production Scenarios in 2030 issued by the Finnish Energy Industries, the need for maximum electric output and the available capacity in Finland will develop according to Figure 4–1.

Figure 4–1 Energy production and peak power demand in Finland



According to Figure 4–1, the difference between the peak demand and current capacity will be 2,500 MW in 2020 and 6,000 MW in 2030. OL4 is needed to maintain self-sufficiency.

1.2. Alternatives for electricity supply

1.2.1. Renewable energy sources

Renewable energy sources can be utilised in the production of electricity and heat and as a raw material for biofuels for traffic. Renewable energy sources in Finnish electricity production include hydropower, biomass (mainly wood but also field biomass), waste and wind power. Solar power cannot be utilised to a significant extent in Finland in the foreseeable future.

In January 2014, The Ministry of Employment and the Economy (MEE) reported to the European Commission on the progress in renewable energy utilization. In regard to the increase of renewable energy consumption, Finland is on the track set by the RES directive to meet the goals for 2020. At the moment, the share of the renewable sources of the end user consumption clearly exceeds the goals set by the non-binding progress track. The actions to promote the renewable energy have progressed as planned in Finland.

1.2.2. Nuclear power

The majority of the production costs of nuclear power are formed of fixed costs. The share of the fuel in the production cost of nuclear electricity is minor. As a result, nuclear power is well-suited for the production of base load power. In addition, the dependence of nuclear electricity's production costs on fluctuations in fuel price and exchange rates is low, because the share of the fuel in overall production costs is minor. Nuclear power plants do not produce carbon dioxide emissions and, as a result, the EU emission trading does not cause any additional costs.

1.2.3. Coal, natural gas, peat and import

Finland and the energy industry have obligated themselves to transfer to a low-coal future by year 2050. When considering the options to invest in new non-combined electricity production, it is not in this context necessary to carry out more detailed studies of investment plans based on the use of coal, natural gas or peat.

It is also not necessary to examine imports separately, because the goal is to increase the Finnish energy self-sufficiency. On an annual basis, the current share of imports of the total electricity consumption is about one-fifth. During peak consumption, dependence on imports is particularly significant.

1.2.4. A summary of the supply alternatives for the additional electricity required

The use of biomass will be the centred mainly on the combined heat and power production, the amount of which can still be increased. In the new construction of wind power, the production costs and the temporal fluctuations inherent in the wind power production must be considered, as well as its consequences: the increased need for adjusting power production.

The addition of renewable energy alone cannot cover the deficiency of the electricity production capacity compared to the power demand. In such case, the increase of condensing power production forms a central alternative. In condensing power, peak and fossil fuels such as coal and natural gas would be considered as fuels. The increase of the condensing power can be covered by nuclear power which is a very good alternative, suitable for new build, compared to peat and fossil fuels, when energy security, competitive cost and emission limitations are considered. The plant unit proposed in this application would fulfil a significant part of the capacity deficiency that will exist in our country and it would clearly decrease the Finnish dependency on electricity import.

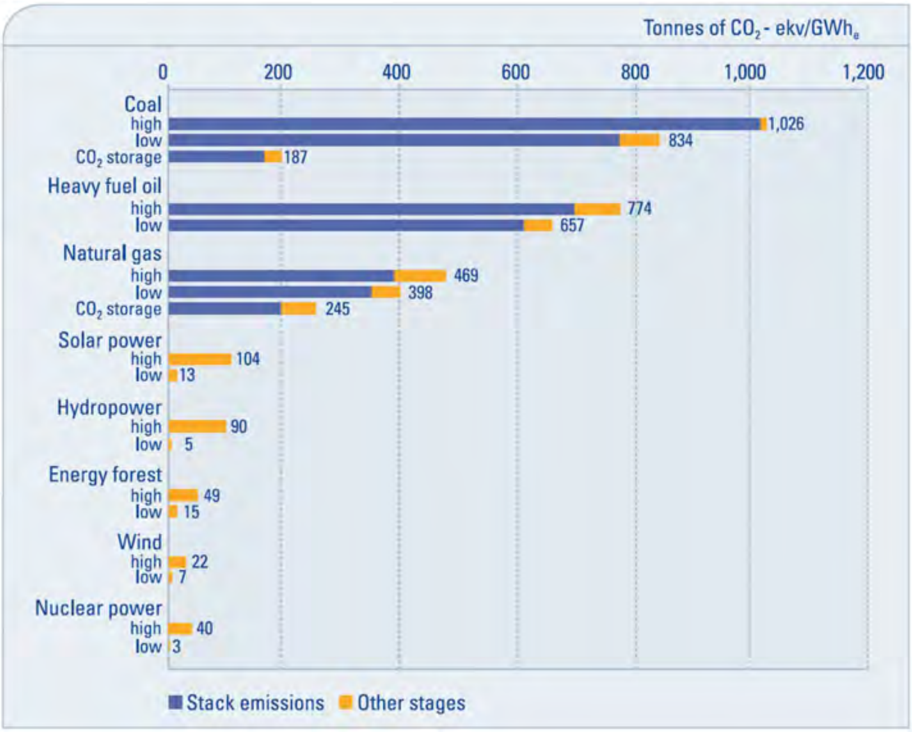
2. ENVIRONMENTAL IMPACT ASSESSMENT FOR ELECTRICITY PRODUCTION

Different energy sources have a different environmental impact with regard to their quantity and extent. Some of the impact is related to the production of fuel, some to the construction of power plants, some to energy production and some to the decommissioning of power plants.

The environmental impact can be assessed in a number of ways. Life cycle analysis is a method used to assess the environmental impact caused by a product, process or action during its life cycle. This analysis also identifies the impact that is not caused at the energy production site or its immediate vicinity.

The most significant greenhouse gas emission in energy production is carbon dioxide. A number of reports have been prepared for the carbon dioxide emissions of different forms of electricity production. The World Energy Council (WEC) has prepared a summary including information from several different reports. The results are presented in Figure 4–2.

Figure 4–2 *Greenhouse gas emissions of different forms of energy, in electricity production only, as equivalent carbon dioxide volumes per produced electric energy. The figure presents the maximum (top) and minimum (low) emissions obtained through different life cycle inspections. Source: World Energy Council.*



Carbon dioxide emissions are increased in energy production by the combustion of coal, oil, natural gas and peat. Biomass is considered to be a neutral fuel for climate change because the carbon dioxide released in its combustion is bound back to nature as plants grow. Hydropower, wind power, nuclear power and solar energy do not directly increase the carbon dioxide content in the atmosphere. However, these forms of energy production cause some quantities of greenhouse gas emissions that are caused by the procurement of materials and fuels, component manufacturing, transportation and the construction and decommissioning of plants.

In addition to carbon dioxide, environmental impacts are caused by sulphur dioxide, nitrogen oxide and particle emissions that also vary from one form of electricity production to another. Tables 4–1 and 4–2 present an estimate of the emissions created if the fourth production unit is not built at Olkiluoto. Because it is difficult to accurately estimate the production structure of electricity at the end of 2010s, the environmental impacts are assessed in a situation where the electricity capacity of the fourth Olkiluoto production unit would be replaced with production from the current average Nordic production capacity.

Table 4–1 *Estimated emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X) and carbon dioxide (CO_2) in a situation where the annual production of OL4 would be replaced in accordance with the average Nordic distribution of electricity production in 2005.*

Average emissions in electricity production						Avoided emissions tons/year	
	Finland kg/MWh	Sweden kg/MWh	Norway kg/MWh	Denmark kg/MWh	Electricity production's weighted value kg/MWh	**Production 8 TWh**	**Production 14 TWh**
CO_2	258.34	19.73	5.61	552.49	115.73	925,818	1,620,182
SO_2	0.37	0.04	0.03	0.50	0.15	1,189	2,080
NO_x	0.47	0.03	0.01	1.22	0.23	1,828	3,199

Table 4–2 *Estimated particle emissions in a situation where the annual production of OL4 would be replaced in accordance with the average Nordic electricity production in 2006.*

					Avoided emissions tons/year	
	Production 2006, GWh	Electricity production efficiency	Nominal emission factor, mg/MJpa	Share of total production 2006	**Production 8 TWh**	**Production 14 TWh**
Coal	42.9	45 %	17.5	11.2 %	125.1	219.0
Oil	3.1	45 %	15.0	0.8 %	7.8	13.6
Peat	6.3	42 %	17.5	1.6 %	19.7	34.5
Natural gas	19.6	57 %	1.5	5.1 %	3.9	6.8
Biofuels	19.5	42 %	17.5	5.1 %	60.9	106.7
Waste	4.2	42 %	3.7	1.1 %	1.1	4.9
					220	385

Currently and in the foreseeable future, condensing coal power is, for most of the year, the form of production that is the most expensive in the running order within the Nordic electricity market area. If the new nuclear power plant unit replaces condensing coal power production in full, the avoided emissions will be, according to the best technology available, 6–10 million tons for carbon dioxide and several thousands of tons for acidifying emissions, depending on the size of the plant (Table 4–3).

Table 4–3 *Avoided emissions (tons/year) in a situation where the new nuclear power plant would fully replace condensing power produced by coal.*

	CO_2	SO_2	NO_x	Fine particles
8 TWh	5,924,127	3,288	3,288	219
14 TWh	10,367,223	5,751	5,751	383

3. IMPACTS ON EMPLOYMENT AND THE REGIONAL STRUCTUR AND ECONOMY

The most substantial parts of the nuclear power plant investment are comprised of earthworks, the construction of power plant buildings and the procurement of equipment.

The employment effect of constructing a new nuclear power plant unit is substantial. The direct employment effect in Finland is expected to be 12,000 to 15,000 person-years. The indirect employment effect in Finland is expected to be 10,000 to 13,000 person-years.

The project’s employment effects in foreign countries exceed those in Finland. However, a significant part of foreign work will be carried out in Finland. The foreign plant supplier’s operations on site will have economic effects through different factors, such as the demand for construction site services, short- and long-term accommodation for foreign employees and trade in consumer goods.

The fourth nuclear power plant unit will require approximately 200 people of operating personnel, and the increased need for outsourced services will correspond to the work input of approximately 100 people. Annual outages will require approximately 700 to 1,000 people of suppliers’ labour force. The annual value of maintenance investments in the fourth plant unit will be EUR 20 million on average.

The construction of the new nuclear power plant unit will increase real estate tax income in the municipality of Eurajoki by a few million euros. The increase in real estate tax income will begin during the construction period and continue throughout the entire service life of the plant. Municipal tax on salaries will be increased by EUR 2 million a year in the region as the number of regular employees in the nuclear power plant at Olkiluoto will increase by approximately 300 people.

4. IMPACT ON THE NORDIC ELECTRICITY MARKET

Finland, Sweden, Norway and Denmark constitute a uniform Nordic electricity market area created during the last ten years as the countries have opened their electricity markets for competition. Electricity consumption within the Nordic electricity market area is about 400 TWh a year. The share of hydropower is one-half, nuclear power constitutes one-fourth and conventional thermal power about one-fourth.

The price of electricity is determined on the Nordic electricity exchange on the basis of demand and supply and the Nordic marginal production cost.

The new nuclear power plant unit will increase the share of nuclear power production. As a result, the need for using more expensive forms of production will be reduced.

5. THE PROJECT'S SIGNIFICANCE FOR OTHER NUCLEAR POWER PLANTS AND NUCLEAR WASTE MANAGEMENT

The new nuclear power plant unit will be located at the power plant site at Olkiluoto where there are two operational nuclear power plant units and the third unit is under construction. The plant area contains infrastructure that serves the NPP units OL1, OL2 and OL3 and that the new unit will utilise. For example, the distribution of general expenses related to administration, operations, maintenance and guarding over four units will significantly reduce the price of produced electricity. The operation and maintenance of the new nuclear power plant unit will be supported on the nuclear power plant competence and services created by corresponding functions in the OL1, OL2 and OL3 units.

The Olkiluoto power plant site has an interim storage facility for spent nuclear fuel serving nuclear waste management of the existing plant units and has final disposal facilities for low- and intermediate-level nuclear waste. The interim storage facility has already been expanded and the final disposal facilities will be expanded for the requirements of OL3 in the near future. The nuclear waste management of the new unit will be supported by these existing facilities, the design of which takes into account the possibility of expanding the capacity.

The nuclear power plant's licence holder will be responsible for the implementation and costs of the plant's nuclear waste management. TVO's existing and planned nuclear waste management arrangements or similar arrangements are also appropriate for managing nuclear waste from the new power plant unit. The company's available and planned arrangements can be used for the management of all nuclear waste produced in the current and future plant units.

DESCRIPTION OF THE APPLICANT'S FINANCIAL PREREQUISITES FOR OPERATIONS AND ECONOMIC VIABILITY OF THE NUCLEAR POWER PROJECT

CONTENTS

DESCRIPTION OF THE APPLICANT'S FINANCIAL PREREQUISITES FOR OPERATIONS AND ECONOMIC VIABILITY OF THE NUCLEAR POWER PROJECT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

Since the favourable decision-in-principle, sustained in 2010 by the Parliament, concerning Nuclear Power Plant (NPP) unit OL4, the project has started the bidding process. The bids were received in January 2013. The process is still ongoing. The information and figures presented in this appendix have been updated to correspond to the current situation.

1. THE APPLICANT'S FINANCIAL PREREQUISITES FOR OPERATIONS

1.1. Shareholders and users of electricity

TVO's line of business is to construct power plants to produce, supply and transmit electricity primarily to its shareholders.

The company's shares are divided into series so that the rights and obligations of the OL1 and OL2 power plant units are directed at the A-series shares, the rights and obligations of the OL3 project are directed at the B-series shares and the rights and obligations of the Meri-Pori coal-fired power plant are directed at the C-series shares. The ownership shares of different sets are described below.

Table 5–1 *TVO sharaholders and shareholding in different series of shares in percentage 31.12.2013.*

	A-series	B-series	C-series	Total
EPV Energia Oy	6.5	6.6	6.5	6.5
Fortum Power and Heat Oy	26.6	25.0	26.6	25.8
Karhun Voima Oy	0.1	0.1	0.1	0.1
Kemira Oyj	1.9	–	1.9	1.0
Oy Mankala Ab	8.1	8.1	8.1	8.1
Pohjolan Voima Oy	56.8	60.2	56.8	58.5
	100%	100%	100%	100%

The largest shareholder in the company is Pohjolan Voima Oy (PVO), whose owners are Finnish forest industry companies, municipalities and towns as well as energy companies owned by them.

The shareholders of Etelä-Pohjanmaan Voima Oy are mostly utilities owned by the municipalities in the province of South Ostrobothnia.

Fortum Power and Heat Oy is part of Fortum Group, whose principal owner is the State of Finland. The company's business comprises the production, sales and transmission of electricity and heat. Its customers include utilities owned by towns and municipalities, industrial companies and other major consumers of electricity. Fortum Power and Heat Oy owns and operates the Loviisa nuclear power plant.

Kemira Group is a chemical industry company operating in four business areas: Paper, Oil & Mining and Municipal & Industrial. Kemira's largest owners are Oras Invest Oy (18.2 %) and Solidium Oy (16.7 %).

Oy Mankala Ab is a company owned by the City of Helsinki, producing and purchasing electricity primarily for its shareholders.

Karhu Voima Oy is part of the Loiste group.

Users of electricity produced by TVO include Finnish society and electricity consuming industry. Through the shareholding energy companies and other companies, TVO's electricity is distributed to about 60 Finnish industrial and utility companies.

TVO's shareholders are responsible for the variable and fixed annual costs in accordance with the Articles of Association. Each of the company's shareholders is responsible for the company's fixed annual costs, including interest on loans and instalments according to the number of shares owned regardless of whether the shareholder in question has used its share in the electricity generated by the company. In addition, each shareholder is responsible for the variable annual costs in the proportion it has consumed the electricity generated or transmitted by the company.

The company sells the electricity it produces to its shareholders at cost price without aiming at profit.

The shareholders and the Articles of Association maintain that TVO has sound financial prerequisites for its operations.

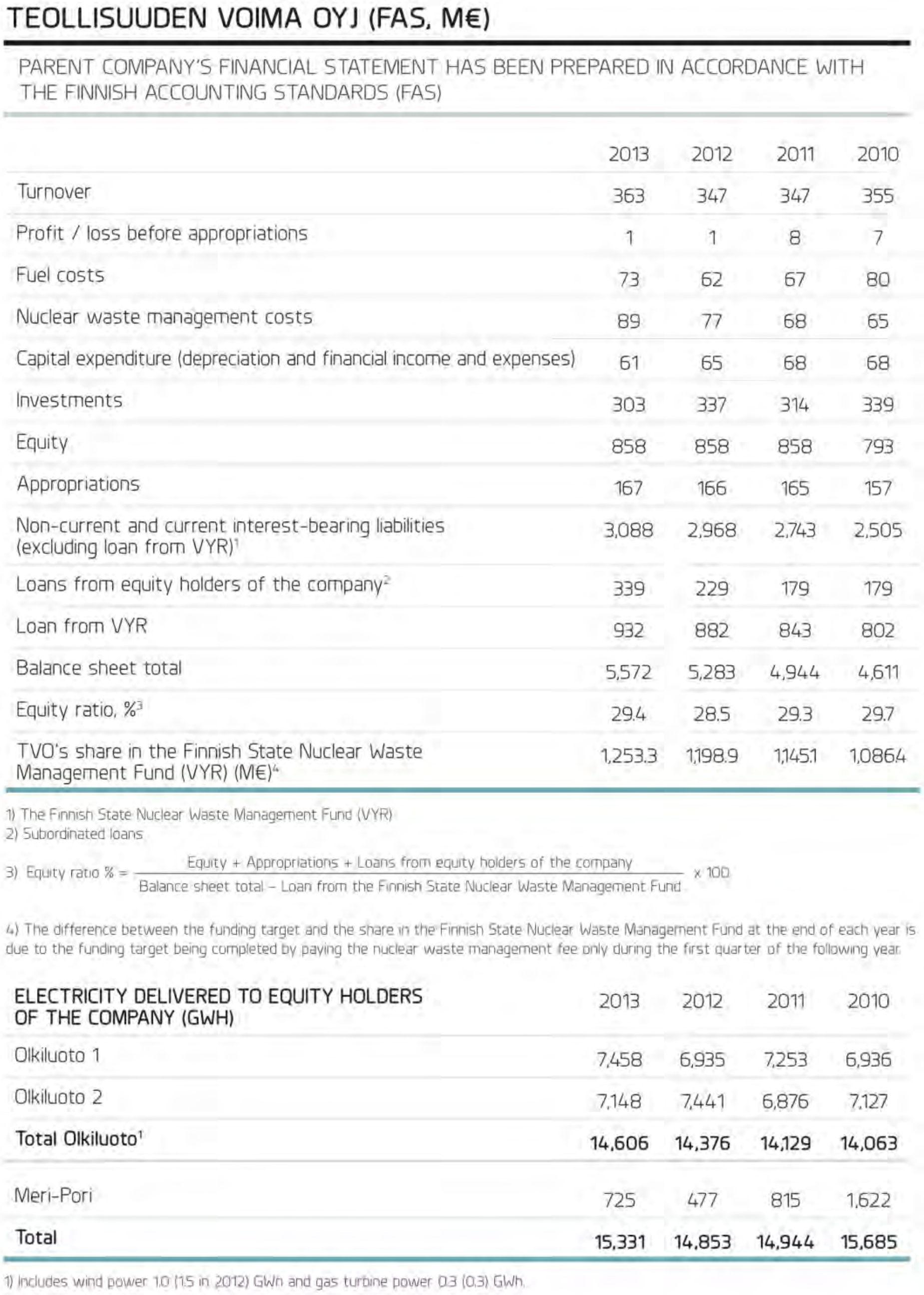
1.2. Financial position of the company

Information about the company's financial position can be found in the enclosed financial statements for 2013 included in the Annual report.

According to the financial statements, the company's balance sheet total on 31 December 2013 stood at EUR 5,572 million. Shareholders' equity and similar items amounted to EUR 1,364 million. The amount of debt was EUR 4,547 million, of which debt owed to the Finnish State Nuclear Waste Management Fund (VYR) and further lent to the company's shareholders amounted to EUR 932 million, and subordinated shareholder loans amounted to EUR 339 million. 4 per cent of the company's loans are allocated to the A-series, 95 per cent to the B-series and 1 per cent to the C-series.

Approximately EUR 1,000 million has been spent on annual maintenance investments, including investments in infrastructure, during the current service life of the OL1 and OL2 plant units. In the years 2010 and 2012, the low-pressure turbines and generators of both plant units were renewed and, as a result, their nominal output capacity was increased to 880 MW from the 860 MW. Approximately EUR 3,600 million of the investment in the OL3 project were implemented by the end of 2013.

Table 5–2 *Development of Teollisuuden Voima Oyj's key figures. Financial statements according to the Financial Accounting Standards (FAS).*



TEOLLISUUDEN VOIMA OYJ (FAS, M€)

PARENT COMPANY'S FINANCIAL STATEMENT HAS BEEN PREPARED IN ACCORDANCE WITH THE FINNISH ACCOUNTING STANDARDS (FAS)

	2013	2012	2011	2010
Turnover	363	347	347	355
Profit / loss before appropriations	1	1	8	7
Fuel costs	73	62	67	80
Nuclear waste management costs	89	77	68	65
Capital expenditure (depreciation and financial income and expenses)	61	65	68	68
Investments	303	337	314	339
Equity	858	858	858	793
Appropriations	167	166	165	157
Non-current and current interest-bearing liabilities (excluding loan from VYR)[1]	3,088	2,968	2,743	2,505
Loans from equity holders of the company[2]	339	229	179	179
Loan from VYR	932	882	843	802
Balance sheet total	5,572	5,283	4,944	4,611
Equity ratio, %[3]	29.4	28.5	29.3	29.7
TVO's share in the Finnish State Nuclear Waste Management Fund (VYR) (M€)[4]	1,253.3	1,198.9	1,145.1	1,086.4

1) The Finnish State Nuclear Waste Management Fund (VYR)
2) Subordinated loans

3) $$\text{Equity ratio \%} = \frac{\text{Equity + Appropriations + Loans from equity holders of the company}}{\text{Balance sheet total − Loan from the Finnish State Nuclear Waste Management Fund}} \times 100$$

4) The difference between the funding target and the share in the Finnish State Nuclear Waste Management Fund at the end of each year is due to the funding target being completed by paying the nuclear waste management fee only during the first quarter of the following year.

ELECTRICITY DELIVERED TO EQUITY HOLDERS OF THE COMPANY (GWH)	2013	2012	2011	2010
Olkiluoto 1	7,458	6,935	7,253	6,936
Olkiluoto 2	7,148	7,441	6,876	7,127
Total Olkiluoto[1]	**14,606**	**14,376**	**14,129**	**14,063**
Meri-Pori	725	477	815	1,622
Total	**15,331**	**14,853**	**14,944**	**15,685**

1) Includes wind power 1.0 (1.5 in 2012) GWh and gas turbine power 0.3 (0.3) GWh.

1.3. Funds for nuclear waste management

TVO’s liabilities for nuclear waste management (the estimated future expenditure for decommissioning plant units and for the management of nuclear waste that has been already produced) stood at EUR 1,318 million at the end of 2013. EUR 1253 million of this amount has been collected in the Finnish State Nuclear Waste Management Fund.

The new NPP unit OL3 that is under construction will join TVO’s preparation system for nuclear waste management when the plant unit starts operating and the assets required will be collected as part of electricity price to the Finnish State Nuclear Waste Management Fund.

The procedure will be the same for the new NPP unit OL4.

1.4. Risk management and insurance

TVO has a comprehensive risk management plan that is revised regularly. Risk management is implemented according to company-level policy documents and good corporate governance practices. The risk management is monitored by the company’s Board of Directors. Risks are to be minimised primarily through internal actions and, in addition, to be covered through insurance.

TVO insures its property with property risk insurance policies that have an "all risk" condition at replacement value. NPP units Olkiluoto 1 and 2 have a valid property insurance policy which has a separate coverage for decontamination costs.

TVO maintains a valid nuclear liability insurance according to the current Nuclear Liability Act. The insurance will pay for damages that TVO as the operator of the nuclear facilities is liable to compensate for by virtue of the Nuclear Liability Act (484/72) and its amendments. The Finnish nuclear liability system is based on the Paris Convention and the Brussels Supplementary Convention, after the ratification of which the change of the Nuclear Liability Act requires the license holder to arrange for an insurance or a security by the amount of EUR 700 million, with a 30 year limitation of actions in personal injuries and which covers environmental damage.

The temporary amendment of the Nuclear Liability Act came into effect from the beginning of year 2012. According to the temporary amendment of the act, the facility owner has an unlimited responsibility for nuclear damage that takes place in Finland, but the responsibility is limited for nuclear damage that has taken place elsewhere than in Finland to 600 million special drawing rights (SDR), which corresponds circa 700 million euros. The facility owner shall have an insurance for responsibilities incurred due to nuclear damage up to at least 600 million SDR.

For OL3 project, the company has a full value insurance covering the construction phase. In addition, the company has a delay insurance, transport insurance and liability insurance covering the OL3 project.

2. ECONOMIC VIABILITY OF THE PROJECT

2.1. General

The project will increase the production of foreseeable and stable base load power with low production costs. The long-term production costs of electricity will have a crucial impact on power plant investment decisions of the applicant and its shareholders.

The project’s economic viability will be examined below on the basis of electricity production costs. It is in the overall good of society that electricity is produced in as inexpensive manner as possible. For this purpose, the costs of electricity produced using alternative power plant types suitable for the production of base load power will be compared and certain central issues related to the production costs will be examined. Key factors related to the economic viability of the nuclear power plant investment will also be presented.

2.2. Cost structure of the options for electricity production

Several national and international estimates have been prepared for the costs arising from the alternative production options for base load electricity. Local conditions have a significant effect on the results.

The cost structures of base load electricity produced using different power plants and fuels differ from each other significantly. This is illustrated below in the figure in Section 2.3 by dividing the total production costs of each production alternative into capital, operational and fuel costs. In addition, any expenses arising from carbon dioxide emissions must be accounted for.

Power plants producing electricity in a stable and foreseeable manner where electricity can be produced in sufficiently large units are the most suitable for the production of base load power.

Nuclear power and wind power are the most capital intensive forms of production but nuclear power is the best-suited for base load power production because of its steady and high utilisation rate. Among the examined base load power alternatives, nuclear power is clearly the most capital-intensive, while natural gas was the least capital-intensive..

The share of investment costs in electricity production costs (without any emission trading costs) is about 60 per cent for nuclear power, 25 per cent for coal, more than 10 per cent for natural gas, about 30 per cent for peat and more than 30 per cent for wood. Thus the investment costs have a significant effect on the economy of nuclear power. On the other hand, the large share of investment costs makes the costs arising from electricity produced using nuclear power stable and predictable.

The share of fuel costs in the total electricity production costs varies greatly between the examined forms of production.

For nuclear power, the share of fuel costs in the calculations is only about 15 per cent of the total electricity production costs, whereas the share is far greater in other energy sources – generally more than one half of the production costs. The small share of fuel costs makes the nuclear power costs stable and predictable.

The fuel costs for nuclear power comprise the raw uranium, its conversion into material suitable for the enrichment process, uranium enrichment, and the manufacture of fuel elements. The share of the actual raw material, i.e. uranium, is approximately one half of the fuel costs, so the share of uranium in the production costs for nuclear electricity is about 7–8 per cent. The rest of the fuel costs comprise the other phases of fuel manufacturing, which constitute normal industrial production and whose costs can be reliably predicted.

The dependence of nuclear power production costs on fluctuations in fuel price and exchange rates is low because the share of the fuel in the total production costs is minor. The dependence of production costs on the market prices of coal, natural gas, peat and wood is significant for these corresponding forms of electricity production. This will significantly increase the insecurity of long-term estimates for these alternatives. Furthermore, the price of electricity produced by coal or natural gas is very sensitive to foreign exchange rate fluctuations.

The forms of production using fossil fuels (coal, gas and peat) include costs arising from carbon dioxide emissions, the size of which affects the relative competitiveness of the nuclear power.

2.3. Reports and calculations prepared

TVO has prepared calculations for the power plant project’s economic viability and funding. The reports prepared indicate that nuclear energy is competitive with regard to the production cost.

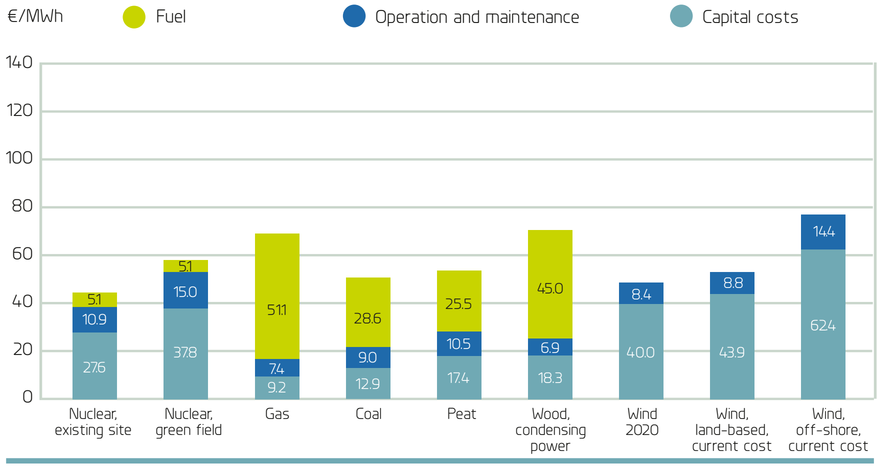
With regard to investment costs for nuclear power plants, the calculations are based on TVO’s experiences and price and implementation schedule information received during the ongoing competition. Correspondingly, fuel and operational costs are based on the realised and estimated costs for Olkiluoto. During the ongoing bidding process a more detailed cost estimate cannot be published. The premature publicity of the cost estimates serves neither the Olkiluoto 4 project nor the overall good of the society.

The viability of the nuclear power is based on the long production phase during which the electricity production is stable with regard to both its expenses and for its production rate. The reliable production of the Olkiluoto NPP and the existing infrastructure promote the realization of the OL4 project.

The costs of alternative basic load power production methods have been also compared in the 2012 report of Lappeenranta University of Technology. The results of the report are shown in Figure 5-1.

The report compared the production costs and cost structures of nuclear power, coal, natural gas, peat, wood and wind power at different annual utilisations. When the plants are used to produce base load power for 8,000 hours per year, the report found that the most affordable plant type is a 1,650 MW NPP unit.

Figure 5–1 *Base load power alternatives without emissions trading assuming an 8,000 hour peak utilisation (except for wind power, for which the peak utilisation is assumed to be 2,200 hours.). The real rate of interest at 5 %, price level of March 2012, no subsidies assumed for wind and wood. Source: Lappeenranta University of Technology 2012, Vakkilainen, Kivistö, Tarjanne.*



In the estimate, the new production unit is located at an existing site with already-operating unit. Thus, capital costs do not include other infrastructure costs such as grid connections, roads, harbour, fresh water supply, sewage treatment systems, environmental control or emergency management procedures and arrangements.

2.4. Realised electricity production in the current Olkiluoto plant units

The electricity production of the current plant units at Olkiluoto has varied between 14.2 TWh and 14.6 TWh over the past five years. Production costs are estimated to increase slightly in the near future because of the increased fuel costs and the increased cost estimates for the final disposal of nuclear waste.

The net electric power of the Olkiluoto 1 and Olkiluoto 2 plant units are 880 MW after the modernisation implemented in 2010–2012.

The annual production objective of the OL3 plant unit under construction is 12–13 TWh on the basis of the utilisation rate assessed for the first years.

The electric power of the new planned nuclear power plant unit will be 1,000–1,800 MW depending on the plant type selected. Based on the above and the utilisation rate assessed for the first years the planned annual production objective is 8–14 TWh. The designed operating period is 60 years.

2.5. Summary

According to the reports prepared, nuclear power is competitive. In addition, costs can be reduced further as the new power plant unit will be built in the existing plant at Olkiluoto, in which case the built infrastructure can be utilised.

A special benefit of nuclear power is the long-term predictability of production costs. Because nuclear power does not generate greenhouse gas emissions and does not cause any related additional costs, the competitiveness of nuclear energy is assumed to improve in the future.

The additional construction of nuclear power is a strategic investment for the energy policy of the entire nation and it will have a long-term stabilising effect on the price level of electricity within the entire market area.

3. APPENDICES

Teollisuuden Voima Oyj, Annual Report 2013.

OVERALL FINANCING PLAN FOR THE NUCLEAR FACILITY PROJECT

CONTENTS

OVERALL FINANCING PLAN FOR THE NUCLEAR FACILITY PROJECT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

Since the favourable decision-in-principle, sustained in 2010 by the Parliament, concerning Nuclear Power Plant (NPP) unit OL4, the project has started the bidding process. During the process, the eventual financing alternatives have been studied. The costs of the project have been covered until today by shareholder loans.

1. INVESTMENT

In the 2008 application for the decision-in-principle, TVO presented a preliminary cost estimate for the NPP unit Olkiluoto 4. After the positive decision-in-principle, which was sustained by the Parliament in the year 2010, TVO has started a bidding process aiming for the procurement of the plant unit. The bids were received in January 2013. The cost estimate of NPP unit Olkiluoto 4 is higher than was estimated in the application for the decision-in-principle of the year 2008. Because of the on-going bidding process, a more detailed cost estimate for the construction of the NPP unit Olkiluoto 4 cannot be published.

With regard to the investment costs of the nuclear power plant unit, the calculations are based on TVO’s own experience, as well as pricing information and implementation schedules received from nuclear power plant suppliers.

The amount of investment costs will be specified in more detail when the competitive bidding process with the goal of purchasing the NPP unit is finished.

2. SOURCES OF FINANCING

The financing of the base investment of the project is arranged so that the owners obligate themselves to increase the capital stock of the company and/or provide credit at such conditions which enable the use of versatile debt financing sources. The majority of the costs will be financed with loans from financial institutions, from the capital markets and by e.g. the use of guarantees and/or direct loans from applicable export guarantee boards. In addition, it may be feasible to utilise funding arranged by the plant suppliers or different alternatives of project financing. According to the studies carried out in the project, the debt portion of the project can be financed on commercial terms.

3. STAGES OF FINANCING

The financing takes into account the special features of both the construction and the operational phase separately. The sources of financing and their mutual relation may be different in the construction and operational phases.

4. REPAYMENT OF LOANS

The company’s long-term target is to maintain an equity ratio of approximately 25 %. According to the financing studies, financing is available with reasonable conditions when the NPP unit OL3 is in regular power operation. The large share of debt financing in the project is enabled by the excellent operational history and reliability of the existing plant units, the predictability of the production costs of the nuclear power and the fact that the shareholders are obligated to purchase the power produced throughout the lifetime of the facility. According to the TVO Articles of Association, the shareholders are responsible for the annual costs specified in the Articles, including the costs and amortizations of the loans.

The external financing needed for the project is intended to be amortized in circa 30 years. The design operational lifetime of the unit is about 60 years.

5. SUMMARY

Taking into account the above plans concerning equity and debt capital, financing for the project can be arranged in a way that is satisfactory to the parties.

OUTLINE OF THE TECHNICAL PRINCIPLES OF THE PLANNED NUCLEAR FACILITY

CONTENTS

OUTLINE OF THE TECHNICAL PRINCIPLES OF THE PLANNED NUCLEAR FACILITY

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

A Nuclear Power Plant (NPP) shall be constructed in Finland so that its use is safe and causes no damage to human beings, environment or property. In the decision-in-principle phase it is verified that the NPP project is in accordance with the overall good of the society. In later licensing stages, the construction and operating license phases, the safety of the plant is evaluated in detailed manner.

The Radiation and Nuclear Safety Authority has evaluated the safety of the plant alternatives presented in the application and noted in its preliminary safety evaluation in the year 2009 that all plant alternatives have design goals and principles which mostly correspond to Finnish safety requirements. At that time, some technical solutions required, according to the authority, more detailed analyses, experimental validation and continued design for later licensing stages. None of the technical solutions evaluated by the Radiation and Nuclear Safety Authority was such that the plant alternatives would not be capable of being constructed in accordance with the Finnish safety requirements.

Since the decision-in-principle of the year 2010, TVO has accomplished more feasibility studies during which the safety features and technologies of the plant alternatives have been further developed. The results of the feasibility studies have been reviewed also by the Radiation and Nuclear Safety Authority.

This appendix presents the general principles of the pressurised and boiling water reactors (PWR and BWR) and the safety features of the plant alternatives considered by TVO, which in many ways utilise the state-of-the-art technology. The descriptions of the plant alternatives have been updated. In the opinion of TVO, all plant alternatives may be realised in Finland according to also the latest Government Decrees and YVL Guides.

1. POWER PLANT PROCESS

The planned new nuclear power plant unit will operate on the principle of a light water reactor plant. Heat generated by uranium fuel is used to produce high-pressure steam. The steam is conducted to a turbine that drives an electric generator. In its basic principle, a nuclear power plant is a steam power plant, just like a coal-fired power plant.

In the reactor, the fuel is in small pellets approximately one centimetre in diameter, encased in gas-tight fuel rods of approximately four metres in length. The fuel rods are assembled into fuel assemblies, and there are hundreds of these in the reactor. The typical amount of uranium fuel in the reactor is on the order of one hundred tonnes.

Natural uranium consists mainly of two isotopes: 99.3 % of the isotope ^{238}U and 0.7 % of the isotope ^{235}U. Fuel for light water reactors is manufactured by enriching the uranium to contain slightly more than 3 % of the isotope ^{235}U, with the rest being isotope ^{238}U.

During operation, the ^{235}U in the fuel produces energy and is transformed into fission products. A fraction of the isotope ^{238}Uis transformed into plutonium, which also produces energy. Depending on the degree of enrichment, spent fuel contains almost 96 % ^{238}U and approximately 3 % fission products, as well as a total of more than 1 % fissionable uranium and plutonium.

Light water reactor plants may be either boiling water reactor plants or pressurised water reactor plants. At Olkiluoto, the nuclear power plant units Olkiluoto 1 and 2 currently in operation are boiling water reactor plants, while the Olkiluoto 3 unit under construction is a pressurised water reactor plant. The Loviisa plant is a pressurised water reactor plant.

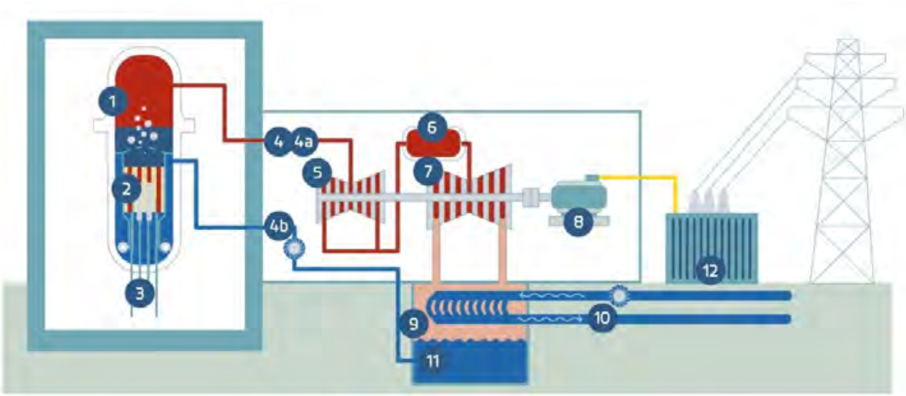
1.1. Boiling water reactor plant

Within the pressure vessel of a boiling water reactor (BWR), water is circulated through the fuel bundles in the reactor core by reactor coolant pumps or natural circulation. This heats the water to a typical temperature of approximately 290 °C, which makes it boil and generate steam at a pressure of approximately 70 to 75 bar.

The saturated steam is conducted through steam separators and a steam dryer located within the pressure vessel to a high-pressure turbine, an intermediate reheater and low-pressure turbines. The turbines are connected by a shaft to a generator that produces electricity.

The steam coming from the low-pressure turbines is conducted to a condenser, in which it is condensed into water using sea water cooling. There is underpressure in the condenser, meaning that in the case of a leak, sea water will leak into the process, not vice versa. From the condenser, the water is pumped through pre-heaters back to the reactor.

***Figure 7–1** The operating principle of a boiling water reactor plant.*



1. Reactor
2. Core
3. Control rods
4. Primary circuit

4a. Steam to the turbine

4b. Feed water to the reactor

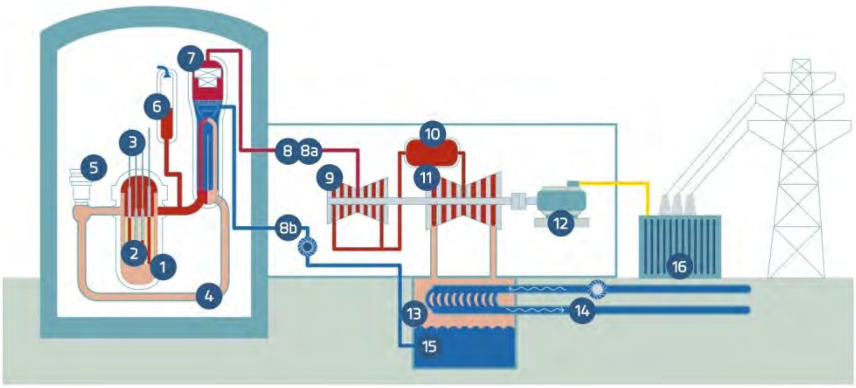
5. High-pressure turbine
6. Reheater
7. Low-pressure turbines
8. Generator
9. Condenser
10. Seawater circuit
11. Condensate
12. Transformer

1.2. Pressurised water reactor plant

Also in a pressurised water reactor (PWR) plant, fuel heats water but the reactor circuit is maintained at such a high pressure that the water will not boil. The pressure in the reactor is typically approx. 150 bar and the temperature is approx. 320 °C.

The pressurised water generates steam in separate heat exchangers belonging to the primary circuit, also known as steam generators, from where the water is pumped back into the reactor. The steam circulates in the secondary circuit, driving the turbines and generator.

***Figure 7–2** The operating principle of a pressurised water reactor plant.*



1. Reactor
2. Core
3. Control rods
4. Primary circuit (water circulation)
5. Reactor coolant pump
6. Pressuriser
7. Steam generator
8. Secondary circuit

8a. Steam to the turbine

8b. Feed water to the steam generators

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

2. TECHNICAL DATA

Table 7-1 below presents some technical data on the prospective NPP unit. The figures are preliminary.

Table 7–1 *Preliminary technical data of the NPP unit OL4.*

Quantity	Value and unit
Electric power	ca. 1 000–1 800 MW_e
Thermal power	2 800–4 600 MW
Overall efficiency	ca. 35–40 %
Fuel	UO_2
Consumption of uranium fuel	ca. 20–40 t/a
Average degree of enrichment	ca 2–5 % of ^{235}U
Uranium content of reactor	ca. 100–150 t
Annual electricity production	ca. 8–14 TWh
Need for cooling water	ca. 40–60 m^3/s

The planned technical service life of the plant unit is approximately 60 years.

3. PLANT ALTERNATIVES INVESTIGATED

Jointly with nuclear power plant suppliers, TVO has investigated the feasibility of certain plant alternatives for being built in Finland. The investigations have shown that there are several plant alternatives available that can be implemented in a way that complies with the Finnish safety requirements, which are advanced by international comparison.

Other types of light water reactors beside those included in the feasibility studies so far may also come into question when choosing the plant alternative to be implemented.

The plant alternatives included in the feasibility studies are presented in Table 7–2 below in an alphabetical order by reactor type.

Table 7–2 *Plant alternatives investigated.*

Reactor type	Name	Supplier	Country of origin	Electric power MW
BWR	ABWR	Toshiba-Westinghouse	Japan, Sweden	ca 1 650
	ESBWR	GE Hitachi	USA	ca 1 650
PWR	APR 1400	Korea Hydro & Nuclear Power	Rep. of Korea	ca 1 450
	APWR	Mitsubishi Heavy Industries	Japan	ca 1 650
	EPR	AREVA	France, Germany	ca 1 650

The designs of the investigated plant alternatives are advanced in comparison with the plants that are currently in operation. A significant new feature in the investigated plant alternatives is that so-called severe accident management has been taken into account in their design from the very beginning. In these extremely unlikely accidents, the reactor core is assumed to suffer severe damage (meltdown). The design of all of the plant alternatives also includes provisions for a large airliner crash, external natural phenomena and the wide-scale malfunction of the internal power supply. The safety principles are discussed in more detail in appendix 8 "Description of the Safety Principles Observed".

The plant alternatives include so-called evolutionary plant types based on existing plants, as well as new passive plant types, the safety features of which are more extensively based on laws of nature. This entails for example gravity-driven operation and various degrees of independence from external power.

In addition to safety, the design of the plant alternatives pays special attention to their constructability and economical feasibility. In order to ensure problem-free operation, all of the plant alternatives share the aim of using equipment based on proven technology in systems essential to the production of electricity and safety.

In the following, short descriptions of each plant alternative are provided in alphabetical order. The following basic information is presented for each plant alternative:

- reactor type, boiling or pressurised water reactor
- manufacturer and country of origin
- design approach, either evolutionary or passive
- approximate thermal power of the reactor
- approximate net electric output of the plant and
- for PWRs, number of steam generator circuits

Furthermore, the principles of implementation of the following safety functions are briefly described for each alternative;

- reactor shutdown
- residual heat removal from the reactor
- emergency core cooling
- decay heat removal from the containment building and
- severe accident management.

Material related to the application has been submitted separately to the Radiation and Nuclear Safety Authority (STUK).

3.1. ABWR

3.1.1. Basic Information

The ABWR boiling water reactor plant by Toshiba of Japan represents the evolutionary approach but also includes some passive safety systems. The United States Nuclear Regulatory Commission granted type approval (design certification) for ABWR in 1997 and during the last few years, the Combined Operation License process for South Texas Project (STP) 3&4 has been ongoing. There are three ABWR plant units in operation in Japan.

The most recent of these, Hamaoka-5, is the reference for the version planned for Finland which has been further developed on the basis of the design of STP 3&4 and of the TVO Licensing Feasibility Study to account for Finnish safety requirements.

The thermal power of the reactor in the plant alternative is approximately 4,300 MW. The net electric output of the plant is approximately 1,650 MW.

3.1.2. Safety functions

Reactor shutdown

One passive system is available for reactor shutdown, based on hydraulic insertion of the control rods into the reactor. Furthermore, there is one active system that inserts the control rods into the core using electric motors, and another active system that is based on pumping boron solution into the reactor. Each of these systems alone is able to safely shut down the reactor in connection with all anticipated operational transients, taking a single failure into account.

Decay heat removal from the reactor under normal operating pressure

An isolation condenser is available for decay heat removal from the reactor. It consists of four heat exchangers and makes it possible to remove decay heat without having to remove any coolant from the reactor. Furthermore, there is an active high-pressure makeup water system with three parallel independent subsystems each having 100 per cent capacity.

Emergency core cooling

An active low-pressure emergency cooling system is available for emergency core cooling. It consists of three parallel independent subsystems each with 100 per cent capacity. In some situations, the operation of the low-pressure emergency core cooling system will additionally require reduction of reactor pressure, and to implement this, eight of the reactor’s eighteen relief and safety valves will contribute to the automatic depressurization function as necessary.

The ABWR unit designed for Finland has further been improved with a low-pressure auxiliary water injection system that can feed water in both to the reactor core and to the pools containing the spent fuel, isolation condensers and the passive containment cooling system.

Decay heat removal from the containment building

There is an active system for the removal of decay heat from the containment building, comprising three redundant and independent subsystems each having 100 % capacity.

If steam is released into the containment building, for example in case of leaks in the reactor circuit, the rise of pressure and temperature in the containment can also be limited using a passive containment cooling system. It comprises four heat exchangers that are connected to the upper drywell section of the containment. The steam in the containment will find its way to the heat exchangers in which it is condensed, and the released heat is conducted to a water pool outside the containment. The condensate resulting from the steam is conducted back to the containment.

Severe accident management

Severe accident management is based on cooling the molten core material discharged from the reactor at the bottom of the containment. For this purpose, a so-called core catcher is designed for the containment that ensures the coolability of the molten core and prevents it from getting into direct contact with the pressure-bearing parts of the containment. In order to ensure cooling, the space below the reactor pressure vessel is automatically flooded by draining water from the condensation pool. Flooding will be triggered automatically by a signal indicating a rupture of the pressure vessel. A separate depressurization system exists for keeping the reactor pressure low in connection with a severe accident. Its valves are designed to stay reliably open also in conditions corresponding to a severe accident.

With regard to its volume and pressure resistance, the containment is designed so that the amount of hydrogen generated in complete oxidation of the zirconium inventory of the core can be retained within the containment building. In the long term, the pressure in the containment building can be reduced by releasing non-condensable gases into the environment through a filtered venting system. This can be done in a controlled manner at a suitable time because containment pressure can be managed using the passive containment cooling system referred to above.

3.2. ESBWR

3.2.1. Basic information

ESBWR is a passive boiling water reactor plant by the American company General Electric Hitachi. The passivity is not limited to safety functions but also the circulation of coolant and the transfer of heat released in the fuel out of the reactor are based on natural circulation.

No plant units of this type are in operation or under construction at present but a combined construction and operating licence application for one ESBWR unit is currently pending approval by the US Nuclear Regulatory Commission. GE has also obtained a design certification for the plant alternative from the US NRC.

The ESBWR reactor has a thermal power of approximately 4,500 MW and a net electric output of approximately 1,650 MW.

3.2.2. Safety functions

Reactor shutdown

For the purpose of reactor shutdown, there is a passive system typical of boiling water reactor plants based on inserting the control rods into the core from below using pressurised nitrogen and water. The operation of hydraulic scram is supplemented in the normal manner through active electromechanical insertion of the control rods.

If, for any reason, the control rods could not be moved at all, rapid shutdown of the reactor is also possible using a passive boron system comprising of two circuits. Both circuits have a tank containing boron solution, the contents of which can be injected into the reactor using pressurised nitrogen gas. Each of the subsystems alone is able to bring the reactor to hot shutdown state.

Each of the three above mentioned systems alone is able to safely shut down the reactor in all anticipated situations where scram is needed.

Decay heat removal from the reactor under normal operating pressure

Decay heat removal from the reactor under normal operating pressure primarily takes place using isolation condensers. The isolation condensers comprise four parallel independent heat exchanger circuits, at least three of which are required to operate in accordance with the design bases for the system. Furthermore, each of the separate circuits is separately tolerant against single failure with regard to active functions (the opening of valves).

The system capacity together with reactor properties (large amount of water, large steam volume) is sufficient to limit the increase in reactor pressure at the closure of the steam line isolation valves so that not a single relief or safety valve needs to open.

Decay heat removal from the reactor at high pressure is also possible using the shutdown reactor cooling system. This system is also used for bringing the reactor to cold shutdown state. The system has two parallel branches, one of which is sufficient to remove the decay heat generated by the reactor at normal operating pressure.

Emergency core cooling

The operation of the low-pressure emergency core cooling system, which is categorised as a safety system, is based on gravitational draining of water from pools in the containment into the reactor. The system comprises four parallel circuits, each of which is further divided into two trains. The design basis for the system is a situation in which one subsystem has a pipe rupture preventing operation, and one of the two trains of another subsystem has a valve fault preventing operation. The system is started by blasting open a squib valve.

The operation of the low-pressure emergency core cooling system requires rapid reduction of reactor pressure. A total of 10 of the reactor’s 18 normal relief and safety valves contribute automatically to this function. The steam released through these valves is conveyed to the condensation pool. Furthermore, there are eight depressurization valves that have no other tasks beside the automatic depressurization. The release from these valves is directed into the upper drywell section of the containment.

At low reactor pressure, emergency core cooling can also be achieved using a system consisting of two parallel circuits with 2 × 100 per cent capacity. However, start-up of the system requires manual action by the operators. The system gets water from the condensation pool in the containment.

If the leak in the reactor circuit is minor, the required additional makeup water can also be obtained from the control rod drive hydraulic system. The system is able to pump water into the reactor at full operating pressure but its capacity is only sufficient to compensate for relatively small leaks. The system gets water from the feedwater storage tank.

Decay heat removal from the containment building

Decay heat removal from the containment building can take place in a completely passive manner in situations where the decay heat generated by the reactor can be transferred to the gas plenum of the containment building as steam. The steam can be condensed in six heat exchangers, which would be put into use in a completely passive manner without the operation of any active device. From the heat exchangers, the heat is transferred to water pools outside the containment, and ultimately as steam to the environment. The volume of water in the pools is sufficient for decay heat removal for 72 hours without replenishment.

Heat can also be removed from the condensation pool using an active system comprising two subsystems that also caters to the task of cooling the fuel pools. The system can also be used for emergency cooling of the core at low reactor pressure as described above in the section concerning emergency core cooling. Cooling the containment to a temperature less than 100 °C requires the operation of an active system.

Severe accident management

Severe accident management is based on cooling the molten core material in the containment. For this purpose, the space below the reactor is equipped with a core catcher. Flooding of the core catcher will be triggered automatically by a signal indicating a rupture of the pressure vessel. The water used for flooding comes from the same tanks used for low-pressure emergency core cooling. The pipelines used for flooding are also partially shared with the passive low-pressure emergency cooling system.

The passive containment cooling system referred to above is also able to operate in the conditions of severe accidents and prevent the containment pressure from exceeding the design limit of the building due to decay power.

Melt-through of the reactor pressure vessel at high pressure can be prevented using the eight depressurization valves mentioned above in the section describing emergency core cooling. The valves are actually a type of squib valve that is opened by blasting. Such valves will thereafter remain open in all conditions.

3.3. APR 1400

3.3.1. Basic information

APR 1400 is a pressurised water reactor plant of the evolutionary type jointly designed by the Korean companies KHNP, KEPCO E&C and DOOSAN. It is based on the System 80+ concept developed by the American company Combustion Engineering. The first four plants of this type are under construction in South Korea, with scheduled commissioning in 2015 and 2016.

APR 1400 has two steam generator circuits. Both steam generator circuits have two parallel cold legs and two reactor coolant pumps.

The thermal power of the reactor is 4,000 MW, and the net electric output of the plant is approximately 1,450 MW.

3.3.2. Safety functions

Reactor shutdown

There is a reactor shutdown system, based on dropping the control rods into the core, which is typical in pressurised water reactors. Reactor shutdown can also be ensured by pumping borated water into the reactor using the high-pressure emergency cooling system. Furthermore, the design has been complemented to fulfil the Finnish requirements by an active emergency boration system that is independent of the control rods.

The reactor shutdown can also be ensured by pumping borated water into the reactor using the high-pressure emergency core cooling system. In addition, in accordance with the original design, the boron concentration of the reactor water can be increased by using the normal system for chemical and volume control of the primary circuit.

Decay heat removal from the reactor under normal operating pressure

An emergency feedwater system having 4 × 100 per cent capacity is available for decay heat removal from the steam generators. Two subsystems have electrical pumps, while two have pumps operated by steam turbines.

Emergency core cooling

There are four parallel trains for emergency cooling of the reactor, each of them containing a high-pressure emergency cooling system and a pressure accumulator. The water from the pressure accumulators will be released into the reactor in a completely passive manner once the primary pressure has dropped sufficiently due to a leak in the primary circuit, for example. The pressure accumulators are equipped with flow limiters that release the water contained in the accumulators in a controlled manner and make it last longer. This has allowed the exclusion of a separate low-pressure emergency cooling system from the plant concept. The high-pressure emergency cooling system is also able to operate at low reactor pressure.

An advanced feature of the emergency core cooling system is that all emergency cooling water is injected directly into the reactor pressure vessel through four nozzles. This improves the efficiency of emergency core cooling particularly in connection with accidents involving leaks from the cold legs.

There are four parallel relief lines available for reducing primary circuit pressure. The released steam is conducted to the emergency cooling water storage pool in the containment, in which it will be condensed.

The combined capacity of the parallel trains of the emergency cooling system described above will be sufficient to ensure the cooling of the core also in case of a major pipe rupture in the primary circuit even if one subsystem has a single failure preventing operation and another is simultaneously inoperable due to maintenance or repair.

An active decay heat removal system consisting of two parallel circuits, both with two pumps, is available at low pressures and temperatures. It can be used to remove the heat from the primary coolant to the ultimate heat sink. At low reactor pressures, the system can also be connected to the containment spray system by operator action. In such case, it will be possible to pump water from the emergency cooling water storage pool into the reactor to ensure the reactor emergency core cooling function.

Decay heat removal from the containment building

A containment spray system is available for decay heat removal from the containment, which has a double-shell structure. The containment spray system has two separate circuits with two parallel pumps in each. If desired, the system can be connected to directly cool the primary circuit and, correspondingly, the pumps within the decay heat removal system can be connected to spray the containment as necessary.

Severe accident management

Severe reactor accidents have been taken into account in the containment building design. The space below the reactor pressure vessel is designed to ensure the best possible spreading of molten core material discharged from the pressure vessel into a layer that can be cooled down. The flooding of this core catcher will be started as the reactor pressure vessel is ruptured.

The flooding of the space below the reactor pressure vessel will be done as necessary by draining water to the space from the emergency cooling water storage pool. There are two parallel lines for draining.

To reduce the primary circuit pressure and to maintain its low value during a severe accident, there is a separate primary circuit depressurisation system.

There is a containment spray system, which was mentioned above, to remove residual heat from the containment in the aftermath of the severe accident.

The containment has been dimensioned so that the total amount of hydrogen released in the perfect oxidization of the core zirconium inventory can be retained inside the containment. The control of the hydrogen concentration and of the non-condensable gases is based on the controlled hydrogen removal using autocatalytic recombiners.

3.4. APWR

3.4.1. Basic information

APWR is a pressurised water reactor plant of the evolution type designed by Mitsubishi Heavy Industries (MHI) of Japan. It is based on four-circuit PWR plants previously delivered by MHI. The APWR plant type is not yet in operation or under construction but the licensing process for two plant units is underway in Japan.

APWR has four steam generator circuits. The thermal power of the reactor is 4,450 MW, and the net electric output of the plant is approximately 1,650 MW.

3.4.2. Safety functions

Reactor shutdown

There is a reactor shutdown system, based on dropping the control rods into the core, which is typical in pressurised water reactors. The reactor can be shut down independent of the control rods by increasing the boron concentration in the reactor water by using the normal system for controlling the primary circuit chemistry and water volume. In addition, the unit designed for Finland has been complemented by a two-division active emergency boration system that is independent of the control rods.

Furthermore, the primary circuit pressure can be rapidly reduced using a separate depressurization system. In this case, the emergency core cooling system will automatically start to pump heavily borated emergency cooling water into the reactor, which will shut it down.

Decay heat removal from the reactor under normal operating pressure

There is an active emergency feedwater system for the removal of decay heat from the primary circuit through the steam generators, comprising four parallel independent subsystems each having 50 % capacity. Two of these are equipped with electric pumps and two with pumps operated by steam turbines.

Emergency core cooling

There are four parallel trains for emergency core cooling, each of them containing a high-pressure emergency cooling system and a pressure accumulator. The water from the pressure accumulators, which fulfil the single failure criterion, will be released into the reactor in a completely passive manner once pressure has dropped to the release limit due to a leak in the primary circuit, for example. The pressure accumulators are equipped with flow limiters that release the water contained in the accumulators in a controlled manner and make it last longer. This has allowed the exclusion of a separate low-pressure emergency cooling system from the plant concept. The high-pressure emergency core cooling system is also able to operate at low reactor pressure.

An advanced feature of the emergency cooling system is that the high-pressure emergency cooling system pumps its water directly into the reactor pressure vessel through four nozzles. The water contained in the pressure accumulators is released into the cold legs of the primary circuits.

There are two parallel relief lines categorised as safety systems for reducing the pressure in the primary circuit, each having 100 per cent capacity with regard to successful emergency core cooling.

The combined capacity of the parallel trains of the emergency core cooling system described above will be sufficient to ensure the cooling of the core also in case of a major pipe rupture in the primary circuit even if one subsystem has a single failure preventing operation and another is simultaneously inoperable due to maintenance or repair.

An active decay heat removal system, which constitutes a combined decay heat removal and containment spray system, is available at low pressures and temperatures. It can be used to transfer heat from the primary circuit coolant to the ultimate heat sink. This system comprises four parallel and independent subsystems, each with 50 per cent capacity. Depending on the situation, the system can be used to cool either the primary circuit or the emergency core cooling water pool located in the containment. At low reactor pressure, the system can also be connected to pump water from the emergency cooling water pool into the reactor by operator action, which will supplement the reactor emergency cooling function.

Decay heat removal from the containment building

The combined decay heat removal and containment spray system mentioned above is available for decay heat removal from the containment building. The system comprises four parallel and independent subsystems, each with 50 per cent capacity. The system can be used to cool the emergency core cooling water pool located in the containment by circulating water in the pool through heat exchangers. The containment atmosphere can also be cooled by spraying water into it through fine spray nozzles. The sprayed water flowing back will transfer heat from the atmosphere to the emergency core cooling water storage.

Severe accident management

Severe reactor accidents have been taken into account in the containment design. A special core catcher has been designed into the space below the reactor pressure vessel. When the reactor pressure ruptures due to melting down, the core catcher is flooded with water. In addition, the design includes a separate core melt distributor so that the core melt exiting the reactor vessel would flow into the core catcher in a coolable manner. The steel liner ensuring the tightness of the containment is covered with a protective layer of concrete in order to prevent the molten core material discharged from the pressure vessel from damaging the steel liner.

A completely dedicated primary circuit depressurization line is available for reducing reactor pressure and maintaining it at a low level in connection with severe accidents.

For decay heat removal from the containment after a severe accident, there is an active system separate from the containment spray system referred to above. It condenses steam from the containment atmosphere using intermediate circuit water circulating in special cooling spirals. From the intermediate circuit, the heat is removed to the atmosphere through another set of cooling spirals. This residual heat removal system is designed as an active system, but its active components are in the secondary circuit outside the containment. Inside the containment, the heat is removed via natural circulation.

The containment building is dimensioned so that the amount of hydrogen released in complete oxidation of the zirconium inventory of the core can be retained within the containment building. The hydrogen concentration and the pressure of non-condensable gases are regulated by passive autocatalytic recombiners.

3.5. EPR

3.5.1. Basic information

EPR is an evolution type plant originally designed a joint venture of the French company Framatome and the German company Siemens KWU. It is based on the most recently commissioned pressurised water plants in both countries. These are called type N4 in France and type Konvoi in Germany. Currently, the nuclear business activities of Framatome and Siemens are part of the AREVA group. EPR plants are under construction in Olkiluoto, France and China.

EPR has four steam generator circuits. The thermal power of the reactor is 4,590 MW, and the net electric output of the plant unit is approximately 1,650 MW.

3.5.2. Safety functions

Reactor shutdown

There is a reactor shutdown system, based on dropping the control rods into the core, which is typical in pressurised water reactors. Another rapid shutdown system independent of the control rods is an active emergency boration system with two redundant and independent subsystems, each having 100 per cent capacity. This system is also capable of safely shutting down the reactor in all anticipated operational transients.

Decay heat removal from the reactor under normal operating pressure

There is an active emergency feedwater system for the removal of decay heat from the primary circuit through the steam generators, comprising four parallel independent subsystems each having 50 per cent capacity.

Emergency core cooling

There are four parallel trains for emergency core cooling of the reactor, each comprising a so-called intermediate-pressure emergency cooling system (operating range below 80 bar), a pressure accumulator and a low-pressure emergency cooling system. There are three parallel relief lines for reducing the pressure in the primary circuit, each having 100 per cent capacity with regard to successful emergency cooling.

The combined capacity of the parallel trains of the emergency core cooling system described above will be sufficient to ensure the cooling of the core also in case of a major pipe rupture in the primary circuit even if one subsystem has a single failure preventing operation and another is simultaneously inoperable due to maintenance or repair.

At low pressures and temperatures, an active decay heat removal system is available for transferring heat from the primary circuit coolant to the ultimate heat sink. This system comprises four parallel and independent subsystems, each with 50 per cent capacity.

Decay heat removal from the containment building

There is an active system for the removal of decay heat from the containment building comprising four parallel and independent subsystems, each having 50 per cent capacity.

Severe accident management

Severe reactor accidents have been taken into account in the containment design. The space below the reactor pressure vessel is designed to ensure the best possible spreading of molten core material discharged from the pressure vessel into a layer that can be cooled down. The spreading area will be flooded with water by a passively actuated and powered function. A completely separate 1 × 100 % primary circuit depressurization line is available for reducing reactor pressure and maintaining it at a low level in connection with severe accidents. It is redundant in terms of active components (valves).

There is an independent active system for removing decay heat from the containment building after a severe reactor accident, comprising two independent subsystems with 100 per cent capacity in each.

The system can also be used for cooling down the structures below the reactor pressure vessel, thus facilitating the cooling of the molten core material.

The containment building is dimensioned so that the amount of hydrogen released in complete oxidation of the zirconium inventory of the core can be retained within the containment building. The hydrogen concentration and the pressure of non-condensable gases are regulated by means of passive, catalytic recombination of hydrogen and oxygen.

DESCRIPTION OF THE SAFETY PRINCIPLES OBSERVED

CONTENTS

DESCRIPTION OF THE SAFETY PRINCIPLES OBSERVED

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

Since the Olkiluoto 4 project was granted a favourable decision-in-principle in 2010, legislation and regulatory guidance have experienced changes. *Inter alia,* new decrees of the Council of State on the safety of a Nuclear Power Plant (NPP) and on the emergency response arrangements have entered into force and the Radiation and Nuclear Safety Authority has published the new regulatory guides (YVL Guides) in December 2013. The new regulations, among other changes, take into account the experiences of the Fukushima accident. The safety principles presented in this chapter have been updated to correspond to the amended regulations.

This appendix describes the principle with which it is ensured that the regulatory limits set on the releases of radioactive emissions or on the radiation dose of the individual are not exceeded in the normal operation of the plant nor during eventual operational transients and accidents. The safety features of the selected plant type will be evaluated in detail in the construction license application phase described in the Section 18 of the Nuclear Energy Act.

1. GENERAL PRINCIPLES

In accordance with the Nuclear Energy Act, the starting point for the design, construction and operation of a nuclear power plant is that the plant must be safe and it shall not cause injury to people or damage to the environment or property. The safety of the NPP shall be maintained as high as is possible using technically reasonable means. These requirements are fulfilled through precautionary measures in design and construction, functions protecting the plant in cases of disturbance and damage, as well as functions limiting the consequences of accidents..

In Finland, the fundamental principle is to comply with or exceed the nuclear safety principles and guidelines set by the International Atomic Energy Agency (IAEA). The new NPP unit shall fulfil the Finnish requirements on the safety, security, emergency response and nuclear waste management, the general principles of which are enshrined in the respective government decrees. Detailed safety requirements are presented in the YVL Guides published by the Radiation and Nuclear Safety Authority. This appendix presents specifically, how the safety principles to be followed will be applied in Olkiluoto 4 project.

2. DECISIONS/DECREES OF THE COUNCIL OF STATE

The design, construction and operation of the nuclear power plant shall be implemented in accordance with the Decision of the Council of State on the safety of nuclear power (VNA 717/2013). The contents of and compliance with the safety principles specified in the decrees are discussed in more detail in Section 4 below.

The arrangements to prevent unlawful actions against the nuclear power plant shall be implemented in accordance with the Decree of the Council of State on the security of the utilisation of nuclear energy (VNA 734/2008). This will be realised by extending the security arrangements of the existing plant units to cover the new plant unit. The security arrangements will be handled in more detail when applying for the construction and operating licences.

The arrangements to limit nuclear damage within the nuclear power plant and its area shall be implemented in accordance with the Decree of the Council of State on emergency response arrangements at nuclear power plants (VNA 716/2013). This will be complied with by extending the emergency response arrangements of the existing plant units to cover the new plant unit. The emergency response arrangements will be handled in more detail when applying for the construction and operating licences.

3. YVL GUIDES

The YVL Guides published by the Radiation and Nuclear Safety Authority form a comprehensive set of regulations that provides detailed specifications of the level of safety required of nuclear power plants in Finland. The Radiation and Nuclear Safety Authority has published new YVL Guides in December 2013.

The nuclear power plant’s compliance with the requirements set forth in the YVL Guides is proven by means of safety analyses that examine the behaviour of the plant in connection with disturbances and accidents. The safety analyses are presented to the authorities in connection with the plant’s preliminary safety analysis report when applying for a construction licence. The final safety analysis report supplements the safety analyses with the effects of details associated with the construction of the plant. The final safety analysis report will be presented to the authorities when applying for an operating licence.

4. COMPLIANCE WITH SAFETY PRINCIPLES

4.1. General principles

4.1.1. General objective

The general objective is to ensure nuclear power plant safety so that nuclear power plant operation does not cause radiation hazards that could endanger the safety of workers or the population in the vicinity or could otherwise harm the environment or property.

This Appendix discusses how safety is ensured. The radiation exposure of employees during operation will be discussed in more detail when applying for the construction and operating licences. The environmental impact is discussed in Appendix 12.

4.1.2. Safety culture

A good safety culture shall be maintained when designing, constructing and operating a nuclear power plant. The management of the organisation in question shall, by virtue of its decisions and actions, demonstrate its commitment to safety-promoting procedures and solutions. The personnel shall be motivated for responsible work, and an open atmosphere encouraging the identification, reporting and elimination of factors endangering safety shall be promoted in the working community. The personnel shall have an opportunity to contribute to the continuous improvement of safety.

The maintenance and development of a good safety culture is affected by the attitudes and operating practices of all the parties involved in the nuclear power plant project, including suppliers at various levels, the power company and the regulatory authority. A good safety culture requires that factors affecting safety must be identified and that safety must be given priority in all situations where decisions must be made between safety and other factors, such as those related to finances, scheduling and production.

TVO observes the characteristics defined by the International Atomic Energy Agency (IAEA) as the criteria for assessing good safety culture. TVO has procedures in place for regularly investigating and developing the state of the safety culture, for example by the means of extensive self-assessments of safety culture. TVO monitors the atmosphere of the organisation through regular job satisfaction surveys and also carries out other surveys to support the development of the organisation.

TVO utilizes a reporting system for deviations and near-miss-events. For the events that are considered most significant for safety or the development of operations, an event report, a special report or a report on the original reason. The occupational safety is tracked at TVO using several indicators. For example, Olkiluoto 3 site uses the TR index to indicate the level of occupational safety. All TVO employees and subcontractors are required to have a valid occupational safety card and a valid initial indoctrination that is renewed at regular intervals. In addition, safety and safety culture training is organised regularly and the participation is tracked.

4.1.3. General and quality management

Section 7j of the Nuclear Energy Act requires that the management system of a nuclear facility shall specifically consider the impact of the conceptions and attitudes of the management and personnel on the maintenance and development of safety. Also systematic management procedures and their regular evaluation and development shall be addressed. All parties of the NPP project are required to have clear objectives and policies that are defined and approved by the top management, so that when these are followed all issues affecting safety are given the attention proportional to their safety significance. The parties shall have management systems that, for their part, support and promote the realisation of the identification marks of a good safety culture in the everyday work.

A management system will be prepared for the design, construction and operations phases of the NPP project. The system will be supported by the line organisation of TVO in an appropriate manner and it will include, *inter alia,* quality management and assurance. The plan for the construction phase, covering also the design phase, will be presented to the authorities at the application of the construction license. Similarly, the management system of the operations phase will be submitted at the application of the operation license. The management systems and the above-mentioned plans are prepared in accordance with YVL Guide A.3.

In addition to the management system covering the design and construction phases, the main supplier of the NPP unit and the fuel supplier will prepare separate quality management systems covering their own operations. Also all organisations which participate in the design, construction, installation or commissioning of objects affecting the safety of the plant are required to have managements systems for their own operations.

At the operating stage, the quality management and assurance procedures will be arranged by observing the same principles applicable to the operation of the existing nuclear power plant units. The new plant unit will become part of TVO’s activity based management system that covers all the nuclear facilities and functions located at the plant site.

All of the basic requirements for quality assurance stated in the YVL Guides will be observed when preparing the quality management systems. The requirements set in the quality management system shall be categorised in accordance with their safety significance so that the strictest requirements will apply to the products or functions most important to nuclear and radiation safety. Furthermore, requirements set forth in generally used quality management standards will be taken into account in the preparation of the quality management system.

4.1.4. Demonstration of compliance with safety regulations

Accident analyses and probabilistic safety analyses shall be carried out for the purpose of justifying the safety of the nuclear power plant and the technical solutions employed in its safety systems.

Analyses are used to prove the plant’s ability to overcome various disturbances and accidents with sufficient safety. The analyses deal with events that provide the best possible coverage of different types of transients and accidents in terms of their nature and severity. The course of disturbances and accidents is estimated starting from the initiating event that triggers the situation and ending in a safe and stable state.

The preliminary safety analysis report submitted to the authorities in connection with the potential application for construction licence includes analyses of anticipated operational transients, postulated accidents used as design bases for the safety systems and so-called severe accidents. Different acceptance criteria have been defined for different classes of events in relation to the loads on the fuel cladding, pressure-bearing primary circuit and reactor containment building, as well as in relation to the environmental impact of the event. These requirements are described in Sections 4.2.1 to 4.2.5 of this Appendix. The safety analyses prove the fulfilment of these criteria.

The analyses are carried out using computer codes whose applicability to modelling the phenomena in question has been proven, for example, by comparing the calculated results with measurement data obtained from model or plant tests.

Probabilistic safety analyses are also used to support the design of the plant unit and its safety systems. They will comprehensively account for operating experience from our own plants and other plants. The probabilistic models start with a wide range of identified disturbances (so-called initiating events) and examine the operation of the plant unit's safety systems in the event of those disturbances. The probabilistic models account for the frequency of the initiating events, single failures of systems and equipment, common-cause failures, as well as actions by plant personnel, including any human error. Probabilistic safety analysis is used to calculate the combined risk effect of all identified initiating events, rank the factors affecting nuclear safety in an order of importance and ensure balanced design of the plant unit in terms of safety. A preliminary probabilistic safety analysis will also be submitted for inspection and approval by the authority as an attachment to the potential application for construction licence.

4.2. Design requirements for ensuring nuclear safety

4.2.1. Levels of defence

Prevention of disturbances

The so-called defence in depth principle is observed in the design of a NPP unit to ensure its safety. According to the principle, the aim is to block the progress of a disturbance at several successive levels.

For both the safety and operating availability of the plant unit, it is the most preferable if the transient can be completely prevented. Thus the application of high quality requirements in the design, construction and operation of the plant unit is essential in order to prevent transients and accidents.

The principle of defence in depth also requires that the plant unit be designed and constructed so that its physical and technical properties counteract the development of disturbances. One of the most important design requirements for the reactor is that it must inherently resist all changes in reactor power. This has been achieved by designing the reactor so that the expansion of vapour volume in the coolant or an increase in the coolant temperature increases the leakage of neutrons out of the core, which lowers reactivity and mitigates the increase of power. Increases in the temperature of the uranium fuel itself also lower the reactivity. A correctly designed and dimensioned reactor is inherently stable with regard to minor power disturbances.

Inherent stability alone is not enough for satisfactory resistance against disturbances with regard to operation of the plant unit. Therefore the plant alternatives are equipped with control systems, the most important of these being the systems for regulating the water level in the reactor (BWR) or in the steam generator (PWR), as well as the regulating systems for reactor pressure and power. The task of the control systems is to eliminate small disturbances in the operating conditions of the plant so that their impact on plant unit operation and production is minimised.

Reactor protection system and anticipated operational transients

If a disturbance in the operating conditions of the plant unit is major enough, the inherent properties of the reactor and the control systems are not enough to eliminate its impact on plant unit operation. In this case, the limiting systems regulating the reactor must limit the reactor power or shut down the reactor in order to put the reactor to a controlled state. Thus the disturbance can be prevented from developing into an accident. Most disturbances involving rapid reactor shutdown belong to the class of so-called anticipated transients. Anticipated transients are defined as events with a probability of one or more occurrences in a period of 100 operating years.

The aim is to design the reactor protection system so that in most disturbances, rapid shutdown, also known as scram, is triggered on at least two conditions which are independent of each other. This way, failure in a single scram condition does not prevent the protection system from working appropriately.

Safety systems at the plant unit and postulated accidents

In some cases the disturbance as such may be so major that reactor shutdown alone is not enough to stop its development. In the case of such a postulated accident, it is the task of the plant unit’s safety systems to ensure fuel coolability and primary circuit integrity. Ensuring fuel coolability means that the fuel must not melt nor be dislocated. The tasks of the safety systems include, among others, reactor overpressurization protection, emergency cooling and removal of decay heat.

The design basis accidents which define the dimensioning of the safety systems are called postulated accidents. The safety assessments of the plant alternatives include, *inter alia*, analyses of the breaks of the major pipelines in the primary circuit and reactivity accidents (control rod drops or ejections). The overpressurization protection analyses can also be considered design basis accident analyses.

Design extension conditions

In addition to the design basis accidents, also so-called design extension condition events shall be studied. These are events where some rather mild initiating event combines with a common cause failure disabling some safety system altogether. Also events which involve a rare fault combination or a very rare external event are considered design extension conditions. For example, a complete loss of internal electricity distribution is considered a rare fault combination. Very rare external events include, *exempli gratia*, an air plane crash and the loss of the ultimate heat sink, i.e. the sea water. According to the current safety philosophy, even these situations must be handled so that major fuel damage is avoided.

Severe reactor accidents

If an improbable multiple fault prevents the appropriate operation of the protection or safety systems during a disturbance, this may cause severe damage to the core. In this case, the defence in depth principle involves the pressure-bearing boundary of the containment building. The severe accident management ensures the integrity of the containment building, which is further discussed in sections 4.2.2 and 4.2.5 in all circumstances.

4.2.2. Structural barriers for preventing the dispersion of radioactive materials

Dispersion of radioactive materials from the fuel of the nuclear reactor to the environment is prevented by means of successive barriers, which are the fuel and its cladding, the cooling circuit (primary circuit) of the nuclear reactor and the containment building.

Uranium fuel in the core is in the form of ceramic pellets that retain most of the radioactive materials formed in the uranium. These pellets of approximately 1 cm diameter are enclosed in hermetically sealed fuel rods. The fuel rods are further bundled into fuel assemblies, and there are hundreds of these in the reactor. The typical amount of uranium fuel in the reactor is on the order of one hundred tonnes.

The reactor core is located inside a pressure vessel that also contains the water cooling the core. Within the pressure vessel of a boiling water reactor, reactor coolant pumps circulate water through the fuel assemblies. This heats the water to a temperature of approximately 290 °C, which makes it boil, generating steam at a pressure of approximately 70 to 75 bar. In a pressurised water reactor, fuel also heats water but the reactor pressure vessel is maintained at such a high pressure that the water will not boil. The pressure in the reactor is typically circa 150 bar and the water temperature at the core outlet is approximately 320 °C.

The reactor containment building forms a tight barrier preventing the dispersion of radioactive materials to the environment in accident situations. It also acts as a structural barrier against both internal and external events. Internal events include, for example, fires and floods, while external events include air plane crash and natural hazards among others.

The potential alternatives for pressurised water reactor plants have a full-pressure containment building operating on the so-called dry principle; the reactor and its main cooling system are located inside the building. In most PWR alternatives, the containment building comprises two protective shells, one inside the other. The inner protective shell is made of steel or pre-stressed concrete with a steel lining. The outer protective shell is made of reinforced concrete. Constant underpressure is maintained in the space between the outer and inner protective shells, preventing even the smallest leak from the containment building from entering the outside atmosphere. In the original design of some pressurised water reactors, the containment building is single-walled, made of pre-stressed concrete and sealed with a steel lining.

The containment building in the boiling water reactor alternatives operates on the pressure suppression principle. This implies that there is a water pool inside the containment building that serves, in certain accident scenarios, as a heat sink and as a source for emergency core cooling water and containment spray system water. The containment building is made of reinforced concrete. Tightness is ensured using a lining plate of steel. The containment building is surrounded by the reactor building, which is ventilated in an accident situation through a filtered emergency ventilation system.

4.2.3. Ensuring fuel integrity

No melting may occur in the fuel pellets during normal reactor operation, and the temperature of the fuel rod cladding may not significantly exceed the coolant temperature. In practice, this means that the linear power of a fuel rod and the total fuel assembly power shall be kept within the allowed limits in relation to the coolant flow in the bundle. The compliance with the restrictions is ensured by means of the core supervision system using reactor-physical calculations and measurement results from the reactor instrumentation.

The power of the fuel rods is limited so that their internal pressure does not exceed the normal operating pressure of the coolant, causing the worsening of heat transfer between the fuel pellet and the coolant. In order to prevent damage caused by mechanical interaction of the fuel pellet and cladding, limits for power changes and rates of power change during operation are specified for each type of fuel. Among other things, these limits take into account the stress corrosion of the cladding.

The fuel is dimensioned so that after being used in the reactor, it is suitable for long-term storage and the processing steps associated with disposal.

With regard to anticipated transients, the requirement is that the probability of fuel damage must be very small. This requirement may also limit the maximum fuel assembly power allowed during normal operation. The endurance of the fuel in transient conditions is proven by so-called transient analyses that constitute a crucial part of the nuclear power plant unit's safety analysis report. Typical transients include the tripping of one or more reactor coolant pumps or disturbances in primary circuit pressure.

Postulated accidents are divided into two categories based on their probability: the probability of level 1 postulated accidents is in the range of 0.01 to 0.001 per year, and the probability of level 2 accidents is lower than this. The latter category includes the actual design basis accidents.

In connection with level 1 accident, the number of fuel rods suffering heat transfer crisis may not exceed one per cent of the total number of fuel rods in the reactor.

Fuel coolability may not be endangered in postulated accidents of level 2. This means that the fuel assemblies may not melt or otherwise suffer damage severe enough to prevent control of the reactivity of the reactor or the entry of cooling water into the assemblies. The fuel cladding temperature may not increase to levels high enough to cause metal/water reactions between the hot metal and steam to any significant extent. Fuel damage in postulated accidents may not occur in more than 10 per cent of the fuel rods. No member of the general population may receive an annual effective dose above 5 mSv.

The behaviour of the reactor during postulated accidents is proven to be acceptable by means of accident analyses. These analyses contribute to the dimensioning the plant unit’s safety systems. In order to ensure sufficient safety margins, the analyses make assumptions about the values of physical quantities and the operation of the safety systems that have an adverse impact on the course of events.

In the potential plant alternatives, criticality accidents are practically possible only during refueling outages. The risk is mainly associated with incorrect transfers of fuel. Also during outages, exceptionally incorrect movement of control rods in boiling water reactors and unplanned dilution of the boron concentration of the coolant in pressurised water reactors may lead to inadvertent criticality. Human activities play a larger role in outage-time risks than during power operation. To make the possibility of a criticality accident infinitesimal, the technical protective measures of the reactor are supplemented with strict administrative restrictions during outages.

In addition to level 1 and 2 postulated accidents, so-called design extension conditions, mentioned in section 4.2.1, must be observed with regard to the potential new plant unit. The largest allowable annual dose to an individual of the general population due to design extension events is 20 mSv. These constitute either events in which a common-cause failure of safety systems occurs in connection with an initiating event that is relatively moderate (see Section 3.2.6), or events that involve a complex combination of faults. With regard to the latter, the examination usually extends to complete loss of electrical power and loss of the ultimate heat sink, which refers to seawater cooling. According to the requirement, the plant must overcome such situations without substantial fuel damage. If recovery from such situations requires action by operations personnel, it is required that adequate time for consideration and implementation is available for such action and that the adequacy of time is proven.

4.2.4. Ensuring primary circuit integrity

In addition to appropriate design and sufficient design margins, ensuring primary circuit integrity is based on care in manufacturing and the use of top-quality materials. This makes it possible to ensure that the magnitude of a flaw leading to a sudden crack in a pressure-bearing device in the primary circuit must be so large that it can either be detected as a leak during plant unit operation or discovered in periodic inspections before the occurrence of an actual accident. The periodic inspection programme therefore plays an important role in ensuring primary circuit integrity.

Primary circuit design also accounts for radiation embrittlement of the reactor pressure vessel wall caused by fast neutrons. Due to the phenomenon, the reactor pressure vessel is designed and constructed in a way that minimises the number of welded seams in the area close to the reactor core. The development of radiation embrittlement is also monitored within the pressure vessel periodic inspection programme.

Failures that prevent steam from being driven into the turbine condenser or cause reactor shutdown to fail may lead to increased pressure in the primary circuit. In such situations, primary circuit pressure is limited to an acceptable level using relief and safety valves. Also other systems, such as the passive isolation condenser of a BWR, and the pressurizer spray of the PWR may be used.

In the boiling water reactor alternatives considered, relief and safety valves are used to control only the initial phase of the pressure transient. After this, the pressure is controlled using the isolation condensers, so there is no need to discharge steam from the primary circuit.

In the boiling water reactors, the relief and safety valves discharge steam directly from the primary circuit to a condensation pool in the containment, in which the discharged steam is condensed into water. In pressurised water reactors, primary circuit pressure can be regulated by means of the pressure on the secondary side of the steam generators. Therefore most of the relief and safety valve capacity in pressurised water reactor plants is located on the secondary side. Because the secondary side water is normally not radioactive, the discharge from these safety valves goes directly to the outside atmosphere. According to the design bases, no anticipated operational transient should require the opening of the primary circuit safety valves.

The design pressure for the primary circuit of the plant unit will not be exceeded during anticipated operational transients where reactor scram operates as intended. The design pressure is 10 per cent to 20 per cent higher than normal operating pressure. In postulated accidents, the design pressure may be exceeded by a maximum of 10 per cent, and in cases where reactor scram fails it may be exceeded by a maximum of 30 per cent. The pressure vessel can endure substantially higher pressure without failing.

The overpressure protection analyses, on which the dimensioning of the overpressure protection system has been based, use very disadvantageous or conservative assumptions: for example, it is assumed that approximately one in four valves fails to open and that the scram limit that is exceeded first is not tripped. Thanks to this conservativeness, the overpressure protection system will have significant overcapacity.

4.2.5. Ensuring containment building integrity

The essential properties of containment buildings for PWR and BWR plants have been discussed above in Section 4.2.2 “Structural barriers for preventing the dispersion of radioactive materials".

Of all postulated accidents, primary circuit pipe breaks inside the containment building cause the most significant loads on the containment building. These include pressure and temperature loads due to the release of hot water and steam, as well as the dynamic effects of pipe failures, which include jet forces and impacts of missiles.

In the case of a pressurised water reactor plant, the dimensioning of the containment building in provision for pipe break accidents is essentially based on the large volume of the full-pressure containment building. This means that the containment building can simply be dimensioned to bear the maximum pressure that the evaporation of water discharged from the primary circuit may cause. In the pressure suppression containment used at boiling water reactor plants, steam discharged from the primary circuit is conducted to a special condensation pool in which it is condensed. This allows the volume of a pressure suppression containment to be relatively small, and the maximum pressure achieved does not depend on the amount of steam discharged from the primary circuit to any significant extent. On the other hand, the volume relations and flow resistances between the different subvolumes are important for the design of such a containment building.

The requirement that the containment must also be able to prevent the dispersion of radioactive materials to the environment in connection with so-called severe accidents has a significant effect on the design of the containment building for the plant unit.

It is the task of nuclear power plant safety systems to ensure that the reactor can be shut down after all postulated accidents, the decay heat generated in the fuel can be removed from the reactor and the dispersion of radioactive materials into the environment can be efficiently prevented or at least limited to a very low level. The aim is to make the reliability of these functions as good as possible, for example by multiplying the number of systems with safety functions, making the parallel systems independent of each other, backing up the power supply of the parallel systems from mutually independent sources and utilising passive safety systems.

In principle, the simultaneous inoperability of all parallel and all in-depth systems is possible, albeit with an extremely low probability. Should the safety systems completely fail, for example in connection with a primary circuit leak, the supply of water into the reactor could be prevented. The consequence might be core meltdown caused by decay heat power from the disintegration of radioactive materials in the reactor core, which is a severe accident. As a consequence of a severe accident, the molten core mass might be relocated to the bottom of the reactor pressure vessel, the bottom of the vessel could be damaged, and molten material could be discharged into the containment building.

The design basis for the design of the potential plant alternatives is that even in the case of severe accidents, the release of radioactive materials must be limited so that it does not cause immediate need to evacuate the population around the nuclear power plants or any long-term restrictions to the use of large areas of water and land.

There are two main approaches to the management of such a severe accident. In the first one, the containment, and particularly its bottom section, is designed to deal with the molten core mass without losing its tightness due to the mass. In addition to this, the Finnish requirements presuppose a specific core catcher which prevents the interaction between the core melt and the containment concrete structure. In the second one, in-vessel cooling of the molten core material is ensured directly through the bottom of the pressure vessel, preventing the molten core from being discharged from the pressure vessel. Filling the bottom section of the containment with water plays a central role in both cases.

In the BWR alternatives, the possibility that hydrogen created by reactions between metal and water might explode is prevented through the lack of oxygen in the containment; during operation, the building is filled with nitrogen. In the PWR alternatives, hydrogen is removed from the containment atmosphere in a controlled manner using igniters or catalytic methods during an accident situation.

The long-term integrity of the containment building is ensured by a filtered venting system or an independent decay heat removal system and recombination of non-condensable gases.

The design of all plant alternatives includes a filtered containment venting system. This can, on the long run, limit the pressure increased caused by the formation of non-condensable gases and by the boiling due to the core melt on a level which the containment building can withstand. The containment is, anyhow, designed so that the pressure suppression and the subsequent radiation release are not necessary in any circumstances within the first 24 hours from the onset of the event. Thus, a grace period to restart the residual heat removal and to eliminate thus the need for release completely is provided. The gases from vented from the containment are stripped of particulate radioactive material with a filter that has a high, over 99.9 % removal rate. The removal of the particulate release prevents the formation of a fall-out that would contaminate the ground.

The independent residual heat removal from the containment can take place either passively or via a dedicated active cooling system which is independent of the other safety systems. Thus, the increase of containment pressure caused by the residual heat of the reactor can be prevented. Additionally, the air-filled containments of PWRs apply the passive, autocatalytic recombination of hydrogen and oxygen, which can prevent also the pressure increase due to formation of non-condensable gases.

4.2.6. Ensuring safety functions

One of the most important design requirements for a modern light water reactor is that it must inherently resist changes in reactor power. Among other things, this means that increases in the temperature of the fuel and coolant or increases in the steam content of the coolant must decrease the reactivity of the reactor core. This allows the reactor operation to remain stable without continuous operation of the control systems. This will significantly reduce the plant's sensitivity to disturbances and, correspondingly, reduce the number of situations that require the operation of the limiting systems and the reactor protection system. This also means that severe reactivity accidents cannot be initiated by any operating disturbance. All of the plant alternatives in question fulfill this requirement of inherent reactor stability.

The purpose of the protection systems is to detect accident situations and start the required safety systems and, after the accident, ensure that the plant remains in a controlled state for a long enough period until the operators intervene with the course of events. The protection systems have been designed so that in each situation where automatic protection is needed, the system is started on the basis of at least two mutually independent parameters.

Generally, the protection function that is required first is the rapid shutdown or scram. There are two mutually independent systems for this, one based on the use of control rods and one based on pumping or passively injecting a boron solution into the reactor. Each of these systems alone is able to shut down the reactor.

After shutdown, the safety systems cater for functions such as the water supply to the reactor and decay heat removal. The safety systems of the different plant alternatives apply the principle of inherent safety or passive operation to a varying degree. This means that the system does not need external power for fulfilling its safety function.

The safety systems have been designed in accordance with the principle of redundancy, which refers to parallel subsystems. For example, the emergency core cooling systems of several plant alternatives have four parallel subsystems, two of which are sufficient to ensure cooling of the fuel during accidents that involve major pipe breaks in the primary circuit (4 × 50 % system). Another alternative is to use three parallel subsystems, each of which is capable of fulfilling the safety function of the system alone if necessary (3 × 100 % system). This allows the systems to fulfil their safety function even if one of the parallel subsystems was inoperable due to maintenance or repair and another subsystem had a fault preventing its operation. The parallel subsystems have been designed in accordance with electrical and physical separation. The latter is also associated with fire compartmentalization.

Another principle observed in the design of safety systems and safety functions is diversity. This means that it must be possible to implement a particular safety function using two systems based on different principles of operation. The two independent reactor shutdown systems mentioned above constitute an example of diversity.

It is possible to decrease the contribution of the common cause failures (simultaneous failures of redundant devices due to the same reason) to the risk of core melt. The effect of common cause failures to the safety of the plant shall be minor. This requirement is applied to new plant alternatives so that there are event analyses with an assumption that the most common initiating events are combined with the total failure of the protection or safety system that is primarily intended to control the event. In such case, there shall be a backup system that can take the plant unit to the safe state without major fuel damage. The diversity requirement applies both to the safety systems proper and to the auxiliary systems indispensable for their operation. This includes also the protection automation systems that actuate safety systems at the necessary times.

Each of the plant alternatives has a backup power system whose task is to ensure the supply of electrical power to the plant during loss of off-site power using diesel generators and accumulators. The backup power system is divided into parallel mutually independent subsystems. All the parallel trains of each safety system receive their power supply from different subsystems of the backup power system. The loss of this emergency power supply would cause a total loss of electric power, which is mitigated by additional, diverse secondary generator system.

To the extent possible, the so-called fail-safe principle has also been observed in the design of equipment important for safety. This means that the device goes into a state advantageous for safety upon loss of external driving power.

4.2.7. Avoiding human errors

The possibility of human errors is reduced by means of appropriate instructions, procedures and training, as well as an efficient quality management system. Ensuring competence is a crucial part of managing the human factor during design, construction and operation. Any errors and deficient procedures shall be corrected immediately when observed, and shall be used as learning opportunities to prevent any recurrence of similar events. This is supported by an advanced quality management system and reporting practices.

Human errors at the design stage can be divided into random and systematic errors. A random error is a single error, for example an incorrect figure. Random design errors will be detected in a multi-stage inspection. Furthermore, modern design tools have certain functions for preventing or detecting errors. A systematic error can be a deficiency or error in a safety requirement specification, for example. These are prevented through a systematic hierarchical system of safety requirements (safety analysis report at the construction stage, system requirements, component-level requirements, as well as environmental requirements common to several systems and components), the application of which will ensure (prove and verify) that upper-level safety requirements have been correctly and comprehensively implemented in the design prerequisites for systems, components and the like. Through the OL3 project, TVO has accumulated experience and competence in the implementation of such systems in practical projects, including managing supply chain.

Human factors are managed at the construction stage using common nuclear power industry procedures, such as the quality management system. The detection of errors is also supported by the fact that components and structures are manufactured in accordance with approved plans and subjected to tests and inspections specified in advance (the results must fulfill acceptance criteria specified in advance). Furthermore, the activities produce traceable documentation that can be used to prove that manufacturing and construction have been carried out according to plans. QA and QC constitute an important part of nuclear safety. TVO's competence in the field has become even stronger through the implementation of the OL3 project.

The impact of the human factor at the operating stage can roughly be divided into three: management of plant modifications, maintenance and operations. The management of human factors associated in the management of plant modifications is based on accurate documentation, maintenance and management of the design bases of the plant. The foundation for this is created at the design and construction stages. TVO also uses a comprehensive plant modification management procedure embedding the principle of multi-stage verification and ending at a comprehensive documented procedure for the testing and validation of the effects of changes.

In the maintenance work, the human factor is controlled using administrative procedures and working methods. As an example of administrative controls, the work planning and administration will issue a permit to work only on a single sub-system at a time. In addition, the systems and components are tested exhaustively after the end of the work.

In operation of the plant, the human factor is controlled, in addition to measures mentioned above, with detailed requirements for the personnel competences, and their systematic tracking. As as part of this, plant type specific training simulators are used.

At the existing plant units, TVO has introduced procedures aimed at reducing, detecting and correcting human errors (so called error-prevention tools), such as peer review, clear communications, independent verification and pre-job briefings. Development related to these is constantly carried out as part of operating activities.

4.2.8. Protection against external events and fires

The design of the potential plant alternatives allows them to endure extreme weather conditions that are estimated to be very rare or improbable at the site, including high and low temperatures, wind, snowload, sea water level, ice conditions and thunder. Furthermore, the possibility of an earthquake is taken into account in the design of plant unit systems, structures and components significant to safety.

Physical separation of the safety systems and their location in well-protected spaces is aimed at protecting the safety functions so that an external event cannot make all of them inoperable simultaneously. Correspondingly, parallel safety systems are located in different fire compartments so that a fire cannot damage them all. Physical separation can protect the parallel parts of safety systems also against other internal events within the plant unit. Such events may include pipe breaks, tank ruptures, explosions and floods.

The design of the new plant unit will, in accordance with the Council of State Decree 734/2008, also take into account a crash by a large passenger airplane and unlawful actions to damage the plant. The security of the information systems and the protection of other significant parts of the facility against unlawful actions are ensured in accordance with the new YVL Guides.

4.2.9. Safety classification

Safety classification ensures that the structures, systems and components are developed, manufactured and installed so that their quality level and the inspections and tests required to verify their quality level are in correct proportion to any item's safety significance. The safety class provides a starting point for specifying the requirements to be made for the design, manufacture, installation, inspection, testing, operation and quality assurance of a structure, system or component.

The safety classification of structures, systems and components, as well as the quality assurance procedures and their foundations will be submitted to the regulatory authority for approval.

4.2.10. Monitoring and control of the nuclear power plant unit

The main control room of the plant unit contains equipment that, at all times, provides information on the current state of the plant unit. Any significant deviations from the normal operating state and failures of systems and equipment are indicated by alarms.

One of the design bases for the protection systems of new plant alternatives is the sufficient time for the personnel to consider their actions, in addition to which many plant alternatives have passive systems. Operator action is, however, necessary in many event sequences after a while. For such events, emergency operation procedures will be written. The emergency operation procedures allow the operations personnel to steer the NPP unit first into safe state from the controlled state, into which the plant automation has brought the NPP unit.

An operator support system will be developed for disturbances and accidents, with information specially compiled and grouped to facilitate the application of the emergency procedures.

The plant design also includes provisions for the loss of the main control room, for example due to fire or unlawful intrusion. Each of the potential plant alternatives has an emergency control room independent of the main control room, which can be used for shutting down the reactor and bringing the plant unit to a controlled and, later, to a safe state.

OUTLINE OF THE OWNERSHIP AND OCCUPATION OF THE SITE PLANNED FOR THE NUCLEAR FACILITY

CONTENTS

OUTLINE OF THE OWNERSHIP AND OCCUPATION OF THE SITE PLANNED FOR THE NUCLEAR FACILITY

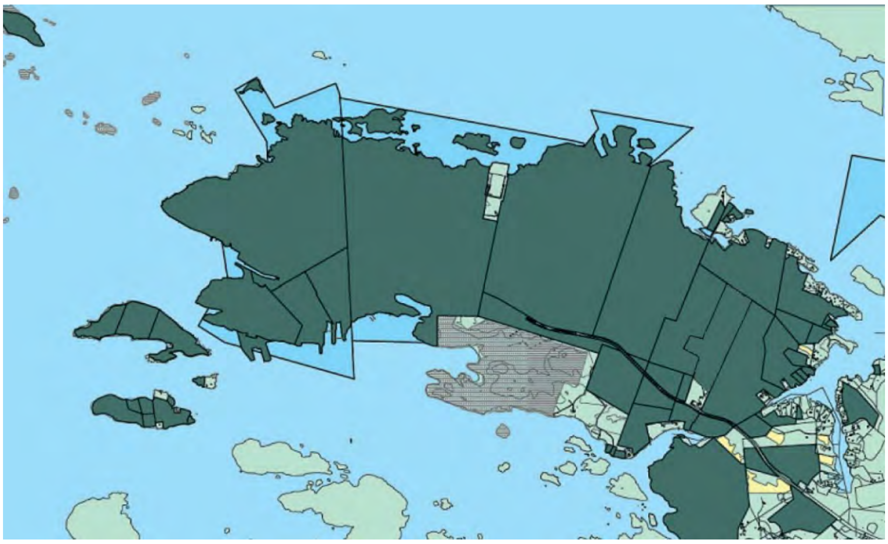
0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

Since the favourable decision-in-principle for the Olkiluoto 4 nuclear power plant unit, ratified in 2010, there has been no significant changes concerning the ownership or occupation of the site. The map illustrating the landowning status has been updated. Out of the two options, the prime location for the plant unit, including the arrangement of cooling water passages, is being displayed. The other, alternative location for the plant unit, displayed in the 2008 application for a decision-in-principle, is in reserve.

1. GENERAL

The intention is to build the new nuclear power plant unit in the Olkiluoto nuclear power plant area located in the western part of Olkiluoto Island. The power plant area houses the applicant's two operating nuclear power plant units and one nuclear power plant unit under construction.

Figure 9–1 *Landowning status for Olkiluoto.*



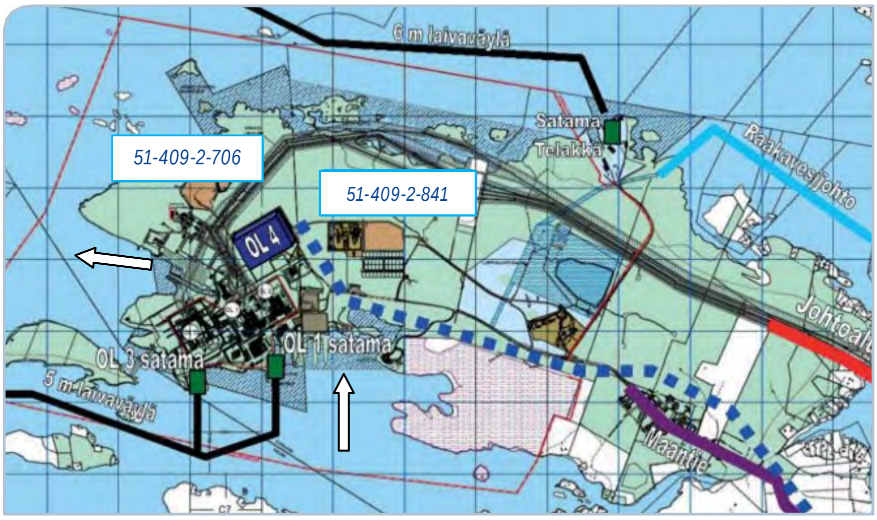
The applicant owns most of Olkiluoto Island, approximately 745 ha (dark green areas in Figure 9–1), which corresponds to approximately 85 per cent of the entire area of the island. The areas in private ownership in the eastern part of Olkiluoto Island (light green areas) mostly contain holiday properties. Applicant controls 180 ha (outlined blue areas) of the waters around Olkiluoto, with additional parts held through joint ownership. The area marked in gray is a nature conservation area owned by Metsähallitus (a state enterprise).

The extensive areas owned by the applicant at Olkiluoto provide good preconditions for the placement of nuclear power plant units. Extensive ownership provides flexibility of the use of the area and an opportunity to ensure and further develop area security.

2. OWNERSHIP AND OCCUPATION OF THE LOCATION

The prime candidate for the location of the new nuclear power plant unit at Olkiluoto is within properties owned and occupied by the applicant, registration numbers 51-409-2-706 and 51-409-2-841. The new plant unit will be located in the western part of Olkiluoto Island between the existing transmission line area and the existing plant units.

Figure 9–2 *The prime location for the new plant unit and the overground structures for the cooling water passages are located within two properties owned by the applicant (51-409-2-706 ja 51-409-2-841).*



The applicant’s operating nuclear power plant units Olkiluoto 1 and Olkiluoto 2, as well as the Olkiluoto 3 nuclear power plant unit under construction, are located close to the location for the new plant unit on properties having the registration numbers 51-409-2-703, 704 and 705.

In the eastern part of Olkiluoto Island and other islands bordered by the eastern part, there are holiday homes and empty holiday home sites, as well as a few privately-owned larger areas. The Liiklankari conservation area located in the southern part of Olkiluoto Island is owned and governed by Metsähallitus.

The applicant also owns the island called Kuusisenmaa off Olkiluoto, as well as properties on islands called Lippo and Leppäkarta. There are no buildings on Kuusisenmaa. Lippo and Leppäkarta also have some holiday properties in private ownership.

In the waters around Olkiluoto, the applicant fully owns 180 ha, in addition to which the applicant has holdings in jointly owned water areas, approximately 70 per cent of the the Olkiluoto and Orjasaari water rights (51-428-876/1) and approximately 40 per cent of the Munakari joint area (51-876-13-0).

DESCRIPTION OF SETTLEMENT AND OTHER ACTIVITIES AND PLANNING ARRANGEMENTS AT THE PLANNED NUCLEAR FACILITY SITE AND IN ITS IMMEDIATE VICINITY

CONTENTS

DESCRIPTION OF SETTLEMENT AND OTHER ACTIVITIES AND PLANNING ARRANGEMENTS AT THE PLANNED NUCLEAR FACILITY SITE AND IN ITS IMMEDIATE VICINITY

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

Since the favourable decision-in-principle for the Olkiluoto 4 nuclear power plant unit, ratified in 2010 by the Parliament, the land use planning of the Olkiluoto area has progressed. Therefore, information concerning land use planning has been updated. The list of neighbouring municipalities of Eurajoki has been updated. In addition, description of conservation areas has been clarified. The new Decree on movement and sojourn restrictions by the Ministry of the Interior has also been taken into account.

1. GENERAL

Certain requirements are imposed on the location of a nuclear power plant in order to ensure the safety of the plant units and the environment. As a location for a nuclear power plant unit, Olkiluoto is well compliant with the requirements set by the authorities and TVO.

The valid land use plans at the location allow the construction of a new nuclear power plant unit. The plans also reserve areas for the disposal of spent nuclear fuel originating from the new nuclear power plant unit. The plan is in harmony with provincial land use.

2. COMMUNITIES

Figure 10–1 *There is no dense settlement referred to in YVL Guide A.2 by the Radiation and Nuclear Safety Authority within 5 kilometres of Olkiluoto.*

Eurajoki is a municipality on the coast of the Gulf of Bothnia and belongs to the economic zone of Rauma. The municipality of Eurajoki has a population of about 6,000. The municipal centre is located just over 10 kilometres north of the centre of Rauma and almost 40 kilometres south of Pori along highway 8.

The neighbouring municipalities are

- Rauma (approximate population 40,000)
- Eura (approximate population 12,400)
- Luvia (approximate population 3,300)
- Nakkila (approximate population 5,700).

The economic zone of Rauma, including the municipalities of Eura, Eurajoki and Rauma, has some 60,000 inhabitants. Pori, which is located some 32 kilometres from Olkiluoto to the northeast, has some 83,000 inhabitants.

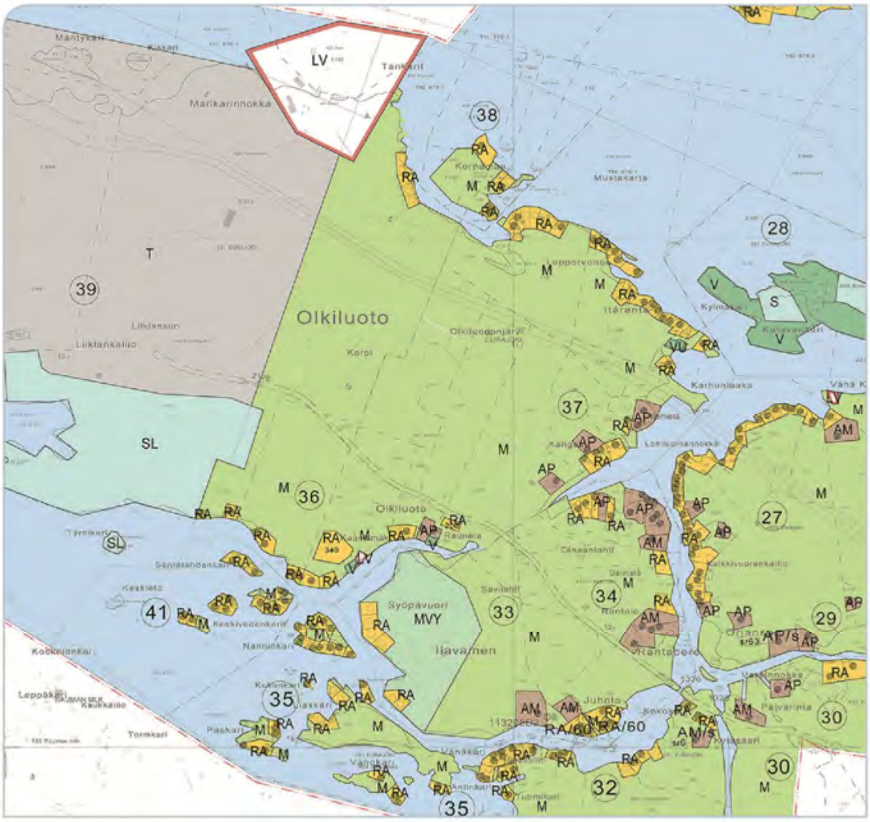
Services, secondary production, agriculture and forestry play a major role in the economic structure of the municipality of Eurajoki. TVO is the largest employer in the municipality. The applicant has some 900 employees at the nuclear power plant, in addition to which more than 300 people work for subcontractors at Olkiluoto. Annual outages usually employ some 1,000 people in addition to the normal workforce at the power plant.

3. SETTLEMENT AT OLKILUOTO

The nearest residential buildings are located approximately three kilometres from the power plant site. There are four residences intended for permanent use on Olkiluoto Island. The village of Ilavainen located to the east of Olkiluoto Island has several residences intended for permanent use.

There are approximately 30 privately owned holiday properties on Olkiluoto Island, located in the eastern end. There are approximately 550 holiday properties within an approximate distance of five kilometres from the power plant site, mostly located on nearby islands and in the villages of Ilavainen and Orjasaari.

Figure 10–2 *Holiday homes to the east of Olkiluoto Island in accordance with the partial shore master plan.*



4. OTHER OPERATIONS

Field cultivation is practised in the vicinity of the power plant area at Olkiluoto only to a minor extent, mostly constituting field cultivation in the eastern part of Olkiluoto Island. Fishing is practised in the nearby waters both professionally and as a hobby.

There is a harbour in general operation on the northern shore of Olkiluoto Island located on property owned by the applicant, and a 6-metre navigable passage, maintained by the Finnish Transport Agency, leads to the harbour.

The holiday home area in the eastern part of Olkiluoto includes the old Raunela estate, which TVO has been restoring and developing as a heritage farm to represent the history of Olkiluoto before the nuclear power plant.

Olkiluoto currently has temporary accommodation facilities for approximately 500 people working at the nuclear power plant, and the capacity can be increased by approximately 500 accommodation units if necessary.

Operations in the villages of Ilavainen and Orjasaari to the east of Olkiluoto Island (within 5 kilometres) and the new plant site's impact on them are minor. However, traffic to Olkiluoto through the villages will increase during construction work.

Operations located within the actual power plant area are discussed in Appendix 11.

5. LAND USE PLANNING

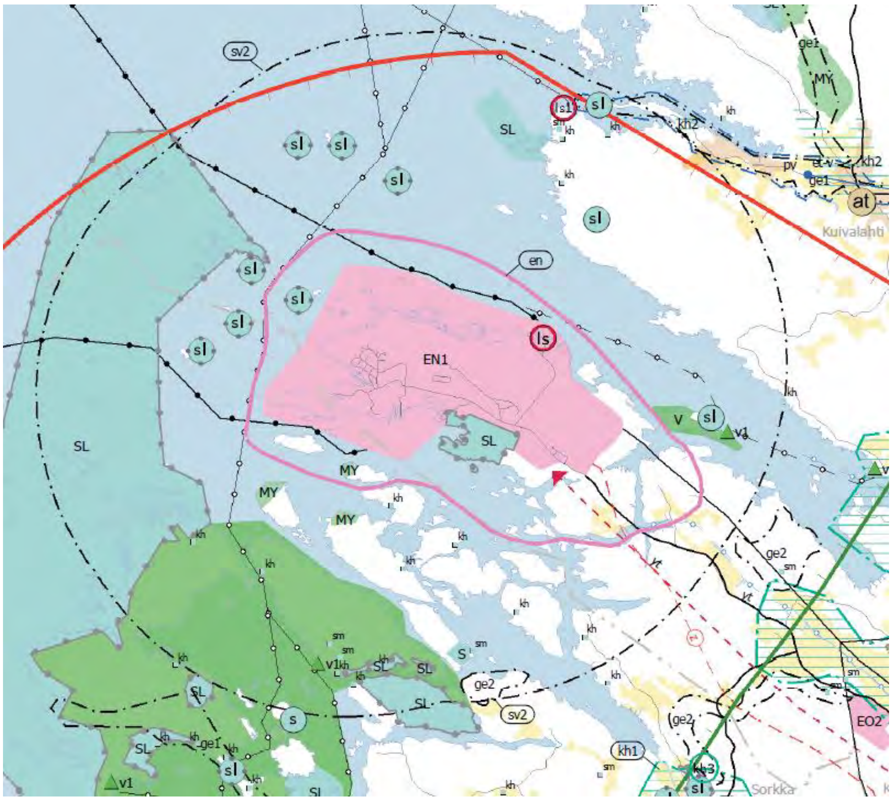
The licensing procedure and construction of the new nuclear power plant unit do not require changes in the valid land use plans at Olkiluoto. The valid plans ensure the prerequisites for long-term safe operation of nuclear power plant units at Olkiluoto.

The earlier regional plan for Satakunta has been replaced by a new provincial plan developed by the Regional Council of Satakunta. This new provincial plan takes into account the objectives set by the state authorities for the land use planning at Olkiluoto as well as the needs of nuclear waste management.

5.1. Provincial plan

The objectives for the use of areas in the Satakunta provincial plan are based on approved national land use objectives that became legally valid in 2001.

Figure 10-3 *National land use objectives related to operations at Olkiluoto are taken into account in the provincial plan shown here.*



The Ministry of the Environment ratified the provincial plan for Satakunta on the 30th of November 2011. The preparation of the provincial plan was started in February 2003 by the Regional Council of Satakunta. The regional plan, effective at that time, was revised and updated to a provincial plan fulfilling the requirements set in the new Land Use and Building Act. The provincial plan for Satakunta was set for the approval of The Ministry of the Environment on the 1st of March, 2010. The provincial plan for Satakunta was prepared as an overall provincial plan and it supports power plant construction at Olkiluoto.

The provincial plan takes into account the objectives set by the state authorities for the land use planning at Olkiluoto as well as the needs of nuclear waste management. The provincial plan designates the Olkiluoto plant site as an energy supply zone (EN). In addition, the plan designates an energy management zone (EN1) for Olkiluoto. It is reserved for facilities, buildings or structures that serve energy production, as well as for facilities and buildings that carry out final disposal of spent nuclear fuel. The surroundings of the plant zone are designated as a development zone for energy management (en), where the needs of energy management operations set specific requirements for the land use. The outermost area (sv2) is designated as a protective zone for the nuclear power plants. The provincial plan also designates the power line routes leaving the area, a regional road, navigable passages for ships and boats, and conservation areas.

According to the provincial plan, detailed planning and design must pay special attention to environmental protection, and the handling and storage of radioactive waste must be arranged in a completely safe manner. The provincial plan also allows other energy production besides the nuclear power plant units, as well as other industry based on the energy production in the area. The Liiklankari area is designated as a nature conservation area in the provincial plan.

There are some restrictions on land use in the immediate surroundings. Provisions have been made to supervise the exclusion area, where movement and sojourn are limited as defined in the Decree by the Ministry of the Interior (1104/2013), as well as the transportation operations and the access to the plant area.

The nearby area surrounding the Olkiluoto nuclear power plants, extending to a distance of about 20 kilometres from the facility, is designated as an emergency planning zone for which relevant authorities have to prepare detailed rescue plans. The amount of population and the population centres within the emergency planning zone may not prevent the use of effective rescue measures. Olkiluoto area fulfills the conditions set for the emergency planning zone. The number of people living permanently in the emergency planning zone is such that the use of effective rescue measures is not prevented. Furthermore, operations and activities that might otherwise endanger the safety of the nuclear power plants are located far enough from Olkiluoto.

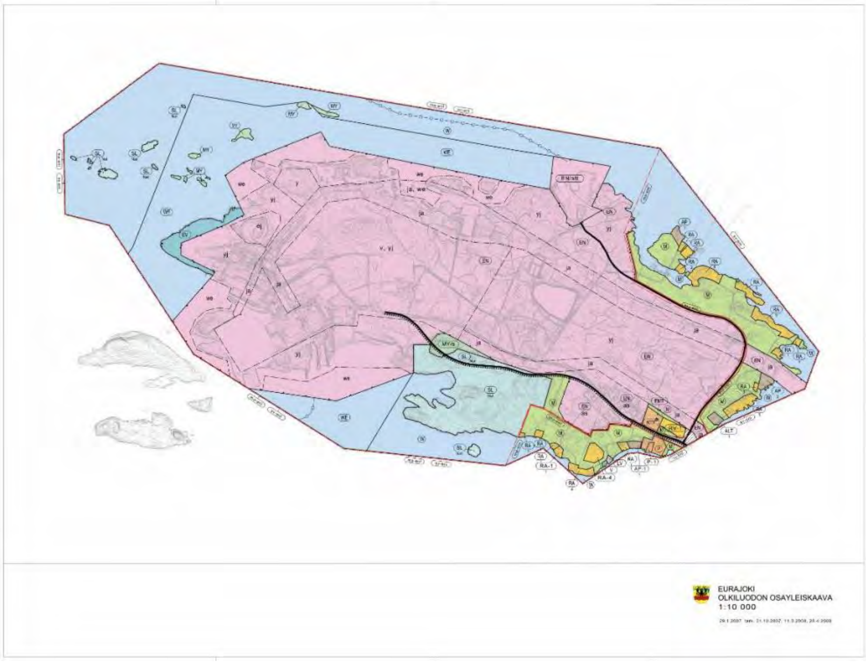
A protective zone surrounds the nuclear power plant area at a distance of about 5 kilometres. Protective zone sets some restrictions on land use. For example, the zone must not be used for the placement of any large residential areas, hospitals or facilities inhabited or visited by a considerable number of people. In addition, protective zone shall not contain socially significant functions that could be affected by an accident at the nuclear power plant. According to YVL Guide A.2, the number of permanent inhabitants, recreational housing, and recreational activities shall be limited inside the protective zone of a nuclear power plant, so that a rescue plan that allows for effective evacuation of the population may be drawn up and implemented for the area. Land use planning can be used to govern the development of the settlement.

YVL Guide A.2 by the Radiation and Nuclear Safety Authority defines the zones and areas surrounding the nuclear power plant. Depending on local conditions, the site area extends to approximately 1 kilometre from the facility. As a rule, only power plant-related activities shall be engaged in this area. The licensee responsible for the operation of the nuclear power plant shall have the authority of decision over all activities within the site area.

5.2. Master plan

The Olkiluoto partial master plan and the partial master plan for the northern shores of Rauma have been ratified. The Olkiluoto partial master plan is non-appealable.

Figure 10-4 *The Olkiluoto partial master plan.*



The primary objective in the land use planning has been to maintain the prerequisites for land use at the largest energy production site in Finland and reserve areas for implementing a final disposal facility for spent nuclear fuel in compliance with Finnish legislation and the requirements set for the safety of the operations.

5.3. Olkiluoto local plan

Local plans in the area of the existing nuclear power plant units, the unit under construction and the planned OL4 plant unit have been ratified and they have been stated to be valid and up-to-date in 2014. The power plant site is designated as a zone for industrial and warehouse buildings allowed for nuclear power plants, other facilities and equipment intended for the production, distribution and transmission of power, as well as buildings, structures and equipment associated with these, unless otherwise restricted.

The current local plan of Olkiluoto comprises 6.55 million m^3 of construction rights in the zone designated as a nuclear power plant area. The nuclear power plant area is located on the western part of Olkiluoto Island.

Most of the water areas included in the building plan are approved for the purposes of power plants, and landing places and other structures required for power plant purposes may be constructed on and off the shore of the industrial and warehouse areas. The building plan also indicates water areas where filling and embankment operations are allowed.

The municipal council of Eurajoki approved the local plan for the final repository of spent fuel in June 2010. The local plan designates the areas and construction rights for the buildings and structures belonging to the final repository facility. The local plan is non-appealable.

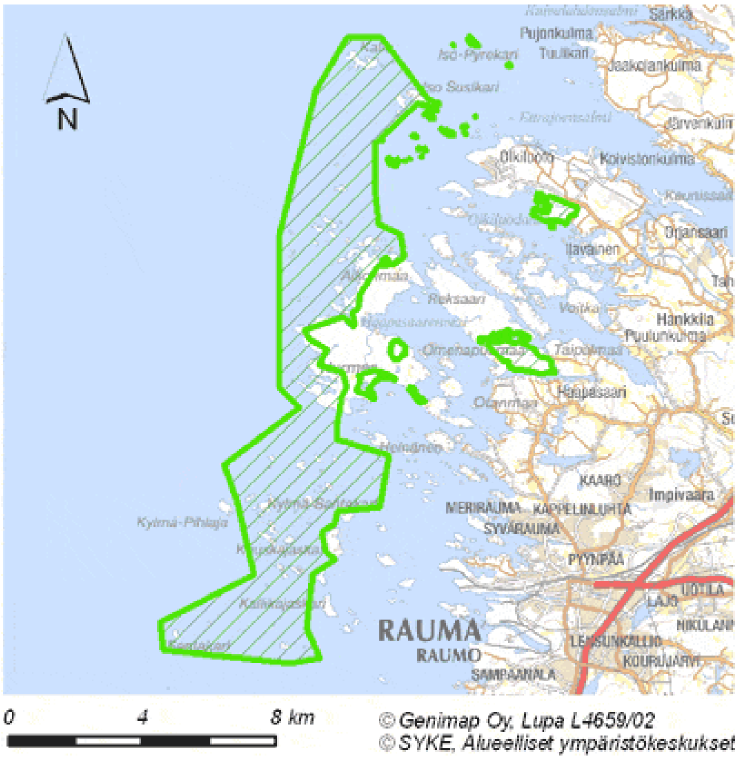
Figure 10–5 *Local plan valid at Olkiluoto in which the area designated for nuclear power plants is marked with purple.*

The Olkiluoto area also has plans for a zone for accommodation buildings serving energy production approved on December 12, 2005, as well as ratified local shore plans to the east of Olkiluoto Island.

5.4. Conservation areas, Natura areas

Natura conservation areas are located both on Olkiluoto Island and on the sea area in front of the island in the immediate vicinity of the Olkiluoto energy management zone. Liiklankari conservation area is located on the southern waterfront in the central part of the island. The closest point of the offshore Natura area is located approximately 2 kilometres to the west of the Olkiluoto power plant area. Based on the Natura assessment, the combined effect of four nuclear power plants does not inflict significant damage to biotopes that are protected within the Natura areas.

Figure 10–6 Natura areas in Olkiluoto and in the immediate surroundings.



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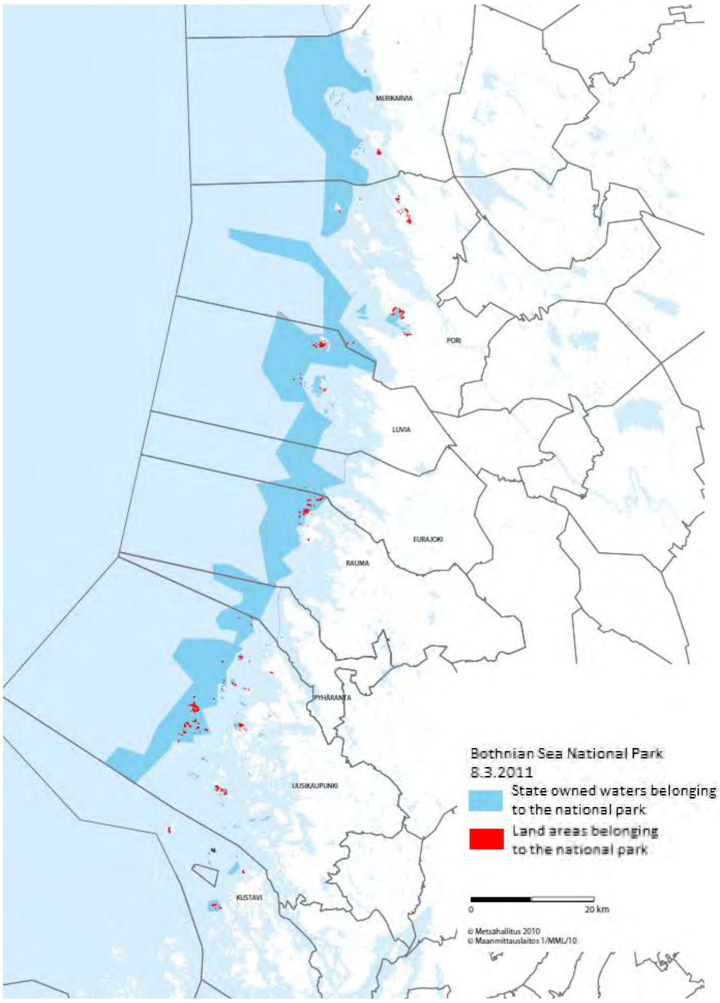
5.5. Bothnian Sea National Park

The Act establishing the Bothnian Sea National Park came into force on the 1st of July, 2011.

The Bothnian Sea National Park extends from Merikarvia to Kustavi. The main purpose of the national park is to conserve the underwater nature and ecosystems of the coastal zone of the Bothnian Sea and to ensure the survival of a viable fish population. The Bothnian Sea National Park does not extend to the sea areas of the nuclear power plants. Both the environmental impact assessment report for the Olkiluoto 4 nuclear power plant unit and the Natura assessment report have been available in the legislative process concerning the Bothnian Sea National Park.

Figure 10–7 *Bothnian Sea National Park.*



ASSESSMENT OF SUITABILITY OF THE PLANNED SITE FOR ITS PURPOSE TAKING INTO ACCOUNT THE EFFECT OF LOCAL CONDITIONS ON SAFETY, SECURITY AND EMERGENCY PREPAREDNESS AS WELL AS THE EFFECT OF THE NUCLEAR POWER PLANT ON THE IMMEDIATE ENVIRONMENT

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ASSESSMENT OF SUITABILITY OF THE PLANNED SITE FOR ITS PURPOSE TAKING INTO ACCOUNT THE EFFECT OF LOCAL CONDITIONS ON SAFETY, SECURITY AND EMERGENCY PREPAREDNESS AS WELL AS THE EFFECT OF THE NUCLEAR POWER PLANT ON THE IMMEDIATE ENVIRONMENT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

Since the favourable decision-in-principle for the Olkiluoto 4 nuclear power plant unit, ratified in 2010 by the Parliament, the information given in Appendix 11 has been updated to coincide with the present situation.

1. GENERAL

Olkiluoto at Eurajoki fulfils the requirements set for a plant site. Land use planning has made preparations and will make further preparations for the additional construction of power plant units. The site of a large power plant unit must also have a sufficient supply of cooling and service water, good traffic connections, a sufficiently large area and suitable geological and topographical conditions. These preconditions are fulfilled well at Olkiluoto.

The Olkiluoto area has been in nuclear power plant use for more than 35 years and has been proven very suitable for the purpose. The land use of the site of the new plant unit is in harmony with other land use on Olkiluoto Island and relies on the existing Olkiluoto infrastructure. The new plant unit can utilise functions supporting the operation of the existing plant units, as well as premises and structures built for them. The new plant unit will not cause any land use restrictions additional to those caused by the existing plant units.

The impact on the environment is minor and limited mainly to the local warm-up of seawater and changed flow conditions caused by the cooling water requirement of the plant units.

2. SUITABILITY OF THE SITE

The new plant unit OL4 will be located in the immediate vicinity of the existing nuclear power plant units OL1 and OL2, as well as the OL3 unit now under construction. In the valid building plan, the power plant site is designated for industrial and warehouse buildings and, according to the planning regulations, may be used for the construction of nuclear power plants and other facilities, equipment and components intended for power production, distribution and transmission, as well as other buildings, constructions and structures related to these unless otherwise restricted. The plan also indicates water areas that may be filled or banked up and in which landing places, other structures and equipment needed by the power plants may be built. The construction of the new power plant unit does not require any amendments to the land use plans.

The existing power plant site at Olkiluoto already has the infrastructure required for nuclear power production. The new plant unit will mostly rely on this infrastructure. The construction of the new power plant unit will cause some rearrangements in the power plant area, for example with regard to fencing, access connections and the intake and discharge of cooling water. The new unit will also require the establishment of a new transmission line area and the construction of a new power line separate from the existing transmission line area at Olkiluoto and its immediate vicinity.

The eastern part of Olkiluoto Island has an agriculture and forestry zone in accordance with the current shore master plan, and there are holiday homes on the eastern shore. The intention is to secure the existence of holiday homes at Olkiluoto in any upcoming plans. The holiday properties are located in a green zone that disallows any other construction. The middle and eastern parts of the island, at a distance from the holiday home area, mostly house the overground structures for the spent fuel disposal facilities such as vent stacks and structures required for the handling of fuel. Due to the distance and the nature of the operations, they will have a negligible impact on the holiday homes. The power plant unit OL4 to be sited in the western part of Olkiluoto will not cause any negative impact on the holiday home area as such. Additional construction will somewhat increase traffic to Olkiluoto.

Studies have shown that the impact of OL4 on Natura areas located in the vicinity will be minor.

2.1. External infrastructure

The external infrastructure required for the OL4 plant unit consists of traffic connections, the conveyance of raw water and the transmission of power to the national grid. Most of this infrastructure already exists.

Figure 11–1 *The existing external infrastructure at Olkiluoto will also be available to OL4, and substantial extensions and changes will only be needed with regard to power transmission. The location of the power transmission line is shown with a blue dashed line.*

For the purpose of power transmission from the new nuclear power plant unit, a new transmission line connection from Olkiluoto to Rauma through the southern part of the island, separate from the current lines, will be planned.

The location of the new line is accommodated in the provincial plan and in the Olkiluoto local plan.

2.2. Internal infrastructure

Figure 11–2 *The internal infrastructure at Olkiluoto can be easily extended to serve the construction and operation of the OL4 plant unit.*

The new plant unit will be able to efficiently utilise the infrastructure built for the needs of the existing plant units at Olkiluoto. Among other facilities, the site contains administrative buildings, a training centre and a visitors' centre, warehouses, repair shops, a back-up heating plant, a raw water tank, a raw water treatment plant, a demineralisation plant, a sanitary water treatment plant, a landfill, a contractors' area, accommodation villages and a gas turbine plant.

TVO has overall responsibility for all handling and storage of radioactive waste at Olkiluoto. Buildings and facilities for waste management include interim storage for spent fuel (KPA storage), interim storage for low-level and intermediate-level operating waste (MAJ and KAJ storage), a final disposal facility for operating waste (VLJ repository), as well as an encapsulation plant and a final repository for spent fuel to be constructed by Posiva Oy. These facilities can be used for the needs of nuclear waste management associated with OL4 either as such or with certain changes.

The area has functional traffic connections with a harbour, roads and parking lots.

2.3. Final disposal of spent nuclear fuel

Spent nuclear fuel originating from the applicant's operations will be disposed of at Olkiluoto. An encapsulation plant and a final repository for spent fuel are intended to be built in the middle part of Olkiluoto Island, to the south of the Korvensuo basin and to the north of the Liiklankari conservation area. When implemented, the area of disposal facilities may extend to a large part of Olkiluoto Island.

3. SECURITY AND EMERGENCY PREPAREDNESS AND THE EFFECT OF THE NUCLEAR POWER PLANT ON THE IMMEDIATE ENVIRONMENT

Security and emergency preparedness for the OL4 plant unit will implemented in accordance with the procedures used at the existing plant units.

The normal operation of the nuclear power plant or anticipated operational transients does not limit land use off-site. However, in the vicinity of the nuclear power plant, precautions for the possibility of a severe accident are taken by preparing plans for the use of nearby areas and for civil defence.

YVL Guide A.2 by the Radiation and Nuclear Safety Authority defines a nuclear power plant site as an area where only power plant related activities are allowed as a rule. However, the plant site, which comprises both land and water, may be used for fishing, hiking and other recreational activities, provided that the operator of the nuclear power plant is able to supervise the area. The intention has been to extend the plant site to approximately one kilometre from the plant fence but the value is indicative and decided separately in each special case.

Preparations for the safety of the Olkiluoto site have been made through only allowing restricted use of everyman’s rights within the Olkiluoto land area and nearby waters. The plant site according to YVL Guide A.2 is affected by access restrictions in accordance with a decision by the Ministry of the Interior subject to separate application. According to the same Guide, the number of permanent inhabitants and recreational housing within five kilometres of the plant should be limited so that an appropriate rescue plan can be drawn up for the area.

The plant site is surrounded by a protective zone shown in the regional plan, which extends to about five kilometres’ distance from the facility. Land use restrictions are in force within the protective zone. Dense settlement, hospitals or facilities inhabited or visited by a considerable number of people are not allowed within the protective zone. In addition, the zone may not contain socially significant functions that could be affected by an accident at the nuclear power plant.

ASSESSMENT REPORT DRAWN UP IN ACCORDANCE WITH THE ACT ON ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE AND THE STATEMENT ISSUED BY THE CONTACT AUTHORITY ABOUT THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT AS WELL AS AN ACCOUNT FOR THE DESIGN CRITERIA THE APPLICANT INTENDS TO APPLY IN ORDER TO AVOID ENVIRONMENTAL DAMAGE AND TO LIMIT ENVIRONMENTAL BURDENS

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APPENDICES

Appendix 12.1.	Extension of the Olkiluoto Nuclear Power Plant by a Fourth Unit, Environmental Impact Assessment Report, 23 January 2008.
Appendix 12.2.	Environmental Impact Assessment Report for the Olkiluoto 4 Nuclear Power Plant Unit; Statement by the Contact Authority, 19 June 2008.

ASSESSMENT REPORT DRAWN UP IN ACCORDANCE WITH THE ACT ON ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE AND THE STATEMENT ISSUED BY THE CONTACT AUTHORITY ABOUT THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT AS WELL AS AN ACCOUNT FOR THE DESIGN CRITERIA THE APPLICANT INTENDS TO APPLY IN ORDER TO AVOID ENVIRONMENTAL DAMAGE AND TO LIMIT ENVIRONMENTAL BURDENS

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

The results and conclusions of the environmental impact assessment that was carried out are still valid as there have been no relevant changes. Neither the power level of the planned new nuclear power plant nor the environmental impact of the plant have changed. In addition, there have been no changes in the functions of the Olkiluoto power plant or in the vicinity of the Olkiluoto plant site that would affect the outcome of the assessment. Both the environmental impact assessment report for the Olkiluoto 4 nuclear power plant unit and the Natura assessment report have been available in the legislative process concerning the Bothnian Sea National Park.

In addition, there have been no such changes in the EIA legislation or in the international agreements binding on Finland (so-called Espoo Convention, 1991) that would call for an update or renewal of the environmental impact assessment process.

The environmental permit required for the planned embankment between Olkiluoto Island and nearby Kuusisenmaa Island is legally valid. The construction of the embankment has not been started.

In TVO's view, the application to supplement the valid decision-in-principle regarding the construction of the Olkiluoto 4 nuclear power plant unit does not demand an update or renewal of the environmental impact assessment process that was carried out according to the Act on Environmental Impact Assessment Procedure.

TVO has asked that the Ministry of Employment and Economy, who acts as the contact authority for the environmental impact assessment process, would evaluate the situation and pronounce, if the setting of a new submittal deadline for the Olkiluoto 4 construction licence application constitutes such a change to the project that would call for a partial renewal of the environmental impact assessment process in order to enforce an international agreement binding on Finland or because there may be significant adverse environmental impacts due to the special features of Finland's nature and environment, pursuant to Section 4 of the Act on Environmental Impact Assessment Procedure.

1. ENVIRONMENTAL IMPACT ASSESSMENT

Environmental impact assessment (EIA) is a systematic process used in preparations for decision-making, with the aim of providing a uniform and comprehensive picture of the project and its alternatives already in the early stage. Another objective of the EIA procedure is to increase the opportunities for citizens to receive information, become involved in the planning of projects and express their opinion.

The Olkiluoto area has a long tradition of comprehensive environmental surveys. When constructing a nuclear power plant unit at a site with existing nuclear power plant units in operation, previous experience of construction and operation can be directly applied to the assessment of the new unit's environmental impact.

An environmental impact assessment in accordance with the EIA Act has been conducted on the new nuclear power plant unit planned for the Olkiluoto plant site.

When assessing the environmental impacts of the Olkiluoto nuclear power plant extension project, the present state of the environment was first examined, and after that, the changes caused by the projects as well as their significance were assessed, taking into account the combined impacts of the operations at Olkiluoto. The environmental impact assessment for the planned nuclear power plant unit covers the entire life cycle of the plant unit. The results are presented in the environmental impact assessment report. Both the environmental impact assessment report and the statement issued by the contact authority about the environmental impact assessment report are included in the application materials as Appendices 12.1 and 12.2.

This Appendix 12 provides a brief description of the environmental impact of the new nuclear power plant unit and the design criteria used to avoid environmental damage and to restrict the burden on the environment. The environmental impact will be discussed in detail when applying for an environmental permit for the new plant unit.

TVO operates an environmental management system that has been certified to comply with the requirements of international standard ISO 14001:2004. In addition, the Olkiluoto power plant holds EMAS registration based on an EU Regulation. TVO's environmental management system includes the consideration of environmental aspects over the entire life cycle of nuclear energy production and the principle of constantly improving the standard of environmental protection.

2. RADIOACTIVE MATERIALS

2.1. Isolation principle

The heat production process in a nuclear power plant is based on the fission of uranium nuclei in the nuclear reactor fuel. This process generates radioactive materials that are isolated from the environment by several layers of protection within each other.

The fuel is sealed in gas-tight cladding within the reactor pressure vessel. The fuel cladding and the reactor pressure vessel with the associated cooling water circulation circuit form two layers of protection around the fuel and within each other. The reactor containment building is the third and outermost layer of protection between the radioactivity contained in the fuel and the environment.

The volume of nuclear fuel in proportion to its energy content is very small. The operation of the heat-producing process does not need any connection with the environment. This allows for the isolation principle implemented by means of the layers of protection described above. According to the principle, the radioactive materials generated in the fuel, which constitute the major part of the total amount of activity originating in the nuclear power plant process, are kept within a restricted small volume inside the plant.

In comparison with the radioactivity in the fuel, a minor amount of radioactive material is created in the cooling water inside the reactor when it flows through the reactor core. Any material released from the fuel through leaks in the fuel claddings will also end up in the reactor cooling water. This activity will either stay in the reactor system or be removed from it into other closed systems, such as the reactor coolant cleaning system, after which the radioactive materials will be treated using radioactive waste management methods.

The same principle of isolation applies to waste management at a nuclear power plant. Radioactive waste is packed and stored under supervision so that it does not release any emissions to the environment. Waste is disposed of in a final repository in the bedrock. The waste containers and surrounding technical protection layers ensure that they are isolated from the living environment for a long time. Even though the technical protection layers lose their integrity over an extended period of time, the activity of the waste has been reduced to a fraction of the original and the amounts of activity released into the environment are minor in terms of the radiation burden. The waste management for the new plant unit is discussed in Appendix 14 to the application.

2.2. Releases during normal operation and operating disturbances

Releases of radioactive material during operation originate in the processing of water removed from the reactor cooling system or gases in cleaning systems. The activity of gaseous substances is reduced before their release into the environment mainly on the basis of delay, meaning that short-lived radionuclides have already lost most of their activity by the time they are released into the environment.

In order to reduce the activity of water releases, any water released into the environment is cleaned by filtration or evaporation.

All systems containing radioactivity are located in rooms within the radiation controlled area. The leakage and sewage waters from the controlled area are piped to collection tanks from where they can be taken for cleaning or, if the activity is low enough, released into the environment. A ventilation system maintains underpressure in the controlled area in comparison with outdoor air. The exhaust flow from ventilation is filtered if necessary and conveyed to the ventilation stack where the activity level of the exhaust air is monitored.

The arrangements for handling and cleaning radioactive materials are implemented so that any releases during normal operation and anticipated operating transients can be kept so low that the radiation dose from the releases into the surrounding population is only a fraction of the limits specified in the Government Decree on the general regulations for the safety of nuclear power plants (Government Decree 717/2013). The limit for releases during normal operation is 0.1 millisieverts per year. The limit applicable to anticipated operating transients is the same, 0.1 millisieverts per year. The allowed limits for radioactive releases from plant units at the same site are specified so that the total emissions do not cause a dose that would exceed the limit.

The radiation dose to the nearby population from the releases during normal operation of the planned plant unit is estimated to be less than 0.001 millisieverts per year, which is in the same order of magnitude as the dose caused by the existing units. The dose is less than 1 per cent of the limit and less than 0.03 per cent of the average annual radiation dose received by Finns from other sources of radiation. The Finns receive an average annual radiation dose of 3.7 millisieverts. Most of this originates in natural sources of radiation, the most significant being radioactive radon gas released to indoor air from the soil. Other exposure mostly originates in background radiation from space and the soil, foodstuffs, construction materials and medical procedures. The radiation dose originating in natural background radiation varies by region. For example, the dose caused by external radiation from the soil and buildings varies between 0.17 and 1.0 millisieverts in different parts of Finland.

The annual radiation dose of less than 0.001 millisieverts caused by the new plant unit to the nearby population poses a theoretical risk of cancer that is insignificant in comparison with the level of risk caused by the average annual dose of 3 millisieverts from natural radiation and its regional variation.

One can summarise that the amounts of radioactive materials released from the new power plant unit into the environment are so minor that they do not have any significance for human health.

2.3. Releases during accidents

In order to prevent accidents and limit their consequences, the safety principles and regulations described in Appendix 8 to the application are observed in the design, construction and operation of the plant unit.

The postulated accidents that serve as a basis for the design of the plant unit examine, among other things, situations where a leak develops in the reactor cooling system and the safety systems operate as designed. In these accident situations, there is no need to impose any restrictions on living and the use of foodstuffs in the vicinity or any other restrictions. The radiation dose caused to the nearby population may not exceed the limits specified in Government Decree 717/2013, which are 5 millisieverts for postulated accidents and 20 millisieverts for design extension conditions. The limits concern the dose accumulated by an individual during a period of one year from the accident. The dose limit for postulated accidents corresponds to the dose received by an average Finn from other sources over a period of just over a year. If the average Finn receives a dose corresponding to the limit for a postulated accident once in his life, his lifetime radiation burden increases by approximately 2 per cent. The change is minor in comparison with the variations in the lifetime dose from natural radioactivity in different regions of Finland.

In the case of a severe accident, it is assumed that the safety systems of the plant are not operational in a situation caused by a reactor system leak or some other damage. This may lead to severe damage to the reactor core, releasing a major part of the radioactive materials in the fuel into the containment building. According to the design requirements, the containment building must keep the amount of radioactivity released into the environment below the limit specified in Government Decree 717/2013. The prescribed limit is such that even in the case of a severe accident, the discharge does not cause immediate health hazards to the surrounding population or any long-term restrictions to the use of large areas of land.

In connection with the application for a construction licence and an operating licence, detailed analyses are used to prove that the plant fulfils the requirements set for accident situations in Government Decree 717/2013. This also includes proving the fact that the possibility of exceeding the limit for a severe accident is extremely minor.

2.4. Environmental impact analysis methods

Established calculation models exist for estimating the conveyance of radioactive materials in the water environment, the atmosphere, the food chain etc. These allow radiation doses to the environment to be calculated on the basis of measured and predicted release amounts. The models pay attention to all the important routes through which the release of radioactive materials may affect people. The information on the environment and the lifestyles of the population required for the models has been determined by means of local surveys in the area surrounding the power plant. The plant site is equipped with weather monitoring equipment that continuously registers meteorological data for the calculation of conveyance in the atmosphere.

Due to the great variation of the variables related to the environment and its exploitation, the dose calculation model is unable to achieve high accuracy. This is compensated by choosing the numerical values of the variables so that they increase the radiation dose calculated on the basis of releases. This so-called conservative approach, which overestimates the doses, is intended to ensure that the actual doses to people are always lower than the calculated values.

2.5. Measures to reduce environmental impact

The minimisation of the environmental impact from radioactive releases is based on the minimisation of releases in accordance with the isolation principle described above. The water treatment systems and off-gas systems of the plant will be designed with this in mind.

The waters and gases released into the environment are efficiently cleaned by separating the radioactivity into filters, for example, which are stored as solid nuclear waste isolated from the environment. The amount of activity released into the environment during operation is so minor that its impact as a radiation dose to the environment is negligible.

The aim of the plant's safety systems is to ensure that releases can be controlled even in accident situations. However, preparations have also been made for measures to avoid an unnecessary radiation burden on the population in an accident situation. The power plant operator's own emergency response organisation is prepared to carry out the required radiation measurements at the plant site and its vicinity, issue the required alarms to the nearby area and the authorities, and to assess the impact of potential releases caused by the accident as radiation doses to the environment. The official rescue organisation is responsible for any measures to protect the population that may be deemed necessary in an accident situation.

2.6. Monitoring programme

Emissions of radioactive materials from the nuclear power plant take place through monitored emission routes. The total activity and nuclide composition of the emissions are measured. The doses caused by the emissions cannot be directly measured in the environment, as they are very minor compared to natural background radiation and its variations. The amounts of radioactivity caused by emissions are monitored by means of an environmental radiation monitoring programme that includes, for example, measurements of the radioactivity in more than 300 environmental samples each year.

3. COOLING AND WASTE WATER

3.1. Load

The thermal load to be conducted from the nuclear power plant unit to the sea depends on the power and efficiency of the plant unit. A nuclear power plant with an electrical power of 1,000 to 1,800 MW requires approximately 40 to 60 m^3 of cooling water per second. The water flows in the pipelines through the turbine condenser and is returned to the sea after a temperature gain of approximately 12 °C. The overall efficiency of the new plant unit is some 35 per cent to 40 per cent.

Waste water generated on the power plant site includes water from the raw water treatment and demineralisation plant, water from the liquid waste treatment plant, water used for flushing the travelling band screens, sanitary waste water and laundry waste water. The waste water fractions are processed appropriately by mechanical, chemical or biological means or a combination of these before being discharged to the sea. The waste water causes minor nitrogen and phosphorus load and oxygen-consuming load in the sea.

Figure 12–1 *Photomontage of the Olkiluoto area. The OL3 plant unit is in the front left. OL4 will be behind the existing plant units OL1 and OL2 and, in the photo, is located at plant site alternative 1. In the photo, the cooling water is taken from the southern side of Olkiluoto Island, to the right of the intakes of the existing plant units, and discharged at the existing discharge point to the west of the island.*

3.2. Environmental impact of the load

The water areas surrounding the plant site allow for an adequate supply of cooling water for the new plant unit and the discharge of cooling water back to the sea. OL4 will increase the amount of cooling water, which will expand the size of the warmed-up sea area and the area unfrozen in winter approximately in direct proportion to the thermal power conducted to the sea.

The increase in water temperature caused by cooling water and the size of the warmed-up area varies by weather, season and the utilisation rate of the power plant. An increase of 1 °C in water temperature due to the combined impact of four plant units can be observed in surface waters at an approximate distance of 10 kilometres from the discharge point. Significant increases in temperature are limited to waters in the immediate vicinity of the discharge point. The most significant impact of the cooling water is caused in the winter to the ice conditions around the plant site.

According to experience, the impact of the cooling water on other properties of sea water is minor. The oxygen conditions in the sea area off Olkiluoto have also been good close to the bottom and almost without exception, and the situation is not estimated to change substantially due to the increased thermal load. The biological impact of the thermal load is evident from the extended growing season in the expanded unfrozen area and from increased total production.

The impact of cooling water on fish populations in the area is expected to remain similar to the present. The most substantial impact of cooling water with regard to fishing takes place in the winter season when the area of unfrozen water and weak ice off Olkiluoto limits fishing from the ice. Cooling water as a whole is not estimated to impose any substantial or extensive harmful effects on the fish populations of the area. Cooling water and its consequences are not estimated to have any effect on the usability of fish.

The increased waste water load is expected to remain so small that the impact probably cannot be distinguished from other nutrient and solid matter loads in the area.

3.3. Environmental impact analysis methods

Model calculations on the dispersal of cooling water and an estimate of the impact of thermal load on the temperatures and the ice conditions in the vicinity of the discharge point have been prepared using a three-dimensional flow model developed at the Environmental Impact Assessment Centre of Finland Ltd (EIA Ltd). The modelling has examined the differences between the intake and discharge point options. The detailed dispersal calculations, obtained as a result of the above, have been used as the basis of the impact assessments. The surveys have included cooling waters for the existing plant units, cooling waters for OL3 under construction and cooling waters for the planned OL4 plant unit.

3.4. Measures to reduce environmental impact

Based on experience from the operation of the existing plant units and results from the flow model referred to in the above, Olkiluoto is a suitable location for the new plant unit. The discharge of cooling water towards the open sea provides for efficient mixing, which helps in keeping the warmed-up sea area as small as possible. This can be implemented at Olkiluoto with short cooling water passages, which minimises the impact from their construction and from energy consumed for pumping the water. The cooling water passages for the new plant unit can be located close to those of the existing plant units, which will minimise the extent of the area losing its natural state. The new plant unit will not increase the temperature of cooling water going into the sea compared to the present situation. The cooling water passages will be located so as to minimise the recirculation of warm discharge water to the cooling water intake side. The cooling water arrangements will be discussed in more detail during the environmental permit procedure for the new plant unit.

The volume of waste water generated shall be minimised through water use planning and recycling. The waste water processing capacity will also cover the duration of construction of the new plant unit, at which time the volume of waste water will be greater than at the operating stage.

3.5. Monitoring programme

An environmental permit pursuant to the Environmental Protection Act will be obtained for the operations of the new power plant unit, and a permit pursuant to the Water Act will be obtained for taking water from the water system to the power plant. Detailed environmental impact monitoring programmes will be prepared on the basis of the permit regulations.

The impact of environmental loads on the water system will be monitored in accordance with a programme approved by the permit authority. The monitoring programme includes temperature measurements, physical and chemical monitoring of water, monitoring of the biological state of water, as well as monitoring of fish populations and fishing conditions. Furthermore, the ice conditions are supervised in the winter and people are warned about weakened ice. The operation of the waste water treatment plant is supervised by monitoring the treatment efficiency.

4. OTHER ENVIRONMENTAL EFFECTS

The new power plant will be located within the Olkiluoto power plant site and will utilise the existing infrastructure of the area. In the landscape view, the construction of a new unit will add one new building resembling the existing plant units to the power plant complex.

Figure 12–2 *Photomontage of Olkiluoto Island viewed from the sea. OL4 on the left, the OL1 and OL2 units in the middle, and OL3 on the right.*

The environmental impact of the power transmission lines for the new plant unit in the Olkiluoto area is assessed in the attached environmental impact assessment report. Fingrid Oyj has carried out environmental impact assessments concerning the power lines supporting the nuclear power plant unit's grid connection and the plant site power lines during 2011-2013.

Traffic on the road to the plant site will increase during construction, which will increase the risk of traffic accidents and the nuisance caused by traffic noise along the road. The increase in traffic caused by the operation of the new plant unit is so minor that the impact is also minor.

The combined noise from the new plant unit and existing operations at Olkiluoto will not exceed the directive values set by Council of State for noise in the nearest affected location.

Low and intermediate level operating waste and conventional waste originating from the new plant unit will be processed similarly to the existing plant units. Low and intermediate level operating waste will be placed in a final disposal facility for operating waste located within the area (VLJ Repository). Conventional waste will be sorted and delivered for recovery.

Waste that is unsuitable for recovery will be placed in a landfill within the area. When properly handled, waste will not cause any adverse environmental impact.

5. CONCLUSIONS

An extensive environmental impact assessment of the nuclear power plant project has been conducted on the basis of statutory requirements. The environmental impact assessment did not find any adverse environmental impact of such significance arising from the construction or operation of the nuclear power plant unit that it could not be accepted or mitigated to an acceptable level. Due to careful compliance with the isolation principle, releases of radioactivity during the operation of the nuclear power plant are so minor that they do not have any impact on the environment or the surrounding population. The releases in accident situations will also be so minor that their environmental impact will be small and will not prevent normal use of the environment. According to investigations carried out, the cooling water from the new power plant unit is not considered to cause any unreasonable impact on the water system.

OUTLINE PLAN ON NUCLEAR FUEL MANAGEMENT

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OUTLINE PLAN ON NUCLEAR FUEL MANAGEMENT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

There have not been any significant changes concerning nuclear fuel management since 2010 when the Parliament ratified the decision-in-principle regarding the construction of the Olkiluoto 4 nuclear power plant unit.

1. GENERAL

This Appendix describes how nuclear fuel management can be arranged for the new plant unit. The management of spent fuel is described in Appendix 14.

The stages of nuclear fuel procurement are the production of uranium concentrates, conversion, enrichment and manufacturing into fuel elements or fuel assemblies.

The manufacturing of fuel is usually procured separately for each unit. However, purchases can be made simultaneously for several plant units. Enrichment, conversion and uranium concentrates can also be procured and competitive bidding can be arranged simultaneously.

2. REQUIRED AMOUNTS

TVO’s existing power plant units OL1 and OL2 each consume approximately 20 tonnes of enriched uranium annually, the production of which requires approximately 130 tonnes of natural uranium in uranium concentrates and approximately 110 tonnes of enrichment work.

The OL3 plant unit under construction will use slightly more than 30 tonnes of enriched uranium annually. The enrichment requires approximately 210 tonnes of natural uranium concentrates and 180 tonnes of enrichment work. The need for uranium concentrates and enrichment work for OL3 in relation to kilowatt-hours produced is approximately 15 per cent lower compared to OL1 and OL2 plant units. This is particularly attributable to the better efficiency of the turbine generator but also to the better neutron economy of the new reactor. The need for uranium at OL1 and OL2 has also been reduced quite a lot over the years as a consequence of fuel development.

As the size of the new plant unit will be 1,000 to 1,800 MW, its estimated annual fuel requirement based on OL3’s consumption will be in the order of 20 to 32 tonnes of uranium, corresponding to 120 to 220 tonnes of natural uranium in uranium concentrates.

3. AVAILABILITY OF RAW URANIUM AND SOURCES OF PRODUCTION

The sufficiency of uranium will not impose any obstacle to the production of nuclear fuel over the next 70 to 100 years. The annual global demand for uranium is approximately 70,000 tonnes of natural uranium, also known as uranium concentrates. Identified and inferred uranium resources having a production cost of less than USD 130 per kilogram amounted to some 5 million tonnes in 2005, and additional resources of this category that will probably be found amounted to some 10 million tonnes. At current consumption, the resources will last for 70 years, and with probable resources included, more than 200 years.

The largest known uranium deposits are in Australia, North America, Kazakhstan, Russia, South Africa, Niger and Namibia. The latest discovered deposits of uranium, particularly in Canada and Australia, have been rich, which means that they allow uranium to be produced at a reasonable cost.

4. PROCUREMENT OF RAW URANIUM

TVO has purchased the initial core uranium as one batch but otherwise TVO diversifies the deliveries of uranium and other purchases related to fuel procurement to several suppliers for the sake of reliability of supply.

TVO’s procurement strategy includes maintaining reserves of uranium concentrates for reliability of supply, and due to market fluctuations in order to avoid purchases at price peaks. The quantities stored are small, and a reserve for several years only ties up a relatively small amount of capital. The intention is to import manufactured fuel to a reserve in Finland several months before it is needed.

5. PROCUREMENT OF CONVERSION, ENRICHMENT AND FUEL MANUFACTURING

Three companies operate major refining and conversion facilities in the Western countries. For the time being, TVO purchases conversion from Canadian and French suppliers. Supplementary amounts are purchased from Russia in connection with the enrichment of uranium. These and a major conversion facility in the USA will also remain the most important suppliers of conversion in the near future.

TVO presently purchases enrichment of uranium from AREVA in France and from Techsnabexport in Russia and from the company Urenco that has production facilities in three EU countries. Said companies will be the most probable suppliers of enrichment also in the future. They enrich uranium using centrifuges.

Fuel manufacturing is presently procured from Sweden, Germany and Spain. Depending on the type of power plant, some other country may come into question, usually at least the power plant supplier. In addition to the above countries, the companies have facilities in at least France, Russia, the USA, Japan and Korea.

6. TRANSPORTS AND STORAGE OF URANIUM AND FUEL

The transports of nuclear material between the stages of fuel procurement, as well as the transports of manufactured fuel to power plant sites, are carried out as supervised transports on conventional transport equipment. The transport packaging and arrangements are governed by EU regulations and national regulations in different countries, the starting point being the recommendations of the International Atomic Energy Agency (IAEA). The amounts being transported are small, and transports represent a small proportion of fuel costs.

The fuel is brought to Finland by sea and further from the harbour to the power plant by lorry. Ground transport from neighbouring countries can also be used. The typical need for transports is five or six full trailer combination loads per year for each reactor.

The import of fuel is subject to licences and approvals by the Radiation and Nuclear Safety Authority pertaining to import, transport routes, equipment and packaging, as well as transport arrangements with emergency preparedness and security plans. The transports fall within the scope of nuclear liability insurance.

Uranium is transported to the conversion plant as uranium concentrate in 200-litre industrial steel drums that are further packed into containers for ground and sea transport. Each drum contains approximately 400 kg of uranium, and one container is typically loaded with 44 drums. Uranium concentrates are also stored in these 200-litre drums.

In the conversion plant, the uranium ore concentrate will be purified and converted into “natural uranium” i.e. into uranium hexafluoride, a salt, which becomes gaseous under reduced pressure when heated. Therefore, the uranium hexafluoride salt is packaged in special pressure proof transport containers. The natural uranium is transported to the enrichment facility in containers with volume of about 8 tonnes of uranium, and enriched uranium is further taken to the fuel manufacturing plant in containers containing approximately 1.5 tonnes of uranium. For transport, the enriched uranium container is packed into a protective packaging, dimensioned to protect the container in case of traffic accident or fire, for example.

Enriched uranium is transported to the manufacturing plants by road, sea and rail. At the plant, the uranium is converted to uranium oxide and further to fuel pellets that are encapsulated into fuel rods. The finished fuel assemblies or fuel elements are transported by sea, for example, to the Port of Rauma, and further transported by lorry to Olkiluoto. Fuel transports typically take place once a year, usually 5 to 6 lorry loads per plant unit. The initial core load requires some more transports.

Radiation from fresh uranium and nuclear fuel is minor. The design bases for packaging include prevention of the most significant hazard of transport, criticality in unexpected situations. In practice, the primary risk associated with the transports is a conventional traffic accident.

Fuel is stored at the power plant primarily in the dry storage of the plant unit. The dry storage facilities are included in the scope of normal safety and security supervision.

7. FUEL COSTS

In a nuclear power plant, the fuel costs are only a small part of the total cost of production of electricity. Changes in fuel prices and exchange rates have only a minor effect on the total cost of electricity production.

OUTLINE OF THE APPLICANT'S PLANS AND THE AVAILABLE METHODS FOR NUCLEAR WASTE MANAGEMENT

CONTENTS

OUTLINE OF THE APPLICANT'S PLANS AND THE AVAILABLE METHODS FOR NUCLEAR WASTE MANAGEMENT

0. CHANGES SINCE THE GRANTING OF THE DECISION-IN-PRINCIPLE IN 2010

The decision-in-principle for the Olkiluoto 4 nuclear power plant unit was ratified by the Parliament in 2010. After that, on the 28th of December 2012, Posiva Oy has submitted, in accordance with Section 18 of the Nuclear Energy Act, a construction licence application for a final repository for spent nuclear fuel to the Council of State. The application for a construction licence for a final repository for spent nuclear fuel concerns a complex of two interconnected nuclear facilities, an above-ground encapsulation plant and an underground final repository, to be built at the Olkiluoto site in the municipality of Eurajoki. The Posiva disposal facility involves also the disposal of spent fuel from the Olkiluoto 4 nuclear power plant unit.

1. GENERAL

The operation of a nuclear power plant produces nuclear waste. In proportion to the amount of energy produced, the amount of waste and the associated space requirements are small. The management of different types of nuclear waste calls for different technologies and schedules. A part of waste management is appropriate or possible to implement only after the operating stage of the power plant.

The principle of nuclear waste management is to isolate the waste from the living environment. In addition, the final disposal of nuclear waste will be designed in a way that does not call for supervision to ensure long-term safety.

The licensee of a nuclear power plant is responsible for the implementation and costs of nuclear waste management. TVO's existing and planned nuclear waste management arrangements or similar are also appropriate for managing the nuclear waste from the new power plant unit. The company's existing and planned arrangements are appropriate for managing all nuclear waste from the existing and future plant units.

2. REGULATIONS AND SUPERVISION RELATED TO NUCLEAR WASTE MANAGEMENT

The central principles for arranging nuclear waste management in Finland are defined in the Nuclear Energy Act, Nuclear Energy Decree, the Government's decision-in-principle regarding the objectives for research, surveying and planning of nuclear waste management on November 10, 1983, the decisions by the Ministry of Trade and Industry on March 19, 1991, (7/815/91 MTI) and September 26, 1995, (11/815/95 MTI) on the principles to be observed in nuclear waste management for nuclear power plants, as well as the operating licences for the existing nuclear power plants. In addition, there is the MTI decision on October 23, 2003, 9/815/2003, which postponed the schedule of a construction licence application from 2010 to 2012. According to these, the producer of nuclear waste shall bear the responsibility for nuclear waste management measures and their costs. According to the Nuclear Energy Act, the producer of waste is obliged to prepare for the future costs of nuclear waste management by making annual payments to the Finnish State Nuclear Waste Management Fund to the amount confirmed by the Ministry of Employment and the Economy and by depositing a security covering the difference between the total costs and the deposited funds. This ensures that nuclear power operators will pay the costs of nuclear waste management measures that are not current yet.

The above decisions by the Ministry of Trade and Industry present the principles, design criteria and schedules for the management of spent nuclear fuel, operating waste and decommissioning waste from nuclear power plants.

In accordance with the Nuclear Energy Act, the Ministry of Employment and the Economy is responsible for the highest management and supervision of nuclear waste management as well. The safety of nuclear waste management is supervised by the Radiation and Nuclear Safety Authority, which thoroughly reviews all nuclear waste management plans in advance and supervises their implementation.

Safety requirements for the final disposal of nuclear waste are stated in the Government Decree on the Safety of Disposal of Nuclear Waste (736/2008).

3. TYPES OF NUCLEAR WASTE AND MANAGEMENT METHODS

Nuclear waste originating in nuclear power plants includes:

- spent nuclear fuel
- low- and intermediate-level operating waste
- decommissioning waste

3.1. Spent nuclear fuel

After removal from the reactor, spent nuclear fuel is stored in water pools at the power plant for 3 to 10 years. The water cools the nuclear fuel and provides protection against the radiation emitted by it. Storage will continue in an interim storage facility for spent fuel which exists at Olkiluoto in Eurajoki. The existing interim storage facility can be expanded if required, or a new facility can be built for the needs of the new nuclear power plant unit. An expansion to the existing interim storage facility for spent fuel has been carried out during 2010-2014. The expansion has been implemented as to allow further additional expansions.

The activity of the nuclear fuel and the heat generated in it decrease during storage. After 20 years in interim storage, for example, the remaining activity of the nuclear fuel is to the order of a few thousandths of the initial value when removed from the reactor.

After the storage phase, the spent nuclear fuel could be reprocessed, and the remaining task would be the disposal of reprocessing waste, or it can be disposed of without reprocessing. However, the Nuclear Energy Act requires that all nuclear waste must be processed and finally disposed of in Finland. Because there are no reprocessing plants in operation or under planning in Finland, the starting point for this application is the final disposal of nuclear fuel without reprocessing.

Jointly with the company then known as Imatran Voima Oy, TVO established a separate company, Posiva Oy, for the final disposal of spent nuclear fuel. Its task is to develop the technology required for the final disposal of spent nuclear fuel from the Olkiluoto and Loviisa nuclear power plants, to carry out the safety and site surveys required for the implementation of disposal and to eventually take charge of the practical implementation of final disposal of spent nuclear fuel from its owners' nuclear power plant units existing in Finland and potentially constructed in Finland. Posiva has carried out a statutory environmental impact assessment of the disposal facility concerning 12,000 tonnes of spent nuclear fuel. Teollisuuden Voima Oyj has proposed that the final disposal of spent fuel from the Olkiluoto 4 nuclear power plant unit will take place at the planned Posiva disposal facility.

The Parliament ratified the Council of State's decision-in-principle concerning final disposal of spent nuclear fuel from the OL1, OL2, LO1 and LO2 plant units in accordance with the Nuclear Energy Act in 2001, followed by the decision-in-principle concerning final disposal of spent nuclear fuel from the OL3 plant unit in 2002. Council of State's decision-in-principle concerning the final disposal of spent nuclear fuel from the Olkiluoto 4 nuclear power plant unit (M 3/2010 vp, May 6, 2010) was ratified by the Parliament on the 1st of July 2010.

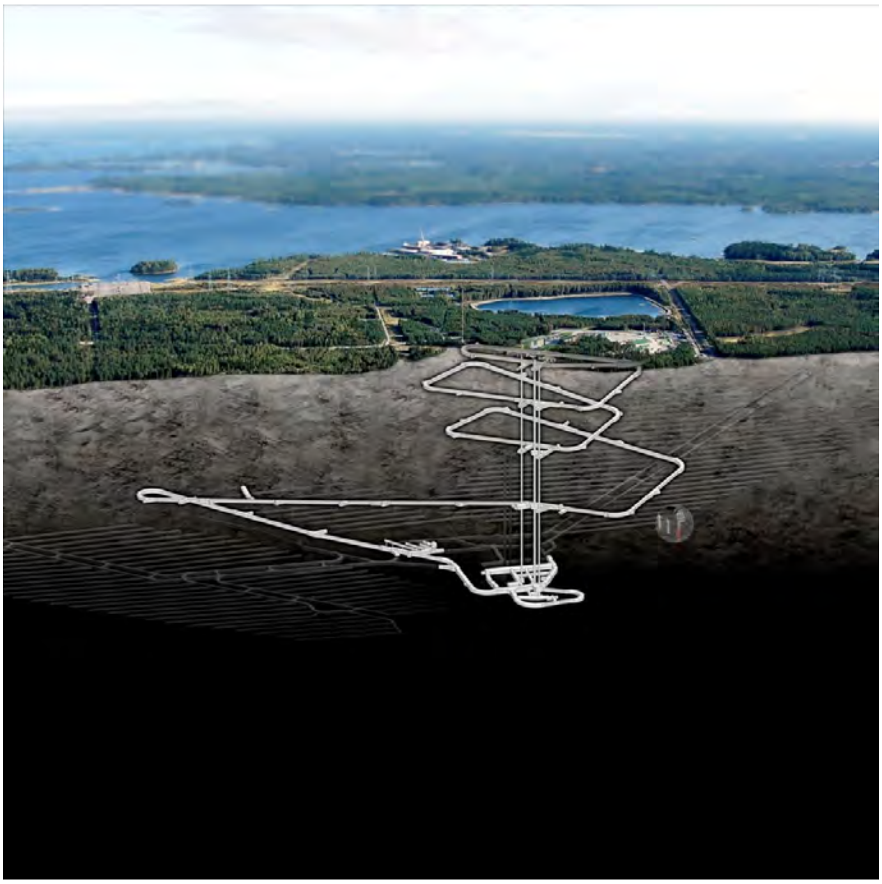
On the 28th of December 2012, Posiva Oy has submitted, in accordance with Section 18 of the Nuclear Energy Act, a construction licence application for a final repository for spent nuclear fuel to the Council of State. This nuclear waste disposal facility complex, consisting of an above-ground encapsulation plant and an underground final repository, is to be built at the Olkiluoto site in the municipality of Eurajoki. The construction licence application covers the final disposal of spent fuel from units OL1, OL2, LO1, LO2, OL3 and OL4.

For the purpose of final disposal, spent nuclear fuel is packaged (encapsulated) in tight metal containers, which are placed deep into the Finnish bedrock to a depth of approximately 400 metres. The final disposal facility comprises an encapsulation plant on the ground and the final disposal facilities below it in the bedrock (Figure 14–1).

The safety of final disposal is based on the so-called multiple barriers principle, according to which spent fuel shall be isolated from the living environment inside several barriers that are as independent of each other as possible, so that any deficiencies or faults in one barrier do not essentially hamper the isolation ability of the entire system. The barriers include the actual fuel matrix, the fuel cladding, the container (canister) for fuel assemblies, the bentonite clay surrounding the container, and the bedrock.

The location of the final disposal facility is Olkiluoto in Eurajoki. The construction of a research facility (ONKALO) is currently underway at the site for the purpose of conducting research that will finally confirm the suitability of the location for final disposal, Figure 14–2.

Figure 14–1 *Posiva's plan for a spent nuclear fuel encapsulation plant and final repository.*



Spent nuclear fuel will be transported within the Olkiluoto power plant area from the reactor buildings to interim storage and from interim storage further to the final disposal facility. All transports of fuel at Olkiluoto take place within the closed plant area, and fuel does not need to be transported on public roads.

Posiva has prepared safety analyses for the transport of spent nuclear fuel, the operation of the disposal facility and the long-term isolation ability of the final disposal solution. According to these, the total radiation burden imposed by final disposal on people and the living environment is negligible. The disposal solution complies with the safety requirements stated in the Government Decree on the Safety of Disposal of Nuclear Waste (736/2008) in terms of both operating safety and long-term safety.

Figure 14–2 *Entrance of the tunnel leading to the spent fuel final disposal research facility (ONKALO) at Olkiluoto.*

3.2. Operating waste

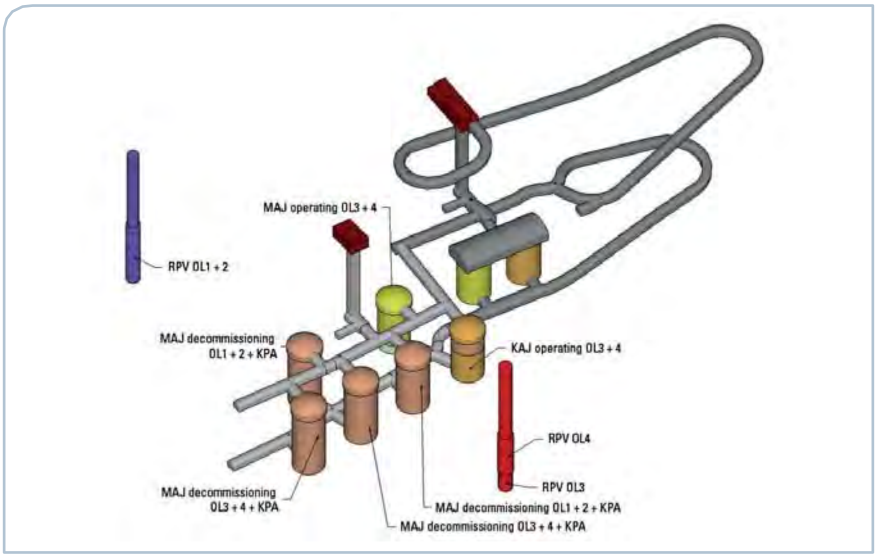
Operating waste refers to low- and intermediate-level radioactive waste arising from the operation of a nuclear power plant, such as ion exchange resins used for cleaning process waters, radioactive wastewater and diverse dry waste from maintenance operations. The starting point for management operating wastes is that all waste shall be processed, stored and finally disposed of in Finland, and that the producer of waste shall be responsible for all costs of waste processing, storage and final disposal.

Most operating waste at Olkiluoto is immediately packed for processing, storage and disposal. The intermediate-level ion exchange resins used for cleaning process water are solidified into bitumen and the mixture is cast into steel drums. Some of the low-level waste (compressible diverse maintenance waste) is compressed into steel drums using a hydraulic press, while others (scrap metal and filter rods) are packed into steel and concrete boxes and steel drums as such. Drums containing compressible waste are also compressed so that the final height is approximately one-half of the original and the diameter is unchanged. Scrap metal can also be compressed before packing. Diverse liquid wastes and sludges are solidified by mixing the waste with a binding agent in a drum that becomes the packaging for the solidifying product.

Locations for all operating waste are existing or planned within the Olkiluoto power plant site. A final disposal facility for operating waste (VLJ repository) was introduced into use at Olkiluoto in 1992. The facility is used for the final disposal of operating waste accumulated during the operation of the power plant. Very low-level waste is released from supervision and taken to a landfill or handed over to a third party for processing and recycling, for example.

The management and final disposal of operating waste from the new plant unit can be implemented on the same principles. More room for final disposal will be excavated near the existing facilities in the same manner as planned for the decommissioning waste. A principal diagram of the facilities required for operating and decommissioning waste from the four nuclear power plant units at Olkiluoto is presented in Figure 14–3.

Figure 14–3 *Final disposal facility for operating waste and a future final disposal facility for decommissioning waste at Olkiluoto in Eurajoki. The control building, the shaft leading down from it, the access tunnel and the two silos on the right are all parts of the existing VLJ repository. The two silos in the centre of the picture will be added during the operational life of OL3 and OL4 units. When plant units are decommissioned, the final disposal facility for operating waste will be further expanded by building four new silos for decommissioning waste (on the left), a process building, a shaft down from the process building, an access tunnel and two separate vertical shafts for the final disposal of reactor pressure vessels.*



3.3. Decommissioning waste

When a nuclear power plant is decommissioned, radioactive materials remain in the structures, systems and equipment as a consequence of either contamination or activation. When the power plant is no longer used, it can be brought to a safe storage state (safe enclosure) or dismantling can be started immediately. Safe enclosure would last for a few decades, after which the radioactive parts would be dismantled and disposed of. Safe enclosure facilitates dismantling work and reduces the amount of waste to be disposed of as the activity decreases. If necessary, the active parts of the nuclear power plant can be dismantled after a shorter storage period, such as one year.

The existing Finnish power plant units can be dismantled using current technology and the decommissioning waste can be safely finally disposed of in the bedrock at the plant site together with operating waste. A significant part of the decommissioning work is similar to the annual maintenance outages in terms of measures and radiation protection. The decommissioning plans are developed continuously and updated at regular intervals. The latest updates will be prepared and submitted to the authorities during 2014.

The new nuclear power plant unit will be decommissioned in accordance with the same principles approved by the authorities that have been used in the decommissioning plans for the existing plant units. The final disposal facilities constructed for operating waste at the power plant site will be extended to allow for the final disposal of decommissioning waste from the new nuclear power plant unit. The safety of the final disposal of decommissioning waste has been reviewed using safety analyses similar to those associated with the safety of the final disposal of spent nuclear fuel and operating waste.

4. COSTS OF NUCLEAR WASTE MANAGEMENT

Preparations are made for the costs of nuclear waste management in accordance with the Nuclear Energy Act, also with regard to the new nuclear power plant project. The principles are the same as those applicable to the existing power plant units.

The nuclear waste management fees paid by TVO are based on annual assessments of the amount of liability, which are presented to the Ministry of Employment and the Economy for approval. The calculations are based on the updated waste management plans of the company and the amounts of waste produced.

The amount of liability covers future expenses caused by the management of nuclear waste from the nuclear power plant. The costs of spent nuclear fuel management include the costs of transports, interim storage, encapsulation and final disposal. The amount of liability also covers the costs of final disposal of operating waste, decommissioning of the power plant and final disposal of the decommissioning waste.

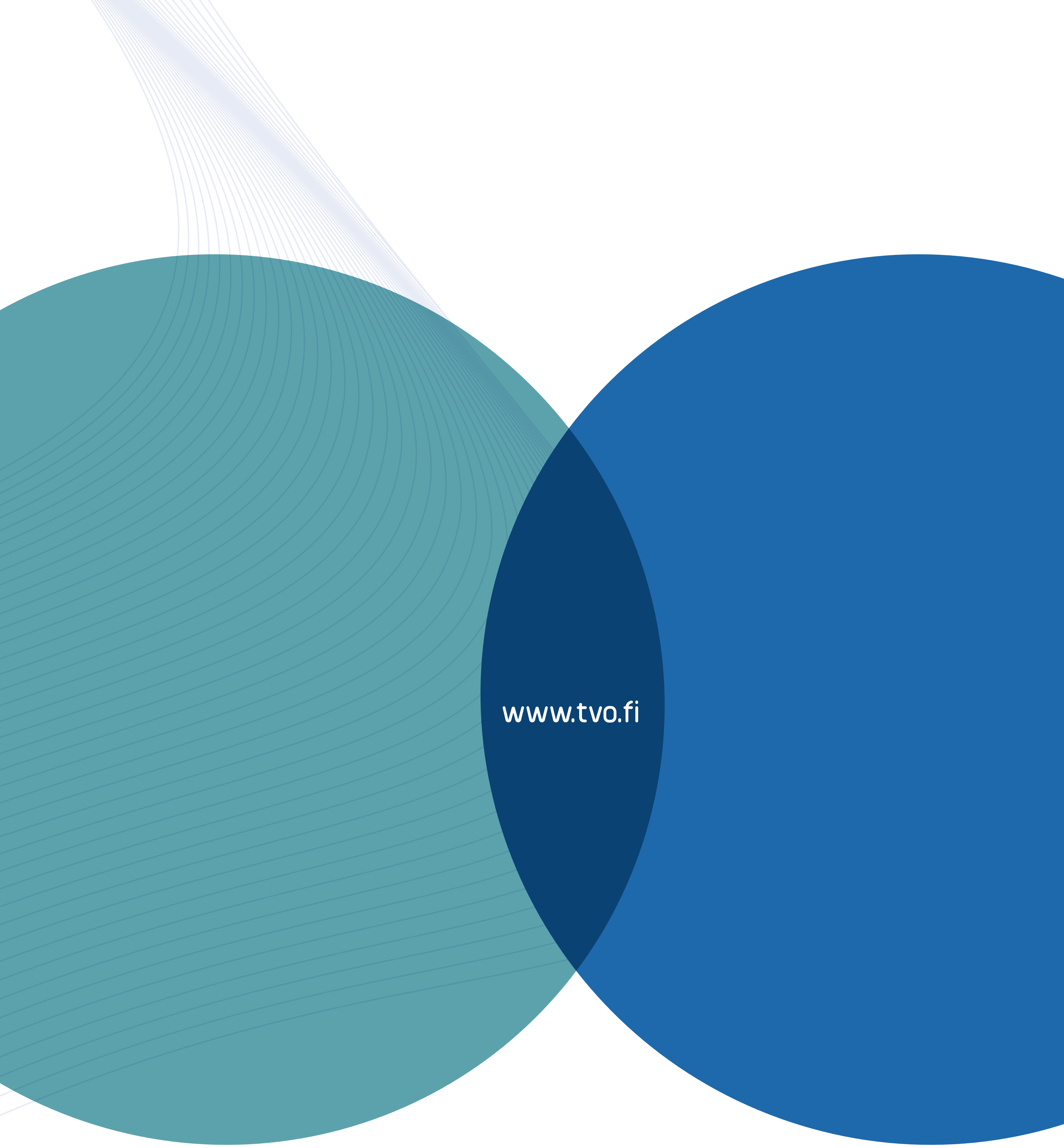
Preparation for the costs of nuclear waste management in accordance with the Nuclear Energy Act is based on the current amount of nuclear waste and the costs of all future actions. The Nuclear Energy Act does not allow the discounting of future costs; these must be calculated and funded in full, corresponding to the real current value. The deposits of funds can be allocated to specified years. The non-funded part must be covered with securities.

The construction of the new nuclear power plant unit will increase the amount of nuclear waste, which will increase the total costs but reduce the unit costs. The nuclear waste management technology and required measures will be the same as those applicable to the existing plant units.

TVO is the most significant financier of the national nuclear waste management research programme. The programme is financed with a statutory fee levied on parties obliged to answer for waste management, and its purpose is to ensure that the authorities will have the required expertise if new issues arise. TVO’s annual payments to the program are approximately one million euros.

5. CONCLUSIONS

The applicant has access to safe methods, the required locations for final disposal facilities and funding for arranging all the nuclear waste management for the new nuclear power plant unit. The planned arrangements correspond to the principles and plans currently applicable at Finnish nuclear power plants. Nuclear waste management for the new nuclear power plant unit can be implemented using existing technology.



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