



The landscape aspects are taken into account when designing the power plant. A field in summer in Ruotsinpyhtää, 2008.

Emissions of radioactive materials during operation of the nuclear power plant will be low, and will have no significant impact in the environment or people.



## 10 Prevention and alleviation of adverse impacts

### 10.1 Construction of the power plant

#### 10.1.1 Noise and traffic impacts

Noise during construction and other disturbances in the immediate vicinity of the plant may be alleviated by performing as many especially noisy or otherwise disturbing construction activities in the daytime as possible.

Furthermore, the placement of activities and temporary noise protection structures can be used to significantly reduce the noise disturbance caused by the construction site. For example, impacts of the noise from the stone crushing plant may be prevented by constructing noise barriers from piles of stone.

Disturbances due to traffic during construction can be alleviated by means of traffic guidance and timing. Whenever necessary, vehicles can be directed to use routes which go outside the most major residential cen-

ters. Whenever possible, heavy traffic will be scheduled for weekdays between 7:00 am and 9:00 pm, and any special deliveries that may slow down the traffic flow will be scheduled for times when there is less regular traffic. Bus transport will be arranged for employees in order to reduce the volume of private car traffic in the area.

Active communication about the construction stages and the impacts of construction to the residents of neighboring areas, in particular, is also advisable.

#### 10.1.2 Dust impacts

Dust impacts from the construction site can be reduced by paving all the permanent roads in the area as soon as possible. Proper speed limits must be set for construction site areas and sand roads, and unpaved roads can be irrigated during the hot summer months, whenever

necessary. The dusting of crushed stone piles can also be prevented with irrigation.

### 10.1.3 Impacts on water systems

The construction works required by the nuclear power plant's cooling water structures and roads, the quay and the ship channel will be conducted during the biologically most inactive time, i.e. late autumn or even winter for some activities. This allows minimizing the biological disadvantages due to muddy water close to the construction site.

### 10.1.4 Impacts of waste and wastewater

Waste generated during construction will be properly sorted, and as large part of the waste as possible will be recycled or utilized in energy production. Hazardous waste will be separately collected and delivered to be properly treated.

The amount of wastewater generated at the construction site will be minimized, and the generated wastewater will be treated mechanically, chemically or biologically or by a combination of the three, depending on its quality.

### 10.1.5 Impacts on people and the society in adjacent areas

A large number of people having their permanent residence elsewhere will stay at the nuclear power plant construction site and close to it during the construction of the plant. The social impacts caused by the construction project can be alleviated by arranging accommodation for the employees in the location town and area as well as in adjacent municipalities. Adequate leisure activities for the employees participating in the construction work will be arranged together with various stakeholders. It is likely that most of the construction employees will come to the area from outside Finland. Adverse social impacts due to cultural differences can be alleviated by arranging training regarding the Finnish culture and practices to foreign employees.

### 10.1.6 Construction of power lines

The best way to alleviate the impacts of the power lines on, for example, land use, landscape and ecological values is to take these impacts as well as possible into account when planning the power line route and the pylons to be used. There are good possibilities to do just this because preliminary power line routes have been studied and various stakeholders are able to offer their views regarding the routes already during the power plant's EIA procedure. This offers good starting points for the power line EIA procedure to be carried out at the selected location and the technical design process that will utilize the results of the EIA procedure; plenty of information regarding environmentally significant issues will already be obtained before the power line EIA procedure begins.

### 10.1.7 Construction of roads

Environmental impacts caused by the construction of roads can be prevented and alleviated by properly designing both road routes and the construction work; issues significant for the environment and people will be taken into account. Technical solutions, such as intersection arrangements, light traffic routes, extensions, etc., can also be used to effectively reduce the detrimental impacts on people and the environment.

## 10.2 Power plant's operational lifetime

### 10.2.1 Environmental management system

An environmental management system is used to systematically link environmental issues to all operations of the nuclear power plant and to continuously improve environmental protection. Environmental aspects and environmental impacts of the operations of the plant are surveyed and evaluated as part of the system. The system includes programs and practices to minimize the environmental impacts of operations. The plant environmental policy and corresponding environmental objectives and goals will be defined. The set goals will be implemented in accordance with defined methods, and their implementation will be monitored. The best-known environmental management systems are systems based on the ISO 14001 standard and the EMAS decree.

### 10.2.2 Impacts of cooling water

Local impacts on water systems from the cooling water can be alleviated by means of a variety of technical solutions. However, several potential alleviation methods bring their own adverse impacts, which in some cases may be more significant than the benefits obtained from the system.

#### 10.2.2.1 Reducing the thermal load to the water system

A part of the heat generated by the nuclear power plant will be conducted to the water system by way of direct cooling. The cooling water will be used to cool the turbine condensers; after that, the water will be discharged back into the water system approximately 10–12°C warmer. The thermal power released to the water system in case of alternative 1 will be approximately 3,000–3,100 MW and in case of alternative 2 approximately 3,600–4,300 MW.

The thermal load released to the water system corresponds to approximately 24–35 TWh of energy per year. The total amount of district heating energy used in the whole of Finland is approximately the same: approximately 30 TWh in 2006 (*Finnish Energy Industries, 2007*).

The only way in which the thermal load released to the water system could be significantly decreased is so-called joint production, i.e. a power plant that generates

electricity and also district heating or industrial steam. The efficiency of a joint production plant is usually approximately 80–90 per cent. The excess thermal load of the nuclear power plant could only be utilized in district heating if the temperature was increased to a minimum of approximately 140°C. However, this would reduce the efficiency of the nuclear power plant's electricity generation system. The lost electricity generation would be approximately 20–30% of the generated amount of heating energy.

### District heating energy

Some nuclear power plants also generate district heating energy. For example, the Beznau nuclear power plant in Switzerland (electric power 730 MW) generates district heating energy for an area of approximately 15,000 residents (NOK, 2008). The thermal power currently used in district heating energy generation in nuclear power plants is only approximately 100 MW at best (IAEA, 1997).

It would be technically possible to implement Fennovoima's nuclear power plant project as a power and heat production plant and it would be financially justifiable in the event of a sufficiently large demand for heat. According to the views of the organization responsible for the project, district heating produced through nuclear power could have a significant role in reducing carbon dioxide emissions in energy production if the production and distribution of district heating could be agreed upon with different operators and the loss heat of a nuclear power plant will be used to largely replace heat production through fossil fuels.

The highest district heating load in Finland is in the Helsinki Metropolitan region. In 2007, 6.4 TWh of district heating energy was sold in the distribution area of the Helsinki district heating grid (*Helsingin Energia*, 2008). This amount corresponds to approximately 18–27% of the energy to be released into the sea at the Fennovoima nuclear power plant.

The Ruotsinpyhtää area is approximately 70 kilometers from the district heating tunnel at Vuosaari, Helsinki. However, the district heating energy would have to be distributed to the Helsinki Metropolitan region at several points, and thus more than 100 kilometers of tunnels would have to be constructed. In practice, it would be possible to generate district heating energy for the entire Helsinki Metropolitan region's needs if the nuclear power plant were to be constructed in Ruotsinpyhtää. Similarly, a plant in Simo would be able to generate district heating energy for Oulu and Kemi; the required heat amounts would be smaller there than in the Helsinki Metropolitan region, however. The distance from the Simo location area to Kemi and Oulu are approximately 10 and 25 kilometers, respectively. The district heating energy consumption figures in these towns in 2006 were approximately 0.2 TWh and 1.3 TWh,

respectively (*Finnish Energy Industries*, 2007).

In order to conduct district heating energy from Ruotsinpyhtää to Helsinki, two pipes with a diameter of approximately 1.5 meters would have to be built, one for outgoing and the other for incoming water. The pipes would travel in a tunnel with a diameter of approximately six meters quarried in rock. A rough cost estimate for construction of the district heating tunnel and pipelines is EUR 1,500 million. Costs would also arise from lost electricity generation output.

At present, the district heating system in the Helsinki Metropolitan region is mostly based on joint generation of electricity and heat. The district heating energy is generated by using natural gas, coal and oil. If the district heating energy came from elsewhere and the electricity generation were still to continue, the waste heat from electricity generation would have to be directed into the sea in front of Helsinki.

Fennovoima is studying the future needs and production methods of district heating and their impacts on the environment and climate at different sites, particularly in the Helsinki region. Fennovoima will perform the studies as a separate project together with its shareholders.

If it is seen to be useful in a site where it is technically and financially feasible for Fennovoima's power plant site that a significant volume of current combined heat and power production or separate heat production capacity is removed from use because of outdated production equipment or environmental reasons, Fennovoima will be prepared to take part in the project by distributing district heating to the site. The implementation of such a project will require a separate environmental impact assessment procedure.

### Industrial steam

Transferring steam required by industrial applications is only feasible from a technical and an economic viewpoint when the distances are short. No industrial facilities requiring large amounts of steam are located within such a distance from any of the alternative nuclear power plant sites, however. Furthermore, even the largest steam users in Finland would only require a very small part of the energy to be transmitted to the sea from the nuclear power plant.

The nuclear power plant is meant for generation of basic power, i.e. it will continuously generate electricity at a steady full power, whereas the requirements for industrial steam – and also district heating energy – vary. This is one of the reasons why it would be difficult to use the nuclear power plant in heat generation.

### Other possibilities to utilize heat energy

Other possible utilization possibilities for the thermal load include, for example, using it in heating the ground

on streets or in recreational areas, such as football fields; using it as a means to promote the growth of fish at fish farms; using it in heating greenhouses; or using it in other agricultural activities. Piloting projects regarding these utilization opportunities have been conducted in several Finnish power plants. However, the heat demands in these activities are so low that the reductions in the thermal load to be discharged to the sea would hardly be reduced. Another problem with such small-scale utilization of thermal energy is also its uneconomical nature and auxiliary impacts on the environment, such as nutrients from fish farming.

### Cooling tower

All the large condensation power plants in Finland use the so-called direct cooling method where the extra thermal load is transferred into cooling water traveling through the power plant and then discharged into a water system. This is because this method is the most effective from a technical and economic viewpoint, there is plenty of cold water available in Finland and the environmental impacts of thermal energy discharged into a water system have been found fairly minor and acceptable in surveys carried out over the decades. The descriptions of the power plant's impacts given in this report also assume that the direct cooling method will be used.

Since water is not so readily available in many countries, another generally used method is so-called indirect cooling, i.e. cooling towers. The extra thermal load is discharged from a cooling tower directly into the air, and the thermal impacts to the water systems will be minimal. However, there are technical, economic and environmental disadvantages with cooling towers. A cooling tower may be a fairly massive construction, in a large power plant a structure that is approximately 150 meters tall, that requires a lot of land and that can be seen from far. A cloud of water vapor forms above a cooling tower, especially in the wintertime. The cloud extends up to one kilometer and can be seen from far. Cooling towers placed next to the power plant, which will be approximately 50–60 meters in height, would be an element dominating the landscape.

Depending on the tower type, cooling towers also cause some noise disturbances, although the disturbances are fairly minor in case of towers operating with the chimney principle, i.e. so-called naturally ventilated towers.

There is enough room for cooling towers in all the alternative locations of the Fennovoima project. Since the 'basic tower models' are usually designed to operate at a maximum temperature of -30°C, the Finnish winter would have to be taken into account when designing towers for the Simo and Pyhäjoki locations in particular. Cooling towers could still be used also under these conditions. Cooling towers are in use in areas where the conditions are similar, such as in Canada and Russia.

In the selected plant locations, the cooling water used would possibly have to be brackish water due to the high water demand (approximately 1–2 m<sup>3</sup>/sec), and the salinity of the water would also pose challenges to the structural solutions and functionality of the towers. Cooling towers which utilize regular seawater and brackish water are in use in several parts of the world, however. The salinity of the seawater in the Bothnian Bay is very close to fresh water, and the salinity at Ruotsinpyhtää is also clearly lower than in the oceans.

The salt included in natural water circulating in a cooling tower will be concentrated due to evaporation. Some of the salt will spread into the surrounding area when water evaporates. Naturally, the salt emissions will be the higher the more salt the water used in the tower contains. The impacts caused by cooling towers' salt emissions highly depend on, for example, the size and location of the plant, however. The emissions can also be effectively reduced by means of technical solutions. In addition to the salt spreading to the environment, another detrimental impact could be the occasional freezing of roads or structures caused by water vapor; these environmental impacts have usually not been too significant, however.

In order to prevent the cooling surfaces from becoming soiled, which would reduce the cooling efficiency, anti-fouling chemicals preventing microbes from growing and attaching onto the surfaces (such as chlorine) have to be used in cooling towers. These chemicals will be discharged into a water system when the water in the tower is replaced. The use of these chemicals will be controlled, however, and in small doses they will only have minimal detrimental environmental impacts.

A cooling tower reduces the power plant's efficiency by approximately 1–3% and will thus reduce the amount of electrical energy generated by the plant. Depending on the price of electricity, the monetary value of such a loss would be approximately EUR 10 million per year.

Furthermore, the investment costs arising from a cooling tower are high: the construction of cooling towers sufficient for a 1,800 MW power plant would cost roughly EUR 50–60 million and for a 2,500 MW power plant approximately EUR 70–80 million.

Due to the environmental disadvantages and technical reasons associated with cooling towers, Fennovoima is not planning to use an indirect cooling system in the power plant.

#### 10.2.2.2 Impact area

It is possible to change the location and form of the cooling water impact area by the placement of the input and discharge structures and by various technical solutions limiting the thermal impact, such as guiding embankments and dams closing straits.

By carefully choosing the place from where the cool-



The EIA process has studied the impacts of cooling water on ice conditions. Wintery shoreline in Pyhäjoki, 2008.

ing water is taken, it is possible to minimize the size of the water area that will be heated due to the input water temperature. The colder the input water, the lower the thermal impact at the discharge zone. Water close to the bottom is colder than the surface water, especially in the summertime, and therefore taking water from close to the bottom may in some cases reduce the size of the area that will be heated.

This impact was observed in all the studied locations, most clearly with the deepest intake alternatives in Ruotsinpyhtää. The impacts of taking water from close to the bottom in the lower sea areas in Simo and Pyhäjoki were not so significant.

If necessary, the impacts of cooling water can be concentrated in a small sea area by separating the cooling water discharge area from the surrounding sea with earth embankments, for example. In such a case, the cooling water impacts will be limited to a small area but the impacts on this area will be more clearly discernible. This has been done, for example, in front of the Forsmark nuclear power plant in Sweden where an area of approximately one square kilometer has been separated

from the rest of the sea. The cooling water is discharged to this area, and it will cool there a little before it is allowed to enter the sea. The area was surrounded by islands already before the power plant was constructed, however, and thus constructing a full circle of embankments was not necessary. The area is used for studying the impacts of cooling water.

Due to the depth of water, separating an area of similar size at the Fennovoima locations is not rational from a technical or an economic viewpoint, nor can it be justified based on environmental grounds due to the fact that it would not offer any major improvements and the construction works would harm the environment.

#### 10.2.2.3 Impacts on ice cover

The impacts of the cooling water in the ice cover can be reduced by the above-mentioned methods aiming at reducing heat emissions.

In theory, the fact that cooling water will melt the ice cover could also be utilized by guiding the water into an area where a lack of ice cover would serve some purpose. Such sites include harbors and ports, for example. In

practice, transferring water far from the power plant area would be technically challenging and expensive, however. There are suitable sites close-by only to the potential power plant site in Simo where the Veitsiluoto Port and the Ajos Port are located close to the discharge area.

### **Ajos Port**

The Ajos Port is located approximately seven kilometers from the cooling water discharge site. However, the cooling water modeling shows that cooling water will not keep the ship channel leading to the port or the port area itself unfrozen.

The port areas could be kept unfrozen by pumping a major part of the cooling water to the Ajos Port. This would require investments in a pipeline and a pumping plant as well as a separate license procedure. Profitability of the project should be separately assessed.

#### **10.2.2.4 Fish getting into the power plant system**

Fish can be prevented from being driven into the cooling water intake system through different technical measures and by technical design of the cooling water intake systems.

The most commonly used method in Finland is protecting the intake with a fine mesh that will prevent larger fish from ending up in the intake pipe. Mesh is often kept in front of the intake pipe in the spring and summer when most fish would be driven into the intake pipe. The problem with using mesh is that it will be quickly clogged up by algae and other debris in the water.

A variety of repellent systems have also been developed to prevent fish from coming close to the intake structures. Most of these systems are based on sound and/or light. Devices based on electrical impulses are also in use in German power plants, for example. The systems have been observed to reduce the number of fish that end up inside the power plant; they do not completely prevent fish from getting in, however. Fennovoima will study the fish repellent technology best applicable for the Baltic Sea conditions and install such a system in the power plant.

The number of fish that end up in the intake system can be reduced when the cooling water intake is constructed close to the bottom and sufficiently far away from the shore. This will also prevent fry and roe which are usually found close to the shore from getting into the intake system. The number of fish ending up in the power plant can also be reduced by designing the cooling water intake system in such a manner that the water flow will remain low at the intake point and the flow effect will be directed into deeper waters by means of guiding embankments, for example.

### **10.2.3 Emissions of radioactive materials**

Emissions of radioactive materials during operation of

the nuclear power plant will be low, and will have no significant impact in the environment or people. The emissions of radioactive materials will be continuously monitored by means of measuring and sampling. This is to ensure that emissions into the air or water will not exceed the plant-specific limits confirmed by the Radiation and Nuclear Safety Authority. Despite the low amounts of radioactive emissions, the means of decreasing them and also other emissions will be continuously surveyed in accordance with the principle of continuous improvement.

#### **10.2.4 Impacts on animals**

Impacts during operation of the nuclear power plant can be reduced by, for example, especially taking into account the birdlife of the area during operation. The risk of birds colliding with power lines can be reduced by improving the visibility of the power line. This can be done by installing bird warning spheres on the power lines, for example. No extensive mirror-like surfaces should be used in the power line structures because these might increase the risk of collisions. If there are any migration or travelling routes of animals in the power plant area, these will be taken into account when designing the form of fenced-in areas and roads, whenever possible.

#### **10.2.5 Landscape impacts**

Since the scale of the nuclear power plant and the adjoining structures will deviate from the surrounding nature, 'hiding' the buildings or structures in the landscape will not be possible. It is possible to make the power plant more fitting for the landscape, however, by selecting the correct surface materials and colors, carefully planning where buildings will be placed and adding vegetation in the power plant area.

Local impacts can be reduced during more specific design by, for example, forming embankments at shores in their natural state or almost in their natural state and adding vegetation in such a manner that they will fit into the natural shoreline of the area. This should be done if there are any recreational sites or holiday homes in the area. The lighting used on the roads to the power plant can be designed in such a manner that it will not be visible from far away (light fixtures spreading light downwards). When designing the power line routes and roads, attention should be paid to how they blend in the landscape. Valuable scenic and cultural sites shall also be taken into account. Architectural solutions may also be used to make the power plant better blend in the surrounding landscape.

#### **10.2.6 Impacts on traffic and safety**

The impacts of the power plant's operation on the traffic volume and traffic safety in the areas adjacent to the power plant can be reduced by arranging the employees'

bus transport to the worksite free of charge. Traffic safety issues must also be taken into account when deciding on the location of new traffic connections and improved traffic connections, and when designing structural solutions. Such solutions include, for example, extensions, lanes for decelerating and accelerating vehicles at intersections, traffic lights and light traffic routes.

### **10.2.7 Noise impacts**

The internal and external noise level of the power plant must meet the guidelines of public authorities regarding occupational safety and environmental noise levels.

When designing the power plant area, attention shall be paid to noise impacts. This shall be done when choosing the locations of activities causing noise and buildings preventing noise, for example. The building materials and technology used in the power plant building can be such that absorbs noise caused by machinery and devices. Vibration can be reduced by placing all vibrating machines on flexible foundations.

The noise transients caused by vehicles passing by and the daily average sound level can be controlled by speed limits, for example.

### **10.2.8 Impacts of wastewater**

The amount of wastewater generated at the nuclear power plant will be minimized by careful planning of water consumption. The wastewater generated by the plant will be properly treated mechanically, chemically or biologically or by a combination of the three, depending on its quality, before discharging the wastewater into the sewer system or water system.

### **10.2.9 Impacts from transport, use and storage of chemicals and oils**

Very small amounts of chemicals and oils hazardous to the environment will be stored and used at the nuclear power plant. The relevant safety instructions and regulations will be adhered to when transporting chemicals. The chemical storage tanks and chemical stores will be built in compliance with the Chemicals Act and regulations issued pursuant to it, as well as SFS standards. There are safety guidelines for preventing chemical accidents for the nuclear power plant, and the staff will be provided with instructions on the safe use of chemicals. Structural provisions for any leaks will be made in order to prevent detrimental amounts of hazardous chemicals from getting into the environment. The accident risks pertaining to storing and using chemicals will be systematically analyzed and minimized.

### **10.2.10 Impacts of waste management**

The objective is to minimize the generation of waste at the nuclear power plant. The detrimental impacts of waste may be alleviated by utilizing as much of the generated waste as possible by recycling or by using it in energy production. All waste will be properly treated, and the waste will not cause any major environmental impacts.

### **10.2.11 Impacts on people and society**

The risks inherent to nuclear power are generally perceived far greater than they actually are. This is why it is important to offer information on the operation of the nuclear power plant and the risks and impacts pertaining to nuclear power in an active, appropriate and comprehensible manner. The fear of nuclear power plants may also be alleviated by providing plain language information to the general public on how safety is ensured in all nuclear power plant operations, how extremely unlikely a nuclear power plant accident is, and what kind of concrete consequences the most severe accident would have.

The nuclear power plant will be presented to the general public at a visitor's center to be built by Fennovoima in connection with the nuclear power plant. Regular and open reports on radioactive measurements and other measurements taken in the surroundings of the plant will be offered.

### **10.2.12 Impacts of accidents**

When designing a nuclear power plant, the primary target is to prevent accidents. Its design prepares for the possibility of operational transients and accidents. The nuclear safety principles also serve to ensure the proper management of accidents. An up-to-date emergency plan shall be drawn up for the nuclear power plant and its vicinity. The emergency response arrangements of the nuclear power plant will be coordinated with the rescue and preparedness plans of the authorities in the case of a nuclear power plant accident. The emergency plans will be continuously updated, and their use will be regularly practiced.

## **10.3 Decommissioning**

The environmental impacts of decommissioning the new nuclear power plant will be evaluated in a separate EIA procedure. A decommissioning plan will be drawn up at the initial stages of plant operation, however. The Radiation and Nuclear Safety Authority will approve the plan, which shall be updated every six years. One of the primary objectives of the plan is to ensure that dismantled radioactive components will not cause any harm to the environment.