19.10.2009 APPENDIX 2

PRELIMINARY SAFETY ASSESSMENT OF THE FENNOVOIMA OY NUCLEAR POWER PLANT PROJECT

APPENDIX 2: FEASIBILITY ASSESSMENT FOR ALTERNATIVE SITES

Unofficial translation

N.B. This is unofficial translation.
Original:
http://www.stuk.fi/ydinturvallisuus/ydinvoimalaitokset/suomen_ydinvoimalaitokset/fi_FI/uudet_laitosyksikot/_files/82314753023869011/default/Alustava%20turvallisuusarvio_PAP-FV_liite2_sijaintipaikka.pdf

1 INTRODUCTION

On January 14, 2009, Fennovoima Oy submitted an application to the Government for a decision-in-principle concerning the construction of a new nuclear power plant at either Simo, Pyhäjoki or Ruotsinpyhtää. The Ministry of Employment and the Economy requested the Radiation and Nuclear Safety Authority (STUK) to conduct a preliminary safety assessment pursuant to section 12 of the Nuclear Energy Act.

According to the application, the Nuclear Power Plant will consist of one or two nuclear power plant units, the buildings and storage facilities required for nuclear fuel management and nuclear waste management, and a repository for the final disposal of low level and medium level reactor waste.

The application includes the following supplements with reports on the proposed alternative sites for the Nuclear Power Plant:

3A	Assessment report pursuant to the Act on Environmental Impact Assessment Procedure (468/1994)
3B	Hanhikivi in Pyhäjoki
3C	Gäddbergsö in Ruotsinpyhtää
3D	Karsikko in Simo

Supplement 3A also contains the information required in section 24 paragraph 6 f of the Nuclear Energy Decree concerning the design principles observed by the applicant to avoid environmental damage and to restrict the burden on the environment.

Supplements 3B, 3C and 3D contain the information required in section 24 paragraphs 6 c-e of the Nuclear Energy Decree:

c) an outline of the ownership and occupation of the site planned for the nuclear facility
d) a description of settlement and other activities and town planning arrangements at the planned nuclear facility site and in its immediate vicinity
e) an evaluation of the suitability of the planned site for its purpose and the restrictions caused by the nuclear facility on land use in the immediate vicinity.

Fennovoima submitted the further information requested in the coordinating authority's statement regarding the EIA report to the Ministry of Employment and the Economy on April 9, 2009. This further information involved, among other things, the radiation doses in the vicinity of the Nuclear Power Plant caused by a release of radioactive materials arising from a severe accident as referred to in section 10 of the Government Decree on the Safety of Nuclear Power Plants (733/2008).

The alternative sites for the new Nuclear Power Plant given in the application for a decision-in-principle are (in alphabetical order):

- Hanhikivi in Pyhäjoki, a headland about 20 km southwest of the town centre of Raahe,
- Gäddbergsö in Ruotsinpyhtää, a headland about 13 km southeast of the town centre of Loviisa,
- Karsikko in Simo, a headland about 12 km southeast of the town centre of Kemi.

Fennovoima submitted to STUK the following report on these alternative sites for the processing of the application:

> STUK E – Report on the safety impacts of local conditions at the alternative sites

and the following reports referred to in the aforementioned report:

- Estimate of the recurrence of weather parameters over a 1,000 year period at potential sites for nuclear power plants (Finnish Meteorological Institute)
- Extreme sea level variations at alternative sites for a nuclear power plant (Finnish Institute of Marine Research)
- Geological pre-studies at potential sites for a nuclear power plant (Geological Survey of Finland)
- Geophysical rock surface studies in Simo, Pyhäjoki and Ruotsinpyhtää (Geological Survey of Finland)
- Study of mineral deposit potential at potential sites for a nuclear power plant (Geological Survey of Finland)
- Impact of sea ice on cooling water inlet structures (Karna Research and Consulting)
- Ground survey report, Simo (Geobotnia)
- Ground survey report, Pyhäjoki (Geobotnia)
- Ground survey report, Ruotsinpyhtää, Gäddbergsö (Geobotnia)
- Ground survey report, Ruotsinpyhtää, Kampuslandet (Geobotnia)
- Drilling in the Karsikko area (Lapland Regional Environment Centre)
- Survey of seismic history and determination of a design basis earthquake as per YVL Guide 2.6 for potential sites for nuclear power plants in Pyhäjoki, Ruotsinpyhtää and Simo (Institute of Seismology)
- Estimate of the probability of an aircraft crash at alternative Fennovoima Oy power plant sites, VTT-R-05213-09 (VTT Technical Research Centre of Finland)
- Report on the handling, storage and transport of hazardous materials in the vicinity of proposed Fennovoima power plant sites (Konsultointi Koivuviita)

- Results of rock studies in Pyhäjoki, Ruotsinpyhtää and Simo: rock samples, water pressure tests, drill sampling, seismic measurements, tension measurements, video imaging (Pohjatekniikka Oy, report in English)
- Reports on groundwater sampling in Pyhäjoki, Ruotsinpyhtää and Simo (Pohjatekniikka Oy).

This supplement to the preliminary safety assessment addresses the suitability of each alternative site and its vicinity for the intended purpose. The investigation involved the impact of the circumstances at each site on nuclear safety, emergency preparedness, security (physical protection) arrangements and nuclear waste management. The feasibility of each site is assessed on the basis of nuclear safety requirements in current regulations. Experiences of the monitoring of units already in operation and under construction are also taken into account, as are the nuclear and radiation safety points that emerged in the environmental impact assessment (EIA) procedures.

2 REGULATIONS APPLYING TO THE SITE AND ITS SAFETY PROPERTIES

The current regulations present requirements for the site and vicinity of a nuclear power plant and other nuclear facilities, and requirements whereby the characteristics and circumstances of the site of the plant must be investigated and taken into account in the design of the plant.

Requirements regarding the site of a nuclear power plant have been enacted in the Nuclear Energy Act (990/1987), in the Government Decrees on the Safety of Nuclear Power Plants (733/2008), on Security in the Use of Nuclear Energy (734/2008), on Emergency Response Arrangements at Nuclear Power Plants (735/2008) and on the Safety of Disposal of Nuclear Waste (736/2008), and also in the YVL Guides released by STUK. International conventions and international law have been taken into account in the Finnish regulations.

In addition to the requirements in the official regulations, the applicant also places demands on the site and its vicinity with a view to ensuring the safe and economic construction and use, and ultimately decommissioning, of the power plant unit.

2.1 Nuclear Energy Act

The site of a nuclear facility is referred to in the following parts of the Nuclear Energy Act:

Section 14. Consideration of the decision-in-principle by the Government, subsection 2

Should the Government find that the prerequisites laid down in subsection 1 have been met, it shall, in reaching its decision-in-principle, consider the issue from the

perspective of the overall good of society, and take into account the benefits and drawbacks arising from the nuclear facility, paying particular attention to:

1) the need for the nuclear facility project with respect to the country's energy supply;
2) the suitability of the intended site of the nuclear facility and its effects on the environment; and
3) arrangements for the nuclear fuel and waste management.

Section 19. Construction of other nuclear facilities

A license for the construction of a nuclear facility other than that referred to in section 18 can be granted:
…
2) if the site of the nuclear facility is appropriate with respect to the safety of the planned operations, and environmental protection has been taken into account appropriately when planning operations;
…
4) if a site has been reserved for the construction of a nuclear facility in a local detailed plan in accordance with the Land Use and Building Act (132/1999), and the applicant is in possession of the site required for the operation of the facility;

Under section 18 of the Nuclear Energy Act, the provisions of section 19 also apply to a nuclear facility having considerable general significance as referred to in section 18. Although section 19 specifically pertains to the grounds for granting a construction license, in the processing of the application for a decision-in-principle it is also necessary to consider whether the proposed site is feasible in terms of safety. It is also necessary to consider whether it is likely that the necessary local land use planning requirements can be fulfilled. The actual local planning procedure can be undertaken after the decision-in-principle process, before the eventual construction license application is submitted.

Section 58. Construction and planning of land use

That provided elsewhere in the law shall apply to the planning of land use in an area intended for the site of a nuclear facility. Before a local detailed plan is drawn up for the area intended for the site of a nuclear facility, and prior to the approval of such a plan where a site is reserved for the construction of a nuclear facility, a statement shall be obtained from the Radiation and Nuclear Safety Authority (STUK).

That provided elsewhere in the law shall apply to the construction of a nuclear facility. Notwithstanding the above, the Radiation and Nuclear Safety Authority (STUK) shall have the right, to the extent required by the supervision duty referred to in section 55(1), and having consulted other authorities if necessary, to issue more detailed regulations concerning construction that result from special requirements as referred to in sections 6 and 7, and from Finland's international contractual obligations concerning the prevention of the proliferation of nuclear weapons.

2.2 Government Decrees

The Government Decree on the Safety of Nuclear Power Plants (733/2008) contains the following general provisions regarding siting:

Section 11. Siting of a nuclear power plant

The safety impact of local conditions, as well as the security and emergency preparedness arrangements, shall be considered when selecting the site of a nuclear power plant. The site shall be such that the impediments and threats posed by the facility to its environment remain extremely minor and heat removal from the plant to the environment can be reliably implemented.

Moreover, the Government Decrees on the Safety of Nuclear Power Plants, on Emergency Response Arrangements at Nuclear Power Plants and on the Safety of Disposal of Nuclear Waste contain several requirements referred to below for which the site of the facility and the characteristics of its environment have relevance.

There are also provisions regarding emergency preparedness arrangements in the Rescue Act (468/2003) and in the Decree of the Ministry of the Interior on rescue services plans prepared for nuclear and radiological emergencies and communication on emergencies (520/2007).

2.3 YVL Guides published by STUK

Requirements for the site of a nuclear facility or references to local conditions at that site may be found in the following YVL Guides published by STUK:

- YVL 1.0 Safety criteria for design of nuclear power plants
- YVL 1.10 Requirements for siting a nuclear power plant
- YVL 2.6 Seismic events and nuclear power plants
- YVL 2.8 Probabilistic safety analysis in safety management of nuclear power plants
- YVL 7.1 Limitation of public exposure in the environment of and limitation of radioactive releases from a nuclear power plant
- YVL 7.2 Assessment of radiation doses to the population in the environment of a nuclear power plant
- YVL 7.3 Calculation of the dispersion of radioactive releases from a nuclear power plant
- YVL 7.4 Nuclear power plant emergency preparedness
- YVL 7.5 Meteorological measurements of a nuclear power plant

– YVL 8.1 Disposal of low and intermediate level waste from the operation of nuclear power plants

There are also requirements for civil defense in the vicinity of a nuclear facility in the STUK guideline VAL 1.1 ‘Radiation protection measures in a radiation hazard situation’ (confirmed by Ministry of the Interior Decision 01285, TU-311, June 15, 2001).

2.4 International regulations

Finland is a party to the international Convention on Nuclear Safety (SopS 74/1996), whose signatories recognize that the Convention entails a commitment to the application of fundamental safety principles for nuclear installations rather than of detailed safety standards and that there are internationally formulated safety guidelines which are updated from time to time and so can provide guidance on contemporary means of achieving a high level of safety. Finland is also a party to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (SopS 36/2001).

The publication ‘Site Evaluation for Nuclear Installations Safety Requirements’ (IAEA NS-R-3, 2003) presents general requirements for the site of a nuclear facility; these are taken into account in Finland’s national regulations. Moreover, the IAEA has issued guidelines for various areas of technology containing detailed recommendations regarding the site of a facility. These recommendations have been taken into account in Finland’s national regulations to the extent required by local conditions.

The Western European Nuclear Regulators’ Association (WENRA) has published recommendations on nuclear safety. The requirements enacted in the Finnish regulations incorporate the WENRA recommendations as regards the site of a facility.

3 EMERGENCY RESPONSE ARRANGEMENTS

3.1 Release of radioactive materials in a severe reactor accident

A nuclear power plant generates large amounts of radioactive materials when in operation. Because the radiation emitted by these materials is harmful to human beings and the living environment, the release of radioactive materials into the environment must be reliably prevented with a series of consecutive engineered barriers. A nuclear power plant shall also be equipped with safety systems to prevent or contain the progress of transients and accidents and their consequences. The construction of a nuclear power plant is subject to stringent safety requirements.

In order to ensure the safety of the population and in keeping with general safety principles, a nuclear power plant shall prepare for the potential release of a substantial quantity of radioactive materials into the environment in case of a severe accident, however low the probability of such an event may be. 'Emergency response arrangements' refer to any action taken to be prepared for accidents or other events compromising safety at or around the nuclear facility. These arrangements particularly pertain to situations involving an actual or potential release of radioactive materials into the environment.

Operation of a reactor in a nuclear power plant is based on fission reactions, splitting of nuclei of uranium atoms in the nuclear fuel by neutron bombardment. Fission reactions release energy and produce radioactive fission products, including noble gases, iodine and cesium. During normal operation, radioactive materials produced are principally bound within the ceramic fuel pellets. However, a small fraction of the gaseous and volatile radioactive materials is released inside the gas-tight fuel rod where the fuel pellets are. The most significant reactor accident risk is caused by the decay of radioactive fission products which continue to generate heat in the nuclear fuel even after the reactor is shut down. If fuel cooling is lost as the result of an accident, the fuel (i.e. the reactor core) may become overheated and damaged to the extent that fission products accumulated in the fuel are released. A severe reactor accident is an accident in which a considerable part of the fuel in the reactor is damaged. In case of fuel damage, the walls of the reactor cooling circuit and the reactor containment building form physical barriers against the release of radioactive materials. Radioactive materials can only be released into the environment if the integrity of all physical barriers fails. However, even in case of a severe accident the most probable scenario is that practically all radioactive materials are retained within the containment building.

3.1.1 Release of radioactive materials

The relevance of the radioactive materials contained in the reactor to emergency preparedness arrangements depends on the quantities of the materials and on their chemical and physical properties. These properties affect how the radioactive materials are released from the fuel, how they are transported within the containment building, the atmosphere, water and the soil, and how they affect the biosphere. The half-life of a radioactive material is a measure of how rapidly the activity of the material is reduced as a result of radioactive decay.

The most easily released substances are radioactive noble gases (xenon and krypton). If the integrity of all physical barriers fails, full inventory of radioactive noble gases will be released into the atmosphere. The noble gases will be transported by air flow and will cause external radiation in the area under the release cloud. The long-term radiation doses caused by noble gases are relatively small, because noble gases do not cause fallout, are not accumulated in the food chain and are not transferred into the body through inhalation or ingestion.

Radioactive iodine vaporizes at a low temperature and is relatively easily released from the failed fuel. A notable percentage of the iodine released from the fuel is deposited to the structures and water pools of the containment building on its way out. However, the possibility of a large release of iodine in case of an accident cannot be entirely ruled out. At the early stage of an accident leading to a release, radioactive iodine may in fact be the major source of radiation doses, as it can accumulate on the ground in the form of fallout and also accumulate in the human body, specifically the thyroid gland, through inhalation and food. The most significant isotope of iodine radiologically is iodine 131. Because the half-life of this isotope is relatively short, about eight days, iodine doses may be a significant factor for a period of days or weeks.

Cesium vaporizes at a low temperature and is relatively easily released from the failed fuel. The most significant isotope of cesium from the point of view of radiation protection is cesium 137. Its half-life is relatively long, about 30 years, meaning that a release of cesium will have high relevance for the long-term impact of an accident. The severity of a nuclear power plant accident is commonly illustrated by the quantity of releases of iodine and cesium.

Of the other solid radioactive materials in the fuel, only a small fraction would be released even in the most severe accident conceivable. The combined radiation dose caused by these materials would be substantially smaller than that caused by iodine and cesium.

The progress of an accident and the magnitude, time and duration of a release of radioactive materials depends on a number of factors, such as the functioning of safety systems and the actions of operators. Because there is a large number of possible chains of events, it is impossible to anticipate precisely when a release might begin and how long it might last. The altitude of a release into the atmosphere and the circumstances of its spreading are also important in terms of environmental impact.

It is unlikely that events that cause the emergency preparedness and rescue services organizations to be alerted, or accidents involving severe damage to the reactor core, would escalate into radiation accidents requiring the protection of the local population. In most of the accident scenarios reviewed, practically all radioactive materials remain within the containment building. In the case of an eventual release, the current weather conditions would crucially affect how the released materials behave outside the nuclear power plant. Dispersion of the release would depend on wind speed. In high winds, the release cloud would travel rapidly, but on the other hand wind also efficiently disperses and dilutes it.

Analyses specific for each power plant unit type concerning the release of radioactive materials and radiation doses in case of a variety of transients and accidents will be submitted to STUK in connection with an eventual construction license application. The processing of an application for a decision-in-principle involves an assessment of whether the basic safety technology design of the power plant unit alternatives is such that it will be possible to fulfill safety requirements in their detailed design. An assessment of the technical design of the power plant unit alternatives is given in supplement 1 to the preliminary safety assessment.

3.1.2 Release in a severe accident

As an indicative example of the impact of a severe accident, the environmental impact assessment (EIA) report on the Fennovoima Nuclear Power Plant Project describes an accident that would lead to a release of cesium 137 exceeding the limit of 100 TBq specified as the threshold of a severe accident in section 10 of the Government Decree on the Safety of Nuclear Power Plants (733/2008).

This scenario assumed core meltdown and a release from the altitude of the plant ventilation stack comprising all of the radioactive noble gases accumulated in the reactor and also 100 TBq of cesium 137, 1,000 TBq of iodine 131 (less than 0.1% of the total), and proportional amounts of other isotopes of cesium and iodine. The release was assumed to begin six hours after the initiating of the accident and to last one hour. The impact of weather conditions on the spreading of the release and the radiation doses caused by the release were examined using several different calculation scenarios. The weather conditions selected for study included both typical and rare unfavorable conditions. The distribution of the occurrence of various meteorological conditions at the alternative sites for the new Nuclear Power Plant given in the application for a decision-in-principle was not provided. No protective measures were taken into account in the calculation of radiation doses caused by the release. On the other hand, it was assumed that food or fodder produced within two kilometers of the facility would not be used for nutrition.

The basic assumptions employed by Fennovoima in the radiation dose analyses differ somewhat from those in the dose calculations presented in the Loviisa 3 and Olkiluoto 4 projects. In the EIA report for Fortum’s Loviisa 3 nuclear power plant project, the release in case of a severe accident was assumed to begin 24 hours after the initiation of the event, and local agricultural products were assumed not to be used for nutrition within 30 km after the accident. The radiation doses calculated by Fortum correspond to weather conditions such that conditions less favorable occur only 5% of the time at an annual level. The different assumptions and scenarios are the reason why the doses presented by Fennovoima in the case of a severe accident are in some calculations substantially higher than those presented by Fortum (and similarly those presented by TVO in the EIA report for the Olkiluoto 4 project).

During the first two days, persons present in the area covered by the release will acquire a radiation dose principally from radioactive materials that are in the release cloud and in fallout on the ground, and from radioactive materials inhaled. The long-term radiation dose is acquired mainly from fallout and from radioactive materials ingested with food.

The following table shows the radiation dose for an adult in the first two days after the accident and over a period of 50 years at various distances from the nuclear power plant and in the weather conditions that would cause the largest doses in the immediate vicinity, as per the calculations in the EIA report.

Distance from the power plant (km)	Radiation dose, first 2 days (mSv)	Radiation dose, 50 years (mSv)
1	270	2,300
3	85	1,400
10	14	420
20	5.9	210

Because one of the alternative sites (Simo) is located in the immediate vicinity of reindeer husbandry territory, Fennovoima presented a separate analysis of radiation doses that would be acquired through consumption of reindeer meat. These calculations show that a person who eats exceptionally large amounts of reindeer meat could acquire a radiation dose over 50 years similar to that shown in the right-hand column of the table above.

The dose calculations are based on German standards, the methods in which are essentially compatible with Finnish requirements (STUK YVL Guides 7.2 and 7.3). The weather conditions at the northernmost alternative site (Simo), are different from those in southern Finland, for instance because in winter the occurrence of stable atmospheric conditions is two to three times higher due to a lower level of daily solar radiation and potentially extensive ice cover on the sea. Stable atmospheric conditions may increase the calculated radiation doses for a human individual at greater distances (dozens of kilometers) from the facility. In the future, it will be possible to obtain regional climate information in connection with national nuclear safety research projects for instance by referring to the information in the wind atlas currently in preparation. Neither northern climate conditions nor the proximity of reindeer husbandry territory can be considered an obstacle to the feasibility of Simo as a site for the Nuclear Power Plant. Extensive studies have been conducted in Finnish Lapland concerning the food chain of lichen to reindeer and the effectiveness of protection measures.

In case of a release, the short-term dose is acquired mainly from the release cloud passing overhead. The long-term dose is acquired mainly from fallout and from radioactive materials ingested with food.

The probability of an accident leading to a release greater than that described in the example is extremely low with a light water reactor designed according to current safety requirements. However, even such highly unlikely events are taken into account in the planning of preparedness and rescue arrangements.

Detectable health effects caused by radiation begin to emerge when the short-term radiation dose exceeds 500 mSv. This means that even if no protection measures at all were undertaken in the immediate vicinity of the Nuclear Power Plant, the release described in the example above would not cause acute radiation sickness in the local population. Protection measures can substantially reduce the radiation exposure. Protection measures are discussed below in section 3.5.3.

In 2006, STUK commissioned VTT to conduct a study focusing on the threshold value of 100 TBq of cesium 137 given in the aforementioned Government Decree. This study indicates that a release of this magnitude close to ground level could constitute grounds for restrictions to grazing and the use of agricultural products during the growing season in a significant area covering dozens or even up to 100 square kilometers. Outside the growing and grazing season, such a release would have no direct impact on agricultural products but could still make necessary soil removal, restrictions on the use of food and natural products and protection measures for local residents during the first few years. The purpose of these protection measures would be to combat the delayed effects of radiation, the most significant of which is an increased risk of cancer in the population exposed to the radiation.

It is the considered opinion of STUK that the radiation dose estimate presented by Fennovoima is sufficient for the processing of the application for a decision-in-principle. The applicant will present more detailed analyses of releases and the radiation doses caused by them in connection with the eventual construction license application. STUK will commission independent analyses of releases and radiation doses for the processing of the construction license application.

3.2 Requirements concerning emergency preparedness arrangements

The essential requirements for emergency preparedness arrangements at a nuclear power plant are given in the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008) and in the STUK YVL Guide 7.4, ‘Nuclear power plant emergency preparedness’. The regulations also contain requirements of co-operation with the local rescue authorities. The applicant must submit plans and reports on its preparedness for emergency response together with the application for a construction license, to which must be appended a preliminary preparedness plan as per section 36(1) paragraph 5 of the Nuclear Energy Decree. When applying for the operating license, the applicant must submit the final preparedness plan and demonstrate that all the other requirements for preparedness arrangements have been fulfilled (emergency response organization, facilities, equipment, training, etc.). STUK will approve the readiness plan in connection with the processing of the applications for the construction and operating licenses.

The Government Decree on Emergency Response Arrangements at Nuclear Power Plants specifies that the planning of emergency response arrangements shall be based on analyses of the progress over time of severe accident scenarios resulting in a potential release. In such a case, variations in the state of the plant, the development of events as a function of time, the radiation situation at the plant, radioactive releases, radioactive release routes and weather conditions shall be taken into account. Emergency situations, i.e. accidents or events whereby the safety of a nuclear power plant deteriorates or there is a risk of such a deterioration, are classified on the basis of their severity and controllability.

In the processing of the application for a decision-in-principle it is considered how well the requirements of the provisions regarding preparedness arrangements and rescue operations in the vicinity can be fulfilled at and around the proposed site.

3.3 Requirements for the protective zone and the emergency planning zone

The Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008) defines the site area, protective zone and emergency planning zone (section 2). The site area is the area in use by the nuclear facility and the surrounding area, where movement and sojourn is restricted by a Decree of the Ministry of the Interior, issued under section 52 of the Police Act (493/1995). The protective zone is an area which extends about 5 km from the nuclear power plant and where land use restrictions are in force. The emergency planning zone is an area extending about 20 km from the nuclear power plant and must be covered by a rescue plan for public protection drawn up by the authorities, as provided for in section 9(2) of the Rescue Act (468/2003).

More detailed requirements for the site of a nuclear power plant and for emergency preparedness arrangements in its vicinity are given in the STUK YVL Guide 1.10 ‘Requirements for siting a nuclear power plant’. The general principle in the siting of nuclear power plants is to have the facilities in a sparsely populated area and far away from large population centers. What justifies placement in a sparsely populated area is that emergency planning will then be directed at a smaller population group and will thus be easier to implement. In the plant’s vicinity, no activities may be carried out that could pose an external threat to the plant.

3.3.1 Hanhikivi in Pyhäjoki

Hanhikivi headland in Pyhäjoki is in a sparsely populated area. There are no permanent residents on the headland, and there are relatively fewer leisure homes here than elsewhere on the waterfront in Pyhäjoki.

The community nearest to the proposed site of the Nuclear Power Plant is the village of Parhalahti, some 4 km away. Parhalahti has a permanent population of about 400. Other nearby communities are the central village of the municipality of Pyhäjoki 7 km away and the town of Raahe some 20 km away. The smaller communities of Piehinki and Yppäri are some 8 and 17 km away, respectively, from the proposed site.

There are no industrial facilities, warehouses or other facilities near Hanhikivi that might cause a hazard at the proposed power plant. The nearest major industrial facilities are the Rautaruukki Oyj steel mill in Raahe and the Oy Polargas Ab air gas plant and LPG storage some 15 km from Hanhikivi.

Highway 8 runs about 5 km from the proposed site, to the east of the Hanhikivi headland. The nearest airports are Oulu airport at Oulunsalo about 70 km away and the general aviation airfield of Raahe-Pattijoki about 30 km away.

The plans for the Nuclear Power Plant site include a harbor that would be used only by the plant itself. The nearest busy harbor is about 16 km away in Raahe, comprising the industrial harbor of Rautaruukki Oyj and the Lapaluoto harbor of the town of Raahe. The shipping channel from the harbor towards the Quark runs about 15 km out to sea from Hanhikivi. The fishing harbor of Tankokarinnokka is on the southwestern shore of the Hanhikivi headland, about 3 km from the proposed site.

The nearest railway line runs from an industrial estate in Raahe about 15 km from Hanhikivi via Raahe railway station to Vihanti. This line is only used for goods traffic.

The proposed site of the Nuclear Power Plant at Hanhikivi is marked as an energy supply area in the proposal for regional land use plan (EN-yv) and in the component local master plan (EN1 and EN2). STUK understands that the areas marked ‘EN1’ and ‘EN2’ in the local master plan will be designated a power plant site area as referred to in Government Decree 735/2008 by a Decision of the Ministry of the Interior. Basically, the site area may only contain functions related to the power plant itself, and no permanent residences. Employee residences or leisure homes are only permissible to a very limited extent. The site area may contain functions unrelated to the operations of the power plant provided that these do not constitute a threat to power plant safety. No public roads run through the site area. Two access routes are planned for the site.

The protective zone, which extends about 5 km from the proposed site, is marked in whole in the draft regional land use plan. Adding the village of Parhalahti, which is partly located within a 5 km radius and has a population of about 400, to the protective zone means that there is a total permanent population of about 450 in the protective zone and also some 40 leisure homes. The nearest leisure homes in the protective zone are on the southwestern shore of Hanhikivenniemi, about 1.5 km from the proposed site of the reactor building of the Nuclear Power Plant.

The emergency planning zone of a nuclear power plant extends to approximately 20 km from the plant. The authorities must draw up detailed rescue plans for public protection that cover the emergency planning zone, as per section 9 of the Rescue Act. This plan must define the emergency planning zone according to municipal borders or communities. Within a radius of about 20 km from the proposed nuclear power plant site at Hanhikivenniemi there is a permanent population of about 11,300, and within a radius of 100 km the population is about 370,000.

The village of Parhalahti, which falls partly within the 5 km radius, is completely included in the protective zone in the draft regional land use plan for the Hanhikivi nuclear power plant site. It is the considered opinion of STUK that the requirements of the YVL Guide 1.10 ‘Requirements for siting a nuclear power plant’ are fulfilled for the site proposed in the application for a decision-in-principle if efficient early warning of the population in the protective zone is ensured and the implementation of protection measures in the event of an accident is secured.

3.3.2 Gäddbergsö in Ruotsinpyhtää

Gäddbergsö headland in Ruotsinpyhtää is in a sparsely populated area. There are some permanent residences on the headland, and leisure homes on the shores.

The nearest large community to the site is Loviisa (population about 7,400), whose town center is about 13 km away. The village of Valko, which is part of the town of Loviisa (population about 1,000) is about 9 km away. The smaller communities of Tesjoki, Ruotsinpyhtää and Pyhtää are some 12, 17 and 16 km away, respectively, from the proposed site.

There are no industrial facilities, warehouses or other facilities near Gäddbergsö that might cause a hazard at the proposed power plant, except for the existing Loviisa nuclear power plant. The proposed Fennovoima site is about 3 km from the existing nuclear power plant units at Hästholmen. The structural focus of the Loviisa economic zone is on small and medium-sized industrial enterprises clustered at the intersection of highway 7 (Länsiportti) about 14 km from the proposed site and at Valko harbor about 9 km away.

Highway 7 runs about 12 km from the proposed site. The nearest airports are Helsinki-Vantaa Airport and Helsinki-Malmi Airport about 80 km away and the airfields of Kymi and Wredeby (mostly flight training, general aviation and sailplanes) about 40 km away.

The harbor of Valko is about 9 km away from the proposed power plant site. The nearest railway line is that running from Valko harbor to Lahti. The deep water channel to Valko harbor runs about 4 km off the southwestern shore of Gäddbergsö at closest; the 3.0 m channel runs about 500 m off Gäddbergsö; and the inner and outer coastal channels of the Gulf of Finland to Kotka and Hamina run to the south of Orrengrund, about 10 and 23 km from Gäddbergsö, respectively. The main shipping channel in the Gulf of Finland, which carries a substantial percentage of Russian crude oil exports, runs just over 30 km from Gäddbergsö.

The Fennovoima application for a decision-in-principle shows the proposed power plant site on the Gäddbergsö headland and land use outlines at all levels of planning. Basically, the site area may only contain functions related to the power plant itself, and no permanent residences. Employee residences or leisure homes are only permissible to a very limited extent. The site area may contain functions unrelated to the operations of the power plant provided that these do not constitute a threat to power plant safety. No public roads run through the site area. There is one access route to the proposed power plant site.

The Fennovoima application for a decision-in-principle describes the distribution of the permanent population around Gäddbergsö in Ruotsinpyhtää at a radius of 5 km and 20 km. The protective zone extending some 5 km from the site has a permanent population of about 70 and some 240 leisure homes. The number of leisure homes is different in different databases because of the different criteria used to register them. According to the terrain database of the National Land Survey of Finland, there are some 500 leisure homes in the protective zone. The nearest are about 1 km from the proposed site. Three fourths of the leisure homes are on the mainland and the rest on nearby islands.

The emergency planning zone of a nuclear power plant extends to approximately 20 km from the plant. The authorities must draw up detailed rescue plans for public protection that cover the emergency planning zone, as per section 9 of the Rescue Act. This plan must define the emergency planning zone according to municipal borders or communities. The emergency planning zone would have a population of about 11,900, and within a radius of 100 km the population is about 1.7 million. There are territories belonging to Estonia and Russia less than 100 km from the proposed power plant site.

It is the considered opinion of STUK that the requirements of the YVL Guide 1.10 ‘Requirements for siting a nuclear power plant’ are fulfilled for the site proposed in the application for a decision-in-principle. The proximity of the Loviisa nuclear power plant would not prevent the construction project from going ahead, but Fennovoima must take it into account in its preparedness arrangements at the construction license stage. Early warning and rapid evacuation of worksite personnel must be ensured in case of an accident occurring at the Loviisa nuclear power plant during construction.

3.3.3 Karsikko in Simo

At Karsikkoniemi in Simo, the permanent population is mainly located in the northern part of the area and along the coast, where there are also leisure homes. The interior of the headland is mostly uninhabited forest and bog.

The communities nearest to the proposed power plant site are the Hepola, Rytikari and Ajos districts of the town of Kemi and the village of Maksniemi in Simo. Hepola is the nearest of these, being about 4 km away from the proposed power plant site; the others are about 5 km away. Other nearby communities are the central village of the municipality of Simo about 17 km away and the town of Kemi (population about 22,800), the center of which is about 12 km from the proposed site.

There are no industrial facilities, warehouses or other facilities near Karsikkoniemi that might cause a hazard at the proposed power plant. The nearest major industrial installation is the Veitsiluoto paper mill about 7 km away. Metsä-Botnia and Finnforest have wood processing plants at Karihaara about 15 km from the proposed site. There are also small and medium-sized industrial enterprises in Kemi and Simo.

Highway 4 runs about 5 km from the proposed site. The nearest airport is in Kemi, about 16 km away.

The plans for the Nuclear Power Plant site include a harbor that would be used only by the plant itself. The nearest busy harbor is about 8 km away in Ajos in Kemi. The oil harbor for northern Finland is at Ajos, about 9 km from the proposed site. The harbor of the Veitsiluoto mills is about 6 km away. The shipping channel to Ajos and Veitsiluoto run about 6 km and 1 km off Karsikkoniemi, respectively. The nearest marina and fishing harbor is on the southeastern shore of Karsikkoniemi about 1.5 km from the proposed site of the reactor building.

The nearest railway line runs from the Veitsiluoto industrial facility to Kemi railway station, passing about 6 km away from the proposed site. This line is only used for goods traffic.

The proposed nuclear power plant site at Karsikkoniemi in Simo is marked as an energy supply area in the draft local detail plan: the EN-1 area may be used for the power plant itself, and the EN-2 area for support activities. STUK understands that the areas marked ‘EN1’ and ‘EN2’ in the local master plan will be designated a power plant site area as referred to in Government Decree 735/2008 by a Decision of the Ministry of the Interior. Basically, the site area may only contain functions related to the power plant itself, and no permanent residences. Employee residences or leisure homes are only permissible to a very limited extent. The site area may contain functions unrelated to the operations of the power plant provided that these do not constitute a threat to power plant safety. No public roads run through the site area. Two access routes are planned for the site.

The proposed site of the Nuclear Power Plant at Hanhikivi is marked as an energy supply area in the draft regional land use plan (EN-1) and in the component local master plan (EN-1 and EN-2). The protective zone, which extends about 5 km from the proposed site, is marked in whole in the draft regional land use plan. The area within 5 km of the proposed site has a permanent population of about 1,250 and some 160 leisure homes. If the protective zone were expanded to include the communities that fall partly within it (Maksniemi in Simo and Hepola in Kemi) or are between 5 km and 6 km away (Rytikari), the permanent population of the protective zone would be about 3,000. The nearest leisure homes in the protective zone are at Karsikkoniemi, about 1 km northeast from the proposed site. Three fourths of the leisure homes in the protective zone are located on the mainland and the rest on nearby islands. There is a fishing harbor on the headland and also leisure activities, all of which would require access past the power plant site.

The emergency planning zone of a nuclear power plant extends to approximately 20 km from the plant. The authorities must draw up detailed rescue plans for public protection that cover the emergency planning zone, as per section 9 of the Rescue Act. This plan must define the emergency planning zone according to municipal borders or communities. The emergency planning zone, within a radius of about 20 km from the proposed nuclear power plant site, has a permanent population of about 32,000, and within a radius of 100 km the population is about 290,000. The Swedish coast and the town of Haaparanta on the Swedish side of the border are about 30 km away from Karsikkoniemi. The Finnish border runs about 20 km offshore from Karsikkoniemi.

The communities partly within or immediately outside the protective zone (Maksniemi, Hepola and Rytikari) are wholly included in the protective zone in the Kemi-Tornio draft regional land use plan for the nuclear power plant site (see section 3.4.3). It is the considered opinion of STUK that the requirements of the YVL Guide 1.10

‘Requirements for siting a nuclear power plant’ are fulfilled for the site proposed in the application for a decision-in-principle if efficient early warning of the population in the protective zone is ensured and the implementation of protection measures in the event of an accident is secured. However, this would require special action from the rescue services and commitment to undertake that action to ensure successful implementation of protection measures. This issue is discussed in more detail in sections 3.5 and 3.6.

3.4 Land use planning

Implementation of the Nuclear Power Plant project requires that a land area is reserved for the plant in the regional land use plan, the local master plan and the local detail plan for the area in question. The following is a review of the planning situation separately for each site. It is the considered opinion of STUK that the planning now in preparation will enable the permit process and construction for a new nuclear power plant unit at any of the proposed sites.

3.4.1 Hanhikivi in Pyhäjoki

For the site at Hanhikivi in Pyhäjoki, planning has progressed to plan drafts at the component master plan level and the local detail plan level. A proposal of the regional land use plan for the Hanhikivi nuclear power plant was open for public inspection from September 30 to October 29, 2009. The draft component master plan and draft local detail plans for the Hanhikivi nuclear power plant site were open to public inspection from November 14 to December 15, 2008. STUK has returned statements on these plans. As the planning progresses, the further information required by the Ministry of Employment and the Economy regarding environmental impact for the processing of the application for a decision-in-principle will be taken into account.

3.4.2 Gäddbergsö in Ruotsinpyhtää

For the proposed nuclear power plant site at Gäddbergsö in Ruotsinpyhtää, planning is under way at all three planning levels. The participation and assessment scheme for the component master plan and local detailed plan for Gäddbergsö in Ruotsinpyhtää was open for public inspection from September 3 to October 2, 2009, and the participation and assessment scheme for the 3rd stage regional land use plan (regional land use plan for a nuclear power plant) was open for public inspection from September 14 to October 13, 2009. STUK will issue statements on these plans. An official consultation for all planning levels was held on August 17, 2009.

3.4.3 Karsikko in Simo

For the site at Karsikkoniemi in Simo, planning has progressed to proposals at the regional land use plan level and to draft plan proposals at the component master plan level and the local detail plan level. A draft of the Kemi-Tornio regional land use plan for a nuclear power plant was open for public inspection from June 15 to August 14, 2009. The draft component master plan of the Municipality of Simo and the Town of

Kemi for the nuclear power plant site and the draft local detail plan for a nuclear power plant of the Municipality of Simo were open for public inspection from November 3 to 28, 2008. STUK has returned statements on these plans.

3.4.4 Power grid connections in planning

A new 400 kV power line will be needed to connect the new power plant unit to the national grid, and 100 kV power lines at the chosen site will have to be strengthened. In the initial stages of planning, power lines will be shown as preliminary reservations in the plans, to be further specified as the planning progresses. Under the Electricity Market Act, responsibility for developing the national grid and maintaining its systems rests with Fingrid Oyj, which is thereby obliged to strengthen the national grid as required and to ensure sufficient disruption capacity. Fingrid Oyj is also responsible for conducting any environmental impact assessments needed for strengthening the national grid. On 15 June 2009, Fingrid returned a statement to the Ministry of Employment and the Economy concerning the Fennovoima application for a decision-in-principle. According to this statement, a nuclear power plant with one or two plant units can be linked to the national grid at any of the proposed alternative sites. Fingrid further presented preliminary plans for how the Fennovoima Nuclear Power Plant could be connected to the national grid and how the national grid should be strengthened depending on the site and output chosen for the power plant.

3.5 Emergency response and rescue plans

Section 9 of the Rescue Act specifies planning obligations in case of major accidents for a nuclear power plant and its immediate vicinity. Requirements for the emergency response plan of a nuclear power plant are specified in the Nuclear Energy Decree (161/1988) and in the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008). The applicant is to append a preliminary emergency response plan to the construction license application and a detailed emergency response plan to the operating license application. The plan must include a descriptive part and instructions for action. The emergency response plan and the action to be taken in an emergency must be coordinated with the emergency response and rescue plans of the authorities.

Detailed requirements for the rescue plan for the vicinity of a nuclear power plant are based on the Decree of the Ministry of the Interior on rescue services plans prepared for nuclear and radiological emergencies and communication on emergencies (520/2007). The licensee must participate in the drawing up and updating of this plan as per section 9(2) of the Rescue Act.

Rescue planning for the vicinity of a nuclear power plant must observe planning principles issued by STUK. Rescue plans do not rely on the detailed analyses that are used for emergency preparedness arrangements at the nuclear power plant itself. In case of an accident, rescue operations and measures to protect the population are based on an estimate of the size and composition of the release, the prevailing weather and atmospheric conditions, and radiation readings from the environment.

Within the emergency planning zone, which extends about 20 km from the plant, the following must be undertaken at an early stage in the direction of the spreading of the release:

- early warning of the population,
- isolation of the accident site and limiting traffic, and
- providing protection against external radiation directly from the release cloud and fallout and against radiation caused by inhalation of radioactive air. Primary protection measures include sheltering indoors and taking iodine tablets prophylactically. The latter is particularly important for children and adolescents.

In the protective zone extending about 5 km from the plant, it may be necessary in an extreme scenario to evacuate the population rapidly before a release occurs in a severe accident.

3.5.1 Warning and emergency alert arrangements, conveying situational awareness, chain of command

According to the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008), the licensee is responsible for alerting its emergency preparedness organization. In an emergency, the on-site emergency manager of the nuclear power plant is responsible for alerting the emergency preparedness organization and giving the alarm signal.

The licensee must immediately inform STUK and the local emergency response center of initiating an emergency response situation and what its classification is; these will in turn alert other relevant authorities and partners. During the emergency situation, the licensee shall submit situation assessment on the event to STUK and the commander of rescue operations alongside recommendations, significant decisions and justifications thereof. The licensee must provide the commander of rescue operations with recommendations for protection measures until STUK assumes responsibility for this.

The population in the vicinity of the nuclear power plant must be alerted by sounding a public alarm signal using fixed and/or mobile alarm devices. The commander of rescue operations decides when to give the public alarm signal. When the public alarm signal is given, an emergency information notice by the authorities must be read on local radio channels. Implementing protection measures requires that the population be quickly and efficiently alerted in the case of a threatening situation. Both the permanent population and leisure homes must be taken into account. Archipelago conditions and the broken shoreline may slow down the alerting of leisure home dwellers and the eventual evacuation of the protection zone. In municipalities in the emergency planning zone, the public alarm signal given by fixed high-power public alarm devices would be complemented by alarm patrols of the rescue services and the police (loudspeaker vehicles). In the archipelago and along broken shoreline, Coast Guard vessels could be used for alarming. In an emergency, the licensee shall participate in warning any members of the population who are under imminent threat, and the division of duties must be agreed in advance with the rescue authorities. Particular attention must be paid to the early warning of people in areas that are close to the nuclear power plant and difficult to evacuate. Developing emergency response and rescue arrangements forms part of the licensee's cooperation with the authorities, and in the future emergency communication systems can be further developed through the potential of modern communications technology.

Under the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008), the on-site emergency manager of the nuclear power plant, as specified in the emergency plan, initiates operations and remains in command of operations at the power plant site until the commander of rescue operations announces that he/she assumes responsibility for said rescue operations. The licensee is in charge of matters related to nuclear safety and radiation protection at the nuclear power plant. The chain of command and division of duties must be described in the emergency response plan of the nuclear power plant and the rescue plan for its vicinity.

3.5.2 Radiation measurements and meteorological measurements

Under the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008), when analyzing the situation, the licensee must assess the technical status of the plant and release of radioactive materials, or threat thereof, and the radiation situation inside the plant and in the site area and emergency planning zone. In emergency situations, the licensee shall be prepared to carry out radiation monitoring at the power plant site and in the protective zone, alongside meteorological measurements, on the basis of which the atmospheric dispersion of radioactive materials in the emergency planning zone will be assessed; this information must be conveyed to the authorities. Radiation monitoring at the power plant site and in the protective zone is to be carried out using fixed radiation measuring sensors and the power plant's monitoring patrols. The rescue authorities must also describe their arrangements for local radiation monitoring in the rescue plan for the vicinity of the power plant, as per Decree of the Ministry of the Interior (520/2007). In an emergency situation, text messages in the authorities radio network (VIRVE) could be used for more efficient conveying of radiation monitoring data from monitoring patrols to the command center. There must be a meteorological observation system in place in the immediate vicinity of the power plant.

3.5.3 Protection measures and protection plans

The STUK guideline VAL 1.1 'Radiation protection measures in a radiation hazard situation' provides emergency preparedness planning basics for radiation hazards, levels for initiating key protection measures, and basics for radiation protection of persons involved in rescue operations. The nuclear power plant's on-site emergency manager issues recommendations on population protective actions to the commander of rescue operations until STUK assumes responsibility for issuing such recommendations. The rescue authorities are responsible for the practical implementation of protection measures.

The guideline states that immediate evacuation of the protective zone of the nuclear power plant (within 5 km of the plant) must be effected if there is a risk of a substantial release of radioactive materials into the environment. This measure is triggered by a general state of emergency declared by the nuclear power plant's emergency preparedness organization. Rescue planning is based on the assumption that there is a time frame of four hours for evacuation from the decision to evacuate. In the emergency planning zone beyond the protective zone (between 5 and 20 km from the plant), measures to be considered include sheltering indoors, taking iodine tablets and evacuation.

The rescue plan for the vicinity must describe emergency alerts and protection measures in various scenarios, as per the Decree of the Ministry of the Interior (520/2007).

There are challenges involved in the rescue planning, such as undertaking rescue operations in the archipelago, in sparsely populated areas along the shore, and in villages on the fringe of the protective zone.

3.5.4 Training, exercises and other joint operations

According to the Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008), the licensee shall arrange appropriate training and exercises for its personnel, and permanent and temporary employees working at the site area, on an annual basis. Cooperation exercises with the authorities shall be arranged regularly, and always prior to the commissioning of a new nuclear power plant unit. The functioning of the rescue plan for the vicinity and the emergency response plans of the power plant and of the authorities must be tested under the leadership of the relevant State Provincial Office at least every three years in joint exercises of the authorities and the power plant emergency preparedness organization, as per the Decree of the Ministry of the Interior 520/2007.

If the site chosen for the Nuclear Power Plant is Gäddbergsö in Ruotsinpyhtää, Fennovoima must provide training for construction site personnel on how to respond in case of an accident at the Loviisa nuclear power plant.

3.6 Potential for implementing emergency preparedness arrangements at the alternative sites

The licensee of a nuclear power plant has certain obligations regarding emergency preparedness arrangements at the nuclear power plant and regarding the vicinity of the power plant. The licensee must provide for sufficient radiation monitoring, advance publicity together with the local rescue authorities, the distribution of iodine tablets in the protective zone and the warning of the population faced by an imminent threat. The rescue authorities have to draw up a rescue plan as per the civil defense requirements in rescue legislation and to manage rescue actions in the case of a radiation hazard. Design requirements for nuclear power plant incidents in this respect are given in more detail in the guideline VAL 1.1 ‘Radiation protection measures in a radiation hazard situation’. In the protective zone, it is a key planning requirement that in the event of a severe accident the population must be alerted and any temporary evacuation effected safely and efficiently.

3.6.1 Implementation of Fennovoima emergency preparedness arrangements according to the application for a decision-in-principle and the EIA report

Fennovoima addressed the planning and implementation of emergency preparedness arrangements at the Fennovoima Nuclear Power Plant in supplement 4A (‘Nuclear power plant safety: Description of observed safety principles’) to the application for a decision-in-principle and in section 8.15.3 (‘Emergency preparedness and civil defense’) of the EIA report. These emphasize the cooperation of the power company and the authorities in preparing for accidents, in drawing up emergency response and rescue plans, and in testing the actions specified in the plans in practice in joint exercises. The EIA report also took into account the proximity of Gäddbergsö in Ruotsinpyhtää to Hästholmen in Loviisa, which must be allowed for in the emergency preparedness arrangements of both nuclear power plants and in the coordination of their operations.

It is the considered opinion of STUK that Fennovoima’s information on the implementation of emergency preparedness arrangements that are the licensee’s responsibility is sufficient for the processing of the application for a decision-in-principle. Fennovoima has engaged in negotiations concerning rescue planning for the local population with the local authorities. Fennovoima has also taken into account the proximity of Gäddbergsö in Ruotsinpyhtää to Hästholmen in Loviisa and allowed for the preparedness and coordination of functions that this would require in an emergency situation.

3.6.2 Statements by the rescue authorities

Hanhikivi in Pyhäjoki / Jokilaakso Rescue Department

The Jokilaakso Rescue Department had nothing to remark regarding the application for a decision-in-principle.

Gäddbergsö in Ruotsinpyhtää / Eastern-Uusimaa Fire and Rescue Services

The statement of the Eastern-Uusimaa Fire and Rescue Services includes the following points:

- If the nuclear power plant projects of Fennovoima Oy and Fortum Power and Heat Oy were both implemented, this would require coordinating the security and emergency preparedness arrangements of both power plants and the sharing of their risks between two actors.
- If the project progresses, the party undertaking the construction work would have to survey the quality and quantity of public services available. This is

necessary for resourcing in the operational and financial plans of the various authorities.
- The application for a construction license must include preliminary plans for security and emergency preparedness arrangements.

Karsikko in Simo / Regional Rescue Services of Lapland

The statement of the Regional Rescue Services of Lapland notes that the population of the protective zone proposed in the Kemi-Tornio draft regional land use plan for the nuclear power plant would be about 3,000. This exceeds the requirements of the STUK YVL Guide 1.10. The statement includes the following specifications for attaining the safety level specified in YVL Guide 1.10:

- The buildings in the fallout area and the sheltering function of various types of buildings can be taken into account when drawing up rescue plans and making evacuation decisions.
- Warning and evacuating the population is more difficult in a sparsely populated area. New technology applications featuring two-way systems are needed to augment traditional alarm systems particularly in the protective zone. This would enable efficient monitoring of whether the alarm has been received and whether an evacuation has been successfully effected.
- Rescue units could be employed to ensure that people in communities have heard the alarm and received protection instructions, and also to assist in voluntary evacuation.
- Evacuation planning must take into account those residents who cannot leave the fallout area by themselves. The planned access routes to the power plant site and the renovation of the E4 highway being completed will help make evacuation smoother.
- A successful rescue operation requires functioning communication as soon as a transient arises, which makes it easier to raise the preparedness level by degrees; the availability of the expertise of cooperating authorities and the partners participating in the rescue operation is also helpful. In case of a fire inside the nuclear power plant, cooperation with other sub-regions and the Regional Rescue Services of Oulu-Koillismaa is essential to ensure sufficient resources. Appropriate command center facilities are needed not only for the nuclear power plant itself but for municipal steering groups and the rescue authorities.
- If the project is implemented, at least one person must be assigned to review the resources of the rescue preparedness and their allocation during the construction permit stage and during operations.
- The permanent population in and near the protective zone must not substantially increase.
- If the project is implemented, it will require major investment in the training of authorities and partners and extensive public education and emergency preparedness coaching.

Ministry of the Interior

The statement of the Ministry of the Interior includes the following points:

- Close cooperation between the regional rescue authorities, the parties that would participate in a rescue operation, and the party implementing the project is important.
- The eventual impact of the project on rescue arrangements and possible added need for resources during the construction and operating stages must be assessed.
- The protection or evacuation of the population in case of an accident and the effects of this on transportation arrangements, for instance, must be taken into account in the project.
- Uniform emergency preparedness and safety criteria must be observed at all nuclear power plant sites, for instance in the determining of no-fly zones.

3.6.3 Summary of the potential for implementing emergency preparedness arrangements at the alternative sites

Hanhikivi in Pyhäjoki

Hanhikivi headland in Pyhäjoki is in a sparsely populated area. The protective zone, in a radius of 5 km from the proposed power plant site, has a permanent population of about 150. The nearest community is the village of Parhalahti (population about 400), which is about 4 km away. In the regional land use plan proposal for the nuclear power plant at Hanhikivi, this village is incorporated into the protective zone as a whole, meaning that the protective zone would have a permanent population of about 450 and also some 40 leisure homes.

There are no areas in the protective zone where it would be difficult to warn and eventually evacuate the population. Two access routes are planned for the Hanhikivi site.

The emergency planning zone, within a radius of about 20 km from the proposed nuclear power plant site, has a permanent population of about 11,300. This zone covers the central village of the municipality of Pyhäjoki and part of the town of Raahe. There are industrial facilities and a harbor 15 to 16 km from the proposed site. The authorities must draw up detailed rescue plans for public protection that cover the emergency planning zone. The authorities also bear the responsibility for the implementation of the rescue plans. It is the considered opinion of STUK that the preparedness arrangements required in the YVL Guide 1.10 can be implemented in the protective zone and the emergency planning zone, provided that the village of Parhalahti is included in the protective zone and that efficient warning and protection measures are planned and in place in case of an accident.

Gäddbergsö in Ruotsinpyhtää

The headland of Gäddbergsö in Ruotsinpyhtää is in a sparsely populated area, as is the whole of the protective zone extending about 5 km from the proposed site of the Nuclear Power Plant. The area has a permanent population of about 70 and hundreds of leisure homes, most of them on the mainland. The nearest densely populated area is the village of Valko, part of the town of Loviisa, about 9 km away.

The Loviisa nuclear power plant is about 3 km away from the proposed site. The proximity of the Loviisa nuclear power plant would not prevent the construction project from going ahead, but Fennovoima must take it into account in its preparedness arrangements at the construction license stage. Training, early warning and rapid evacuation of worksite personnel must be ensured in case of an accident occurring at the Loviisa nuclear power plant during construction.

Most of the permanent residents in the protective zone live along Saaristotie. Some of the residences are behind the proposed site with a view to the evacuation direction. In the archipelago and along the fragmented shoreline, warning and possibly evacuating the population is a considerable challenge and must be given particular attention. There is one access route to Gäddbergsö headland. Developing emergency response and rescue arrangements forms part of the licensee's cooperation with the authorities, and in the future emergency communication systems can be further developed through the potential of modern communications technology.

The emergency planning zone, within a radius of about 20 km from the proposed nuclear power plant site, has a permanent population of about 11,900. It includes the town of Loviisa and the central villages of the municipalities of Pyhtää and Ruotsinpyhtää. The industry in the area consists of small and medium-sized enterprises apart from the Loviisa power plant. The industrial facilities are located about 9 km and 14 km from the proposed site. Valko harbor is about 9 km away. The authorities have drawn up a detailed civil defense rescue plan in case of an accident at the Loviisa nuclear power plant. If the Fennovoima project is implemented, this plan must be augmented regarding Gäddbergsö in Ruotsinpyhtää, and functions must be coordinated by the licensees and the rescue authorities. It is the considered opinion of STUK that if this is done, the requirements of the YVL Guide 1.10 will be fulfilled in the protective zone and the emergency planning zone.

Karsikko in Simo

The Karsikkoniemi headland in Simo is in a sparsely populated area. There are only individual permanent residences there. The communities nearest to the proposed power plant site are the Hepola, Rytikari and Ajos districts of the town of Kemi and the village of Maksniemi in Simo. Hepola is the nearest of these, being about 4 km away from the proposed power plant site; the others are about 5 km away. STUK noted in its statement about the planning of land use that the impact of the protective zone must be taken into account in regional land use planning so that any communities falling partly within the protective zone must be incorporated fully into it. This has been noted in the Kemi-Tornio regional land use plan proposal for a nuclear power plant.

The area within 5 km of the proposed site has a permanent population of about 1,250 and some 160 leisure homes. If the protective zone were expanded to include the communities that fall partly within it (Maksniemi in Simo and Hepola in Kemi) or are between 5 km and 6 km away (Rytikari), the permanent population of the protective zone would be about 3,000. This exceeds the requirements of the STUK YVL Guide 1.10. The Regional Rescue Services of Lapland, in its statement referred to above in section 3.6.2, proposes adjustments to achieve compliance with the safety level required in the YVL Guide. These include using modern technology for early warning of the population and for evacuation monitoring; efficient planning and implementation of evacuation; restricting the number of permanent residents in the protective zone and its immediate vicinity; and efficient communications and liaison with the authorities and rescue service partners. There are also small areas in Laitakari and on the southeast shore of the headland that are behind the proposed power plant site with a view to the evacuation direction, and here particular attention needs to be paid to warning and eventually evacuating the population. Two access routes are planned for the Karsikkoniemi site. STUK is satisfied that the safety level required in the YVL Guide 1.10 can be attained in the protective zone if a comprehensive rescue plan is drawn up on the basis of the statement of the Regional Rescue Services of Lapland and if the licensee ensures that the population can be quickly warned and protective measures rapidly implemented in case of an accident. However, this would require special action from the rescue services and commitment to undertake that action to ensure successful implementation of protection measures.

The emergency planning zone, within a radius of about 20 km from the proposed nuclear power plant site, has a permanent population of about 32,000. This zone includes not only the aforementioned villages but also the town center of Kemi. The nearest busy harbors are 8 to 9 km away, and the nearest industrial facilities are 7 and 15 km away from the proposed site. Harbors and industrial facilities must also prepare for the eventuality of an accident at the nuclear power plant. The authorities must draw up detailed rescue plans for public protection that cover the emergency planning zone. The authorities also bear the responsibility for the implementation of the rescue plans.

STUK is satisfied that the safety level required in the YVL Guide 1.10 can be attained for the proposed site at Karsikko in Simo, provided that comprehensive rescue plans are drawn up for the protective zone and the emergency planning zone, and a commitment is made to executing them if the situation so demands.

4 SECURITY ARRANGEMENTS

4.1 Regulations on security arrangements

The Government Decree on Security in the Use of Nuclear Energy (734/2008) includes the following requirements on how security arrangements must be taken into account in the general design of a nuclear power plant:

Section 4. General planning of a nuclear facility

Structures, systems and components important to the safety of a nuclear facility as well as the sites of nuclear material and nuclear waste shall be designed to facilitate the effective implementation of security, taking into account the requirements for nuclear and radiation safety.

Security shall be based on the utilization of several security zones placed within each other so that systems and components important to safety, and nuclear material and nuclear waste, are afforded particular protection and access control and the control of goods traffic can be arranged.

The interfaces of security zones will form efficient structural obstacles to unlawful action.

The STUK YVL Guide 1.10 'Requirements for siting a nuclear power plant' includes the following detailed requirements for the power plant site that have a bearing on the implementation of security arrangements:

A nuclear power plant site [referred to as the 'site area' in the Government Decree 735/2008] *extends to about a kilometer's distance from the facility. ... The licensee responsible for the operation of the nuclear power plant shall have authority of decision over all activities in the area and shall be able to remove unauthorized individuals from the site, if necessary, or prevent such individuals from entering it. The plant site may contain other non-facility related activities provided that they do not pose a threat to plant safety. A traffic lane may traverse the site if the volume of traffic is small and if traffic can be directed elsewhere, if necessary. Visits onsite are allowed provided that the licensee has the possibility to control the movement of visitors.* [YVL Guide 1.10, chapter 2]

'Security arrangements' refers to action taken to guard the use of nuclear energy against illegal activities at the nuclear facility or in its grounds, or in any other facility or transportation involved in using nuclear energy. The following requirements for security arrangements are given in section 7 l of the Nuclear Energy Act:

- Arrangements for security during the use of nuclear energy shall be based on threat scenarios involved, and analyses of the need for protection.

- A nuclear facility shall have security personnel trained for the planning and implementation of arrangements for security (*security organization*). Security personnel shall also be employed for securing the transportation and storage of nuclear material and nuclear waste.
- The tasks and qualification requirements of the security organization and security personnel shall be defined, and they shall have monitoring equipment, communication equipment, protective equipment and forcible means equipment available as required for their tasks.
- This forcible means equipment shall be proportioned to the threat scenarios and protection needs involved, so that it is suitable for the purpose.
- Measures belonging to the regular security control of a nuclear facility shall be appropriately communicated to the employees of the nuclear facility and other people transacting business within the nuclear facility site.

Under the Government Decree on the Security in the Use of Nuclear Energy (734/2008), security arrangements include control of vehicles, persons, objects and materials as well as goods transport equipment in order to ensure that no dangerous objects are brought onto the nuclear facility site. Movement in the nuclear facility site shall be restricted and supervised so that effective account is taken of security and safety aspects. In particular, the licensee shall ensure that nuclear material, nuclear waste, radioactive materials or confidential information materials cannot be removed from the nuclear facility without the appropriate authorization.

4.2 Potential for implementing security arrangements at the proposed Nuclear Power Plant

Fennovoima notes in its application for a decision-in-principle that planning and action for the event of emergency situations are being prepared in cooperation with security authorities. Precautions against any unlawful actions will be taken using various structural and organizational safety arrangements. A crash by a large passenger aircraft is allowed for in the design of the plant's safety-critical buildings as a factor impacting the plant's size. Fennovoima also notes that it can draw on the security arrangement expertise of the German E.ON power company.

STUK is satisfied that there are no features in the alternative sites or in the design of the power plant unit alternatives that would constitute an obstacle to implementing the security arrangements that are the responsibility of the licensee.

A preliminary security plan will be submitted to STUK for the processing of the eventual construction license application, and the final plan in connection with the eventual operating license application. In drawing up the security plan, the sufficiency of the resources of the local police and organizations providing official assistance must be assessed.

The police stations nearest to the alternative sites are:

Hanhikivi in Pyhäjoki	Raahe	distance by road	25 km
Gäddbergsö in Ruotsinpyhtää	Loviisa	distance by road	20 km
Karsikko in Simo	Kemi	distance by road	17 km

Changes in the general operating environment and in local circumstances may change the requirements for security arrangements at nuclear power plants and the threat scenarios underlying them. Security arrangements will be constantly evaluated and developed while the plant is in operation. A thorough assessment will be undertaken in connection with the construction license and operating license applications, and at least once every ten years during operations, in connection with the renewal of the operating license and periodical safety evaluations.

STUK is satisfied that Fennovoima has the potential to implement the security arrangements that are the responsibility of the licensee for a new nuclear power plant and related other nuclear facilities as detailed in the application for a decision-in-principle at any of the alternative sites as required by regulations.

The nuclear power plant security arrangements will be implemented in cooperation with local and national police and security authorities. It is essential for successful implementation that the police and the assisting authorities have sufficient resources available for quick and efficient response close to the power plant site.

5 SAFETY FACTORS RELATED TO SITE

The Government Decree on the Safety of Nuclear Power Plants (733/2008) specifies the following regarding the site of a nuclear power plant:

Section 17. Protection against external events

The design of a nuclear power plant shall take account of external events that may challenge safety functions. Systems, structures and components are to be designed, located and protected so that the impacts of external events on plant safety remain minor. External events to be accounted for include at least exceptional weather conditions, seismic events and other factors resulting from the environment or human activity. Design must also take account of illegal activities undertaken to damage the plant, and a large airliner crash.

More detailed requirements are given in the following STUK guidelines:

- YVL 1.10 Requirements for siting a nuclear power plant
- YVL 1.0 Safety criteria for design of nuclear power plants
- YVL 2.6 Seismic events and nuclear power plants
- YVL 2.8 Probabilistic safety analysis in safety management of nuclear power plants

5.1 Geology and seismology

Fennovoima has commissioned geological and soil surveys of the alternative sites from the Geological Survey of Finland and consultant companies in the field. The purpose of the soil surveys was to study the properties of the soil and the depth of the bedrock. Findings from the topographical and magnetic studies of the bedrock were presented in the application for a decision-in-principle. In August and September 2009, as the application was being processed, Fennovoima submitted to STUK findings from drilling studies and seismic surveys of the bedrock at the alternative sites.

In Finland, the buildings central to the safety of a nuclear power plant must be built on the bedrock. Soil surveys are used to ascertain that the bedrock is sufficiently near the surface that it can be used to build foundations. Geological studies are employed to study rock fracturing and hydraulic conductivity, which are relevant in assessing the suitability of the site for final disposal of low and medium level reactor waste in the bedrock.

A groundwater survey and mineral resources survey have also been conducted for each site. There are no known exploitable mineral deposits in the areas concerned, and according to the Geological Survey of Finland it is unlikely that such deposits might be discovered. The nearest regionally significant groundwater areas are a few kilometers away from the proposed plant site at each site, and the project would pose no threat to them.

The STUK YVL Guide 2.6 gives requirements regarding the taking into account of earthquakes in the design of a nuclear power plant. A ‘design basis earthquake’ is so defined that, in the current geological circumstances, stronger earthquakes are anticipated not more often than once in a hundred thousand years on median level. The design basis earthquake is defined using peak ground acceleration (PGA) and a seismic ground response spectrum incorporating various vibration frequencies. The minimum value of the horizontal component of PGA shall be 0.1 g, or greater if site-specific studies so require (g = 9.81 m/s2 is normal gravity). As per the YVL Guide 2.6, the vertical component of PGA is calculated as 2/3 of the horizontal component. The appendix to YVL 2.6 shows a ground response spectrum for southern Finland (south of the 63rd parallel). The shape of the ground response spectrum (and the maximum acceleration for the Olkiluoto area) was approved when the project for Finland’s fifth nuclear power plant unit was being prepared in 2001.

Fennovoima commissioned a study from the Institute of Seismology at the University of Helsinki to determine the design basis earthquake for each of the alternative sites. So far, the maximum acceleration equivalent to a design basis earthquake has been determined.

There are plans to revise the YVL Guide 2.6 in the near future. For this purpose, STUK has commissioned a study reviewing the results for southern Finland and extending the survey to northern Finland. The study authors are ÅF-Consult Oy and the Institute of

Seismology. ÅF-Consult has the software required to calculate a design basis earthquake. The Institute of Seismology has the best expertise about Finland's seismological properties, and also records of all earthquakes occurring in Finland. In Finland, a design basis earthquake is only determined for nuclear power plants and other significant nuclear facilities, no other buildings or systems.

5.1.1 Hanhikivi in Pyhäjoki

The Hanhikivi area is very low. At the proposed nuclear power plant site, the ground is on average only +1.5 m above sea level (N60 system). Soil surveys have been conducted at 80 points at the Hanhikivi site. The bedrock level is mainly between +1 and –3 m. At one of the survey points, the bedrock is some 14 m below ground level, but this point would not be under the reactor. There is some exposed bedrock at the site; generally the rock is covered by layers of loose moraine.

Because the headland is so low in elevation, significant earthmoving will have to be undertaken to raise the general elevation of the site (see section 5.2, Sea level). Fennovoima estimates the earthmoving required to involve about one million cubic meters. The shores in the area are flat and shallow. Fennovoima estimates that the water table varies between –0.5 m and +1.5 m relative to sea level.

The bedrock at the Hanhikivi site is conglomerate about 1,900 million years old and suitable in its properties for the construction of a nuclear power plant.

Preliminary studies suggest that the Hanhikivenniemi headland is a uniform section of bedrock, with little or no fracturing. The fine-grained rock type in the area, smooth apertures and other geological properties relevant for construction will be taken into account in the design and building technology solutions of the reactor waste final repository.

In summer 2009, Fennovoima commissioned Pohjatekniikka Oy to undertake rock surveys involving two boreholes, two drilled holes, tension measurements and seismic soundings. The preliminary summary report for the rock studies notes that the fracture density in the bedrock in the area is variable but mainly low or moderate. No broad fault zones were found in the drill sampling, though minor fracture zones and individual fractures with high water conductivity were found. The bedrock properties found in these studies can be taken into account in the geotechnical design. The rock studies at Hanhikivi revealed no disadvantageous properties that would have a bearing on the construction of the power plant or of the reactor waste repository.

Hanhikivenniemi is located in the inner part of the continent on the Fennoscandia shield, where the average seismicity level is low. According to a report produced by the Institute of Seismology for Fennovoima, the value of the horizontal component of PGA in a design basis earthquake (stronger earthquakes anticipated not more often than once in a hundred thousand years) as referred to in the YVL Guide 2.6 is 0.12 g. According to a report commissioned by STUK from ÅF-Consult, the horizontal component of PGA in Pyhäjoki is 0.085 g. The difference in results is due to the ÅF-

Consult report being more specific about the geographical distribution of earthquakes than the report commissioned by Fennovoima. The aforementioned acceleration values are low and can easily be accounted for in the design of the power plant.

STUK is satisfied that sufficient geological and seismological studies have been conducted at Hanhikivi in Pyhäjoki for the new nuclear power plant to enable processing of the application for a decision-in-principle. No disadvantageous geological or seismological features have emerged in the report that would prevent the construction at Hanhikivi of the nuclear facilities specified in the application for a decision-in-principle.

5.1.2 Gäddbergsö in Ruotsinpyhtää

The Gäddbergsö headland is characterized by steep cliffs. The terrain is rocky with boulders and also stretches of exposed bedrock. The elevation of the rock surface varies between 0 m and +18 m; near the proposed site, the highest point of the rock rises to +35 m. Soil surveys have been conducted at 34 points at the site. Depressions contain layers of clay and moraine 3 m to 10 m in thickness. The soil surveys also revealed that the water table varied between +4.5 m and +11.7 m.

The bedrock at the Gäddbergsö site is rapakivi granite about 1,650 years old and suitable in its properties for the construction of a nuclear power plant. Rapakivi granite typically has orthogonal fracturing and horizontal faults.

It is known on the basis of site studies for other nuclear facilities that rapakivi granite areas are known to feature local kaolinization, which may have a bearing on the strength of the bedrock. This must be taken into account for instance in the design of the sea water tunnels and the reactor waste repository.

The elevated bedrock areas in the north part of Gäddbergsö are uniform zones of rock separated by fault zones. On averaging, rock fracturing is moderate on Gäddbergsö. In its application for a decision-in-principle, Fennovoima notes that the horizontal faults and other geological properties relevant for construction will be taken into account in the design and building technology solutions of the reactor waste final repository.

In summer 2009, Fennovoima commissioned Pohjatekniikka Oy to undertake rock surveys involving two boreholes, two drilled holes, tension measurements and seismic soundings. The preliminary summary report for the rock studies notes that the fracture density in the bedrock in the area is low or moderate. One or two fault zones were identified in the area. The rock studies at Gäddbergsö revealed no disadvantageous properties that would have a bearing on the construction of the power plant or of the reactor waste repository.

Fennovoima states that the preliminary ground level at all alternative sites has been set at +4.0 m, but at Gäddbergsö a considerably higher level could be selected, because the terrain is higher in elevation by its nature.

Gäddbergsö is located in the inner part of the continent on the Fennoscandia shield, where the average seismicity level is low. According to a report produced by the Institute of Seismology for Fennovoima, the value of the horizontal component of PGA in a design basis earthquake (stronger earthquakes anticipated not more often than once in a hundred thousand years) as referred to in the YVL Guide 2.6 is 0.12 g. The report submitted by Fennovoima cites slightly larger acceleration values than in earlier seismic studies on southern Finland. This is because in the current report the source area is the whole of southern Finland, i.e. it is assumed that the incidence of earthquakes is the same in the whole of southern Finland. Because the source area is so large, local seismic features are rendered irrelevant. The aforementioned acceleration value is low and can easily be accounted for in the design of the power plant.

STUK is satisfied that sufficient geological and seismological studies have been conducted at Gäddbergsö in Ruotsinpyhtää for the new nuclear power plant to enable processing of the application for a decision-in-principle. No disadvantageous geological or seismological features have emerged in the report that would prevent the construction at Gäddbergsö of the nuclear facilities specified in the application for a decision-in-principle.

5.1.3 Karsikko in Simo

The Karsikko area in Simo consists of moraine terrain. The area is partly eutrophic, and there is relatively little exposed bedrock. The ground level varies between 0 m and +8 m. The shores in the area are flat and shallow. Soil surveys have been conducted at 55 points in the area, yielding an overview of its geological properties. The rock surface seems relatively smooth-featured, and the bedrock is between 2 m and 7 m below the surface. A number of observations were made during the soil surveys regarding the water table, which varied between +0.4 m and +6 m.

The preliminary reports note that the bedrock in the Karsikko area is granite-gneiss about 2,500 million years old, with a solid structural load-bearing capacity. The Karsikonniemi headland is monolithic. The fracture clustering in the bedrock and other geological properties relevant for construction will be taken into account in the design and building technology solutions of the reactor waste final repository.

In summer 2009, Fennovoima commissioned Pohjatekniikka Oy to undertake rock surveys involving two boreholes, two drilled holes, tension measurements and seismic soundings. The results show that fracturing is considerable at some points in the bedrock, and there are fault zones. The conclusion of the preliminary rock studies summary report is that Karsikko is a possible site for building a nuclear power plant. However, because of the weaknesses caused by fracture clustering and because of non-homogeneous fracturing, the placement of each building and the reactor waste repository must be carefully considered. The summary also notes that modern strengthening technology can ensure safe construction even on bedrock of variable quality. The applicant must present a detailed description at the construction license application stage of how these properties of the bedrock will be taken into account in the design process.

Karsikko is located in the inner part of the continent on the Fennoscandia shield, where the average seismicity level is low. According to a report commissioned by Fennovoima from the Institute of Seismology, the horizontal component of PGA as per the YVL Guide 2.6 is 0.23 g in Simo. Fennovoima has provisionally announced that it will be using the value 0.23 g as the horizontal component of PGA at all alternative sites, even though the values obtained for Pyhäjoki and Ruotsinpyhtää were substantially lower.

According to a report commissioned by STUK from ÅF-Consult, the horizontal component of PGA in Simo is 0.26 g. The difference between this and the value of 0.23 g in the Fennovoima report is negligible, considering the uncertainty involved in earthquake data.

The STUK report also shows the ground response spectrum reflecting the frequency distribution of vibrations. This shows that the spectrum peaks at about 25 Hz in Simo; this is a clearly higher frequency than in southern Finland, where the peak is at about 10 Hz. The difference in the range below 10 Hz, which is the most relevant for buildings and heavy mechanical equipment, is not as great as the difference between the horizontal components of PGA. However, high frequencies may have a bearing on the design of electronic devices, for instance. Fennovoima will submit a proposal for the ground response spectrum to be used in construction for approval to STUK in connection with the construction license application at the latest.

The estimated design basis earthquake is clearly stronger in Simo than at any other Fennovoima alternative site or the sites of existing nuclear power plants in Finland. The horizontal component of PGA in Simo is similar to design values in central Europe or the eastern parts of the USA. There is thus no seismic objection to building a nuclear power plant at Karsikko in Simo fully in compliance with safety requirements. However, seismic design is of greater importance to overall safety in Simo than at the other alternative sites.

If Karsikko in Simo is selected as the site of the Nuclear Power Plant, Fennovoima must pay particular attention to obtaining sufficient expertise for seismic design and seismic qualification methods. It is characteristic of seismic loads that they affect all equipment in a plant simultaneously and must thus be taken comprehensively into account in the design of the plant. STUK and its technical support organizations should also estimate their needs to improve their expertise in this area for instance within the framework of a national nuclear safety program.

STUK is satisfied that sufficient geological and seismological studies have been conducted at Karsikko in Simo for the new nuclear power plant to enable processing of the application for a decision-in-principle. Geological and seismological features have emerged that require attention in the design of the plant but would not prevent the construction at Karsikko of the nuclear facilities specified in the application for a decision-in-principle .

5.2 Sea level

Exceptional variation in sea level is allowed for in the design of the new nuclear power plant unit. The design values are influenced by variation above and below mean sea level and long-term changes in mean sea level.

Sea level variation has been measured at measuring stations of the Finnish Institute of Marine Research near the alternative sites for several decades.

The nearest measuring point to Pyhäjoki is in Raahe, where measurements were begun in 1922. The highest and lowest sea levels relative to mean sea level measured in Raahe are +1.62 m (1984) and –1.29 m (1936), respectively. In the N60 system, which is geodetically determined, these values correspond to +1.33 m and –1.58 m in 2009.

The nearest measuring point to Ruotsinpyhtää is Hamina, where measurements were begun in 1928. The highest and lowest sea levels relative to mean sea level measured in Hamina are +1.97 m (2005) and –1.10 m (1928), respectively. In the N60 system, which is geodetically determined, these values correspond to +1.95 m and –1.12 m in 2009.

The nearest measuring point to Simo is in Kemi, where measurements were begun in 1922. The highest and lowest sea levels relative to mean sea level measured in Kemi are +2.01 m (1982) and –1.25 m (1923), respectively. In the N60 system, which is geodetically determined, these values correspond to +1.76 m and –1.50 m in 2009.

For the purpose of appraising flooding risks, measurements relative to the mean sea level are representative. Because the elevations of the construction sites are given in the N60 system, it is necessary to convert the historical extreme values to the N60 system. In a reference report related to the application for a decision-in-principle, Fennovoima presented estimates based on the report of the Finnish Institute of Maritime Research of maximum and minimum sea levels occurring once in a million years with 50% reliability, together with their uncertainty ranges, in the N60 system calibrated for the year 2075: Pyhäjoki maximum +2.80 m (+2.60 m to +3.30 m) and minimum –3.20 m (–3.40 m to –2.70 m), Ruotsinpyhtää maximum +3.20 m (+2.90 m to +3.60 m) and minimum –1.80 m (–2.00 m to –1.40 m), Simo maximum +3.50 m (+3.30 m to +4.00 m) and minimum –3.00 m (–3.20 m to –2.50 m).

Fennovoima is using an elevation of +4.0 m in the N60 system (ground level plus threshold height) as its baseline for all alternative sites for the time being. The basis for this is the maximum sea level estimated to occur once in a million years at 50% reliability in Simo (+3.5 m) plus an additional 0.5 m to allow for wave height.

The low sea level design value used is –2.4 m, the frequency of which is about once in a thousand years. An exceptionally low sea level could impair the intake of cooling water, but such situations typically last less than 24 hours. The plant design will allow for the complete loss of sea water coolant for at least three days. Low sea level is not as safety-critical as high sea level, which could cause flooding of the plant facilities and equipment malfunctions requiring extensive repairs.

In the long term, sea level will be affected by land uplift, long-term changes in wind conditions in the North Atlantic, and the global rising of sea levels due to thermal expansion of water and the melting of sea ice caused by global warming.

The change in sea level caused by climate change by 2100 has been estimated for instance in the reports of the UN Intergovernmental Panel on Climate Change (IPCC). The most likely scenario puts the sea level rise at about 0.30 m and the worst case scenario at about 0.59 m by 2100. In Finland, we need to take into account not only the sea level rise but also land uplift. In the scenarios presented by the IPCC, the sea level would actually continue to drop in relative terms in Simo and Pyhäjoki because of land uplift, and in Ruotsinpyhtää the relative increase in sea level would be negligible.

The Finnish Institute of Marine Research (which has since been merged into the Finnish Meteorological Institute) also explored other internationally published estimates of sea level change within the Finnish Research Program on Nuclear Power Plant Safety (SAFIR2010). Some scientific reports present values higher than those of the IPCC. However, the IPCC experts have not considered these extreme values credible. The most pessimistic estimate has the sea level in the oceans rising by about +2.0 m by 2100.

The Finnish Institute of Marine Research estimates that in this century, taking land uplift into account, the mean sea level in the Loviisa-Ruotsinpyhtää area will rise by about 0.2 m. The uncertainty for this estimate (at reliabilities of 1% / 99%) range from a drop of –0.2 m to a rise of +1.5 m. In Simo and Pyhäjoki, the rise would be slighter.

The reports indicate that it is probable that the rise of the sea level in the oceans will continue to be slower than the land uplift on the coast of the Gulf of Bothnia. Therefore, the maximum design value for sea level in Simo and Pyhäjoki should be determined by the range of variation at the beginning of the service life of the power plant. The difference between this and the data presented by Fennovoima is no more than about 0.5 m. The preliminary construction baseline elevation of +4.0 m proposed by Fennovoima includes a smaller margin than for instance in the +3.5 m (N60) employed at the Olkiluoto power plant, because the variation in sea level around Simo and Ruotsinpyhtää is clearly greater than around Rauma. The current Fennovoima data on sea level design values may require some reviewing for the final design process. STUK is satisfied that such reviewing will have no impact on the acceptability of the chosen site.

The estimated variation in sea level and the necessary safety margins can be taken into account in the design of the new power plant unit. The extreme sea level values used as input values in the design will be determined before submitting the construction license application, on the basis of the best available knowledge.

5.3 Packed ice

Packed ice is a formation of sheets of drift ice piled up by the wind. Packed ice appears nearly everywhere in Finland’s sea areas, but particularly in the Gulf of Bothnia and its northernmost reach, the Bay of Bothnia. Packed ice can reach a few meters above the water while extending considerably further down below.

Packed ice could theoretically damage the water intake structures of a nuclear power plant and endanger coolant availability. Packed ice should be taken into account particularly at the sites in Simo and Pyhäjoki.

Fennovoima has requested STUK to carry out a survey preliminarily inspecting the strain caused by packed ice on the cooling water structures as well as the possible measures in the structural design to prepare for packed ice. The strain caused by packed ice on the cooling water intake and discharge structures needs to be taken into account in the design of the plant to ensure the cooling of the plant in extreme ice conditions.

Packed ice is always taken into account in ordinary marine construction in Arctic areas. STUK is satisfied that there is nothing to prevent taking packed ice into account in designing a nuclear power plant.

5.4 Other factors affecting the availability of sea water

The turbine condenser of the proposed Nuclear Power Plant would use sea water for cooling, just like in all the other units existing and under construction in Finland. There are no known obstacles to implementing the sea water intake and discharge arrangements as presented in the application for a decision-in-principle. Fennovoima will commission the detailed geological surveys required for the excavation of the sea water tunnels in connection with preparing the eventual construction license application. The effects of the heated coolant discharged into the sea have been studied in the EIA report.

Some of the units operating in Finland have experienced sudden formation of pipe ice, hindering the sea water intake. Because of this, a system has been added in these units to return heated coolant to the sea water intake system, and instructions for dealing with hazards caused by pipe ice have been improved. Pipe ice will be allowed for in the design of the Fennovoima Nuclear Power Plant from the first.

Some of the units operating in Finland have experienced disruptions in the sea water intake because of algae and shellfish. In the Fennovoima Nuclear Power Plant, the aim will be to prevent such blockages with design solutions. More generally, the plant will be designed so as to be able to sustain an extended loss of sea water coolant.

5.5 Weather phenomena

Fennovoima has submitted to STUK estimates prepared by the Finnish Meteorological Institute regarding extreme weather phenomena at the alternative sites. The possible effects of climate change on local conditions are being studied in the Finnish Research Program on Nuclear Power Plant Safety (SAFIR2010). The probable extremes in weather phenomena at the plant site will be taken into account in the design of the new Nuclear Power Plant.

The weather phenomena that must be considered when designing a nuclear power plant include high winds (also tornadoes), extremely high or low outside temperatures, lightning, rain, snow, frost and ice formation.

Of the alternative sites proposed by Fennovoima, Simo and Pyhäjoki are substantially further to the north than Finland’s existing nuclear power plants. Even worldwide, there is only one nuclear power plant that lies further north – the one on the Kola Peninsula in Russia. The most significant difference between Simo and Pyhäjoki on the one hand and Finland’s existing nuclear power plants on the other is that the minimum outdoor temperature is much lower there. STUK is satisfied that the extreme low temperatures that may be considered possible in northern Finland can be taken into account in the design of the plant. As far as STUK knows, however, the potential plant suppliers of Fennovoima have no experience of building a nuclear power plant in such temperature conditions. Therefore Fennovoima, and also STUK as the supervising authority, must pay special attention to how local weather conditions are taken into account in plant design.

5.6 Raw fresh water intake

The processes in a nuclear power plant require substantial quantities of purified fresh water. In some plant types, large quantities of purified process water are required in cases of disruption in the sea water cooling system and for the management of certain accident scenarios. A nuclear power plant must have facilities for the pumping, storage, purification and desalination of raw fresh water. Fennovoima has explored alternative ways of obtaining raw water at each alternative site and described these in the environmental impact assessment report. The reports on raw water sourcing are sufficient for the processing of the application for a decision-in-principle.

5.7 Threats at the site arising from normal human activity

Threats arising from normal human activity that could pose a danger to a nuclear power plant include major oil spills at sea, releases of toxic and combustible gases in transportation, in storage or at an industrial facility, and explosions.

In the case of a major leakage of hazardous material, the isolation area typically extends a few hundred meters from the site of the leak, but in worst cases about 2 km away.

Production and storage facilities that handle hazardous chemicals and explosives must be located so that in case of an accident they do not pose a danger to people, the environment or property. To ensure this, such facilities are inspected under what is known as the Seveso Directive (96/82/EC). Such facilities are surrounded by a consultation zone; for any planning changes in this zone, a statement must be obtained from the Safety Technology Authority (TUKES) and the local rescue services. TUKES maintains a list of facilities to which the Seveso Directive applies and how wide their consultation zones are.

The documentation submitted by Fennovoima and studies undertaken by STUK investigate the transportation, storage and use of hazardous materials in the emergency planning zones of the alternative sites, i.e. within about 20 km of the plant sites.

At Karsikko in Simo, the sites investigated are the harbor of Ajos and the adjoining oil terminal (about 8 km away), the Veitsiluoto paper mill and harbor (6 km), the Ajos deep-water shipping channel (7 km at its nearest point), the Veitsiluoto shipping channel (1 km at its nearest point), the railway line between Kemi and Oulu (6 km) and highway 4 (5 km).

The Seveso Directive facilities closest to the alternative site at Karsikko in Simo are the storage facilities of Neste Oil Oyj and Baltic Tank Oy at Ajos and the production facilities of Metsä-Botnia Oy and Stora-Enso Oyj at Veitsiluoto. At all these facilities, the consultation zone extends 1.5 km beyond the site boundary, which is a short distance compared to the distance to the proposed power plant site at Karsikko.

On June 18, 2009, Fennovoima submitted a report to STUK concerning hazardous material transportations in the vicinity of the alternative sites and an estimate of the potential threat posed by such transportations to the proposed Nuclear Power Plant. The report did not identify any such hazardous material transportations or storage facilities that could constitute a potential threat to the proposed Nuclear Power Plant.

Hazardous materials are transported via the harbor at Ajos, such as hydrogen fluoride to the steel mill in Tornio. However, the harbor and transportation routes are so far from Karsikko that even a serious transportation accident would not pose a threat to the Nuclear Power Plant at the proposed site.

Hanhikivi in Pyhäjoki and Gäddbergsö in Ruotsinpyhtää are much farther away from hazardous material transportation routes and storage facilities than Karsikko in Simo. Also, the volumes of such transportation and storage are much lower than in Simo. For Gäddbergsö, it should be noted that it is located farther away from the transportation routes and storage facilities of the harbor of Loviisa than the existing Loviisa nuclear power plant.

The Seveso Directive facilities nearest to the proposed site at Hanhikivi in Pyhäjoki are the production facilities of Rautaruukki Oyj and Air Liquide Finland Oy in Raahe. Their consultation areas are 1.5 km and 1 km, respectively, and the distance to Hanhikivi is far greater (15 km).

The Seveso Directive facilities nearest to the proposed site at Gäddbergsö in Ruotsinpyhtää are the proposed West Tank Oy storage facility in Valko harbor, about 8 km from Gäddbergsö with a protective zone of 1.5 km, and the Loviisa nuclear power plant, about 2.5 km away with a protective zone of 1 km.

In summary, there are no hazardous material transportations or storage facilities, and no industrial facilities using or producing hazardous materials, near any of the alternative sites of the Fennovoima Nuclear Power Plant that could pose a threat to the power plant site. As regards explosions and combustible gases, it should also be noted that the Nuclear Power Plant will be designed to withstand a crash by a large passenger aircraft and the possibly resulting violent fuel fire. The design of the ventilation system of the control room of the Nuclear Power Plant will take into account the possible presence of toxic gases in the outdoor air.

West Tank Oy is planning an oil storage facility to be built at Valko harbor in Loviisa for storing gasoline and light fuel oil or diesel oil. The impact of this facility on the safety of the Loviisa nuclear power plant has been assessed in connection with the monitoring of the existing power plant units. In the event of a transportation accident, the light oil products that might be released into the sea would not endanger the safety of the proposed nuclear power plant at Gäddbergsö. Even in the event of a fire at the storage facility, the smoke gases generated would not pose a risk to the power plant because of the distance.
The main shipping channel in the Gulf of Finland, where numerous large oil tankers travel, runs about 30 km off the shore from Gäddbergsö. In case of a major oil spill at sea, it is possible that oil would be conveyed to the water intake area of the proposed nuclear power plant site at Gäddbergsö. If oil were to enter a sea water coolant system, it could decrease the efficiency of the cooling or in the worst case clog up cooling systems. Because of this, the nearby Loviisa nuclear power station has agreed on oil hazard notification procedures with the Finnish Environment Institute, which coordinates oil spill response activities, and has prepared for cleanup action in its current water intake areas. Similar arrangements can be put in place at the proposed new Nuclear Power Plant.

Under existing regulations, a new nuclear power plant unit must be designed so as to sustain the loss of sea water cooling for a period of at least three days. Blockages caused by algae, pipe ice or general rubbish can typically be cleared in a matter of hours. In the case of a major oil spill at sea, it is in principle possible that oil remains in the sea water intake area for a longer period of time. STUK understands that there are still uncertainties involved in understanding the behavior of crude oil in sea water and how successful oil spill response activities are. Therefore it should be assessed when designing the Nuclear Power Plant potentially to be built on the Gäddbergsö headland whether provision should be made for the loss of sea water cooling for a period of more than three days. STUK understands that it is possible to achieve this reliably through various technological arrangements. Detailed design principles will be presented together with the construction license application.

5.8 Air traffic

The feasibility study of the alternative sites includes a study of air traffic and airports in the vicinity. Fennovoima submitted to STUK a report prepared by VTT on the likelihood of an accident caused by an aircraft crash for all of the alternative sites.

Under section 8 of the Aviation Act (1242/2005), a no-fly zone may be defined around a nuclear power plant. No-fly zones are enacted on a case-by-case basis by Government decree. However, the law does not state that there must be a no-fly zone around every nuclear power plant. The law also does not stipulate how large the no-fly zone should be if there is one. The existing nuclear power plants at Loviisa and Olkiluoto have no-fly zones with a radius of 4 km and an altitude of 2,000 m, provided for in section 3 of Government Decree 929/2006.

The airports closest to Hanhikivi in Pyhäjoki are the Raahe general aviation airfield about 30 km away and the Oulunsalo commercial airport 70 km away. At Gäddbergsö in Ruotsinpyhtää, the nearest significant airport is Helsinki-Vantaa Airport, some 80 km away. If a nuclear power plant were built at either of these sites, it would not have any effect on the operations of the airport, nor would air traffic cause any safety concerns at these sites. It is entirely possible to enact a no-fly zone at Hanhikivi or Gäddbergsö similar to that of the existing nuclear power plants. In fact, the proposed power plant site at Gäddbergsö is located within the existing no-fly zone of the Loviisa nuclear power plant.

The purpose of the no-fly zone is to prevent disruptions caused by light aircraft and to reduce the risk of crashes. Obviously the no-fly zone is of no effect in preventing a terrorist attack.

At Karsikko in Simo, by contrast, the nearest airport is the Kemi-Tornio commercial airport about 16 km away. The preliminary placement of the reactor building puts it about 7 km to one side of the airport's takeoff/approach path. Fennovoima has submitted to STUK for information an estimate prepared by Finavia concerning the number of aircraft that would potentially fly over the proposed power plant site at Karsikko in Simo. According to information received from Finavia, aircraft taking off from or landing at Kemi-Tornio airport do not normally fly over the proposed power plant site, but occasionally do.

Finavia, the body that operates Finnish airports, has returned a statement to the Ministry of Employment and the Economy concerning the Fennovoima Nuclear Power Plant project, stating: *"From the point of view of Kemi-Tornio airport, the largest possible no-fly zone would be a cylindrical area centered at 65°38'18"N 24°41'40"E (WGS-84), with a radius of 2 km and a ceiling of 300 m MSL. This would place the no-fly zone outside the Kemi control zone and below the terminal control area; it would thus have no effect on air traffic services and would cause no significant restrictions to air traffic. However, even a slight shift to the north of the proposed site would require a reduction in the dimensions of the no-fly zone. The proposed site could also not be* *shifted substantially to the west. There is no problem with a shift to the east or the south."*

It should be taken into account when considering the need for a no-fly zone that new nuclear power plants must in any case be designed to withstand a direct impact by a large passenger aircraft without significant release of radioactive materials into the environment. Compliance with this requirement in the various power plant unit alternatives is discussed in Supplement 1 to this preliminary safety assessment. Notwithstanding the above, a crash by a large passenger aircraft could cause substantial damage to the plant and must be ruled out as far as possible; thus, passenger aircraft should fly over the plant site as infrequently as possible. Discussions with the Finnish Civil Aviation Authority and Finavia have indicated that passenger aircraft take off and land at Kemi-Tornio airport in controlled airspace. STUK understands that the flying of passenger aircraft over the power plant can be restricted by air traffic control, and the airport's approach patterns can be modified accordingly.

A crash by a light aircraft would cause little damage to a nuclear power plant designed in compliance with current requirements. STUK does not consider light aircraft flying over the plant site to be a significant safety factor. If necessary, for instance in case of an accident, a temporary no-fly zone can always be imposed.

STUK is satisfied that air traffic does not constitute an obstacle to the construction of the Nuclear Power Plant at any of the alternative sites examined. In the case of Karsikko in Simo, a closer assessment of the number of flights that would pass over the proposed power plant site and, if necessary, their restriction, require cooperation with the Finnish Civil Aviation Authority and Finavia. The number of flights passing over the power plant site is affected for instance by the development of the method used for the approach to Kemi-Tornio airport.

6 SUMMARY

The studies conducted for the proposed sites of the new nuclear power plant unit described in the Fennovoima application for a decision-in-principle regarding the population, land use, planning, local conditions and their effect on the security, safety and emergency preparedness arrangements of the proposed Nuclear Power Plant are sufficient for the processing of the application.

Some of the design values referred to in the application, such as the maximum sea level and the PGA in earthquake design, may require further specification for the final design process.

The alternative site in Karsikko in Simo involves characteristics that must be paid special attention in the design of the plant, in emergency preparedness and rescue planning, and in cooperation between the applicant and the authorities. A special feature at Gäddbergsö in Ruotsinpyhtää is the proximity of oil transportations in the Gulf of Finland and the related risk of a major oil spill. The design of a new nuclear power plant unit must reliably provide for an extended loss of sea water cooling due to a large amount of oil in the sea.

It is the considered opinion of STUK that there are no features at any of the proposed alternative sites that would constitute an obstacle to the construction of a new nuclear power plant and related facilities, as referred to in the application for a decision-in-principle, in compliance with the safety requirements, or to the implementation of the required security and emergency preparedness arrangements.