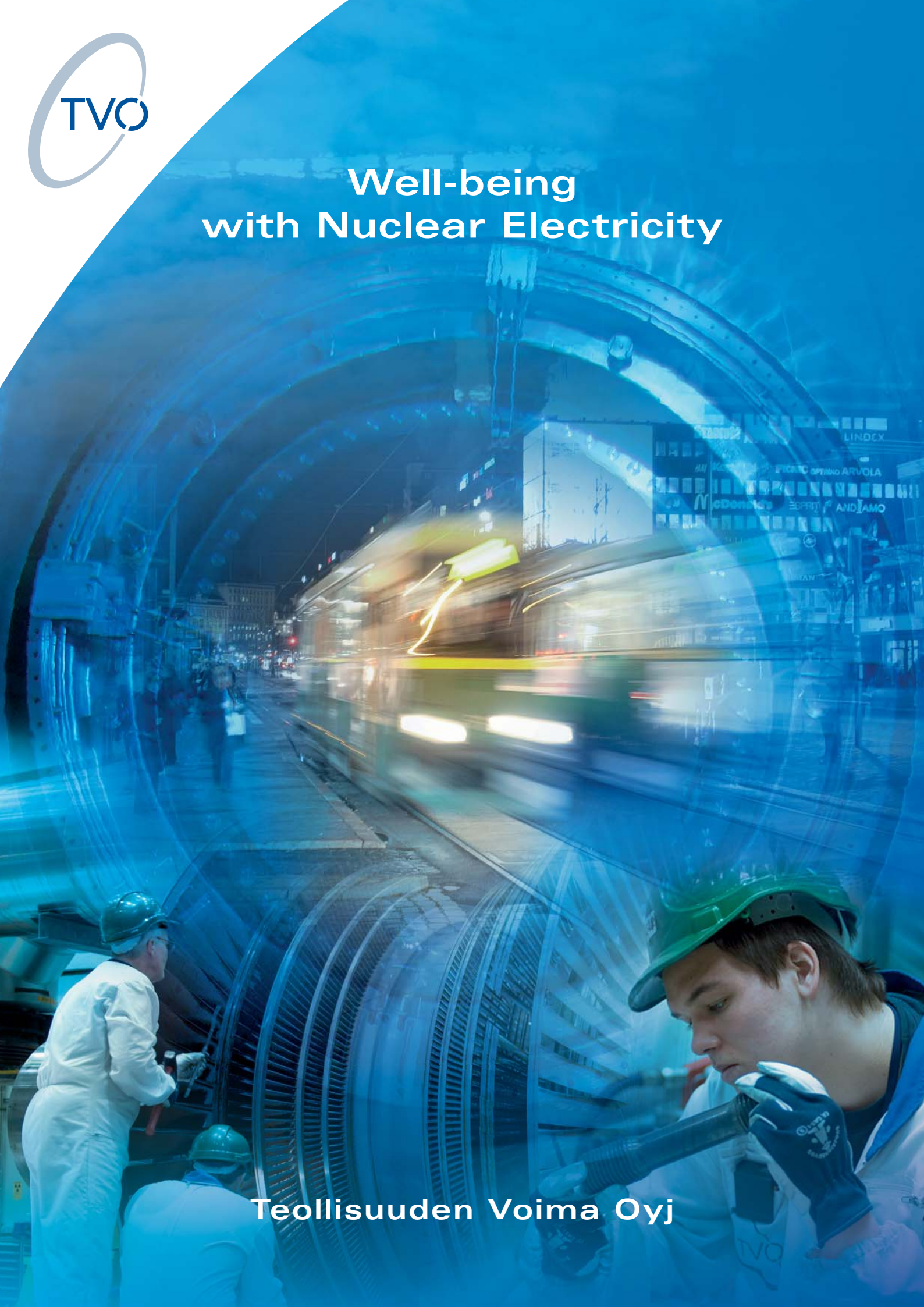


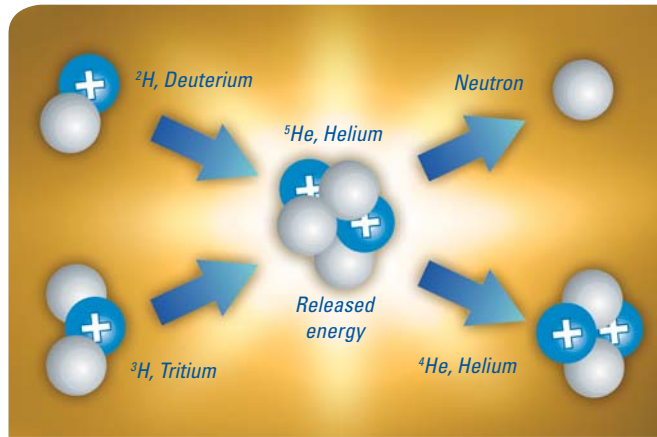


# Well-being with Nuclear Electricity



Teollisuuden Voima Oyj

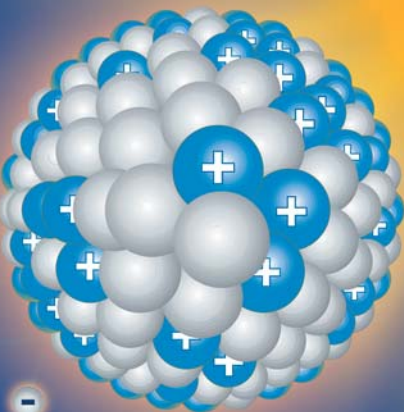
The life-sustaining heat generation from the sun is based on fusion reaction. The technical implementation of fusion power plant still requires decades of development work.



The sun is the sustenance of life and an energy source.



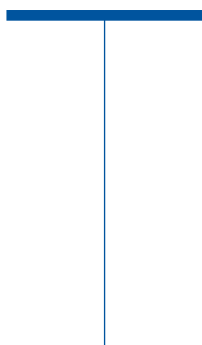
Current nuclear power plants are based on fission reaction.



Electricity keeps the wheels of society turning.

$$E=mc^2$$

# Life needs energy



Life is based on an endless cycle of energy. Energy does not disappear, but changes its state according to the laws of physics. The transformation takes place of its own accord in the natural world or comes about through human activity.

The sun is like a giant power plant; it derives its energy from an internally generated fusion in which hydrogen nuclei combine to form helium nuclei. Nearly all known energy reserves are based directly or indirectly on the energy from the sun.

Naturally occurring energy sources include coal, oil, natural gas, uranium, peat, wood and other biomasses, the potential energy in water, wind, solar energy and geothermal heat.

The majority of current global energy production is based on burning fossil fuels such as coal, oil and natural gas. The burning fuel reacts with oxygen, thus producing carbon dioxide and simultaneously releasing heat, i.e. energy.

## What is energy?

Energy can be defined as the ability to work. Energy changes its state and often this transformation manifests itself as work. Matter and energy are two aspects of the same thing. Matter can be changed into energy and energy into matter.

The basic unit of energy is the joule (J). The unit of power, or the velocity at which the energy is used, is the watt (W).

## Fusion and fission

Fusion refers to a nuclear reaction where light atomic nuclei combine to create heavier nuclei and release energy.

Fission is the opposite of fusion and refers to disintegration - splitting. Fission is a reaction in which a heavy atomic nucleus is split into two intermediate-mass nuclei, which releases energy.

## Fission in a nuclear power plant

The current nuclear power plants are based on fission technology. Nuclear energy is released by splitting the heavy nuclei of uranium fuel in a nuclear reactor into intermediate-mass nuclei, which releases energy and neutrons. Releasing the neutrons causes a chain reaction that keeps the nuclear reactor working. Energy is released by fission primarily as kinetic energy, which is transformed into thermal energy and then into electricity.

## What is electricity?

An electric charge is one of the basic properties of an elementary particle. It manifests itself as a force action between charged particles. An electric current is the movement of electric charges. Electricity is produced by generators. Electricity can be transmitted relatively easily and transformed into other forms of energy. The basic unit of electricity consumption is the kilowatt-hour (kWh).

## How is electricity generated?

In a power plant, the production of energy, including electricity, means converting different energy sources into a form that can be exploited.

Water, steam, gas or wind, for example, spins the turbines in a power plant. The turbines spin the generators and rotational energy is transformed into electricity in the generator.

## The story of uranium\*

The universe has been shaped into its present form as a result of countless stellar nuclear reactions, and one of the outcomes is our solar system and our own planet, Earth. The story of nuclear reactions is, therefore, also a part of the story of humankind.

The universe, which was created in a hot initial explosion billions of years ago, comprised at first only hydrogen and helium, from which the galaxies and stars were condensed under gravitational force. Other elements were created in the stellar nuclear reactions. The elements important for life, such as carbon, nitrogen, oxygen and sulphur were created in slow fusion reactions in massive stars. Elements heavier than iron, such as uranium, were created in collapses of giant stars i.e. supernova explosions.

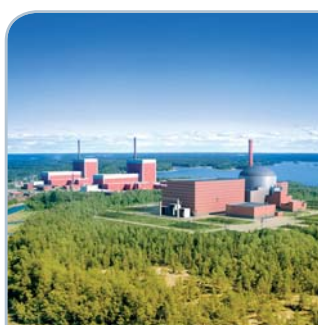


\* Theory nowadays valid in the scientific field.

# TVO generates electricity for the nation



Teollisuuden Voima Oyj (TVO) generates electricity for its shareholders at cost price and builds new power production capacity. TVO is a private limited company founded in 1969. It is part of the Pohjolan Voima Group.



TVO generates electricity in Olkiluoto in Eurajoki using nuclear power and wind power. In addition, TVO has a 45% share in the Meri-Pori coal-fired power plant. The electricity is distributed to TVO's owners, who distribute it further to consumers all over Finland. Around half of the electricity goes to industry and the rest to households, agriculture and the service sector.

TVO's Olkiluoto nuclear power plant units, Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2), are identical and equipped with boiling water reactors. After the modernisation of the turbine plants the electrical output of each unit is 860 MW, i.e. a total of 1,720 MW. TVO's share of the output of the Fortum Meri-Pori coal-fired power plant is 257 MW. The wind power plant in Olkiluoto generates 1 MW.

## New OL3 unit under construction

In 2005, the Government granted a construction licence for the Olkiluoto 3 unit, OL3, to be built in Olkiluoto. The municipality of Eurajoki also approved the building permit in 2005. When completed, the OL3 unit will produce around 1,600 MW of electricity.

The Franco-German consortium AREVA NP/Siemens has overall responsibility for the construction project.



*TVO produces electricity using nuclear power, coal and wind.*

## Responsibility, pre-emptive thinking, transparency and continuous improvement

TVO's values are responsibility, pre-emptive thinking, transparency and continuous improvement. The company's vision is to be a world-class nuclear power company that has earned the respect of Finnish society, and its mission is to produce electricity for its shareholders safely, reliably, in an environmentally sustainable way and economically.

## Long-term approach, systematic planning and meticulous care

The long-term, systematic and cautious approach of TVO keeps the current OL1 and OL2 units safe, up-to-date, well maintained, reliable and competitive in terms of production costs.

The new Olkiluoto 3 unit is a high-quality, safe project that complies with the technical requirements.

## Posiva and TVONS

Posiva Oy is owned by TVO and Fortum Power and Heat Oy. Its business strategy is to manage the final disposal of spent nuclear fuel from its shareholders' nuclear power plants in Olkiluoto and Loviisa. TVO has a 60% interest in Posiva Oy.

The subsidiary company TVO Nuclear Services Oy (TVONS) markets and sells TVO's expertise in nuclear power.

# Olkiluoto, the centre of nuclear power expertise



Electricity keeps the society on the move, which translates into work and prosperity for the whole nation. At TVO, we bear our share of the responsibility for supplying electricity to the Finnish industry and to the Finnish electricity consumers. We produce electricity safely and reliably, without producing carbon dioxide emissions and without disturbing the environment.

Nuclear power is a sustainable form of electricity generation. Its environmental impacts in the entire production chain – from the uranium mine to the final disposal of spent fuel – are insignificant. In Olkiluoto there is a repository for low and intermediate-level waste, and research ensures that the spent fuel from our plant units can be safely disposed of in the local bedrock.

In Olkiluoto we also have the means to construct a fourth nuclear power plant unit on the island. An application for a decision-in-principle was submitted to the Government in April 2008. The environmental impacts have been assessed with care. The construction of Olkiluoto 3 has strengthened our expertise, and the infrastructure is in place on the island. The municipality of Eurajoki has approved the project.

During its 40-years history our company has become one of the world's leading producers of nuclear power, and we are constantly praised for our expertise and skills in the field. Our vision is to be a highly valued Finnish nuclear power company and a forerunner in the industry.

I hope that the information in this brochure will give You, the reader, an idea of how we at TVO as a producer of electricity live up to the expectations that our shareholders and society place on us.

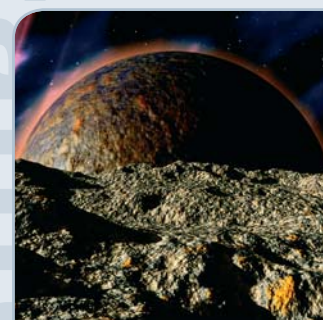
**Jarmo Tanhua**  
President and CEO

TVO's owners and shareholding 31.12.2009				
	A-series	B-series	C-series	Total
EPV Energia Oy	6.5	6.6	6.5	6.5
Fortum Power and Heat Oy	26.6	25.0	26.6	25.9
Karhu Voima Oy	0.1	0.1	0.1	0.1
Kemira Oyj	1.9	-	1.9	1.1
Oy Mankala Ab	8.1	8.1	8.1	8.1
Pohjolan Voima Oy	56.8	60.2	56.8	58.3
	100.0	100.0	100.0	100.0

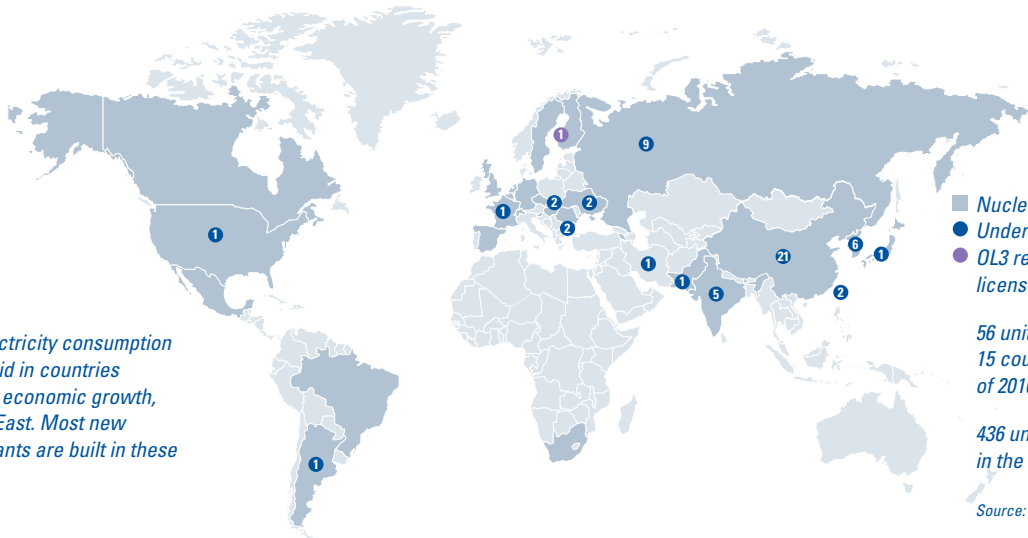
Electricity generated by TVO is distributed for consumption through its shareholders. TVO has three share series, A, B and C, which grant entitlement to electricity generated by the different power plant units.

*\* Our own solar system is thought to have been created when an entire star collapsed in a supernova explosion and its contents subsequently spread into space to form an inter-stellar cloud. Later, when the cloud began to contract, the Sun was condensed in the centre with planet elements around it. In the intense heat, the constituents were arranged in the evolving Earth according to their weight: the heaviest in the middle and the lightest on the outer shell. The heat released by the fission of the radioactive materials in the Earth, i.e. a reaction that kept the Earth in a molten state, was needed for arranging the constituents.*

*Heavy elements, such as uranium, iron and nickel sank into the Earth's interior. Fissions by the radioactive materials still heat the inner part of the Earth and preserve it in a molten state.*



*\* Theory nowadays valid in the scientific field.*



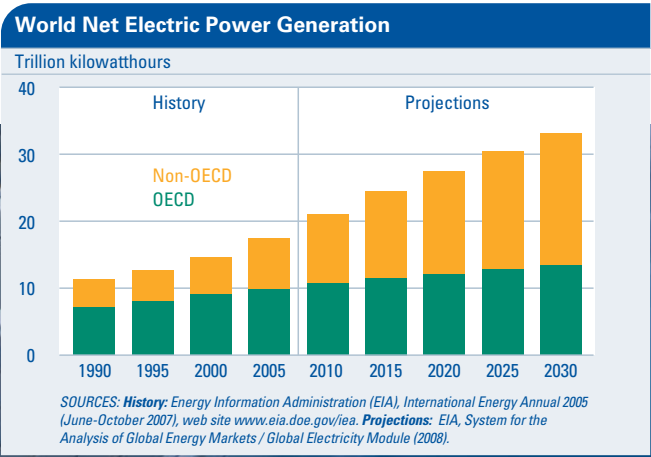
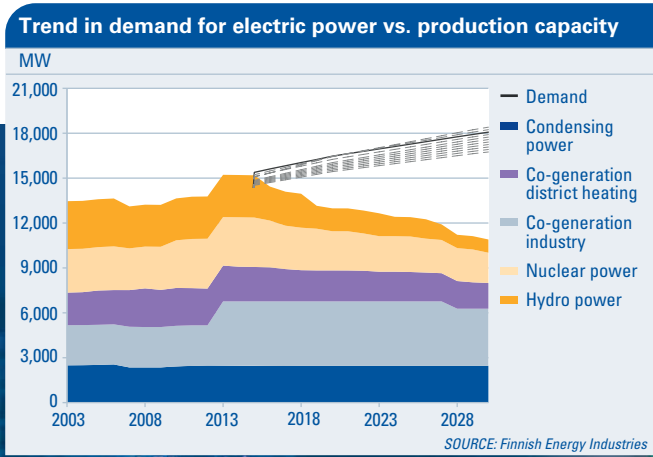
The growth in electricity consumption is particularly rapid in countries experiencing fast economic growth, mainly in the Far East. Most new nuclear power plants are built in these countries.

■ Nuclear power in use  
● Under construction  
● OL3 received a construction license in 2005

56 units under construction in 15 countries in the beginning of 2010.

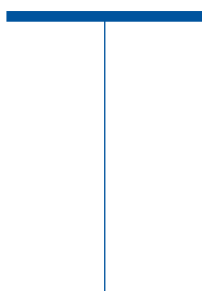
436 units in 29 countries in use in the beginning of 2010.

Source: IAEA



The demand for electricity is growing, even though new industrial processes and domestic appliances are designed to be energy-efficient. New electrical goods for both working life and leisure time are constantly coming onto the market.

# Electricity makes the world go round



Electricity is one of the cornerstones of modern society. It is an important basic commodity for households and an essential ingredient in production and industry. In the next 20 years global electricity consumption is expected to almost double.

A viable energy system is a guarantee of the functionality of the country's economy and thus contributes to the well-being of everyone who lives in Finland.

The consumption of electricity in Finland is divided almost equally between industry and the other sectors of society: households, services and agriculture.

Electricity is needed for industrial processes, for heating industrial premises and homes during the cold seasons and for cooling when it is warm. It is used for heating water, for refrigeration, and for the increasing quantities of leisure equipment and electronics.

## Demand for electricity is increasing in Finland

Economic growth increases the need for electricity as the rising standard of living raises household consumption.

The consumption of electricity in Finland grew throughout the 1900s, and the growth is expected to continue over the long term at an average rate of over 1% a year. The industry sector predicted in the autumn of 2009 that the consumption of electricity will reach almost 110 TWh in Finland by 2030.

In affluent, prosperous Finland, the need for electricity will increase in all areas. Despite continuing improvements in the already high energy efficiency, the need for electricity will grow in the industry. The manufacture of industrial products of even higher quality, in particular, increases the demand for electricity.

It is expected that the consumption of electricity in services will increase in the future - to approximately 40 percent.

The habitable floor space is larger than before in Finland, and families have become smaller in size. The number of holiday homes and second homes has been growing in Finland, and they are better equipped. There will also be a larger number of electrical appliances in the future. The use of electric heat pumps for heating will gradually become more common. Electricity consumption will also rise in the future in the form of an energy source for cars.

## Greater demand for electricity production

According to a study conducted by the Finnish Energy Industries, Finland needs major investment in new electricity production capacity. Over the next 10 years or so, the country will see the decommissioning of many power plants that are becoming obsolete. Dependence on imports has to be reduced greatly, as the capacity of Finland's neighbouring regions for producing electricity for export is constantly diminishing. The demand for electricity is growing, in spite of the improvements that are constantly being made in the area of energy efficiency.

It is estimated that by 2030, 7,000–8,000 megawatts of new electricity generation capacity will be needed, and by 2050 the figure rises to 19,000–27,000 MW.

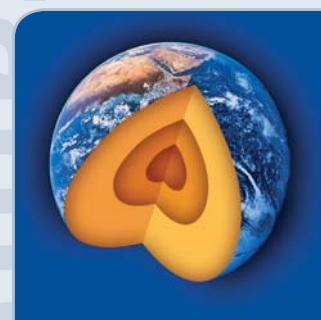
This shortfall needs to be made up for as far as possible through the production of Finnish CO<sup>2</sup>-free electricity at a reasonable price. By and large, nuclear power is a high-standard energy source owing to its excellent security of supply, its competitive production costs and its low emissions.

*\* Earth's molten inner core creates a powerful magnetic field that functions as a protective shell and a preserver of life.*

*The radioactive materials in the inner core, such as uranium, keep the iron in a molten state.*

*The magnetic field prevents high-energy electromagnetic radiation and particle fallout from the Sun, i.e. the solar wind from accessing the Earth. The solar wind's attempt to penetrate the Earth can be seen in the form of the Northern Lights.*

*The hot core of the Earth also creates a phenomenon known as plate tectonics, as a result of which the carbon accumulated in sedimentary rock spreads deep into the Earth's mantle and is re-released through volcanic activity. This carbon circulation keeps Earth's temperature in balance and prepares the way for life-supporting conditions.*



*\* Theory nowadays valid in the scientific field.*

# Competitiveness for industry, well-being for the nation



More than half of the electricity demand in Finland is consumed by industry, and more than half of this amount is the industrial base load continuously required by the forest, metal and chemical industries. Nuclear power is particularly well suited for the generation of this base load power.



TVO generates about one sixth of the electricity consumed in Finland. A total of 80.8 billion kilowatt-hours (TWh) was consumed in Finland in 2009, and TVO generated about 15.3 TWh of it.

Since the late 1970s, TVO has generated more than 370 TWh of electricity for the Finnish society.

The electricity produced by TVO serves the Finnish industry and society as a whole, and guarantees well-being for Finnish consumers.



## TVO generates base load power in a cost-effective manner

Nuclear power is very well suited to the Finnish electricity production system.

The cost of fuel is low in a nuclear power plant, accounting for some 15% of production costs. The fluctuation in the price of fuel affects production costs less with nuclear energy than, for example, with electricity from gas or coal.

The price of electricity produced from nuclear power is stable and predictable. Nuclear power is particularly well suited to the satisfying of the basic demand for electricity.

The initial investment constitutes the largest share of the production costs of nuclear power. It accounts for around 60% of the costs for a new unit in Olkiluoto and the share decreases gradually during the plant's service life over the years. The operation costs of a new power plant unit account for some 15% of production costs, and waste management for about 10%.



*The well-being of industry means well-being of the Finnish society.*

The provision for the disposal of spent nuclear fuel accounts for the largest share of waste management costs. The money for future waste management comes out of the price of the electricity produced and is collected into the State Nuclear Waste Management Fund.

## High capacity factors indicate good performance

A nuclear power plant's capacity factor indicates how well the plant is achieving the planned output and availability goals. The capacity factors for both TVO's plant units, OL1 and OL2, have always ranked in the top class in global terms. High capacity factors are a sign of reliable operation.

## Safety measured on the international INES scale

The international, seven-level INES scale (International Nuclear Event Scale) is used to describe incidents in nuclear power plants. No INES events that would have seriously affected safety have occurred at the TVO units.

The safety of the plant is always the priority in all TVO's operations. Plant safety is continuously monitored.

## No greenhouse gases

The generation of nuclear energy produces virtually no emissions under normal conditions. A nuclear power plant does not produce emissions that promote the greenhouse effect or acidification, or particle emissions that deteriorate the air quality.

The international agreements for controlling climate change also call for carbon dioxide emissions reductions in Finland. Electricity produced by TVO helps achieve these targets. During their operating life, the TVO units have already reduced the carbon dioxide emissions of the Finnish electricity production by around a third compared with the corresponding amount of electricity produced with coal.

### Well-being and services for everyday life

Services include many types of activities aimed at increasing wellbeing.

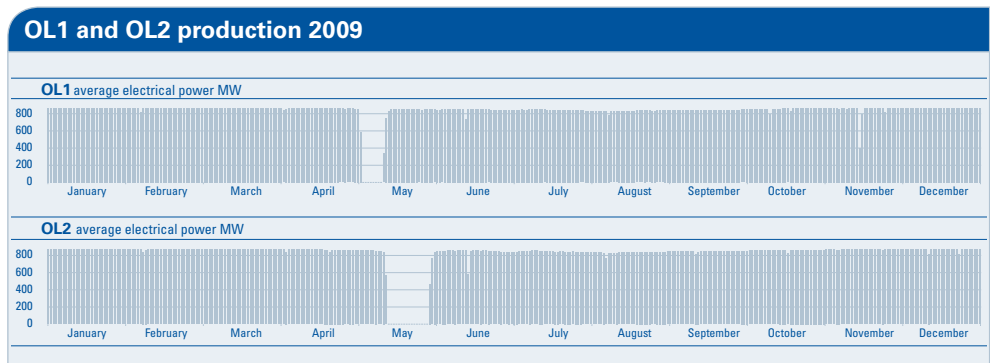
People's everyday life and daily routines are more dependent on electricity than ever before. An interruption in the supply

of electricity can, at worst, paralyse the functions of society. On-line retail services and banking now play a significant part in services that benefit the consumer.

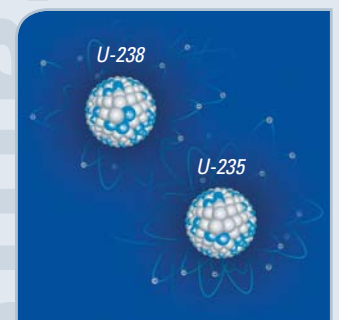
The number of appliances making housework easier is increasing. Electrical appliances simplify the everyday life for both working-age people and people of advanced years.

The number of elderly people is growing in Finland and the need for different services, especially health services, is increasing. Every effort is made in Finland to support safe, independent living. New, modern electric solutions make the everyday life of all citizens easier in many different ways.

*The fuel of a nuclear power plant is uranium, the heaviest element in the nature. The uranium occurring in nature is generally the U-238 form. Atoms of the same element that differ from each other in terms of the number of neutrons in the nucleus are called isotopes. U-238 is the heaviest uranium isotope. There are more neutrons in its nucleus than in the lighter U-235 isotope, which accounts for about 0.7 per cent of natural uranium. Nuclear power plants also use the uranium which has been obtained as a result of nuclear disarmament.*



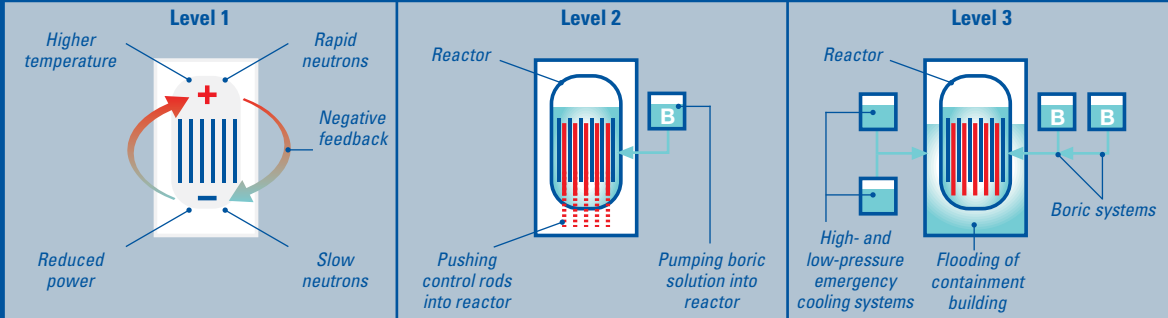
*The Olkiluoto power plant units generate electricity day and night, summer and winter. The only exceptions are the annual outages and various periodic tests.*



**Safety relies on two main principles:**

1. The defence-in-depth principle
2. Multiple barriers to release

**Examples of the defence-in-depth principle**

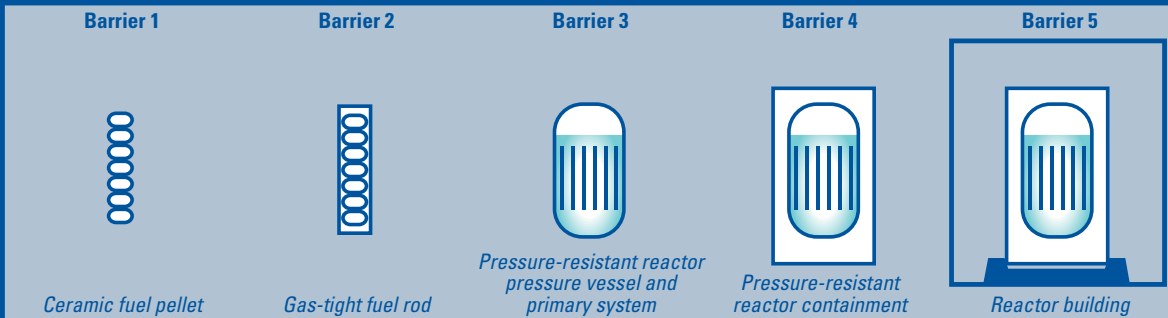


As the reactor temperature rises, its power is reduced, as the increased boiling produces fewer slow neutrons and thus slows down the chain reaction.

The reactor can be shut down in a few seconds by means of two systems with different operating principles.

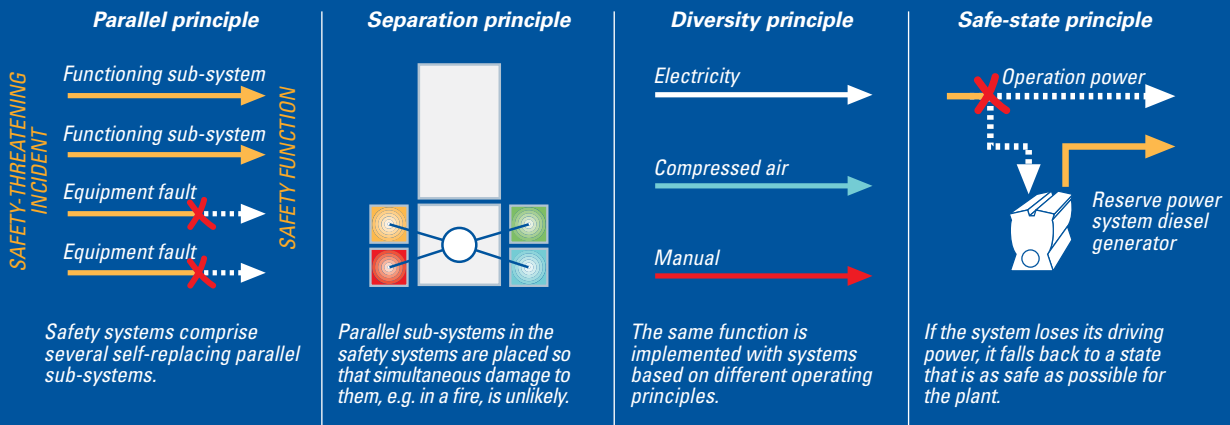
In an accident situation the safety systems prevent or alleviate the consequences.

**Multiple barriers**

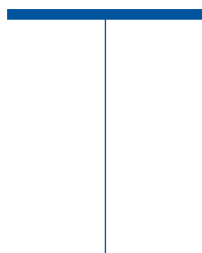


One of the main principles of nuclear safety is the arrangement of multiple barriers between radioactive materials and the environment.

**Examples of other important safety principles**



# Safe generation of nuclear energy



The primary objective of all staff at TVO's nuclear power plant is to ensure the safe operation of the plant units under all circumstances. No chances are taken when it comes to safety. The staff strives to anticipate malfunctions and eliminate them with an array of technical safety systems.

The starting point in planning a nuclear power plant is the assumption that there will be technical faults and operators can make human errors. The potential for different malfunctions is carefully analysed during the design stage of a nuclear power plant and units are equipped with an array of technical safety systems that are based on proven and tested technology and reliable test results.

## Multiple safety systems

The nuclear power plant units in Olkiluoto are equipped with multiple safety systems operating on different principles to help detect malfunctions and bring them rapidly under control.

The automation and electricity supply for the safety systems is separate from the systems for normal operation.

According to Government decision 395/91, the systems for the main safety functions must be able to operate even if any individual component in the system is inoperable, or if any component affecting the safety function is unavailable because of repairs or maintenance.

## Anticipating malfunctions

TVO uses probability-based safety and usability models for anticipating malfunctions.

TVO continuously improves operations and safety by collecting reports on even the minor 'near miss' incidents from each staff member.

## Constant supervision by the authorities

The operation of TVO's nuclear power plant is continuously supervised in accordance with the Nuclear Energy Act and the Nuclear Energy Decree. Authorities supervise the operation of plant units in accordance with strict guidelines.

The Radiation and Nuclear Safety Authority (STUK) is the supervisory authority for the Finnish nuclear power plants. TVO regularly submits reports on its operation to STUK.

Nuclear fuel is also supervised by the International Atomic Energy Agency (IAEA) and the European Atomic Energy Community (EURATOM).

## Continuous training with a simulator

The training of operators for OL1 and OL2 takes about three years. Training includes theoretical studies as well as simulator training, which accurately simulates the plant operations.

The nuclear power plant units are only operated by people who have demonstrated their knowledge of the plant and their ability to manage the systems. Competence tests and theoretical exams are administered by STUK. Only persons who have passed the exam and gained a licence can work as plant operators at OL1, OL2 and the new OL3 plant.



*A shift supervisor and operators, all holding a licence for operating the plant, are present in the control rooms of the units at all times.*

*The radiation level caused by uranium in natural surroundings is low. Uranium is a common element in nature; it is more common than gold, for example.*

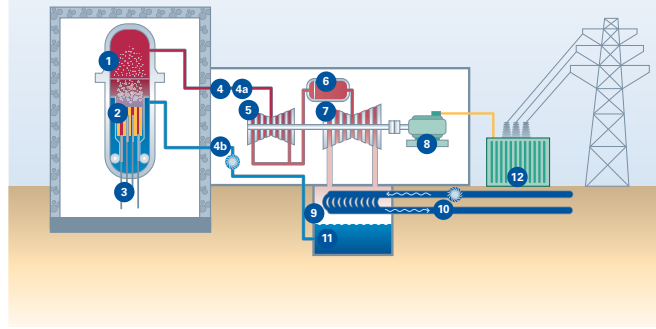
*The estimated amount of uranium dissolved in the Earth's seas is 4 billion tonnes. The Earth's crust generally holds an average of about four grammes of uranium per tonne. Uranium reserves are expected to last for centuries.*

*The largest known uranium deposits are in Australia, Canada, Kazakhstan, Uzbekistan, South Africa and Namibia. Uranium is mined from deposits in which there are between 0.3 and 200 kilos of uranium per tonne of ore. In Finland there are some 4,500 kilos of uranium in an area of one square kilometre at a depth of one metre in the outer layer. It is known that there are several uranium areas in Finland, and their mining possibilities are being studied.*



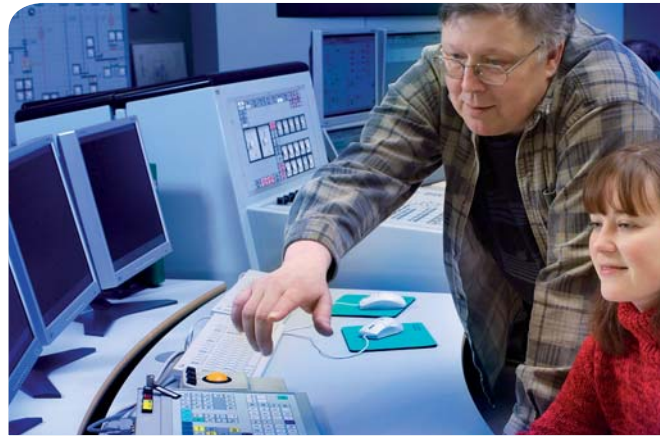
The operation principle of a boiling water reactor (BWR)

- 1. Reactor
- 2. Core
- 3. Control rods
- 4. Primary circuit
- 4a. Steam for the turbine
- 4b. Water for the reactor
- 5. High pressure turbine

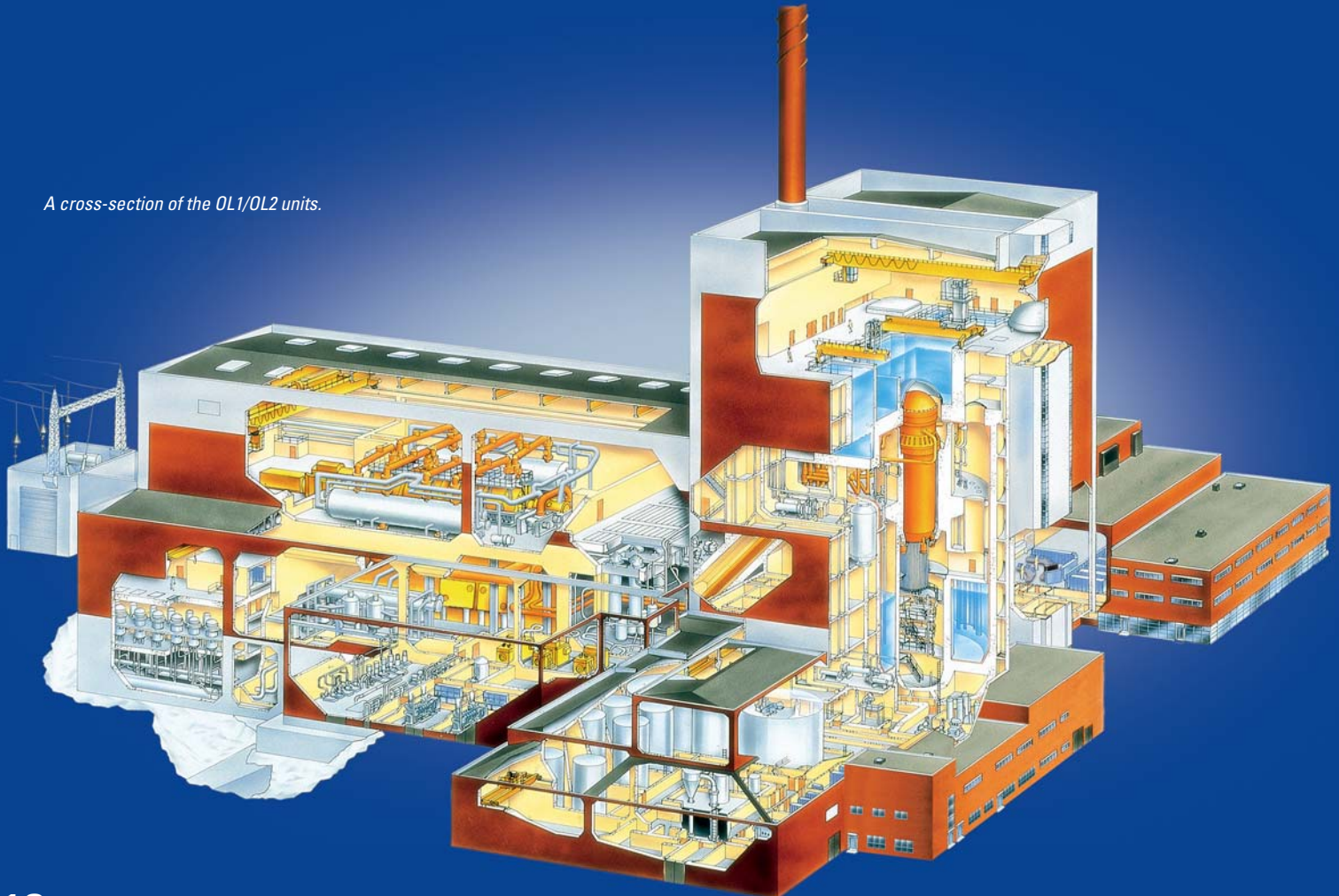


- 6. Reheater
- 7. Low pressure turbine
- 8. Generator
- 9. Condenser
- 10. Sea water circuit
- 11. Condensation water
- 12. Transformer

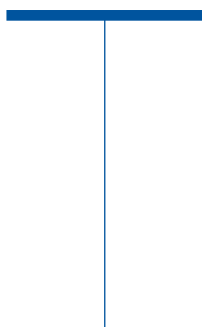
Training for nuclear power plant operators lasts several years.



A cross-section of the OL1/OL2 units.



# OL1 and OL2 are kept up-to-date



The cornerstone of TVO's operations is to ensure that its existing plant units, OL1 and OL2, are kept safe, up-to-date, reliable and in a perfect condition and that the production costs remain at a competitive level. This is achieved through the company's long-term, systematic and cautious approach.

TVO keeps its OL1 and OL2 nuclear power plant units up-to-date. The units are continuously modernised and developed further in order to meet the latest requirements.

## Units serviced and inspected every year

Outages take place each year at both plant units. By the end of 2009, a total of 58 annual outages have been performed.

A two-week maintenance outage takes place every two years. Besides refuelling, scheduled inspections and preventive maintenance and repair activities, including also major modifications and modernisations are carried out and the condition of the unit is inspected during the outage. In the interim a shorter refuelling outage is carried out. In addition to refuelling and repairs, the condition of the unit is inspected in the refuelling outage.

## Continuous and systematic modernisation

In addition to the regular annual outages, once in about ten years TVO also carries out an extensive maintenance outage. This is when the major modifications are carried out.



*The long annual outages scheduled for 2010 (OL1) and 2011 (OL2) will involve the replacement of the low pressure turbines among others.*

A modernisation project was carried out at the OL1 and OL2 units between 1995 and 1998, focusing on the reactors and the turbines. In all, approximately 40 large projects were included in this plant modernisation programme.

The renovation of the turbine plant was carried out in 2005 and 2006. The reheaters, high pressure turbines, turbine automation and the 6.6 kV medium voltage switchgear units were replaced.

The long annual outages scheduled for 2010 (OL1) and 2011 (OL2) will involve the replacement of the low pressure turbines, seawater pumps, the inner isolation valves in the main steam pipes, and the main generators. These changes increase the efficiency of the turbine plant and should result in an output increase of up to 25 MW per plant unit.

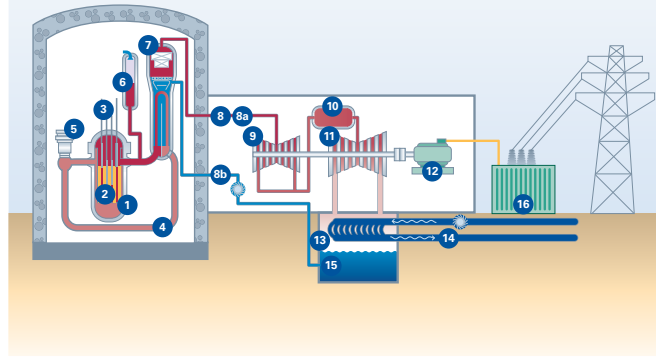
## Thorough testing after modifications

An extensive pre-operation test will be undertaken at the plant units after the structural changes have been implemented. Test runs performed in accordance with the test operation programme are controlled on-site by the Finnish Radiation and Nuclear Safety Authority (STUK).

*At the first enrichment phase, the mined uranium ore is turned into uranium concentrate with about 70 per cent of uranium. For the isotope enrichment it is converted into gaseous uranium hexafluoride. The amount of fissionable U-235 in the isotope concentrate is quintupled. The enriched uranium is reconverted into uranium dioxide powder which is then sintered into fuel pellets. These are loaded into fuel rods and combined into assemblies. In reactors OL1 and OL2 at Olkiluoto, one assembly contains about 180 kilos of uranium. The OL3 fuel assemblies contain around 530 kg of uranium. The uranium fuel used by TVO is produced in Germany, Sweden and Spain. The enriched uranium is faintly radioactive. Fresh, unused uranium fuel is not a radiation risk.*



The operation principle of a pressurized water reactor (PWR)



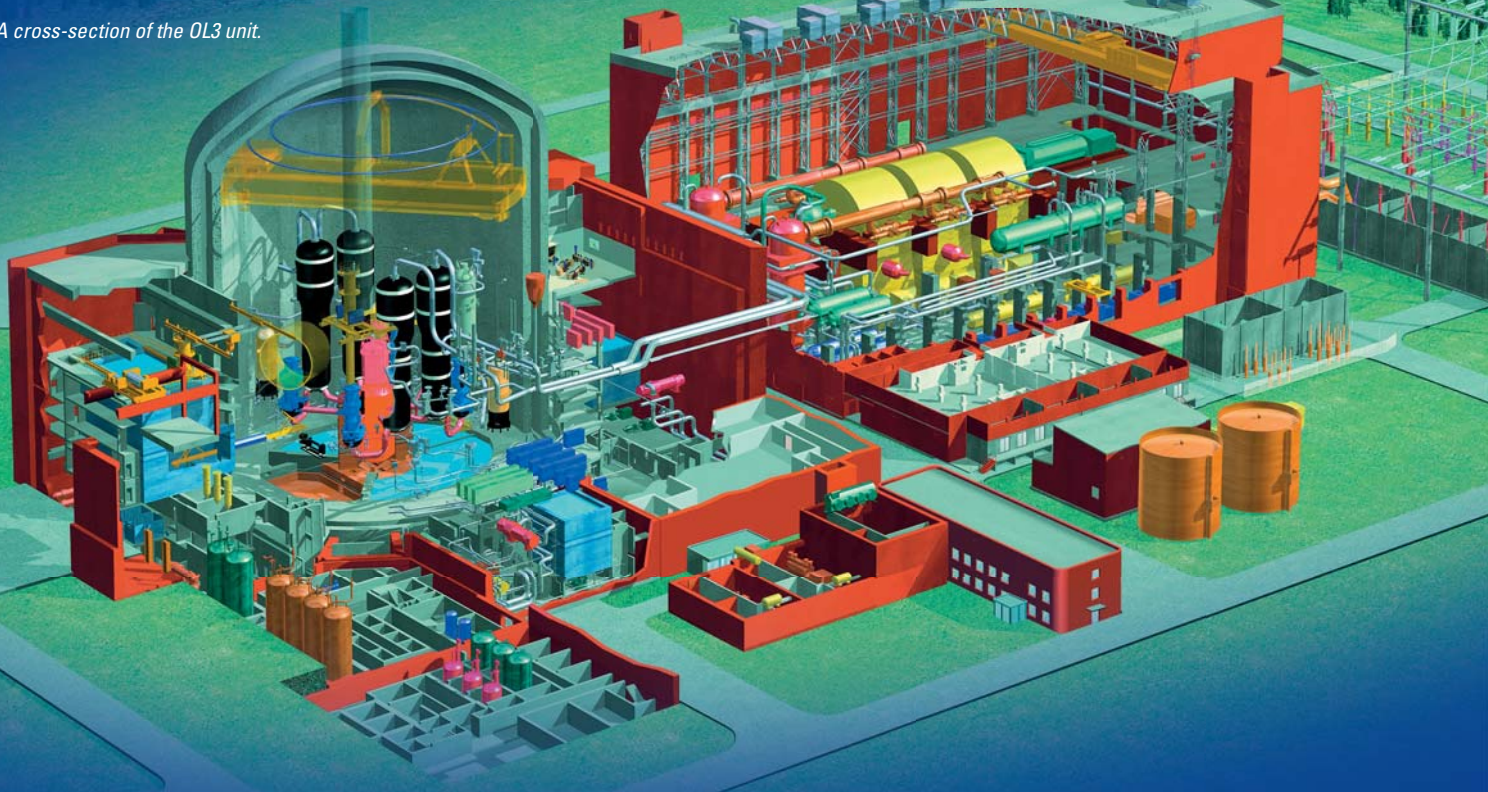
- 1. Reactor
- 2. Core
- 3. Control rods
- 4. Primary circuit (water circuit)
- 5. Main reactor coolant pump
- 6. Pressurizer
- 7. Steam generator
- 8. Secondary circuit
- 8a. Steam for the turbine

- 8b. Water for the steam generator
- 9. High pressure turbine
- 10. Reheater
- 11. Low pressure turbine
- 12. Generator
- 13. Condenser
- 14. Sea water circuit
- 15. Condensation water
- 16. Main transformer

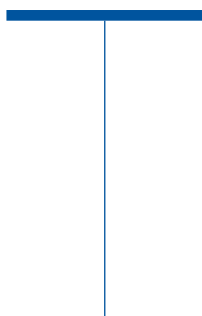


The reactor pressure vessel arrived by sea at Olkiluoto in early 2009.

A cross-section of the OL3 unit.



# The latest technology at OL3



Finland's fifth nuclear power plant unit OL3 is being built at the western end of Olkiluoto Island, next to the OL1 and OL2 units. The Franco-German consortium formed between AREVA NP and Siemens is responsible for the delivery of the OL3 unit in its entirety on a 'turn-key' basis.

Within the consortium, AREVA NP is responsible for the delivery of the nuclear island and Siemens for the turbine island. Both companies are leaders in their respective fields.

## Progressive and moderate evolution of proven technology

The new OL3 unit is equipped with an EPR-type reactor (European Pressurized water Reactor). The electrical output of the plant unit is approximately 1,600 MW.

OL3 is advanced in many respects, representing the state-of-the-art technology in the nuclear industry. In particular, OL3 contains many improved safety features. The positive operating experience and proven technology of N4 and Konvoi units in France and Germany, respectively, form the basis for the technical design of the unit.

A number of new technical features have been added to further improve safety, production capacity and reliability.



*The construction project calls for precision, also in the paperwork.*

## Major improvements compared with Europe's newest plants

Among the many improvements in the design of OL3, the key ones are:

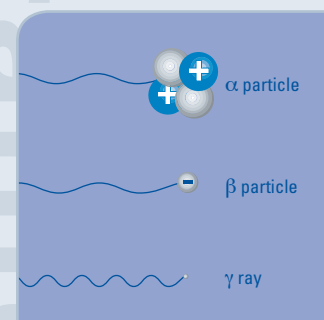
- The possibility for a severe reactor accident has been taken into account in the basic design and the construction of the unit.
- The digital control and automation system has an analogue back-up system.
- The unit has been designed to withstand the impact of a large airliner.

Furthermore, the electricity production will be more efficient and economical. There will also be less radioactive waste produced per each megawatt-hour due to the more efficient use of nuclear fuel.

## Electricity for several decades

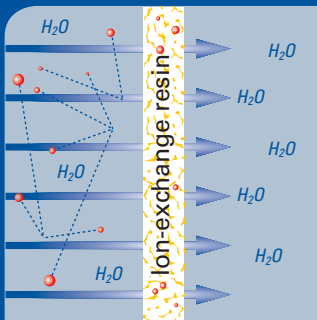
The planned service life of the OL3 unit is at least 60 years. Components and structures, which are difficult to replace, such as the reactor pressure vessel and the reactor containment building, have been designed to last at least six decades. Other structures and components can be replaced more frequently, if necessary.

*Radioactive materials and the radiation emitted by them are present everywhere in nature.  $\alpha$ -radiation and  $\beta$ -radiation are both long-wave particle radiation, against which thin layers such as skin or plastic give protection. When an atom nucleus is split in the nuclear fission at a power plant, not only  $\alpha$  and  $\beta$  radiation but also short-wave penetrative gamma radiation is created. Water, lead, concrete and steel give protection against gamma radiation. Finns receive most of their radiation dosage from radiation occurring in natural conditions. More than half of the Finns' radiation dosage comes from radon, which is created in the radioactive decay chain of the uranium found in natural surroundings.*





All the material to be used in the nuclear power plant is checked.



The process water is filtered as clean as possible.

Employees at the plant unit wear protective clothing and accessories appropriate for the tasks. Work sites are always protected in accordance with the instructions provided by radiation monitoring personnel.



Nuclear power plant operators continuously undergo further training. Training on a simulator forms an important part of the training. The licence entitling a person to run a plant is valid for three years at a time.

Jarmo Kosi, the local inspector of STUK, is responsible for such tasks as monitoring the plant operation, issuing the start-up permit after outages and supervising the licence exams.

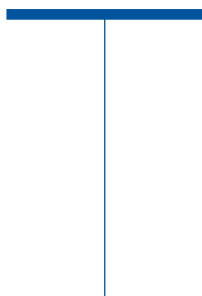


### Classification on the INES scale

		INES events at TVO										
		Class	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Major accident	7	7	-	-	-	-	-	-	-	-	-	-
Serious accident	6	6	-	-	-	-	-	-	-	-	-	-
Accident with off-site risk	5	5	-	-	-	-	-	-	-	-	-	-
Accident without off-site risk	4	4	-	-	-	-	-	-	-	-	-	-
Serious incident	3	3	-	-	-	-	-	-	-	-	-	-
Incident	2	2	-	-	-	-	-	-	-	-	-	-
Anomaly	1	1	-	1	1	7	-	3	-	2	5	3
No safety significance	0	0	6	7	5	10	6	3	4	5	5	2

Exceptional events at nuclear power plants are classified according to the International Nuclear Event Scale (INES). In Finland, the classification is carried out by the Finnish Radiation and Nuclear Safety Authority (STUK). INES 1 events at Olkiluoto have included a minor fire which started from an oil leak and the isolation valve of a steam line failing to close in scheduled testing.

# Constantly developing safety culture



Continuous improvement and pre-emptive thinking are two of TVO's values. There is always room for improvement, and pro-activity helps prevent malfunctions. The safety culture emerges from working practices and the attitudes of individuals.

According to the definition by the International Atomic Energy Agency (IAEA), safety culture is an "assembly of characteristics and attitudes in organisations and individuals, which establish that, as an overriding priority, nuclear safety issues receive the attention warranted by their significance". The definition applies generally to the nuclear power sector.

At TVO safety culture is considered a prerequisite for company operations. Safety is the most important issue in decision-making. TVO's management, supervisors and staff consider safety a fundamental part of all company activity. All staff and subcontractors are continuously trained in safety issues.

TVO is an active player in international nuclear power organisations and is involved in developing safety at both its own nuclear power plant units and within the nuclear power sector as a whole.

## Self-assessment – a part of safety culture

TVO has introduced self-assessment as an aid to continuous development.



*Petri Koistinen, Head of HRD, is responsible for safety culture evaluation and development. Safety is taken into account in the day-to-day operations, particularly in relation to human factors.*

Information on the state of safety culture is collected in different ways to form the basis of the assessment and the data gathered are analysed carefully. Questionnaires are used for collecting information, and guidelines, manuals, research results and records are examined. Discussions in small groups are part of the self-assessment process.

The results of self-assessment are carefully analysed. Operating models are drawn up on the basis of

the results to make further improvements in TVO's operations.

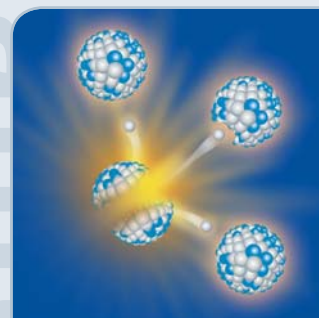
## High level of professionalism and work ethic

The staff at TVO knows that working at a nuclear power plant calls for a high level of professionalism and discipline.

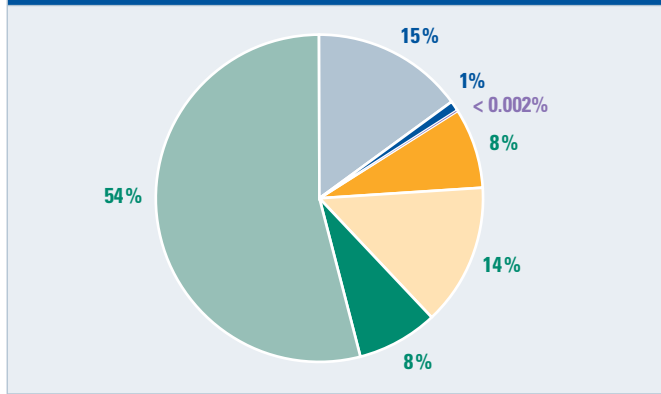
Employees at TVO keep looking for areas in their units where improvements can be made and participate in designing even better work procedures.

TVO's operations and production are held in high regard by the global nuclear sector. TVO and its personnel constantly strive for improvement.

*In a nuclear power plant reactor a part of the fuel's uranium nuclei are split and at the same time 2 or 3 neutrons are released. The kinetic energy from fission product atoms and neutrons is converted into heat when they collide with the surrounding atom nuclei. The neutrons slow down upon impact with water molecules and a decelerated neutron can split a new uranium nucleus. The number of nuclear fissions is controlled by regulating the neutrons' speed or, for example, by binding the neutrons to the material of the control rod. The heat is conducted in the form of steam to the turbine, and the kinetic energy of the turbine shaft is then converted into electricity in the generator.*



Radiation dose received by an average Finn, breakdown by source



**ARTIFICIAL SOURCES**

- Medical exposure 15%
- Nuclear fallout (Chernobyl, nuclear testing) 1%
- Olkiluoto nuclear power plant < 0.002%

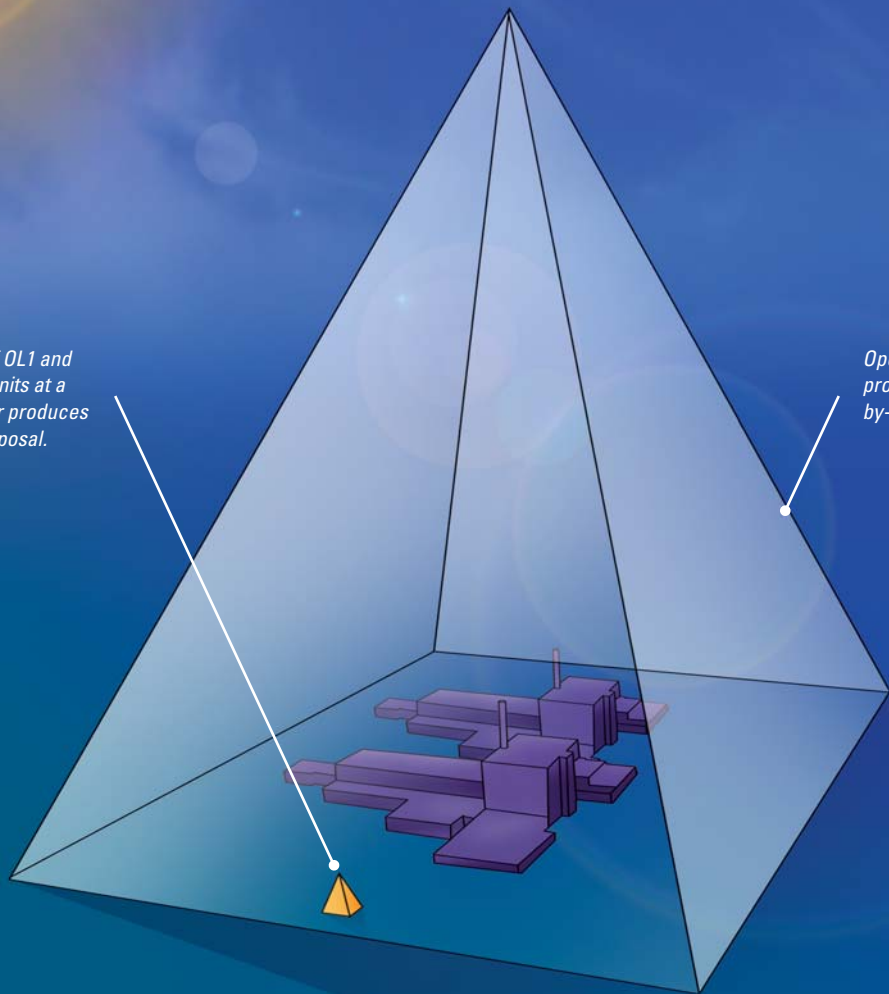
**NATURAL SOURCES**

- Cosmic rays (sun and space) 8%
- External radiation from soil and buildings (building materials) 14%
- Natural radioactivity in the body 8%
- Radon gas in indoor air 54%



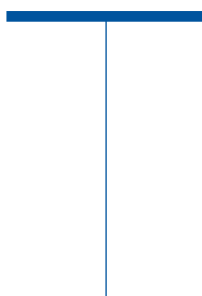
The potential environmental impacts of nuclear power plants are constantly monitored by, for example, taking samples.

Forty years of operation of OL1 and OL2 nuclear power plant units at a 90 per cent capacity factor produces 970 m<sup>3</sup> of spent fuel for disposal.



Operation at a coal-fired plant produces near 28,000,000 m<sup>3</sup> of by-products and waste.

# Emissions a fraction of official limits



The state of the environment around the Olkiluoto nuclear power plant is monitored regularly. The power plant's permissible emission limit values are specified in the operating conditions and the water permit.

Nuclear energy operations cause virtually no emissions, nor do nuclear power plants produce emissions that contribute to the greenhouse effect and acidification. The most extensive environmental impact from a nuclear power plant is the increase in local sea water temperature by a few degrees.

## Environmental management system guides operations

TVO's environmental management system ensures that operations advance towards higher levels of environmental protection.

TVO is constantly identifying environmental issues, for which it establishes monitoring and measurement programmes and sets annual targets to improve environmental protection.

## Minor air emissions

The limit values for radioactive emissions from the nuclear power plant are set by the authorities.

TVO's radioactive emissions into the air fall clearly below the official limits and are, at most, a few per mille of the permitted values. Radiation doses are so small that they are dwarfed by the much greater natural background radiation levels.

The environment around the nuclear power plant is measured with monitoring instruments. No radioactive substances originating from the nuclear power plant have

been detected in tests on residents in the vicinity of the plant.

## Minimal discharges into the sea

The activation and fission products discharged into seawater from the plant are only a few tenths of a per cent of limit values and tritium emissions are only some per cents of the officially set levels.

The process water in the nuclear power plant is continuously purified and any fission and activation products are removed. The spent ion-exchange resins are solidified in bitumen and sent in tightly packed drums for final disposal in the low-level and intermediate-level waste repository, the VLJ cave in Olkiluoto.

## Radiation from the nuclear power plants dwarfed by natural background radiation levels

Nuclear power is responsible for less than 0.1% of the average annual radiation dose in Finland. The permissible emission level of radioactive substances into the immediate environment has been determined so as to prevent everybody living in the vicinity of the plant from receiving a radiation dose greater than 0.1 millisieverts a year. In Finland people receive an average annual radiation dose of around 4 millisievert.

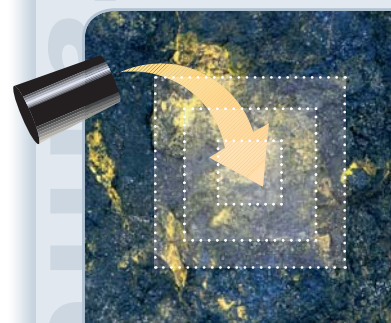


Food produced in the vicinity of Olkiluoto is monitored regularly.

*In natural nuclear reactors, the fission of uranium was initiated without human influence.*

*Rich uranium deposits created conditions in which the natural reaction could start.*

*The best-known natural reactor is Oklo in Gabon, where a chain reaction commenced two billion years ago, resulting in a natural reactor. The reactor is thought to have been in operation for hundreds of thousands of years. The final outcome was the generation of the same radioactive materials as in spent nuclear fuel. Most of the nuclear waste created in a natural reactor has gradually degraded into stable elements. The location of the fission products have resulted into the conclusion that the "nuclear waste" created in the operation of a natural reactor has not moved from its place of origin.*



*Correspondingly, the spent nuclear fuel of modern-day power plants is stored in the uranium's original birthplace, deep in the bowels of the Earth, with multiple layers of safety arrangements.*



Low-level waste includes protective clothing, flame-retardant fabrics and plastics.

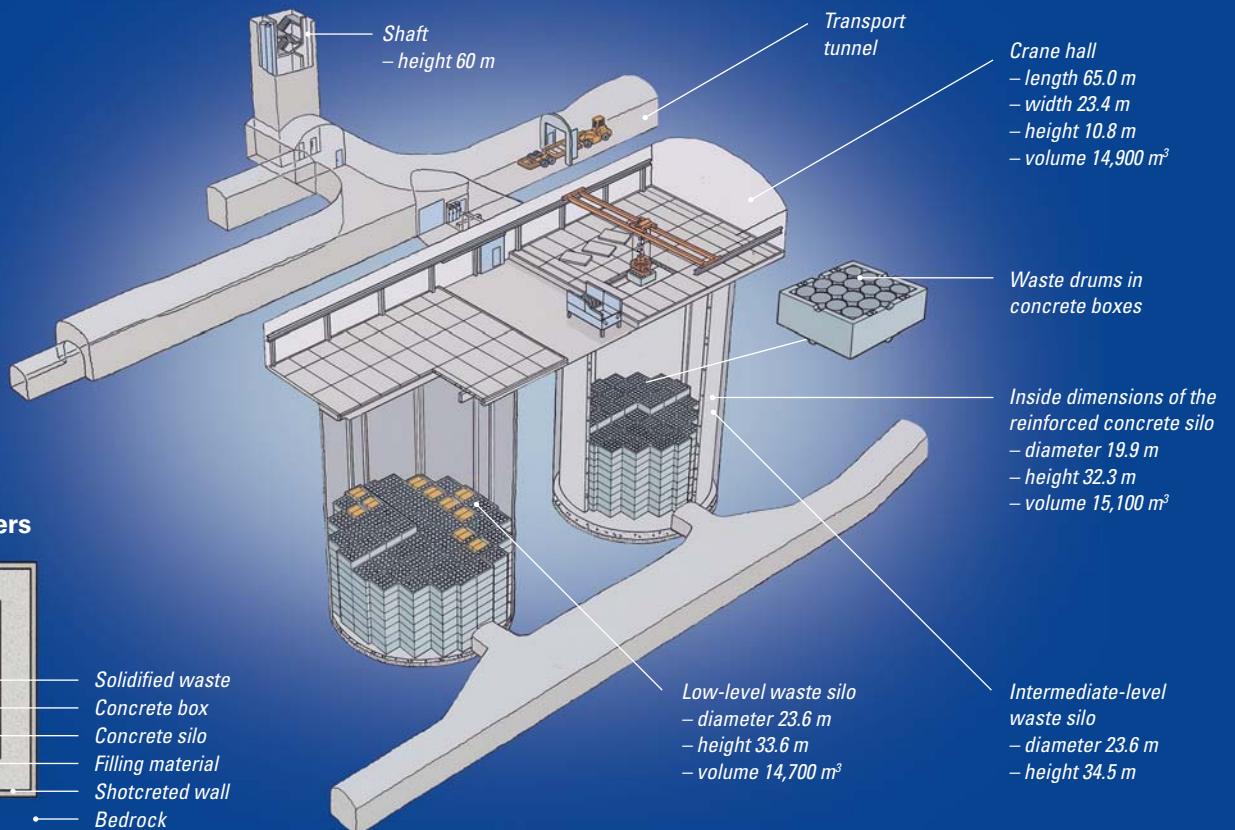


The ion-exchange resins used to purify the process water are solidified with bitumen and cast into steel drums. The bituminization process is controlled from the waste management building control room.

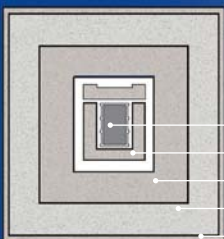


The silos are at the depth of 60–100 meters.

### Final repository for operating waste (VLJ)

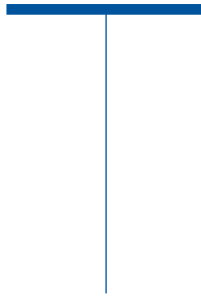


### Multiple barriers



- Solidified waste
- Concrete box
- Concrete silo
- Filling material
- Shotcreted wall
- Bedrock

# Low-level and intermediate-level waste



At the Olkiluoto nuclear power plant, waste is sorted and processed in accordance with the environmental management system. Some of the waste contains radioactive materials, and these are always processed separately.

Waste generated in the operation of the power plant and in annual outages is called operating waste, which is further divided into low-level and intermediate-level waste.

## Protective clothing and ion-exchange resins

Low-level waste is mix municipal waste contaminated with radioactive material. It includes flame-retardant fabrics, plastics, protective clothing, tools and machine parts and pipes removed from the power plant.

Intermediate-level waste consists of the ion-exchange resins used to purify the process water.

## Waste is packed in the waste processing building

Both Olkiluoto 1 and 2 power plant units have a waste processing building where operating waste is packed in steel drums. Soft low-level waste is packed in 200 litre drums, which are then compacted to about half their original size to fit twice the number of drums in the repository. The compacted drums are packed in concrete boxes. Low-level scrap metal is cut up or

crushed and packed directly in concrete boxes.

The ion-exchange resins used for purifying the process water are dried and solidified in bitumen, and then cast in 200-litre drums. These drums are also packed in concrete boxes.

## Final repository: the VLJ cave

The repository for low-level and intermediate-level waste is the VLJ cave on the Olkiluoto site. The waste packed in concrete boxes is transported on a radiation-shielded vehicle into the cave, where it is transferred to the low-level and intermediate-level silos excavated into the bedrock at a depth of 60 to 100 m.

There is also a separate space in the VLJ cave for storing the small quantities of radioactive waste generated in scientific research and health care activities in Finland.

The safety of the VLJ cave is secured by surrounding the radioactive materials with multiple barriers. The most effective barrier is the bedrock itself, but it is supplemented with other barriers.



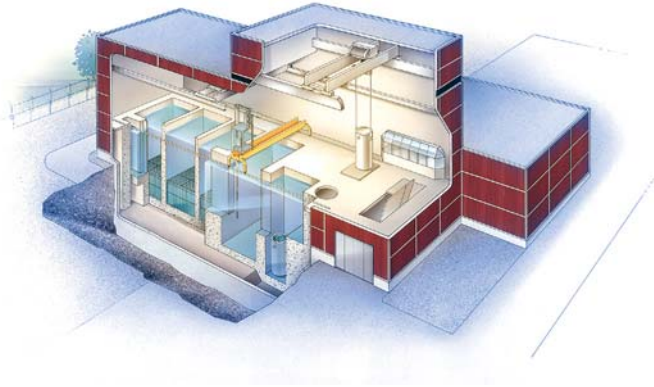
Waste is taken to the repository with a radiation-shielded vehicle.

*\* The elements will continue their course in the solar system and galaxy. Our solar system was created about five billion years ago and it will hurl its mass into space once again after billions of years. The atoms will return to the cycle of the elements and be used again in the creation of new stars, planets and life.*



*\* Theory nowadays valid in the scientific field.*

*Spent uranium fuel from the OL1 and OL2 units is stored in water pools in the interim storage facility known as the KPA Store.*



*Spent fuel assemblies are placed in pools to cool them down and to dampen their radiation. A little over 2 meters of water is enough to protect against radiation.*



# Final disposal of spent nuclear fuel

Spent fuel will be disposed of in the bedrock at a depth of hundreds of metres. Posiva Oy, owned by TVO and Fortum Power and Heat Oy, is responsible for the final disposal of spent nuclear fuel generated at its shareholders' nuclear power plants in Olkiluoto and Loviisa. Posiva Oy is constructing an underground rock characterisation facility in Olkiluoto.

Finnish law prohibits the import and export of nuclear waste. All nuclear waste generated in Finland is to be processed, stored and disposed of in a repository within the Finnish territory.

After removal from the reactor, spent fuel assemblies are placed in pools in the reactor hall to cool down for a few years. During this time, the radioactivity of the fuel is reduced considerably, to less than a hundredth part.

## Interim storage facility (the KPA store)

After a few years of cooling, the spent fuel assemblies are packed in a strong transfer container filled with water. This container is transported with a specially designed vehicle to the on-site interim storage facility, the KPA store.

Before being transferred to the final repository, spent fuel assemblies spend some 40 years in storage pools in the KPA store.

## Disposal of spent fuel at Olkiluoto

Studies on the final disposal of highly radioactive spent nuclear fuel were initiated by TVO in the late 1970s, and Olkiluoto was selected as the final disposal site in 2001. The responsibility for the practical construction of the repository rests with Posiva Oy, a joint venture of TVO and Fortum Heat and Power Oy. The final disposal will begin in 2020.

Spent fuel from the current units in Olkiluoto

and the unit under construction, and spent fuel from the current units in Loviisa will be disposed of in the repository. Posiva Oy has filed with the Government an application for a decision-in-principle on the expansion of the repository in Olkiluoto to accommodate the spent nuclear fuel of Olkiluoto 4 and Loviisa 3.

## Construction of final disposal characterisation facilities has begun

In 2004, Posiva Oy started the construction of an underground characterisation facility called ONKALO. The final disposal depth will be reached in year 2010. After that it is possible to collect confirmed information from the planned disposal depth. Posiva aims to submit the application for the construction license of the final disposal facility in year 2012.

## Funds have already been collected in the State Nuclear Waste Management Fund

According to the principles laid down in the Nuclear Energy Act, funds for undertaking nuclear waste management are collected in advance in the price of nuclear electricity. Funds are set aside in the State Nuclear Waste Management Fund, which at the end of 2009 totalled around EUR 1.8 billion. TVO's contribution to this is around EUR 1.1 billion. These funds also cover the decommissioning costs of the nuclear power plants.

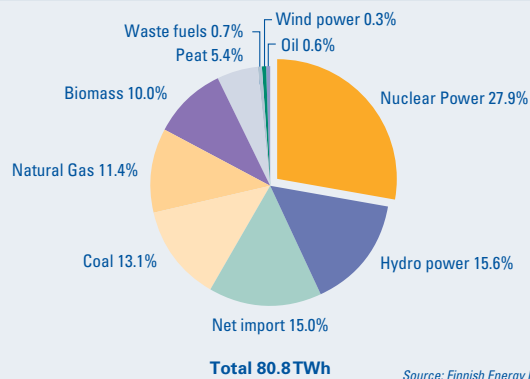


*Construction of the final repository is preceded by careful studies of the integrity and geological stability of the bedrock. The spent fuel will be packed in copper-cast iron canisters and stored some 420 m below ground.*



*Spent fuel assemblies are transported to the interim storage facility in a transfer container made of spheroidal graphite cast iron.*

**Electricity production in Finland by energy source 2009 (80.8 TWh)**



Source: Finnish Energy Industries

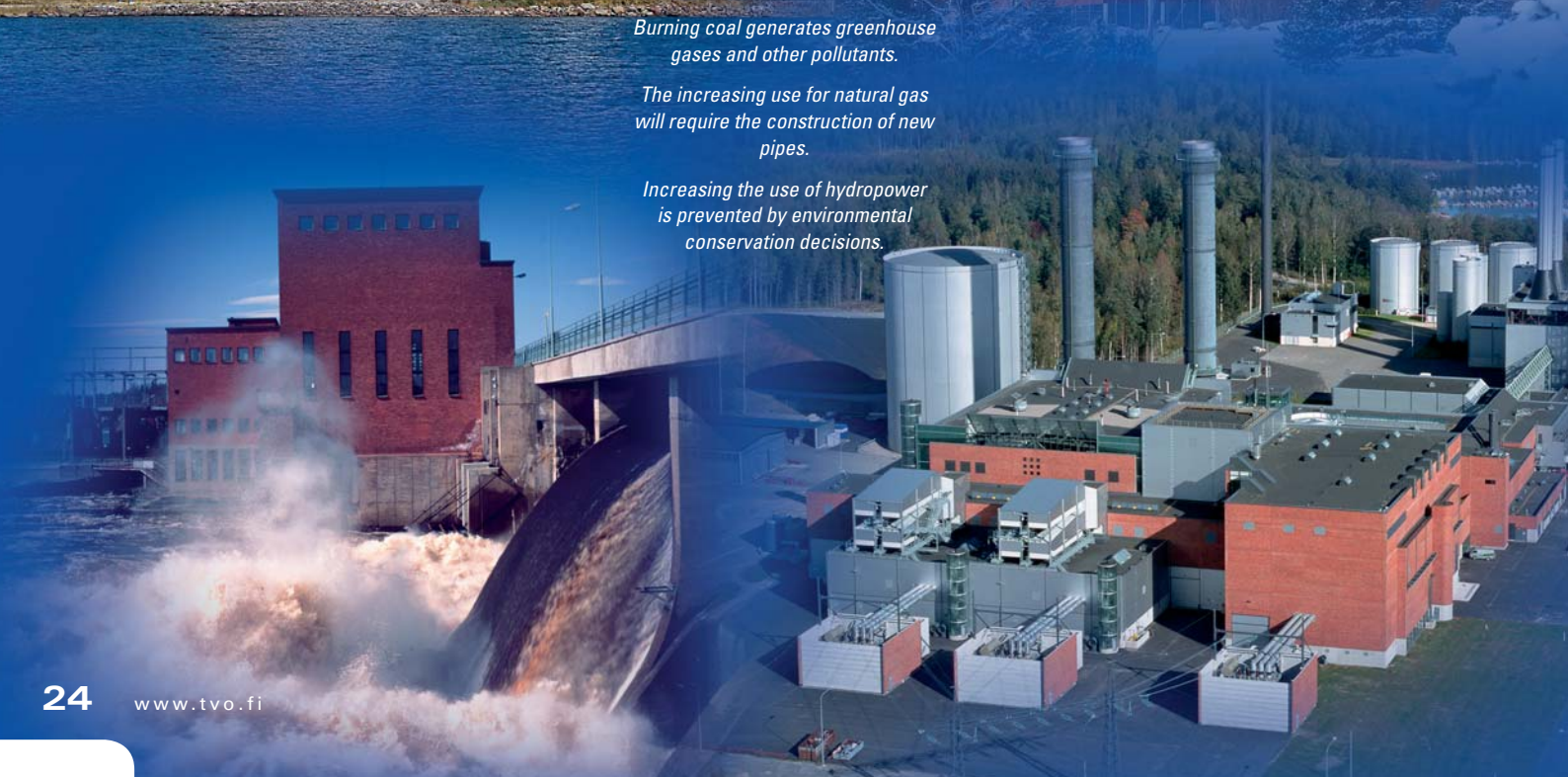
*Finland employs several different ways of generating electricity. Finland also imports a considerable amount of electricity from Russia, the other Nordic countries, and Estonia.*



*Burning coal generates greenhouse gases and other pollutants.*

*The increasing use for natural gas will require the construction of new pipes.*

*Increasing the use of hydropower is prevented by environmental conservation decisions.*



# Nuclear power plays an important role in electricity production in Finland

Electricity production in Finland is diversified and decentralized and relies on different production methods. The main energy sources for electricity are nuclear power, hydropower, coal, natural gas, wood fuels, peat and wind. Electricity production and the whole energy system face major changes in Finland because a target has been set for the completely emission-free energy system.

There are about 400 power plants in Finland. Nuclear power plants generate around one fourth of all the electricity consumed in Finland.

The two nuclear power plant units in Olkiluoto produced in 2009 about one sixth of the electricity consumed in Finland.

Finland can remain as independent as possible from political and other decisions made by other countries, if the main proportion of the electricity we need is produced in our country.

## Import

Over the last decade Finland has imported between 5 and 20 per cent of the electricity it has consumed. Import from Russia has accounted for over a half of this amount. The imported electricity has been produced with nuclear power, hydropower, coal, oil and natural gas.

## Coal

Flue gases are generated when fossil fuels are burned and the most problematic of these is carbon dioxide. Fortum and TVO, the owners of Meri-Pori coal fired power plant, have started a project aiming at developing a large-scale experimental power plant for the recovery and storage of carbon dioxide. The final decision on the investment will be made during years 2001 and 2012. The system would then be in operation at the end of year 2015. Sulphur dioxide, nitrogen oxides and fine particles are also released into the atmosphere when fossil fuels are burnt.

## Natural gas

The natural gas that is consumed in Finland comes from Western Siberia from a distance of about 3,300 km. Additional pipelines will

need to be constructed to guarantee the supply of natural gas. The extending of the gas pipeline to the west coast is still at a planning stage. The connecting of Finland to the European network is dependent on the willingness of the parties to invest in the scheme and on the situation in the central European markets.

## Hydropower

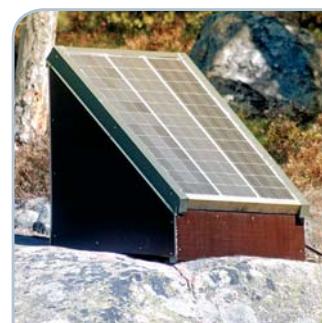
Almost all Finnish waterways that have not been protected by conservation decisions have already been harnessed for hydropower generation. Large-scale additional construction of hydropower for the production of electricity will not be possible in Finland unless some of the conservation decisions are reconsidered.

## Domestic fuels

The use of renewable energy is being promoted by investment aids and tax incentives. Most of the increase in renewable energy has been in bioenergy, i.e. energy recovered from wood and other types of biomass. Peat is a slowly renewable biomass. The current consumption rate of peat in Finland more or less corresponds to the renewal rate. Waste fuels, peat and other biofuels accounted for around 16% of the production of electricity in Finland in 2009.

## Wind

Wide-scale exploitation of wind power is limited by high costs, the need for regulating power due to fluctuations in production, and finding suitable locations. In Finland large-scale additional construction of wind power capacity presumes a remarkable increase also in hydropower capacity for use as a regulating power.



*Wind, field bio mass and solar panels are suitable for small-scale electricity production.*

40 year's experience and  
800 nuclear power experts.



### Olkiluoto is prepared for a fourth unit



- ① Olkiluoto 1
- ② Olkiluoto 2
- ③ Olkiluoto 3
- ④ Olkiluoto 4
- ⑤ Main office
- ⑥ Fire and rescue station
- ⑦ Maintenance centre and main warehouse
- ⑧ Interim storage for spent nuclear fuel
- ⑨ Repository for power plant waste
- ⑩ Training centre, simulators
- ⑪ Reserve power plant
- ⑫ Powerlines OL1, OL2 and OL3
- ⑬ New electric power line (plan)
- ⑭ Ship lane
- ⑮ Harbour
- ⑯ Accommodation village
- ⑰ Contractor area
- ⑱ Road network
- ⑲ Visitor Centre
- ⑳ Final disposal facility for spent fuel

# Olkiluoto, the core of nuclear expertise

TVO is well prepared to begin the construction of the fourth plant unit, and to carry out the project in a safe manner. The company is ready to put all its four plant units into use in order to produce reliable nuclear electricity for Finland at a fair price and to help mitigate the climate change.

TVO filed in April 2008 an application for a decision-in-principle on the construction of a fourth nuclear power plant unit in Olkiluoto. At the same time, Posiva Oy, co-owned by TVO and Fortum, submitted a separate application for a decision-in-principle on the final disposal of spent nuclear fuel from OL4.

## Olkiluoto is prepared for a fourth unit

Various fundamental structures are required for the production of nuclear power, in addition to the plant itself. The plans for the Olkiluoto area have made it possible to develop the island for nuclear power production. The municipality of Eurajoki has consistently shown its support for major construction projects implemented by TVO and Posiva over the years.

The island is well prepared for producing, constructing, operating and maintaining nuclear energy facilities as well as for managing nuclear waste. The island's cooling water capacity is excellent, and roads, grid connections, workshops, warehouses, water and wastewater networks, a shipping channel, a gas turbine plant, an electric power supply, a training centre, accommodation villages and a Visitor Centre have already been constructed. Approximately 800 experienced TVO professionals and thousands of workers involved in the OL3 construction project work on the island.

## Nuclear waste management under control in Olkiluoto

The site has an interim storage facility for spent nuclear fuel and a final repository for low- and intermediate-level operating waste, the VLJ cave. Protective clothing, machine and equipment parts and ion-exchange resins are packed tightly and then stored in the VLJ cave. The spent nuclear fuel in the interim storage facility will be cooled in storage pools for at least 40 years after leaving the reactor, during which time the fuel's radioactivity will fall considerably. Posiva Oy is responsible for the safe disposal of the spent nuclear fuel from the plants operated by its owners. It intends to begin the final disposal of nuclear fuel in Olkiluoto in 2020.

## Finnish expertise and the long time experience

The main factor in the success of OL4 is the know-how and experience of TVO's approximately 800 experts. The capacity factors of OL1 and OL2 are among the best in the world, testifying to these skills and to the excellent condition of the plant units. During TVO's 40-year history the company has developed an uncompromising safety culture and safety is always the priority in its electrical power production. Olkiluoto is prepared for a fourth unit.



*Decades of excellent relations with our neighbours have resulted in broad regional and local support for TVO. As part of the licensing process for OL4, the EIA procedure involved wide-ranging discussions with local residents.*



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