BOHUNICE V2 NUCLEAR POWER PLANT

Clean energy

SLOVENSKÉ ELEKTRÁRNE

Enel

Enel Group
in Figures

Countries	Continents	Net installed capacity
40[1)]	4	98.7 GW

Electricity production	Electricity distribution	Electricity sales
296 TWh	414 TWh	317 TWh

Enel is an International Group active in 40 countries on four continents.

Among the listed utilities in Europe, Enel is the second-largest by installed capacity and one of the leaders in terms of shareholders' number, with 1.2 million investors. The Group is also present in the top rankings of world's largest utilities by market capitalisation.

Enel generates 296 TWh/year of electricity using a balanced mix of energy resources. The generation plants have a total capacity of 98,700 MW, with over a third provided by renewable sources of energy; use of the latter is increasing constantly, especially in North, Central, and South America. The Group distributes energy by 1.9 million km of power lines.

Moreover, Enel sells electricity to 56 million customers and gas to 5 million end-users, including residential and business customers.

Slovenské elektrárne is the Company in the Enel Group that operates in Slovakia.

Renewable installed capacity	Share of electricity without CO_2 emissions	Customers
36,673 MW	42%	61 million

Employees	EBITDA	Investments
73,537	16.7[2)] billion €	27.2[3)] billion €

Values as of 30 June 2013
Data source: Enel
Please refer to notes on inside back cover

Slovenské elektrárne
in Figures

Slovenské elektrárne, subsidiary of Enel Group, is the largest power generating company in Slovakia and the second largest in Central and Eastern Europe. It also generates and sells heat, and provides ancillary services to the power grid. Slovenské elektrárne has 5,739 MWe of installed capacity (31 December 2012) in an ideal production mix of nuclear, hydro and thermal sources. It operates 34 hydroelectric, 2 nuclear, 2 thermoelectric and 2 photovoltaic plants.

Installed capacity

5,739[4)]
MW

Electricity production

22
TWh

Electricity supply

20
TWh

Investments

682
million €

Human resources

4,794
employees

EBITDA

834
million €

Sales to final customers

4.6
TWh

Savings of CO_2 emissions from one Unit of NPP

4
mil. tonnes

Events according to INES scale

0[5)]
operational events

Values as of 31 December 2012
Data source: Slovenské elektrárne
Please refer to notes on inside back cover

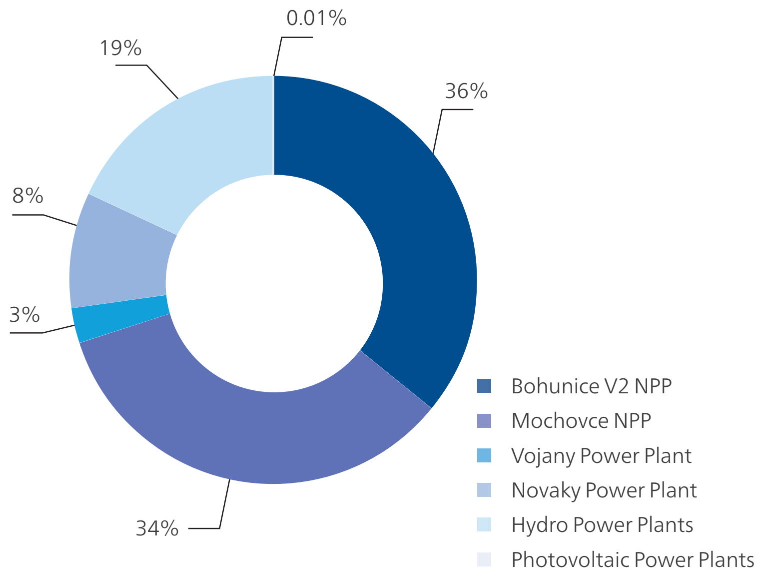



Nuclear
in Energy Mix

Nuclear power plants have a firm place in the global energy mix and their role is increasing with the reduction of fossil fuel reserves. Nuclear energy as a 'carbon-free' source has an irreplaceable role in terms of EU member states' commitment to reduce CO_2 emissions by 20% from 1990 to 2020.

Nuclear power plants emit no greenhouse gas into the atmosphere. In this way, NPPs annually contribute to CO_2 emission reduction by 800 million tonnes worldwide and by 15 million tonnes in Slovakia. Without nuclear–generated electricity, emissions in the EU would increase by two-thirds.

Electricity generated in 2012 (~22 TWh)



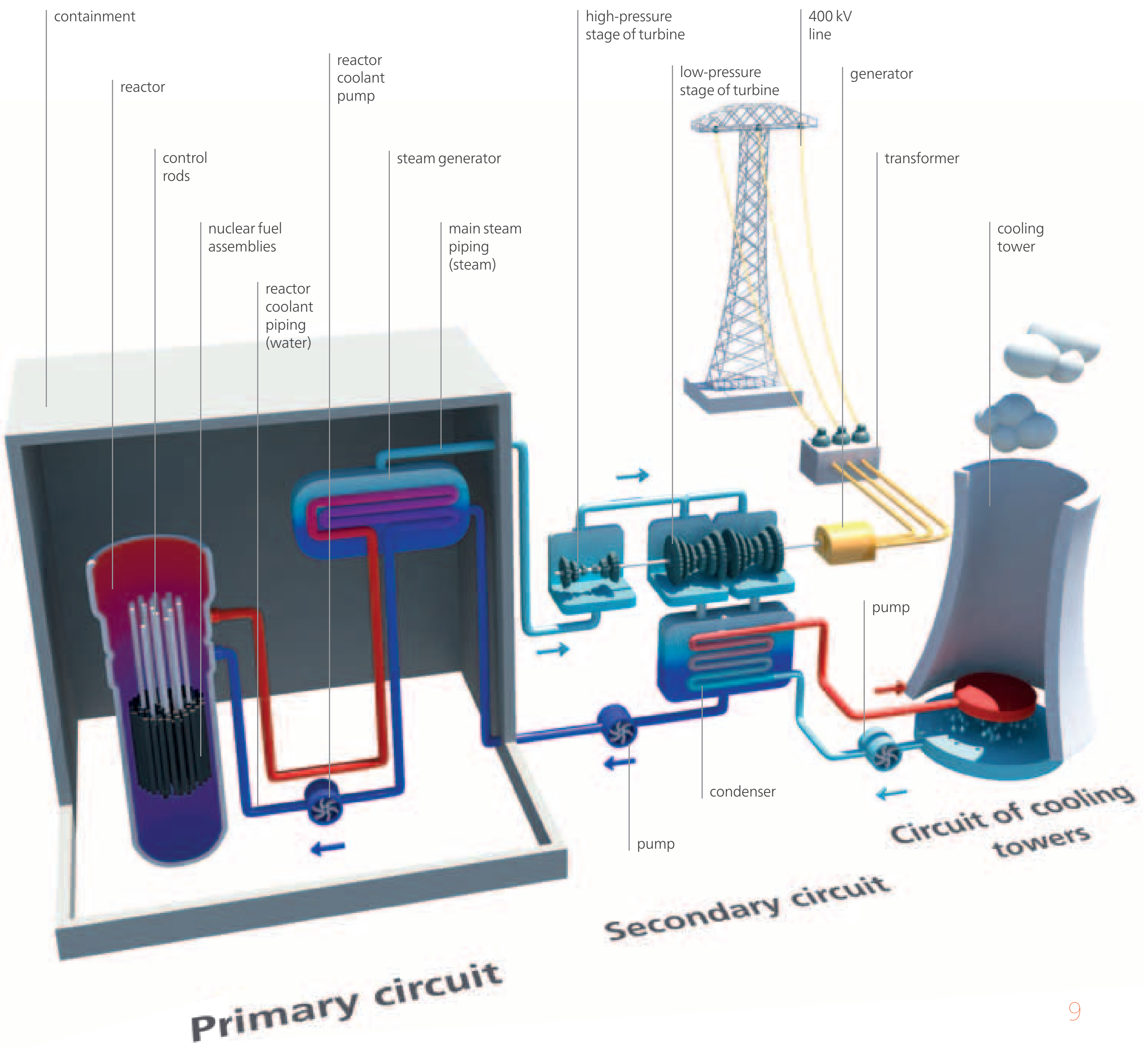
Slovenské elektrárne generates 89% of its electricity without GHG emissions

Electricity Generation

The principle of electricity generation in a nuclear power plant is quite similar to a conventional fossil fuel plant – the main difference is in the source of heat which is then converted into electricity. In conventional power plants, the heat source is a fossil fuel (coal, gas, biomass), while in nuclear power plants the heat source is nuclear fuel.

There are fuel assemblies inside the reactor. The coolant (chemically treated water) flows through channels in the fuel assemblies and removes heat generated in the fission reaction.
The heated water of the primary circuit passes from the reactor at the temperature of about 300°C and is conveyed to heat exchangers – steam generators. Here, the primary water transfers the heat removed from the core to the colder water of the secondary circuit. Both circuits are hermetically separated. Cooled primary water returns to the reactor; the secondary circuit water evaporates in the steam generators. High-pressure steam produced in this way is led into turbines where it strikes turbine blades and causes them to rotate. The turbine shaft is connected to the generator which produces electricity. After expanding in the turbine, the steam condenses in the condenser and returns back to the steam generator as water. The condenser is cooled by the third cooling circuit – in cooling towers. Water evaporated from cooling towers is compensated from the nearby Váh River. In this way, there is no possibility for direct contact between the primary water cooling the reactor and water returned to the environment in the form of steam from the cooling towers.

Thermal scheme of VVER 440/V-213



Nuclear Fuel Cycle

The nuclear fuel cycle is a series of industrial processes which involves the production of electricity from uranium fission in nuclear power plants. Uranium is a relatively common element - a slightly radioactive metal that occurs in the Earth's crust. It is about 500 times more abundant than gold and about as common as tin. It is present in most rocks and soils as well as in rivers and in sea water. It must be processed before it can be used as fuel for a nuclear reactor.

1. Uranium Mining & Treatment

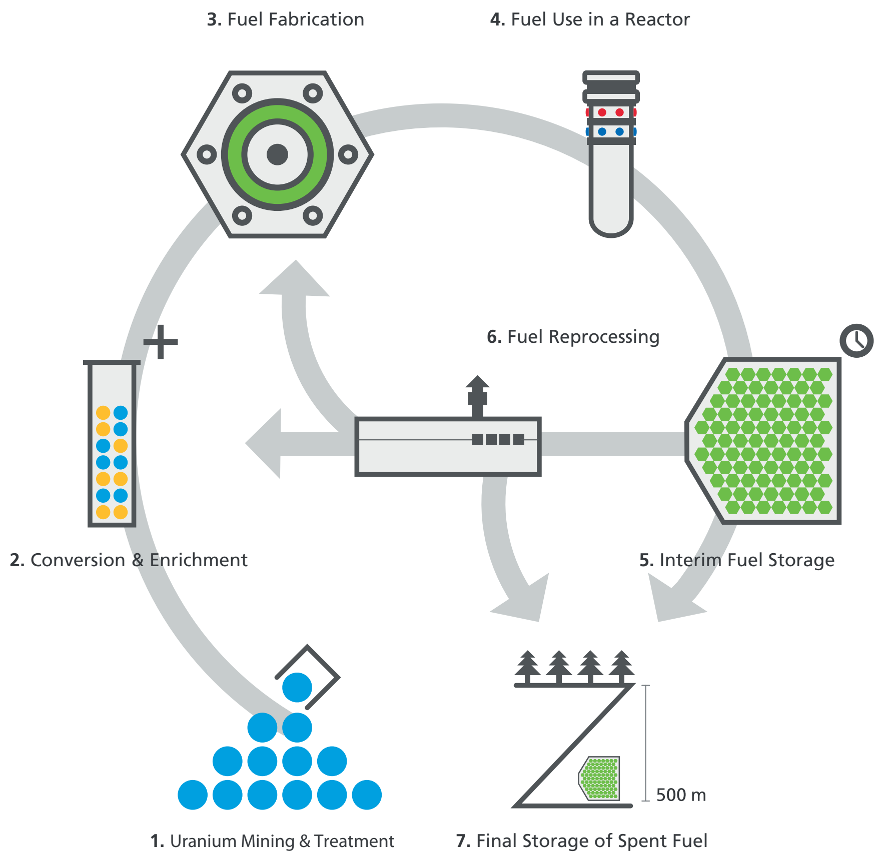
Uranium ore is extracted in underground or open-pit mines. The ore may contain from 0.1% to 3% uranium. The greatest amounts of uranium ore are extracted in Canada, Australia, and Kazakhstan. Through crushing and chemical treatment (leaching), the so-called 'yellow cake' is obtained, which contains more than 80% uranium.

2. Conversion & Enrichment

Uranium compounds present in the yellow cake are converted into gaseous form (uranium hexafluoride – UF_6) suitable for the enrichment of uranium 235. Uranium, which is present in natural resources, consists primarily of two isotopes: U-238 and U-235. There is only a very small concentration of fissionable U-235 in natural uranium 238 (0.7% on average). Therefore, it is necessary to enrich its concentration in the fuel up to 4.95%. The use of centrifuges is the most common commercial process of enrichment.

3. Fuel Fabrication

UF_6 is chemically treated to form UO_2 (uranium dioxide) powder. It is then pressed and sintered at a high temperature (1,400°C) into ceramic-pellet form, which is hermetically encased in zircalloy tubes. A fuel rod is formed of 126 tubes. The operation of one VVER-440 reactor requires 7 to 9 tonnes of uranium fuel. Fresh nuclear fuel does not pose any significant risk as it is a weak source of radiation and is activated only in a nuclear reactor.



4. Fuel Use in a Reactor

The energy released by the fission of uranium in a reactor is removed by the coolant (water) and then converted into electricity in a turbine generator. Fuel in the reactor must always be flooded with water, otherwise it might become overheated. At temperatures above 1,500°C the fuel cladding starts melting, at temperatures above 2,500°C even the fuel melts down. Some of the U-238 in the fuel is turned into plutonium in the reactor core. The main plutonium isotope is also fissile and this yields about one-third of the energy in a typical nuclear reactor.

5. Interim Fuel Storage

After 5 to 6 years of operation in the reactor, the spent fuel is moved to a spent-fuel pool immediately adjacent to the reactor. There it is cooled and its radiation level decreases. Water provides an excellent radiation shield and absorbs residual heat produced by the spent fuel. After 5 years of cooling, the spent fuel can be transported to the interim storage in Bohunice, where it is stored in water ponds. The construction of dry interim storage (special containers cooled only by natural air circulation) is being considered on the Mochovce site, too, thus eliminating future spent fuel transports.

6. Fuel Reprocessing

Spent fuel contains about 95% uranium, 1% plutonium and 4% highly radioactive fission products formed in the reactor. The fuel can be recycled in reprocessing plants, where it is separated into three components: uranium, plutonium and waste. Uranium and plutonium are used in fresh fuel containing a mixture of the fissile isotopes U and Pu (MOX fuel). The reprocessing process, however, is finance- and energy-demanding, therefore there are only a few reprocessing plants in the world. Spent fuel from Slovak NPPs is not reprocessed, but temporarily stored in interim storage.

7. Final Storage of Spent Fuel

At present there are no storage facilities available for the final disposal of spent fuel. Though studies of the optimal approach to the final disposal of spent fuel are in progress, there is no urgent need for a final solution as the total volume of spent fuel is relatively small and can easily be stored in interim storage. Furthermore, other options for using the spent fuel with new technologies are being investigated. A geological survey in Slovakia is being conducted to identify possible sites for final disposal. It is assumed that a final repository could be available by around 2030.

Safety
of V2 Units 3 & 4

The design of Units 3&4 of the Bohunice V2 NPP (type VVER 440 V-213) included a number of design improvements as compared to the older design of V1 Units 1&2 (type VVER 440 V-230), of which the most important was a new containment with a pressure suppression system.

International evaluations (IAEA, WANO) confirmed high safety level of the reactors in Slovakia.

VVER technology is based on a robust design, relatively low unit power, and high volumes of water in the cooling circuits. Therefore, the power plant is very effective in accident prevention and has inherently high level of nuclear safety.

A triple-redundancy design has been adopted for safety systems, which means that each plant safety system is actually replicated into three redundant, independent and fully-separated sub-systems, each of them being fully capable of performing the required safety function.

The power plant has a full scope simulator able to reproduce plant performance and behaviour for the effective training of control room operators.

3 x 100 %
safety systems

Modernisation
and Power Upgrade

The modernisation of V2 NPP units was triggered by increasing international safety requirements for the operation of NPPs. The objective of the modernisation and safety upgrade programme was to ensure that the operation is safe, reliable, and efficient.

Modernisation, carried out from 2002 to 2008 during planned shutdowns of the units, met the objectives in line with IAEA recommendations and in several cases the original requirements were not only met, but even exceeded. Moreover, from 2009 to 2013 the severe accident management measures (beyond-design accidents with fuel melting) were performed.

Due to the premature shutdown of two Bohunice V1 NPP units, it was necessary to look for a fast replacement of the lost production capacity. Based on the best international experience, Slovenske elektrarne has also adopted the approach of power upgrade at all the operated nuclear units, as well as the evaluation of long-term operation (LTO) possibility. The LTO programme is based on the positive results of component ageing management programmes. Recent results have established preconditions for the safe and reliable operation of the V2 units for 60 years.

The nominal reactor power of Bohunice NPP V2 Units 3&4 was increased by 7% in 2010 (from 1,375 MWt to 1,471 MWt). Along with conventional island modifications the electric output was increased up to 505 MWe of each unit that covers approximately 10% of household consumption in Slovakia.

The nominal reactor power
was increased by 7%
in 2010

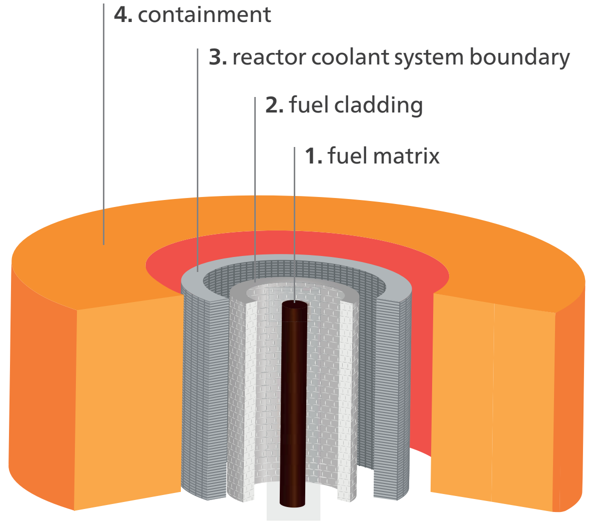
Containment

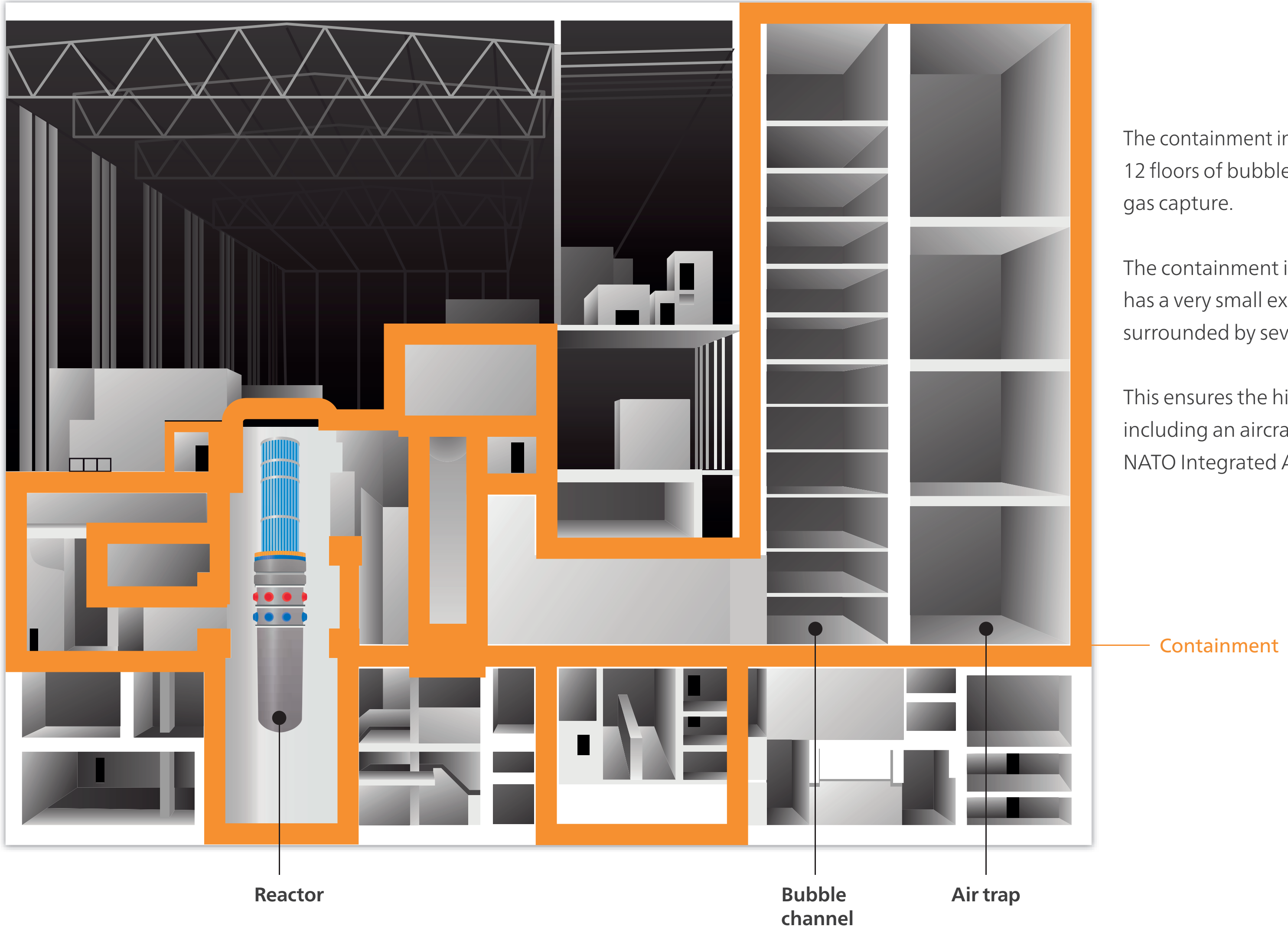
Both Bohunice V2 units are equipped with reinforced concrete protective shell (containment) system of the nuclear island fully capable of minimising the scope of any off-site radiological accident consequences.

The containment capability to withstand accidents is supported by extensive studies and tests performed at the European level.

This type of containment functions on the principle of condensing the steam released from the reactor coolant system in case of a piping rupture, thus reducing pressure inside the containment.

Containment is one of the four barries preventing the leak of radiation into the environment





The containment includes a bubble condenser system composed of 12 floors of bubble channels for condensing steam and 4 air traps for gas capture.

The containment is made up of 1.5 m-thick reinforced-concrete walls, has a very small exposed surface, is favourably site-integrated, and surrounded by several civil structures.

This ensures the highest level of protection against external hazards, including an aircraft crash. Moreover, the Slovak Republic is a part of the NATO Integrated Air Defence System covering air threats.

Containment walls are

1.5 m thick

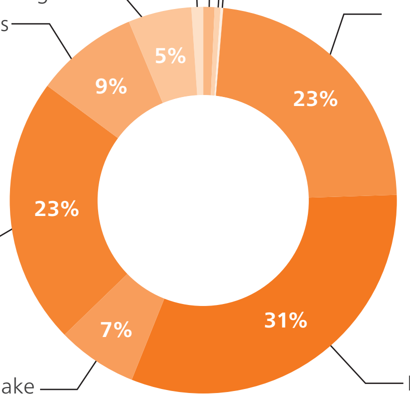
Radiation

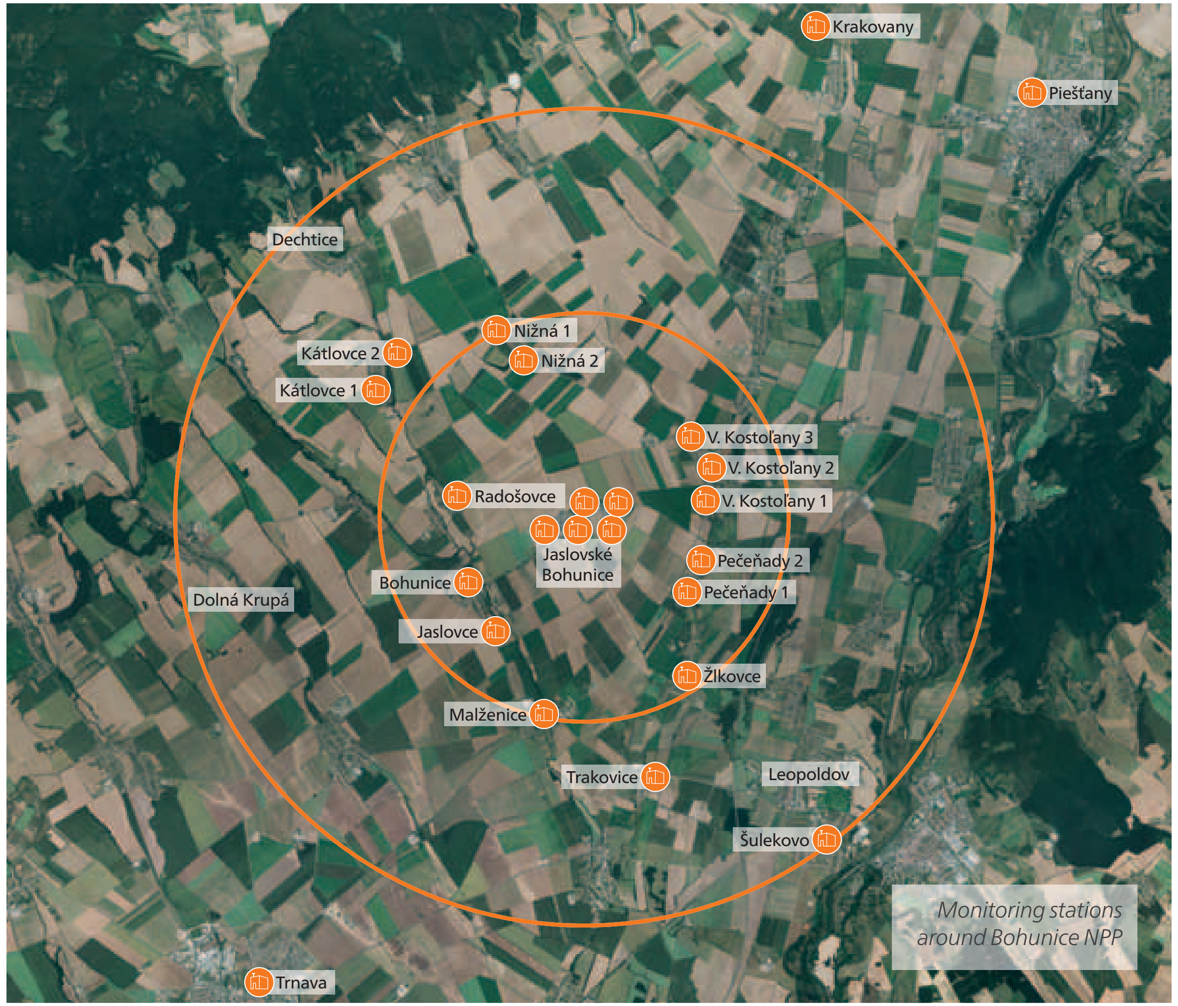
Protection

For radiation protection of the power plant staff and population, the ALARA principle is applied. This principle ensures that the radiation exposure inside and outside the power plant is As Low As Reasonably Achievable and well below the limits set by legislation.

The impact of the NPP operation on the environment and human health is negligible with respect to other radiation sources present in everyday life. There are 24 monitoring stations of the tele-dosimetry system in the 20 km radius around the power plant, which continuously monitors the dose rate of gamma radiation, volume activity of aerosols and radioactive iodine in the air, soil, water and food chain (feed, milk, agricultural produces). The volume of radioactive substances contained in liquid and gaseous discharges is considerably lower than the limits set out by authorities.

Overall human radiation exposure





NPP contribution to overall human radiation exposure

0.001%

One Unit saves

4 mil. t

CO_2 emissions every year

Environment

Nuclear power plants are environmentally friendly and contribute significantly to the obligation to reduce the emission of harmful gases into the atmosphere.

Environmental protection relates to all aspects of life and its level directly or indirectly influences quality of life. Environmental protection at nuclear power plants focuses on waters, wastes, air and serious industrial accidents. Environmental impacts are minimised through the introduced Environmental management system that is a part of Integrated management system.

Nuclear plants produce a small amount of radioactive waste. One unit annually produces approximately 17 m^3 of liquid and 15 tonnes of solid low-activity waste and 8 tonnes of spent fuel. Liquid and solid radioactive waste is treated at the Bohunice Treatment Centre. Treated waste is stored in fibre-concrete containers in the National Radioactive Waste Repository in Mochovce.

The water required for cooling is taken from the Sĺňava water reservoir built on the nearby Váh River.

Stress
Tests

Immediately after the Fukushima accident, European politicians, representatives of the nuclear industry and regulatory bodies agreed on the undertaking of power-plant safety reviews. All 15 member states of the EU operating nuclear power plants were involved. The testing of the two Bohunice NPP V2 units and all four Mochovce NPP units was carried out mainly through engineering analyses, calculations and reports.

Stress tests analysed extraordinary external events – earthquakes, floods, and impacts of other events that might result in the multiple loss of power-plant safety functions. The combination of events, including loss of power supply, long-term water supply breakdown, as well as loss of power supply due to extreme climate conditions were also assessed.

Stress tests revealed no deficiencies requiring immediate action; the further safe operation of the operating units was put in doubt.

Over 55 years of experience in nuclear energy,

and 5,000 job opportunities in Slovakia

Benefits for the Region

Nuclear power plants are the pillar of the Slovak power industry, supplying over 50% of electricity to the grid and contributing to international commitment of Slovakia in reducing the greenhouse gas emissions.
Bohunice NPP has been generating and distributing eco heat since 1988. Annually it supplies approximately 2,000 TJ to towns of Trnava, Hlohovec, Leopoldov and Jaslovské Bohunice village by hot water pipelines.
In order to improve and make communication with the public more transparent, regional associations of municipalities were established at Mochovce and Bohunice regions, who nominate members to Civic Information Committees. Those are in direct contact with the power plants management. Visitor centres are also available for the broad public at both locations.
The Company supports local projects in the areas of culture, education, nature, sport, and the social area through the Energy for the Country programme.

Basic Figures

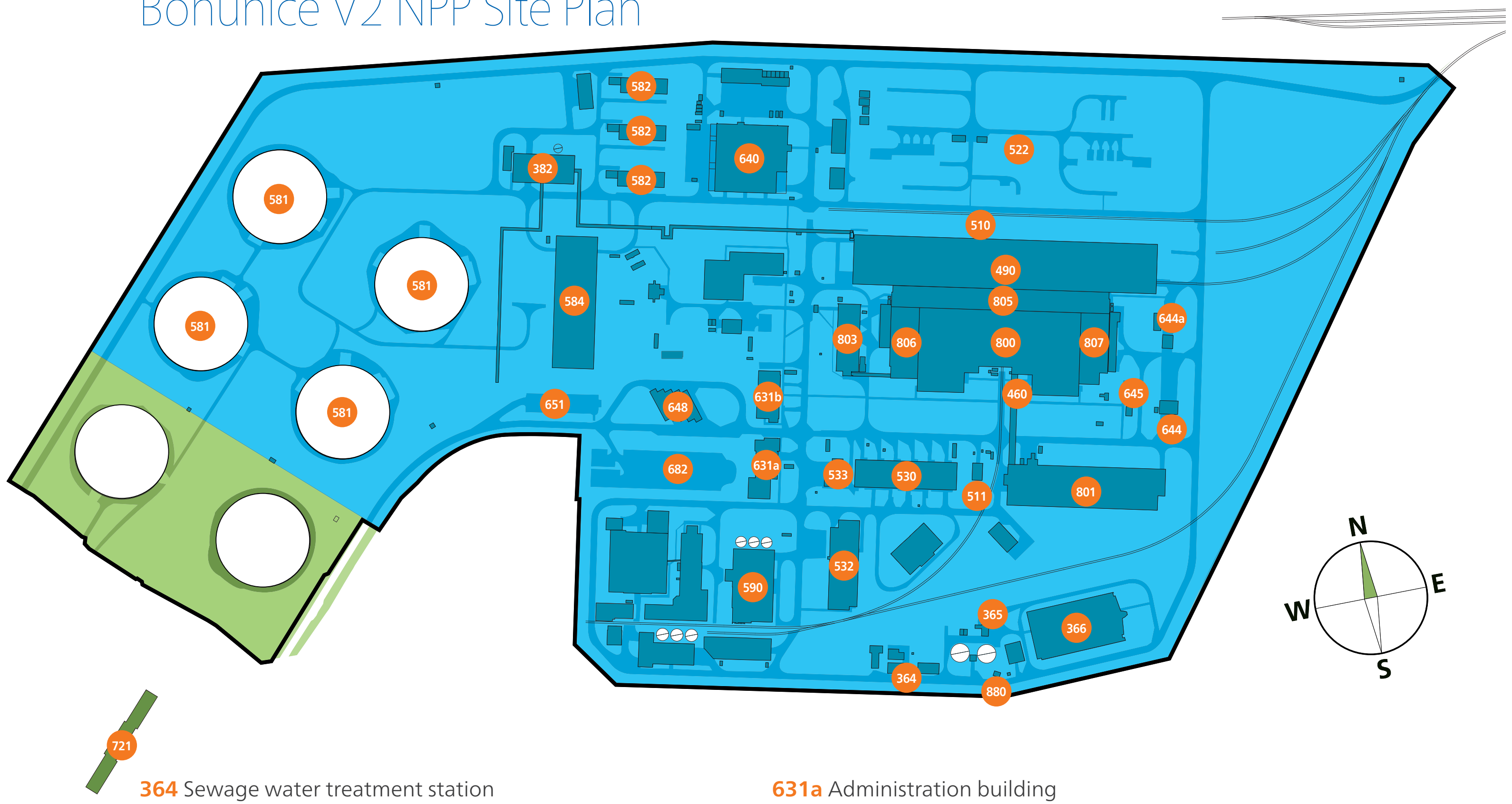
	Units 3&4
Reactor type	PWR – pressurised water reactor VVER 440/V-213
Reactor thermal power	1,375 MWt*/1,471 MWt**
Electrical gross power	440 MWe*/506 MWe**
Primary circuit	6 loops
Working pressure/temperature:	12.26 MPa/268 – 298°C
Reactor pressure vessel (h/ø)	11,800 mm/3,840 mm
Secondary circuit	
Steam generator (6 per unit)	PGV - 213
Volume of steam generated per 1 PG	483 tons per hour
Steam pressure and temperature at SG outlet	4.83 MPa/261.8°C
Turbine generator (2 per unit)	253 MWe
Generator rated power	273 MVA
Terminal voltage	15.75 kV
Rated current	3 x 10,007 A
Tertiary circuit	
Max. temperature of cooling water	33°C
Height of cooling towers (4 per 2 units)	120 m

** original upgrade ** after power upgrade*

Bohunice NPP History

	A1	V1	V2
Start of construction	1958	1972	1976
Start of operation	1972	1978/1980	1984/1985
End of operation	1977	2006/2008	–
Modernisation	–	1992 – 2000	2002 – 2008
Power upgrade	–	–	2009 – 2013

Bohunice V2 NPP Site Plan



364 Sewage water treatment station
365 Nuclear island industrial water pumping station
366 Retention tanks
382 Central heat source exchange station
460 Venting stack
490 Turbine generator hall
510 External transformers area
511 Transformer station
522 110 kV, 200 kV and 400 kV external switgears
530 Dieselgenerator station
532 Compresor station
533 HP compressor station
581 Cooling towers
582 Fan-type cooling towers
584 Central pumping station
590 Control centre building
631a Administration building
631b Canteen
640 Maintenance workshops
644 Hydrogen storage
644a Oxygen storage
645 Nitrogen storage
648 Bus terminal
651-682 Parking
721 Building of investors
800 Reactor building
801 Auxiliary building
803 Operation building
805 Longitudinal electrical building
806 Unit 3 transversal electrical building
807 Unit 4 transversal electrical building
880 Waste water measurement

1) It includes all countries where the Group has at least 1 MW in capacity or where sales activities are carried out.
It also includes the countries where the Enel Group has business relations, projects in progress or representative offices.
2) Data os of 31. 12. 2012.
3) Cumulative investment plan in the period 2013-17, of which EUR 10.7 billion in development. Total CAPEX does not include connection fees.
4) Installed capacity, gross production and net electricity supply including Gabčíkovo HPP (VEG). VEG is owned by Vodohospodárska výstavba, š.p., and operated by Slovenské elektrárne.
5) International Nuclear Events Scale.

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