PROJECT:

Long Term Operation of Krško Nuclear Power Plant (2023 – 2043)

(The lifetime extension of Krško NPP from 40 to 60 years)

Krško, 14 October 2021, rev. 3

TITLE:	**PROJECT: LONG TERM OPERATION OF KRŠKO NUCLEAR POWER PLANT (2023 – 2043)**
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History of changes

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Rev.2	20 September 2021	- changes include the actual state of the installation. In 2021 a series of changes to the building were completed that are the result of post-Fukushima campaigns.
Rev.3	14 October 2021	- minor textual corrections, harmonisation of terminology and the meaning of abbreviations, updating of references - quantities of radioactive waste and spent fuel given for the same year, end of 2020

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Abbreviations:

AAF	Alternative Auxiliary Feedwater
AMP	Aging Management Program
ARRS	Slovenian Research Agency
ARSO	Slovenian Environment Agency
ASI	Alternative Safety Injection
BB1,2	Bunkered building 1 or 2
BS OHSAS 18001:2007	Occupational health and safety management system according to the standard
CAMP	Code Applications and Maintenance Program
CDF	Core Damage Frequency
CSARP	Cooperative Severe Accident Research Program
CT3	Cooling Towers
CW	Circulating Water System
DB	Design Basis Accident
DBF	Design Basis Flood
DEC TS	Design Extension Conditions Technical Specification
DEH	Digital Electro Hydraulic
DG3	Diesel Generator 3
EES	Electrical power grid
ENSREG	The European Nuclear Safety Regulators Group
EPRI	Electric Power Research Institute
ETS	Emissions Trading System
EU	European Union
FHB	Fuel Handling Building
GALL	Generic Aging Lessons Learned
HTS	High Temperature Seals
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
SF	Spent fuel
INPO	Institute of Nuclear Power Operations
IPCC	The Intergovernmental Panel on Climate Change
ISEG	Independent Safety Engineering Group
ISO 14001:2015	Environmental management system
ISO 45001:2018	Standard for occupational health and safety management systems
JV5	Rules on Radiation and Nuclear Safety Factors
JV9	Rules on the operational safety of radiation and nuclear installations
LOCA	Loss of Coolant Accident
LTO	Long Term Operation
MAAE	International Atomic Energy Agency, see IAEA
MD1	Safety bus 1
MD2	Safety bus 2
MOP	Ministry of the Environment and Spatial Planning
NEA	Nuclear Energy Agency
NEK	Krško Nuclear Power Plant
NEK MD-2	Management system – Process organisation
NECP	Integrated National Energy and Climate Plan of the Republic of Slovenia
NOMIS	Nuclear Operation and Maintenance Information System
LILW	Low- and intermediate-level radioactive waste
NUMEX	Nuclear Maintenance Experience Information System
NZIR	Protection and Rescue Plan
OSART	Operational Safety Review Team
OE	Operating experience
OECD	Organisation for Economic Co-operation and Development
OPC	Operative support centre
OSART	Operational Safety Review Team

OVD	Environmental permit
RES	Renewable energy sources
OVS	Environmental Protection Consent
PAR	Passive Autocatalytic Recombiners
PB	Pretreatment building
PCFVS	Passive Containment Filtering Vent System
PDEH	Programmable Digital Electro Hydraulic
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood
PNV	Safety Upgrade Program
POD	Extension of NEK's operational lifetime from 40 to 60 years, i.e. until 2043
PP	Preliminary procedure
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PVO	Environmental impact assessments
PW	Pretreatment Water System
PWROG	Pressurized Water Reactor Owners Group
RW	Radioactive waste
RETS	Radiological Effluent Technical Specification
RH	Republic of Croatia
RNO	(radiologically) supervised area in accordance with ZVISJV-1
RS	Republic of Slovenia
RTP	Distribution Transformer Station
RWSB	Radioactive Waste Storage Building
SAMG	Severe Accident Management Guidelines
SBO	Station Blackout
SFDS	Spent Fuel Dry Storage
SFP	Spent fuel pool system
SK	Supercompacting
SOER	Significant Operating Experience Report
SSC	Structures, systems and components
SV	Sanitary Drain System
SW	Essential service water system
GHG	Greenhouse gases
TPC	Technical support centre
TS	NEK Technical Specifications
PVO Decree	Decree on activities affecting the environment that require an environmental impact assessment
USAR	Updated Safety Analysis Report
U.S. NRC	United States Nuclear Regulatory Commission
URSJV	Slovenian Nuclear Safety Administration
VVA	Probabilistic safety analyses, see PSA
VZD	Occupational health and safety
ZVISJV-1	Ionising Radiation Protection and Nuclear Safety Act
ZVO-1	Environment Protection Act
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association
WMB	Waste Manipulation Building
WOG	Westinghouse Owners Group

1. Summary

With an output power of 696 MWe, Krško Nuclear Power Plant (hereinafter: NEK) produces approximately 38% of total Slovenian electricity, which is about half of all low-carbon electricity in Slovenia.

In 1983, NEK commenced commercial operation. At the time of construction, a minimum operational lifetime of forty years was envisaged for the facility. However, a number of safety and other upgrades, including numerous analyses, were carried out which indicate that from the point of view of climate protection, the reduction of greenhouse gas (GHG) emissions, phasing out the use of fossil fuels, safety and economy, the extension of NEK's operational lifetime would be a prudent solution that is also recognised globally. Technical conditions have therefore been put in place for NEK to operate for at least another twenty years, i.e. to the end of 2043.

NEK operates on the basis of an operating licence [3] that is directly related to the NEK safety analysis report [2], and contains all the conditions and limits for the power plant's safe operation. NEK has a valid open-ended operating licence, meaning it is technically capable of operating at least until 2043, provided that, in accordance with the applicable legislation, it performs a Periodic Safety Review (PSR) every ten years and obtains approval from the administrative body, the Slovenian Nuclear Safety Administration (hereinafter: URSJV). NEK is obliged to ensure all aspects of the power plant's safe operation.

NEK operates in accordance with all the regulations of the Republic of Slovenia and within the operating limits and conditions set out in the Ionising Radiation Protection and Nuclear Safety Act (hereinafter: ZVISJV-1) and subordinate acts, the operating licence [3], NEK Technical Specifications (TS [9], RETS [11] and DECTS [10]), water permits ([5], [6] and [7]), environmental permit [4] etc. The extension of the operational lifetime will enable NEK to remain in operation for a further 20 years, i.e. until 2043, within the same limits, and not exceed any existing legal requirements or restrictions.

The continual upgrades and modifications that have been carried out ensure a level of safety that is significantly higher than what was in place at the time the power plant was built. The established safety standards and requirements, which are much stricter for the nuclear industry than for any other technology currently in place for the production of electricity, make nuclear technology the safest way of producing electricity known to mankind [57].

In accordance with decision no. 35405-286/2016-42 of 2 October 2020 [1], issued by the Slovenian Environment Agency (ARSO), NEK must obtain the Environmental Protection Consent (OVS) to extend its operational lifetime from 2023 to 2043. The process for obtaining the OVS runs in compliance with the Environmental Protection Act (ZVO-1) [40].

In the process for the acquisition of the OVS it is necessary to comply with the provisions of the Aarhus [43] and Espoo [42] Conventions, which means that the transboundary assessment will also be carried out.

2. Introduction

2.1. General observations on NEK

Nuklearna Elektrarna Krško d.o.o. with an output power of 696 MWe produces approximately 38% of total Slovenian electricity, which ranks NEK at the very top of Slovenian electricity producers. In accordance with the bilateral treaty, NEK exports half of the electricity it produces to the Republic of Croatia [30]. The production of electricity is in the base-load mode (constant operation at full power) and ensures the stability of the power grid. As NEK does not release any greenhouse gases during electricity production, it is classed as a low-carbon production facility. The Slovenian share of the electricity produced by NEK accounts for roughly one half of total low-carbon electricity in Slovenia.

NEK operates in compliance with the following: Approval to commence NEK operation, the decision by the Energy Inspectorate of RS No. 31-04/83-5 of 6 February 1984, amendment to NEK operating licence, decision by the Slovenian Nuclear Safety Administration (hereinafter: URSJV) no. 3570-8/2012/5 of 22 April 2013 [3], and NEK Updated Safety Analysis Report (hereinafter: USAR) [2].

2.1.1. Safe, reliable and competitive production of electricity

NEK commenced commercial operation in 1983. At the time of construction, a minimum operational lifetime of forty years was envisaged for the facility. However, a number of safety and other upgrades, including numerous analyses, were carried out and indicated, in terms of safety and economy, that the extension of NEK's operational lifetime would be a prudent solution that is also recognised globally. These upgrades and analyses created the technical conditions for NEK to operate for at least a further twenty years, i.e. until the end of 2043.

NEK’s main priority is to ensure reliable and safe operation under any conditions. Since its construction, NEK has carried out a number of upgrades to enhance the safety and efficiency of the facility. These upgrades also ensure the environmental compliance of production. The production effects of many years of investment are reflected in greater efficiency of production processes, resulting in an increase in electricity production, i.e. from 4.5 TWh/year to 5.45 TWh/year. This significant increase can be attributed to the extension of the nuclear fuel cycle to 18 months, shortening regular outage times, preventive replacement of equipment and updates to work processes. Said increase in production, which on average brings an additional 1,000 GWh/year in electricity production without direct CO_2 emissions, is equivalent to the optimal annual electricity production by all eight hydropower plants in the lower part of the Sava.

NEK operates safely and meets the strictest environmental and industrial standards.

2.1.2. Nuclear safety is the main priority

Safety is always prioritised at nuclear power plants. The current international safety standards and requirements are much stricter for the nuclear industry than for any other technology currently in place for the production of electricity. In order to meet all these requirements, existing nuclear power plants have numerous and diverse nuclear safety systems in place, which over three generations of their development have achieved a very high level of reliability and efficiency. Nuclear technology complies with the latest international safety standards, which is why it is now the safest way of electricity production known to man [57].

Compliance with and meeting the outlined safety requirements in the nuclear industry is subject to established international and national monitoring procedures in the form of different inspections and international assessment missions.

Many international missions, which focus on all aspects of operation with the greatest emphasis on ensuring nuclear safety, regularly assess NEK. Inspections are carried out by: The International Atomic Energy Agency (hereinafter: IAEA), the World Association of Nuclear Operators (hereinafter: WANO or INPO) and others. After the WANO safety review, NEK was categorised into the first performance class as one of the best nuclear power plants on a global scale.

During the last 10 years, the following missions have taken place at NEK:

a special safety review (EU stress tests) in 2012, IAEA – Topical Peer Review Ageing Management in 2018, OSART (Operational Safety Review Team) organised by the IAEA in 2017, and the WANO Peer Review in 2014 and 2018.

Special Safety Review (EU stress tests)

In the framework of the EU stress tests conducted by the European Commission following the Fukushima accident in March 2011 NEK was the only nuclear power plant in Europe with no issued recommendations, which placed it at the very top of European power plants. The results of the report show that NEK is well designed and built and, taking into account its additional available equipment, it demonstrates a high preparedness level in case of severe accidents. NEK carried out an in-depth analysis of beyond design-basis accidents and drafted the Safety Upgrade Program [25]. The Safety Upgrade Program that has been approved by the Slovenian Nuclear Safety Administration [26] comprises a number of improvements and additional systems for managing beyond design-basis accidents. Following the implementation of the safety upgrade program, NEK will be comparable, in terms of safety, with the newer types of nuclear power plants that are currently being built around the world.

One of the major safety upgrades in progress is the construction of a dry storage building for spent fuel. The dry storage system allows spent fuel to be transferred into special canisters and storage casks that provide passive cooling and shielding against ionising radiation.

Safety reviews by the International Atomic Energy Agency (OSART)

In 2017, the International Atomic Energy Agency (hereinafter: IAEA) already conducted its fourth Operational Safety Review Team (hereinafter: OSART) mission. As Slovenia is a member of the IAEA, the Government of the Republic of Slovenia must approve formal procedures, such as an invitation sent to such a mission. The Slovenian Nuclear Safety Administration (hereinafter: URSJV) reports to the Government on findings and submits the OSART mission report to it. Three such missions have been carried out at NEK in the past: in 1984, 1993 and 2003.

In the report, the OSART mission members emphasised that after the 2017 OSART mission NEK systematically analysed all given recommendations and proposals, and prepared a plan of corrective actions. The OSART mission has concluded that the implemented measures, as well as those in progress, fully meet the recommendations and proposals given by the original OSART mission. The URSJV regularly checks the implementation status of the OSART measures in additional meetings and inspections. All measures were implemented by mid-2019.

WANO Peer Review in 2014 and 2018

In 2014, the World Association of Nuclear Operators (hereinafter: WANO) conducted a comprehensive operational review. NEK received the highest overall rating for nuclear safety and operational preparedness. This was already the fourth verification of this type (the previous ones took place in 1995, 1999 and 2007).

In the last review in 2018, the mission members highlighted the above-average implementation of the recommendations originating from international operational experience and achievements in the field of safety culture, which represents a set of principles that serve as guidance on the work procedures at nuclear facilities and are considered the foundation of safe and stable operation.

The performance and quality of the full scope training simulator for operating personnel was pointed out as an example of good practices for other nuclear power plants.

The highest overall assessment for nuclear safety and operational efficiency represents NEK's additional commitment to further improvements in the field of management, communication, internal policies, work-related expectations and cooperation in order to meet all expectations.

2.2. The long term operation of NEK in connection with Slovenia's future energy supply

To ensure reliable energy supply, Slovenia will have to combine different sources of electricity, which, in terms of their efficiency and considering their spatial impact, will be sufficient to cover the estimated future electricity consumption. Due to the planned increase in electrification of traffic (use of electric vehicles), heating (use of heat pumps), and the electrification and phasing out the use of fossil fuels in other sectors, Slovenia will require an ever-increasing share of stable electricity. According to estimates [14], [15], the deficit in electricity will continue to rise in Slovenia (for several years now, Slovenia has been importing electricity to cover about 20% of its consumption). By 2030, Slovenia will have a deficit of at least 1 TWh/year of electricity in the context of NEK's envisaged operation, regardless of development of technology, significantly more efficient consumption of electricity and intensive introduction of new renewable energy sources (RES). As a result, Slovenia should either import this energy deficit or provide it by constructing new power plants, which in such a short time cannot even be spatially planned, let alone built and put into operation.

In compliance with the Paris Agreement and the UN Framework Convention on Climate Change, the EU has set itself the goal of reducing greenhouse gas emissions by 40% by 2030 relative to 1990, which means a 36% reduction in GHG emissions relative to 2005. In compliance with the regulation on binding emission reductions for EU Member States, Slovenia has committed itself to reducing its GHG emissions in sectors that are not included in the Emissions Trading System, by at least 15% by 2030 in relation to the level of 2005. Alongside the target for 2030, the regulation also determines a linear trajectory, which taking into account the flexibility defined in the regulation, must not be surpassed. The Integrated National Energy and Climate Plan of the Republic of Slovenia (NECP) [14] determines higher goals concerning the reduction of non-ETS GHG emissions by 2030, i.e. by at least 20% relative to 2005.

Thermal power plants and heating plants are included in the Emissions Trading System. The goal for reducing emissions EU-wide by 2030 for the Emissions Trading System is 43% relative to 2005. In accordance with these targets, the production of electricity by fossil fuel power plants should also be reduced, as the ever increasing cost of CO_2 emissions will dictate the economic viability of the operation of these plants. Fossil fuel power plants are expected to be shut down in the future as they will no longer be able to compete with low carbon technologies.

In December 2019, the European Council expressed its support for the goal of EU climate neutrality by 2050. The common goal of reducing greenhouse gases on an EU level is becoming more ambitious and has increased from a 40% to 55% reduction in emissions by 2030 relative to 1990. The Effort Sharing Regulation increases goals for Members States in the non-ETS sector, there is an ongoing discussion.

In light of the aforementioned facts, NEK's operation is gaining importance, as it does not need fossil energy sources for operation and does not release any greenhouse gases during operation.

During the procedure to prepare the NECP, which for the period until 2030 (with the vision stretching forward to 2040) determines goals, policies and measures for decarbonisation, energy efficiency, energy security, the internal energy market and research, innovations and competitiveness, it was decided that the strategic environmental impact assessment (SEA) had to be carried out, including an acceptability assessment for the nature conservation areas, and that the strategic environmental assessment report and Appendix for assessment of the acceptability for nature conservation areas had to be prepared.

In the SEA procedure, carried out for the NECP, a strategic environmental assessment report was prepared [16], which defines, describes and evaluates the impacts of implementation of the plan on the environment, and possible alternatives, taking into account the objectives and geographical characteristics of the area covered by the plan. The acceptability of influences of the plan on the conservation area was also evaluated. It was found that the influences are acceptable, taking into account mitigation measures outlined in the plan (NECP).

On 28 February 2020, the Government of the Republic of Slovenia approved the NECP, which envisages the extension of NEK's operational lifetime beyond 2023. Both scenarios (scenario with the existing measures and the NECP scenario) envisage that NEK continues to produce electricity.

With the Resolution on Slovenia's Long-Term Climate Strategy until 2050 (Official Gazette of RS, No. 119/21) Slovenia is setting itself the goal of achieving zero emissions, i.e. climate neutrality by 2050. The Resolution determines that the strategic sectoral target in reducing GHG emissions and increasing energy sinks is to reduce GHG emissions by 90-99 % by 2050 relative to 2005. For the adopted guidelines and measures until 2030 the Resolution summarises the National Energy and Climate Plan. The main guidelines until 2050 determine areas in which measures are to be taken, which alongside the measures for efficient energy use, circular economy and other measures to reduce energy needs, will be crucial for Slovenia on the road to achieving the goals of climate neutrality. They include the domain of nuclear energy, whereby Slovenia is planning on the long term use of nuclear energy.

3. Description of the present state in 2021

3.1. NEK's location, siting (spatial positioning), overview of parcels

NEK is located in the Municipality of Krško, southeast of the town of Krško, in the cadastral municipality of Leskovec, at the address Vrbina 12, Krško, in the area of long-term energy use on the left bank of the Sava. NEK is located at latitude: 45.938210 (north) and longitude: 15.515288 (east) or 45.5617556 (north) and 15.3055037 (east) in WGS-84 coordinates and by Gauss-Kruger coordinates x = 88353.76 m and y = 540326.67 m.

When Krško polje was recognised as a potential location for the construction of a nuclear power plant, a work team of the Slovenian Energy Association carried out the initial research in the period from 1964 to 1969. The investors of the first nuclear power plant were Savske elektrarne Ljubljana and Elektroprivreda Zagreb, which together with the investment group carried out preparatory works, made a call and selected the most favourable bidder.

In August 1974, the investors entered into a contract with the American company Westinghouse Electric Corporation for the supply of equipment and construction of a 632 MW nuclear power plant. The nuclear power plant was designed by Gilbert Associates Inc., the contractors at the construction site were the domestic companies Gradis and Hidroelektra while the assembly was performed by the Hidromontaža and Đuro Đaković companies.

On 1 December 1974, the foundation stone was laid for the Krško Nuclear Power Plant. In February 1984 NEK acquired the permit for regular operation [3].

The area has good road and rail connections as it is located near the intersection of regional roads and in the immediate vicinity of the railway line. The nearest residential areas are located northeast (buildings in Spodnji Stari Grad), at a distance of approximately 700 m, north (buildings in Spodnja Libna) at a distance of approximately 850 m and approximately 1.4 km southwest (Žadovinek) from the site of the planned activity.

The nearest kindergartens (Vrtec Krško, Vrtec Dolenja vas) are located more than 2 km northeast and northwest, the nearest primary school (Osnovna šola Leskovec pri Krškem) about 2.6 km west and the nearest secondary school (Šolski center Krško-Sevnica) 2.2 km northwest of the NEK location. The Krško Retirement Home is more than 2 km away from the site.

The terrain is flat and the site of the planned activity is at altitude ca. 155 m.

North of the location the following manufacturing companies operate:

- SECOM d.o.o., principal activity: 22.230 (Manufacture of products from plastic for construction);
- GEN energija d.o.o., principal activity: 64.200 (Activities of holding companies);
- GEN-I d.o.o., principal activity: 35.140 (Electricity trading);
- Saramati Adem, d.o.o., principal activity: 41.200 (Construction of residential and non-residential buildings).

East of the location the following companies operate:

- KOSTAK d.d. Center za ravnanje z odpadki (IED installation), principal activity: 36.000 (Water collection, treatment and supply).

At a distance of 800 - 2,000 m from the location, there are three IEDs: VIPAP VIDEM KRŠKO d.d., KRKA d.d. and KOSTAK d.d. (IEDs are installations that can cause large-scale pollution). There are currently no installations with upper-tier or lower-tier major accident hazard (Seveso) in the area of Krško.

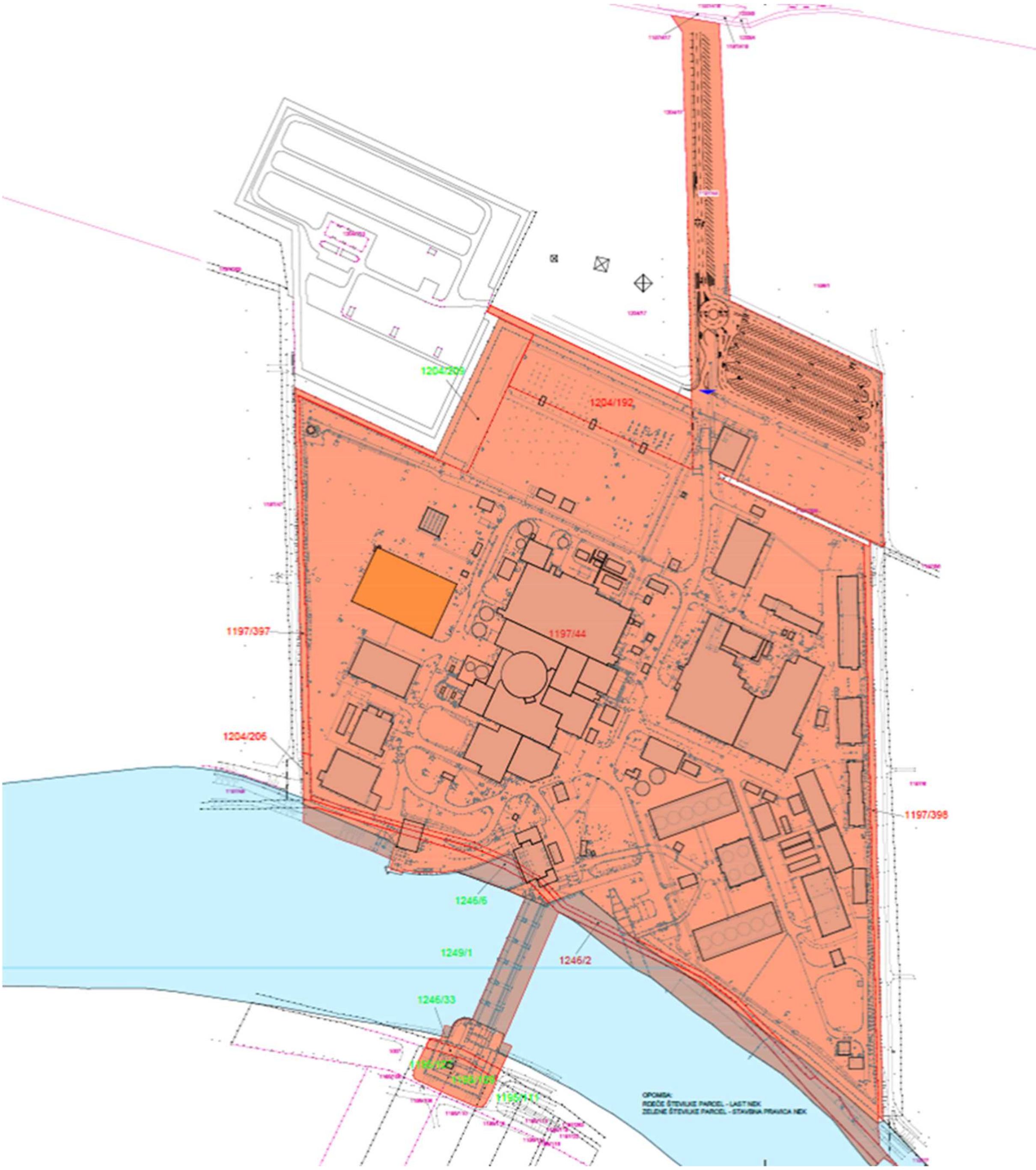


Figure 1: Plan view of reviewed buildings

OPOMBA:	NOTE:
RDEČE ŠTEVILKE PARCEL – LASTNIK	RED PARCEL NUMBERS – OWNER
ZELENE ŠTEVILKE PARCEL – STAVBNA PRAVICA NEK	GREEN PARCEL NUMBERS – NEK SUPERFICIES

The area of impact assessments encompasses the following parcel numbers in cadastral municipality 1321 Leskovec:

- plots owned by NEK: 1197/44, 1204/192, 1197/397, 1246/2, 1197/398 (partly) and 1204/206 (partly)
- parts of plots, on which NEK holds building rights: 1204/209, 1246/6, 1249/1, 1246/33, 1195/107, 1195/109, 1195/111.

Spatially, NEK is regulated by the Land-use plan for Krško Nuclear Power Plant (Official Gazette of SRS, No. 48/87, Official Gazette of RS, No. 59/97 and Official Gazette of RS, No. 21/2020).

3.1.1. Seismic safety

The Reactor Site Criteria 10 CFR 100 App. A, which were applied in the design and construction of NEK, require that structures, components and systems of importance for nuclear safety be designed and constructed as earthquake-resistant structures, which is also in accordance with Slovenian legislation (JV5 Rules, [69]). The buildings and systems of NEK are designed to resist earthquakes in accordance with RG 1.60. Originally a design basis earthquake was considered for a safe shut-down of the power plant (SSE) with 0.3 g peak ground acceleration (PGA) at its foundations. All the buildings were designed with the assumption that the foundations are on the surface, which turned out to be a very conservative assumption. This is one of the key assumptions which gives NEK its high level of earthquake safety and which was already proven in the set of seismic probabilistic safety assessments [75].

After the end of the extensive probabilistic safety analyses for earthquakes [75], which also included a seismic hazard analysis of the NEK site, the studies for potential locations for LILW and Krško NPP2 (JEK2) in the direct vicinity of NEK involved extensive additional geological, geotechnical and seismological research. This research focused on individual geological structures (earthquake sources and faults), with the aim of better understanding the seismic-tectonic structure of the Krško basin and reducing uncertainties in input data for determining the seismic hazard of the location and setting a basis for estimating possible capable faults. The set of preliminary conclusions of this multidisciplinary research carried out in the broader area of the location for constructing Krško NPP2 (JEK2) since 2008 [76], [77], produced no indications of the possibility of capable faults that could, in the event of an earthquake, permanently deform the surface of the location, and there were no new findings that could significantly change the existing estimate of seismic hazard at the NEK site, which was produced in the years 2002-2004 after 10 years of previous research [78].

The stress tests at NEK [20] proved that accelerations during an earthquake, in which impacts on the structures and systems of the power plant could be expected, are significantly higher than the design basis accelerations, which proves the high level of nuclear and seismic safety of NEK nuclear facilities. Subsequently, seismic and nuclear safety were additionally enhanced through the provision of mobile equipment and connections to it, the construction of the third diesel generator DG3 and the implementation of the power plant safety upgrade program. All new buildings and systems constructed as part of the power plant safety upgrade program on the main nuclear island are designed for a peak ground acceleration at surface that is twice the design basis acceleration at foundation of the existing NEK facilities and systems (i.e. 0.6 g). The new buildings and systems built outside the main island (a specially reinforced safety building, the new technical support centre) as well as the spent fuel dry storage facility, which is still under construction, have been designed to resist a 30% greater peak ground acceleration (0.78 g), allowing for any uncertainties in the analysis of seismic hazards. On the basis of the analysis of seismic hazards for the NEK site [76] earthquakes are to be expected with PGAs of 0.56 g and a return period of 10,000 years.

The stress test report provides an estimate of the seismic magnitude at which damage to the core, the containment and the cliff edge effect could occur. Peak ground accelerations at which damage to the reactor core could occur have been estimated in the range of 0.8 g peak ground acceleration. Ground accelerations at which large and early releases could occur should be higher than 1.0 g PGA. Any subsequent filtered releases could occur in the range of ground accelerations between 0.8 and 0.9 g. The integrity of the spent fuel pool would not be compromised up to ground accelerations measuring more than 0.9 g [20]. Seismic analyses have shown that earthquakes with a PGA greater than 0.8 g are very rare at the NEK site and their expected return period is estimated at more than 50,000 years. [20].

In compliance with US regulatory guidelines, NEK has installed seismic instrumentation (11 sensors) for earthquake shock detection to allow a comparison of response spectra (calculated from the measured accelerograms) with the design basis response spectra at the locations of individual sensors. If the peak ground acceleration at open surface exceeds 0.01 g, the sensors record ground motion from the earthquake. If such an event occurs, all critical parts of the power plant are checked after the earthquake. If the earthquake intensity, expressed with peak ground acceleration on the open surface, exceeds half the maximum design basis acceleration, the power plant shuts down as a precaution and is restarted only after confirmation that the earthquake has not caused any damage to buildings, systems or equipment of the power plant.

3.1.2. Floods

Flood protection was envisaged in the plans for the power plant and embankments were constructed along the Sava, upstream and downstream of the power plant. The entrances and openings in the buildings are built above the altitude of anticipated 10,000 year floods. The power plant is safe in the event of a design basis flood, even without a protective embankment.

In addition to the design basis flood (DBF), the power plant is also protected against probable maximum floods (PMF) with appropriately designed intermediate structures placed between the Sava and the external installations, and the protective embankment against water intrusion into the area.

The area is also built to withstand extremely heavy local rain and storms by means of its basic design and a built-in drainage system. Further information is available in the stress test report [20]. The flood safety of NEK’s buildings is ensured also in the event of dam failure in any of the hydroelectric power plants located upstream.

Design Basis Floods (DBF)

NEK was designed to withstand floods that occur at a frequency of 0.01% per year (a flood with a return period of 10,000 years was determined on the basis of hydrological data from the period 1926 to 2000). The estimated maximum flow of the Sava in the event of such a flood would amount to 4,790 m^3/s, which corresponds to an elevation of 155.35 metres above the Adriatic Sea level (m.a.A.s.l.). The NEK plant yard is situated at elevation 155.20 m.a.A.s.l. The entrances and openings of the buildings in the NEK complex, located in the centre of the area, visible in the figure (Figure 2), are situated above the level of 155.50 m.a.A.s.l. This ensures that water cannot enter the buildings in the event of the Sava embankments failing.

Probable Maximum Flood (PMF)

In addition to design basis floods (a 10,000-year return period), NEK is also protected against probable maximum floods (PMF), in which the maximum flow of the Sava reaches 7,081 m^3/s. A PMF is a hypothetical flood considered to be the most severe, reasonably possible flood by using maximum probable precipitation and other hydrological factors, contributing to maximum water outflow, such as successive storms and simultaneous snowmelt. The elevation of a PMF of 7,081 m^3/s at the NEK dam amounts to 155.61 m.a.A.s.l. [2]. NEK is protected from PMF by flood embankments.

The cliff edge effect for floods is estimated for Sava flow rates that are 2.3 times higher than the design basis 10,000-year flood and 1.7 times higher than the PMFs. The annual probability for flows of this magnitude is estimated to be less than 10^{-6} [20].

A timeline of flood safety improvements at NEK since 2010

In 2010 the study entitled "Preparation of new revision of PMF study and Conceptual design package for flood protection" (FGG, 2010), [79] based on a large number of unfavourable precipitation scenarios, determined a PMF of 7,081 m^3/s in accordance with standard ANSI/ANS-2.8-1992 (ANS, 1992).

On the basis of this PMF evaluation, in 2012 NEK raised the flood embankments along the Sava in the length of 1,430 m and the Potočnica in the length of 460 m, which ensures an increased safety height of at least 75 cm based on study A. The elevation of the Potočnica embankment has been raised to 159.90 m.a.A.s.l., while the elevation of the Sava embankment measures between 158,82 m.a.A.s.l. at the new round-about and 157.18 m.a.A.s.l. at the NEK dam.

In compliance with the results of study NEKSIS-A200/081D: "Krško NPP – Measures for preserving NEK's flood safety, Study of Variants, Revision B (IBE, August 2015)" [80] the uncertainty of the hydraulic model, used to verify the effects of the construction of Brežice HPP and other infrastructure on and along the Sava on NEK's safety in the event of extremely high flows, meant it was necessary to undertake additional measures to improve NEK's flood safety.

In 2018 the second reconstruction of flood embankments along the Sava and the Potočnica was carried out on the basis of analyses of the study NEKSIS-A200/081D [80]. The elevation of the flood barriers along the Potočnica was raised by 0.5 m through the construction of a parapet wall on the embankment so the current level of protection is 160.10 m.a.A.s.l. The height of the embankment along the Sava was raised only by 10 cm on a 100 m stretch.

Calculations were made to determine the flow of the Sava where the water would reach the top of these raised embankments. The flow would be 11,130 m^3/s.

Before the reservoir for HPP Brežice was built, the flow that would overflow the embankments was 10,600 m^3/s.

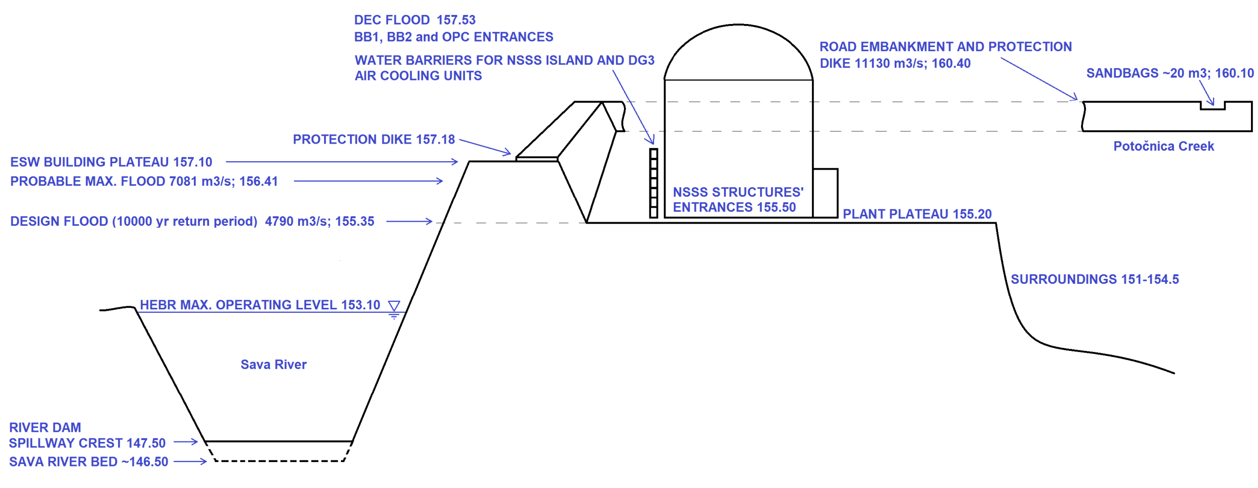


Figure 2: Flood protection

3.1.3. Other Extreme Weather Conditions

NEK has prepared a technical report entitled Screening of External Hazards [58], which provides a review of external hazards, i.e. all external hazards, except earthquakes, and all other hazards not included in internal events, internal floods, internal fires and high-energy pipe breaks.

External hazards, included in the screening, are summarised from the report EPRI– Identification of External Hazards for Analysis in WENRA Issue T: Natural hazards, Guidance Document [59].

A review of external hazards has shown that all external hazards were duly taken into account in the NEK analyses and procedures, so no amendments to the existing model of probabilistic safety assessments (PSA) are necessary.

All external hazards (except air crashes, external floods, strong winds, ice and extreme drought, which are quantitatively assessed) have been reviewed and sorted on the basis of certain criteria, so no separate further assessment of their quantitative contribution to the core damage frequency (CDF) has been required. In NEK ESD-TR-18/16, Screening of External Hazards [58], 104 external events are defined. The design basis values, i.e. protection against significant extreme weather conditions are described in the table below.

Table1: Extreme Weather Conditions

Extreme Weather Conditions	Design basis values
Strong winds	Safety buildings are designed to withstand winds of up to 140 km/h. The expanded design basis values demand the resistance of new DEC SSC to strong winds with maximum speeds of up to 240 km/h.
Extreme temperatures (low, high)	Design basis safety equipment and buildings are designed for temperatures ranging from -28 °C to 40 °C. The newly fitted DEC safety equipment and buildings are designed for lower/higher external temperatures (-35,1°C/+46°C).
Lightning strike	NEK's lightning conductors are designed for a 10,000 year return period (current of up to 400 kA; specific lightning strike density of 1.4 km^2/year).
Snow and glaze ice	NEK's structure and systems are built to withstand heavy loads (from 120 kg/m^2 to 375 kg/m^2).

3.2. NEK technology

NEK produces heat through the fission of uranium nuclei in the reactor. The reactor consists of the reactor vessel with its fuel elements which constitute the core. In the primary circuit, demineralised water with boric acid circulates through the reactor. Under pressure it carries the released heat into the steam generators. In the steam generators on the secondary side, steam is produced which drives the turbine and this in turn drives the electricity generator. When the steam leaves the turbine it condenses in the condenser which is cooled by water from the Sava. The condensate is then pumped back into the steam generators where it again turns into steam. Water from the Sava flows through the condenser (the so-called tertiary loop), where it makes the steam condense and rejects surplus energy into the river. All the reactor equipment and that of the corresponding primary cooling loop is located in the reactor building which is also called the containment building because of its function.

The reactor vessel containing the fuel elements is tightly closed and under high pressure during operation. The power plant's operation must be shut down and the reactor coolant system cooled down when the planned refuelling is to be carried out. The period between two refuellings is called the fuel cycle, which lasts 18 months at NEK. After the end of each fuel cycle the spent fuel elements are replaced with fresh ones. A fuel element usually stays in the core for at least two fuel cycles.

3.2.1. Primary Circuit

The primary circuit consists of: the reactor, steam generators, reactor coolant pumps, pressuriser and piping.

The heat released in the reactor core heats the water which circulates in the primary circuit. The heat of the water is transmitted through the walls of the pipes in the steam generators to the water in the secondary circuit. The circulation of the water in the primary circuit is ensured by the reactor coolant pumps. The pressuriser maintains the pressure in the primary circuit and thereby prevents the water from boiling at the core. All components of the primary circuit are installed in the containment that isolates the primary system from the environment, even in the event of an incident.

3.2.2. Secondary Circuit

The secondary circuit consists of: the steam generators, turbine, generator, condenser, feed water pumps and piping. The steam generators are in fact boilers in which water from the secondary circuit evaporates to steam to power the turbine. In the turbine the energy from the steam is converted into mechanical energy. The generator converts this energy into electricity and transfers it to the electricity grid via transformers.

Spent steam from the turbine flows into the condenser where in contact with cold pipes it condenses, i.e. is converted into water. The feed water pumps pump the water from the condenser back into the steam generator where steam is again produced.

3.2.3. Tertiary Circuit

The tertiary circuit consists of: the condenser, cooling pumps, cooling towers and piping. The tertiary circuit is intended for cooling the condenser and removing the unused (surplus heat) into the Sava. The cooling pumps draw the water from the Sava into the condenser and then discharge it back to the river. When the water flows through the condenser, it heats, as it absorbs the heat from the spent steam. Heating the river water is the power plant’s most significant impact on the environment as it can affect the biological properties of the Sava. This impact is limited by administrative decisions specifying the permitted temperature increase [4] and the amount of water intake [5], [6], [7]. In the event of adverse weather conditions, the cooling towers are used. In extremely unfavourable weather conditions, the power of the nuclear power plant has to be reduced to keep the set values within the specified limits.

3.2.4. Basic technical data about the facility

Basic technical characteristics are contained in the tables below: Table 2 – Table 8.

Table 2: Basic data about the power plant

Reactor type:	Pressurised light-water reactor
Reactor thermal power:	1994 MW
Gross electric power:	727 MW
Net electric power:	696 MW
Thermal efficiency:	36.6%

Table 3 Basic data about the fuel

Number of fuel elements:	121
Number of fuel rods in a fuel element:	235
Fuel rod array:	16 x 16
Fuel rod length:	3.658 m

Cladding material:	Zircaloy-4, ZIRLO
Chemical composition of fuel:	UO_2
Total quantity of uranium:	48.7 tonnes

Table 4: Basic data about the reactor coolant

Chemical composition:	H_2O
Additives:	H_3BO_3
Number of cooling loops:	2
Pressure:	15.41 MPa (157 ata)
Temperature at reactor inlet:	287 °C
Temperature at reactor outlet:	324 °C

Table 5: Basic data about the control rods

Number of control rod assemblies:	33
Neutron absorber:	Ag-In-Cd
Composition percentage:	80-15-5 %

Table 6: Basic data about the steam generators

Material:	INCONEL 690 TT
Number of steam generators:	2
Pressure of steam leaving generator:	6.5 MPa (63.5 ata)
Steam flow rate from both generators:	1,088 kg/s

Table 7: Basic data about the turbine and generator

Maximum power:	730 MW
Inlet pressure of fresh steam:	6.4 MPa (63 ata)
Temperature of fresh steam:	280.7 °C
Turbine rotation speed:	157 rad/s (1,500 rot./min)
Steam moisture at inlet:	0.10%
Condensation pressure (vacuum):	5.1 kPa (0.052 ata)
Average condensate temperature:	33 °C

Rated power of generator:	850 MVA
Rated voltage:	21 kV
Rated frequency of generator:	50 Hz
Rated cos θ:	0.876

Table 8: Basic data about the transformers

Block transformers	
Rated power:	2 x 500 MVA
Voltage ratio:	21/400 kV
Unit transformers	
Maximum permitted continuous power:	2 x 30 MVA
Voltage ratio:	21 /6.3 kV
Auxiliary transformer	
Maximum permitted continuous power:	60 MVA
Voltage ratio:	105/6.3/6.3 kV

3.2.5. Safety systems

Safety systems prevent damage to the nuclear fuel and the uncontrolled release of radioactive substances into the environment in the event of accidents. A high level of attention has been paid to nuclear safety already in the phase when the reactor and power plant were being designed. The design of safety systems provides safety functions in all operational states, even in the event of specific equipment failure.

The nuclear power plant is in a safe state if **three basic safety conditions** are met at all times:

- effective core reactivity control (reactor power control),
- cooling of the nuclear fuel in the reactor, the spent fuel pool and in the spent fuel dry storage,
- confinement of radioactive substances (prevented release of radioactive substances into the environment).

The release of radioactive substances into the environment is **prevented by 4 successive safety barriers**:

- The **first barrier** is nuclear fuel (or fuel pellets) retaining radioactive substances within itself.
- The **second barrier** is a waterproof cladding that encloses fuel pellets and prevents leakage of radioactive substances from fuel.
- The **third barrier** is the primary system boundary (pipe walls, reactor vessels and other primary components) that retains radioactive water for reactor cooling.

- The **fourth barrier** is the containment that hermetically separates the primary system from the environment.

The basic objective of the first three barriers is to prevent radioactive substances from passing to the next barrier, while the fourth barrier prevents radioactive substances from being released directly into the power plant's surroundings.

Since the operation of safety systems in the event of a defect and failure or a very unlikely accident at a nuclear power plant is paramount, all safety systems are redundant (NEK has two trains of safety systems). To comply with safety conditions and maintain safety barriers, the operation of only one train of safety systems is always sufficient. Furthermore, all safety systems and their individual devices are systematically tested during the operation of the power plant and during regular outages.

3.2.6. Ensuring Safety Functions

During operational states, design basis accidents and design extension conditions, NEK must ensure the so-called critical safety functions:

- nuclear fuel reactivity control (and spent fuel in spent fuel pool and/or spent fuel storage),
- Heat removal from the core and spent fuel pool via the essential service water system (SW system), which cools the component cooling system (CC system) by drawing river water from the reservoir behind the dam through the heat exchangers. In this way residual heat both from the spent fuel pool and residual heat from the shutdown of the reactor is removed. The system is duplicated so each physically and electrically independent loop has a built-in heat exchanger and one pump with accompanying filters and valves. A third pump is also connected to the system via a connecting line, and it can be connected to either of the two cooling loops. The system enables residual heat to be removed both in normal shutdowns, as well as in states of emergency.
- The confinement of radioactive substances and the prevention of their uncontrolled release into the environment.

In ensuring safety functions, the following principles should be taken into consideration:

- the principle of defence in-depth;
- single failure criterion;
- the principle of independence;
- the principle of diversity;
- the principle of redundancy;
- the fail-safe principle;
- the principle of verified components;
- the principle of a graded approach.

NEK must regularly check the design basis which ensures the safety of the facility. A review of the design basis should also be performed during each periodic safety review and after operational events affecting radiation or nuclear safety, as well as upon releasing new important information about radiation or nuclear safety (e.g. site characteristics assessment, safety analysis and development of safety standards or practices).

In reviewing the design basis, deterministic and probabilistic safety analyses or engineering assessment are applied to identify needs and potential for improvement, whereby the design solutions are compared with the prescribed requirements and good practice. NEK uses the findings from these analyses in updating its systems and structures accordingly or implements other measures necessary for ensuring radiation/nuclear safety.

Moreover, by analysing design extension conditions, NEK ensures there are sufficient reserves available to prevent cases where a minor variation in a particular parameter could cause severe and unacceptable consequences, the cliff edge effect.

As part of its design changes and modifications, NEK also verifies the effect on existing design bases of the building or system/component. A review of changes to design bases is also the subject of the Periodic Safety Review (PSR), which is carried out every 10 years. If a possible effect is discovered, analyses are used to determine the type and form of the effect, and the necessary modifications of project bases are determined. Reviews are carried out in accordance with Article 19 of the JV5 Rules [69].

External and Internal Initiating Events

In the operation of a power plant, an initiating event is any event that can trigger a sequence of events (scenario) and can lead to undesirable consequences. Detailed data is available in the annual report of Probabilistic Safety Analyses [60].

General breakdown of initiating events:

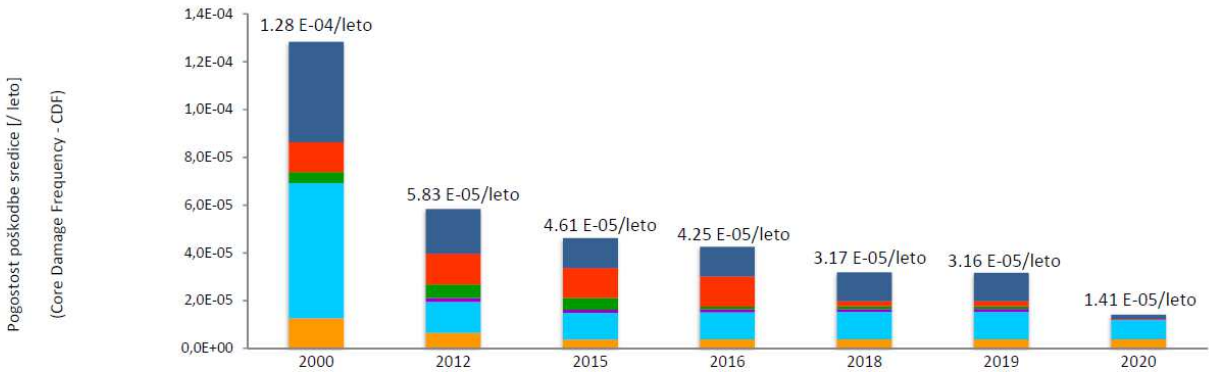
a. Internal Initiating Events (IIE)

   Internal initiating events are divided into the following categories:

   - LOCA category or primary coolant system piping break ("Loss of Coolant Accident");
   - The non-LOCA category includes: pipe break on secondary side, transients, loss of support systems, events with loss of off-site power supply and transients without automatic reactor scram.

b. External initiating events in the power plant and/or internal hazards, such as internal floods, internal fires and high energy line breaks (HELB).

c. External hazards/external initiating events outside the plant, such as seismic events, strong winds, external floods, human induced events (aircraft crashes, transport and industrial accidents) and other external events.



	2000	2012	2015	2016	2018	2019	2020
Notranji začetni dogodki	4,20E-05	1,87E-05	1,24E-05	1,24E-05	1,20E-05	1,18E-05	1,81E-06
Notranji požari	1,25E-05	1,28E-05	1,26E-05	1,26E-05	2,14E-06	2,14E-06	3,53E-07
Notranje poplave	4,53E-06	5,61E-06	4,87E-06	1,14E-06	1,13E-06	1,14E-06	9,03E-09
Visoko energijski izpusti		1,79E-06	1,39E-06	1,36E-06	1,24E-06	1,28E-06	2,82E-08
Seizmični dogodki	5,67E-05	1,29E-05	1,11E-05	1,12E-05	1,14E-05	1,14E-05	8,04E-06
Ostali zunanji začetni dogodki	1,26E-05	6,50E-06	3,73E-06	3,83E-06	3,83E-06	3,83E-06	3,83E-06

Figure 3: The history of core damage frequency due to internal initiating events, external initiating events from the power plant and external initiating events from the surroundings

Pogostost poškodbe sredice [/leto] (Core Damage Frequency – CDF)	Core Damage Frequency – CDF [/year]
1.28 E-04/leto	1.28 E-04/year
5.83 E-05/leto	5.83 E-05/year
4.61 E-05/leto	4.61 E-05/year
4.25 E-05/leto	4.25 E-05/year
3.17 E-05/leto	3.17 E-05/year
3.16 E-05/leto	3.16 E-05/year
1.41 E-05/leto	1.41 E-05/year
Notranji začetni dogodki	Internal initiating events
Notranji požari	Internal fires
Notranje poplave	Internal floods
Visoko energijski izpusti	High energy releases
Seizmični dogodki	Seismic events
Ostali zunanji začetni dogodki	Other external initiating events

The graph shows that in 2012 there is a decrease in frequency of core damage due to seismic events and internal events, which is the result of the installation of an additional safety diesel generator (DG3). DG3 is designed to withstand greater seismic burdens and this contributes to a lower CDF. In the same way the construction of an emergency control room in 2018 has reduced the core damage frequency due to internal fires.

3.2.7. Incident and Emergency Preparedness at the Nuclear Power Plant

Protection and Rescue Plan (NZIR)

NEK has prepared a special emergency plan. The Protection and Rescue Plan in NEK (referred to as: NZIR) [81] addresses a nuclear and radiological accident at NEK.

The main purpose of planning and maintaining a state of preparedness for an emergency is to ensure the protection, health and safety of the population in the surrounding areas and personnel at the nuclear power plant by preventing the emergency from deteriorating further and by eliminating or mitigating the consequences of the emergency and providing the conditions for the restoration of the normal state.

NEK is responsible for maintaining a state of preparedness and for taking action in an emergency on the power plant site, and also for informing the competent institutions concerning the emergency in the power plant to enable protective action in the surrounding area.

The purpose of NEK's NZIR is to define:

1. the scope of the planning, the prerequisites of planning and the response concept;
2. NEK task forces and organisation in the event of an emergency, with responsibilities and tasks for managing, coordinating and implementing measures to manage the emergency determined in advance;
3. additional support to NEK for emergency management;
4. emergency management measures, which comprise:
    - identification of the emergency's occurrence, hazard level classification and activation of first responders;
    - operative and corrective measures in the power plant in the event of an emergency;
    - measures in the power plant in the event of design extension conditions and strategies for handling non design basis accidents;
    - assessment of nuclear safety and the consequences of the emergency; proposals for immediate protective measures for the population;

- informing of commanders and personnel of Civil Protection (CZ) and other competent authorities in the surrounding area about the occurrence and status of the emergency, as well as about the proposed protective actions for the population in endangered areas;
- informing the public about the emergency;
- protective measures for the protection, rescue and assistance task force in the power plant;

5. NEK assets, centres, equipment and communication facilities for emergency management;
6. professional training of NEK personnel for emergency cases and external supporting personnel for carrying out tasks in emergency management as defined in NZIR;
7. how NEK personnel are informed about protection and other measures in the event of an emergency;
8. how preparedness is maintained, the coordination of NEK activities with competent local, regional and national authorities in ensuring preparedness and taking action in the event of an emergency;
9. how to establish the conditions necessary to restore the power plant to a normal state.

Considering the results of NEK safety analyses, it is estimated that radioactive substances that are accumulated in the reactor core and in spent fuel are the main hazard source for the environment.

Design Basis Accidents and Design Extension Conditions (DEC)

NEK plans and maintains preparedness for the entire range of emergencies that could or would result in compromising the nuclear safety of the power plant and the release of radioactive substances into the environment. This involves radiological accidents, power plant events or states that may have indirect impacts on nuclear safety in the power plant, nuclear accidents involving minimum radiological consequences in the environment and very unlikely design basis and beyond design basis nuclear accidents involving radiological consequences in the power plant and in the environment.

NEK was designed to withstand so-called design basis accidents and to manage them using its safety systems. In Section 15 ACCIDENT ANALYSIS and section 20. DESIGN EXTENSION CONDITIONS of the USAR [2] are described design basis and DEC accidents. In section 19 there is also a description of handling non design basis severe accidents (accident management). The purpose of the analysis of postulated design basis accidents is to set the requirements and acceptable criteria for systems, structures and components (referred to as: SSC). With these requirements, SSCs are able to ensure their safety function and the operating criteria during and after the event are defined. The purpose of all safety systems is to protect people from releases and radiation. NEK was designed in accordance with the 10 CFR 50, Appendix A, General Design Criterion 19 exposure limits. Furthermore, NEK is keeping track of global practice in the field of models upgrade and development to improve analyses in many technical reports. The FER-MEIS report "Calculation of Doses at Certain Distances for Design Basis Accidents (DBA) or Beyond Design Basis Conditions (BDB) at NEK" [56] reflects the estimated dose for design basis accidents at certain distances from NEK.

Following the Fukushima accident, NEK carried out a series of accident analyses involving design extension conditions. These accidents were not addressed in the original design of the power plant and/or as part of the design basis accidents. The analyses addressed the combinations of accidents, based on which an additional upgrade of the nuclear power plant was required (Design Extension Conditions – DEC). The upgrade took place as part of the Safety Upgrade Program (PNV), described in Section 3.3. The new additional systems installed within the PNV, ensure that NEK will manage beyond design basis accidents using the extended range of equipment and upgrades. The equipment was divided into DEC-A and DEC-B equipment.

NEK can use the DEC-A equipment to prevent the reactor core meltdown. The DEC-B equipment, however, was intended for managing the occurrence of a very unlikely core meltdown and focuses on protecting the final barrier before release, i.e. the integrity of the containment. The passive filter system (PCFVS) serves to relieve the pressure in the containment, while environmentally harmful substances remain trapped in the filters. A direct release into the environment upon core melting is thus very unlikely.

The estimated doses at different distances from NEK in the event of an emergency, where the use of the PCFV system would be foreseen, are given in the FER-MEIS report "Calculation of Doses at Certain Distances for DBA or Beyond Design Basis Conditions (BDB) at NEK" [56].

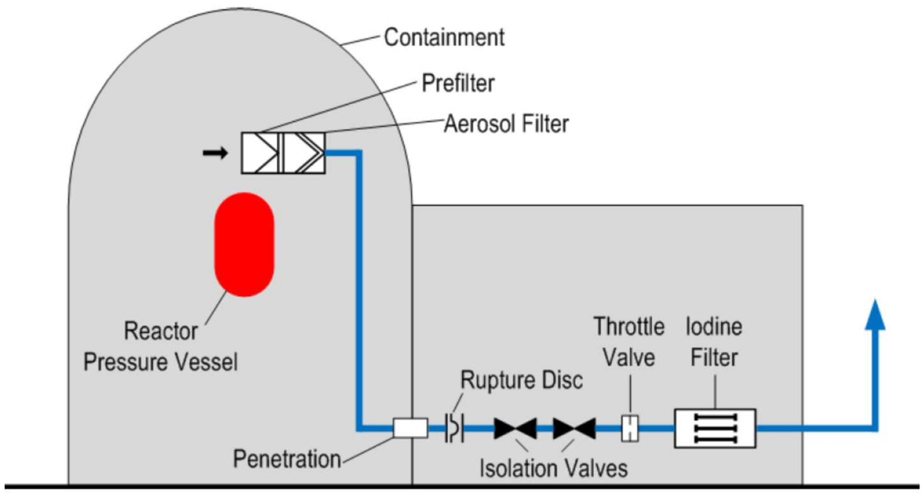


Figure 4: Schematic diagram of passive containment filtering vent system

Both approaches to design basis and beyond design basis accidents are an upgrade of US regulations and in compliance with the Slovenian Ionising Radiation Protection and Nuclear Safety Act (referred to as: ZVISJV-1) [45].

3.2.8. Aging Management Program

NEK has established an equipment aging program (referred to as: AMP) to monitor systems, structures and components (referred to as: SSC) during the operation of the power plant through the basic (40 years) and the extended operating period. The AMP program defines in detail the responsibilities, activities and methodology for monitoring equipment aging. The AMP program also foresees measures to reduce or eliminate aging impacts.

The AMP consists of various NEK programs, procedures and activities, which ensure that all planned functions of systems, structures and components managed by the AMP are identified and properly reviewed in terms of aging impacts. Aging impacts are closely monitored. The findings are used to determine actions that enable the SSC to fulfil their intended function until the end of NEK's operational lifetime, and also in the case of the power plant's operational lifetime being extended. NEK AMP is designed and compliant with the NUREG-1801 – Generic Aging Lessons Learned (GALL) Report. The AMP program thus comprehensively covers the plant aging, including mechanical, electrical and construction SSC, with which it systematically recognises the aging mechanisms and their impacts on the SSC that are important for safety, identification of possible consequences arising from aging and the determination of emergency measures towards maintaining SSC operability and reliability.

The actual control of SSC due to aging and other activities related to the control of equipment, which are indicated in the procedures, are carried out by way of the work order system and the preventive maintenance program.

The NEK aging program is thus based on 10 CFR 54 – "Requirements for Renewal of Operating Licences for Nuclear Power Plants". Other activities are controlled through the so-called Maintenance Rule (10 CFR 50.56) and the Environmental Qualification programs (10 CFR 50.49). The activities related to equipment replacement are included in the long-term investment plan and maintenance activities.

3.2.9. Fire safety

NEK has established a NEK Fire Safety Program - Fire Safety Rules [62], which determines: fire safety organisation, fire safety measures and control over how they are implemented, gives rules for handling in the event of a fire and specifies a training program to support successful fire protection.

NEK's buildings are separated from each other for fire safety. The buildings are divided into fire sectors whose purpose is to limit a potential fire to a smaller area and segregate redundant parts of safety systems. The distribution of safety systems into separate fire sectors, additional protection against spreading of the fire, automatic alarm and extinguisher systems, all reduce the effect of a potential fire on the working of the safety functions (USAR [2] section 9.5.1).

Both active and passive fire protection are implemented at NEK. Passive fire protection is ensured by means of structural and other measures, which reduce the probability of a fire occurring and prevent it from spreading between the fire sectors. Elements of passive fire protection include firewalls, sealed penetrations, fire doors and automatic fire dampers.

Active measures of fire protection are intended for extinguishing a potential fire. The systems installed at NEK which ensure active fire protection include: detection and alarm system, safety lighting, system for providing firewater, automatic sprinkler systems, smoke and heat removal systems.

The principle of in-depth defence is observed in the implementation of fire safety at NEK. In doing so, it is necessary to carry out the following actions in compliance with JV5 Rules [69]:

- measures that prevent fires from occurring,
- rapid detection, control and extinguishing of any fire, and
- reduce the possible impact of fire on critical safety functions of the power plant in a way which does not compromise the ability for a safe shutdown.

Fire safety measures are all the activities that ensure the minimum probability of a fire outbreak. These include: maintenance of order and cleanliness, control of works involving thermal effects, control of combustible substances, the fire permit, fire guard and fire barriers. Other precautionary and active fire safety measures involve fire-fighting procedures and actions for the operation, maintenance, testing and technical instructions of fire-fighting systems.

Furthermore, NEK has determined measures for prevention of explosion hazards and safety of combustible waste, electrical, gas appliances and other ignition sources, as defined in the Explosion Hazard Analysis.

Measures for safe evacuation and rapid intervention are also defined in case undesired events occur. These include the activities: suitable evacuation routes passable at all times, knowledge of the evacuation alarm, training, knowledge of the facility and understanding one's task during evacuation, adequate illumination of evacuation routes, etc.

Other preventive and active fire safety measures include fire-fighting procedures and activities for the operation, maintenance, testing and technical instructions of fire-fighting systems.

3.2.10. Radioactive waste

Ever since the beginnings of nuclear energy use in Slovenia, experts have been aware of both its benefits and risks. That is why both international and Slovenian nuclear energy is subject to very strict environmental, safety and ethical standards applicable to radioactive waste management. All radioactive material and objects containing radioactive substances are under constant surveillance from their generation to their disposal.

NEK keeps accurate records on the use of radioactive material. Someone is always responsible for radioactive waste from the moment it is generated until its final disposal. All these measures ensure the safe use of nuclear energy both now and in the future. In Slovenia we have already mastered the technology of safe treatment of all types of radioactive waste. This is why nuclear energy is an example of a sustainable energy source.

Gaseous Radioactive Waste

A gas mixture originating from the primary cooling system and containing radionuclides of noble gases or other elements in the form of vapours and aerosols is considered to be gaseous radioactive waste (referred to as: RW). It is stored in hold-up tanks for gas decay, in which their activity reduces over time due to natural radioactive decay.

Charcoal and high-efficiency particulate filters installed in the ventilation system filter the gases prior to their controlled release.

Spent charcoal filters become waste. If the filters are contaminated they are considered to be RW. If they are not contaminated they are handed over to an organisation authorised for the collection of such waste (in compliance with legal requirements).

Liquid Radioactive Waste

Liquids contaminated with radionuclides, the activity concentration of which exceeds the clearance levels for release from radiological control, are considered as liquid RW.

This type of waste represents a considerable share of the total amount of RW generated in the nuclear power plant, which is why it undergoes special treatment and preparation to reduce its volume. Several procedures and methods of liquid RW treatment are used, the choice depending on quantity and physicochemical properties. After treatment, two separate products are obtained: a concentrate with an increased concentration of radionuclides and a decontaminated liquid. The concentrate is further processed to assume a solid stable form suitable for transport and storage. The decontaminated liquid or water is either reused or released on the basis of radiochemical analyses, a special control and approval. The processes used for treating liquid RW at NEK are listed in the table below (Table 9).

Table 9: Processes used for treating liquid RW at NEK

PROCESS	Medium	FORM OF WASTE
Evaporating in the evaporator	Liquids	Sludge after evaporation (concentrate)
Ion exchange	Water containing ionic contaminants	Spent ion-exchange resins (dried)

PROCESS	Medium	FORM OF WASTE
Filtration	All liquids with particles	Cartridge filters

Solid Radioactive Waste

Solid RW is waste material whose specific activity exceeds the clearance levels for release from radiological control in accordance with the regulation governing radiation activities.

Depending on the level and type of radioactivity, solid RW is classified in the following categories: transient radioactive, very low-level radioactive, low- and intermediate-level radioactive waste (these are further classified in the subcategories of short-lived and long-lived), high-level radioactive and radioactive waste with natural radionuclides. The largest category in terms of quantity which consequently takes up the most space in NEK storage is the short-lived low- and intermediate-level radioactive waste.

Solid RW includes solidified and encapsulated RW (evaporation residues in silicate concrete), filters and contaminated solid waste, such as plastics, paper, cloths, personal protective equipment, tools and machine parts.

In accordance with the Decree on Radiation Activities [72] criteria are determined on the basis of which a large amount of waste whose activities are below clearance levels can be released from further regulatory control. By means of different measures (sorting, protection, decontamination, correct use, etc.) we can prevent or reduce the possibility of contaminating or activating materials and thereby reduce the generation of radioactive waste. If the specific activity and surface contamination of the material, which can be reused, processed, disposed of in the usual way or incinerated, does not surpass the clearance levels indicated in the Decree on Radiation Activities [72] (taken from European, IAEA and international standards), permission can be obtained from the URSJV, in compliance with Article 24 of the ZVISJV-1, for the release from regulatory control of such radioactive material, providing that all required criteria for the planned release from regulatory control are fulfilled.

Substances and objects that do not get contaminated during their use in the radiologically controlled area, and/or may be removed from the area in small quantities after being radiologically controlled, are treated in accordance with the procedure: Removal of Equipment, Tools, Clean Substances and Samples from NEK's radiologically controlled area. The procedure determines the radiological control of clean equipment, tools and clean materials, which the user or responsible person wants to take out of the radiologically controlled area to use without restrictions. This also includes small quantities of material in the form of samples for further analysis.

Before the equipment and tools are taken out, the surface contamination of external and internal surfaces is checked. Before clean materials, which have not been used and are not contaminated are taken out, their specific activity and surface contamination of the packaging are verified. This is carried out with a portable detector or with the monitor for small items at the exit of the radiologically controlled area which measures activity. The packaging of the sample must not be contaminated and must be resistant to impacts and suitable for transport. Unconditional removal is allowed only when the level of surface contamination and specific activity are below the prescribed limit in compliance with the Decree on Radiation Activities [72].

In accordance with the Decree on Radiation Activities [72] criteria are determined on the basis of which a large amount of waste whose activities are below clearance levels can be released from further administrative control. This is implemented in accordance with the following procedure: Request for the release from radiological control of waste.

The volume of non-solidified solid RW is reduced using mechanical and chemical processes, the choice depending on the waste properties. The table (Table 10) shows the processes that are used to reduce the volume of non-solidified solid RW.

Table 10: Processes for reducing the volume of non-solidified solid RW

PROCESS	SUBSTANCES FOR WHICH THE PROCESS IS USED	REDUCTION FACTOR
Compaction using a low-pressure press into a drum	Fabrics, plastics, metal, cables, small equipment/tools etc.	≤ 4
Supercompaction of drums	Fabrics, plastics, paper, metal, smaller metal parts etc.	≤ 10
Incineration	All combustible substances	≤ 30
Pyrolysis	Combustible substances, ion exchangers	≤ 60
Melting	Metals	≤ 10
Cutting, crushing	All substances	≤ 2

Waste is stored within the NEK perimeter fence in the radioactive waste storage building (RWSB) and described in Chapter 11 of the USAR [2], entitled RADIOACTIVE WASTE MANAGEMENT. The stored waste meets special storage criteria that comply with the Rules on Radioactive Waste and Spent Fuel Management [71]. These Rules regulate the classification of radioactive waste according to radioactivity level and type, radioactive waste and spent fuel management, the scope of reporting on radioactive waste and spent fuel generation, and the manner and scope of keeping central records on radioactive waste and spent fuel generation, and keeping records on stored and disposed radioactive waste and spent fuel.

3.2.11. Spent fuel

Since it began operating, NEK has stored all spent fuel (referred to as: SF) inside the fence encircling the power plant's technological section. The power plant's original design foresaw the storage of SF in the spent fuel pool (SFP) in the fuel handling building (FHB). The removal of residual heat from the SF takes place via the active cooling system of the spent fuel pool. The set of safety upgrades that were carried out included an improvement for the alternative cooling of the spent fuel pool.

An analysis of possible improvements to the storage of spent fuel was part of the response to the Fukushima accident by the nuclear industry and administrative bodies. It follows from the conclusions of analyses by NEK and the decisions of the Slovenian Nuclear Safety Administration that due to new safety requirements, the introduction of dry storage for spent fuel constitutes an important safety upgrade. No device, system or energy source is needed for cooling and operation with this kind of storage as it works passively.

The main purpose of the dry storage building for spent fuel is a technological upgrade of the temporary SF storage. The introduction of SF dry storage technology represents a safer way of storing SF as the cooling system is passive. Additionally, both radiation safety and the robustness of the system are improved. The building and containers with spent fuel will be located on the NEK site, inside the fence encircling the power plant's technological section.

Dry storage is a safer way of storing spent fuel under the same environmental and radiation conditions as are prescribed in the existing operating licence. Dry storage is recognised worldwide as the safest and most widespread technological solution for SF storage. Dry storage is completely passive. In addition to the passive cooling method, better radiation safety and robustness, dry SF storage also has other benefits, above all due to better protection against intentional and unintentional negative influences or human acts. The proposed technical solution for dry storage of spent fuel is noted in the Resolution on the National Programme for Radioactive Waste and Spent Fuel Management 2016-2025 (ReNPRRO16-25); [32].

After several years of cooling in the spent fuel pool, the SF is transferred to special canisters (Figure 5), that are hermetically sealed and placed in a suitable overpack (for transfer, storage or transport) [35].

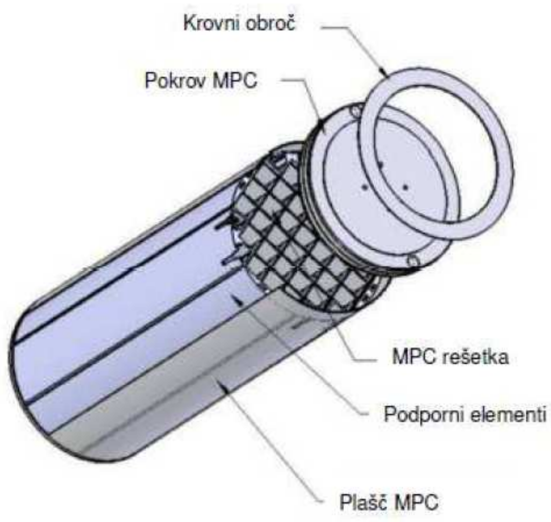


Figure 5: Spent fuel multi-purpose canister (MPC)

Krovni obroč	Shield ring
Pokrov MPC	MPC lid
MPC rešetka	MPC fuel basket
Podporni elementi	Supporting elements
Plašč MPC	MPC overpack

These canisters in special storage overpacks are then placed in the SF dry storage building (Figure 6). The building is divided into several areas: manipulation, technical and storage area. Spent fuel will be stored in the building until a decision is made on the national strategy for SF disposal or re-processing.

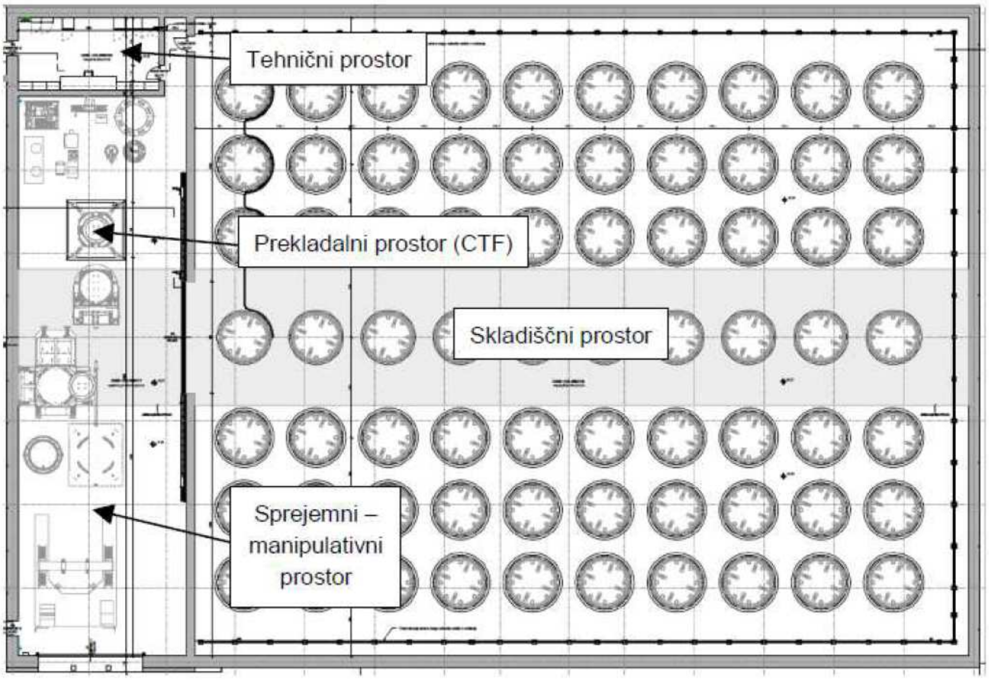


Figure 6: Floor plan of SF dry storage building

Tehnični prostor	Technical area
Prekladalni prostor (CTF)	Canister transfer facility (CTF)
Skladiščni prostor	Storage area
Sprejemni – manipulativni prostor	Acceptance, manipulation area

The dry storage building will enable storage of SF in 70 containers, each of which can contain 37 fuel elements. For the power plant's expected operational lifetime, 62 containers are foreseen, and 8 containers represent reserve storage capacities. Spent fuel will be stored in the building until a decision is made on the national strategy for SF disposal or re-processing.

There was therefore a total of 1,323 fuel elements stored in the spent fuel pool at the end of 2020, including two special containers with fuel rods and a fission chamber from 2017. If NEK operated until the end of 2023, a total of 1,553 elements of spent fuel would be generated. If NEK operates until the end of 2043, a total of 2,281 spent fuel elements are estimated to be generated. The first phase of dry storage loading follows in 2023, when the initial 592 spent fuel elements will be transferred. In the second phase, the next 592 spent fuel elements will be transferred (more in section 5.2.8).

3.3. Safety Upgrade Program (PNV)

In compliance with Slovenian legislation in the field of nuclear safety (JV5 Rules, [69]) NEK has analysed the systems, structures and components from the point of view of severe accidents. Deriving from the analysis, NEK should take all reasonable measures to prevent and mitigate the consequences of severe accidents within the set deadlines. Following the accident at Japan's Fukushima Daiichi power plant in March 2011, this process was given high priority. Based on the URSJV Decision No. 3570-11/2011/7 of 1 September 2011, a severe accident analysis and preparation of a program of safety upgrades was demanded. In its reasoning, the aforementioned decision specifically highlights good practice in Europe that NEK should take into account in its analysis.

The Fukushima nuclear power plant accident has made the entire nuclear industry realise that severe accidents can happen, and that technological readiness is required to be able to prevent and manage them. The accident triggered rapid responses in all countries with nuclear technology. Based on the methodology prepared jointly by all countries of the European Community, the URSJV instructed NEK in Decision no. 3570-9/2011/2 of 30 May 2011 to carry out an extraordinary safety review. The report was prepared by 31 October 2011 and mainly reflects the assessment of the nuclear safety measures in place at the time in the event of external emergencies and the preparation of proposals for short-term improvements. As part of these proposals, additional modifications were made to allow the connection of mobile equipment. On 23 December 2011, the URSJV submitted the National Report on Stress Tests [20] to ENSREG and published it on its website. The NEK Safety Upgrade Program [25] was implemented as a response by the Slovenian Nuclear Industry based on the national post-Fukushima action plan according to EU stress tests and not in connection with NEK's long term operation.

NEK always took preventive precautions and reacted to important events in the nuclear industry, thereby ensuring appropriate nuclear safety. Even prior to the accident in Japan, NEK was already implementing certain upgrades, such as the installation of a third diesel generator to power the safety systems, which contributes to safety and also supports modernising initiatives in the wake of the Fukushima disaster. It also reacted rapidly and effectively in the wake of the Fukushima disaster. The program proposed by NEK as a response to the URSJV decision complies with WENRA demands and is comparable with the industrial practice of other European countries.

In August 2013, the European Commission published a final report containing the results of the extraordinary safety reviews of all power plants [21]. The report confirms that NEK achieves extremely good results and is adequately prepared for extreme events. The report further includes an overview of recommendations for safety improvements to be carried out in individual nuclear power plants. According to this overview, NEK is the only nuclear power plant that did not receive a single recommendation – also because it already carried out actions B.5.b (compiled due to the WTC attack on 11 September 2001), drew up a draft PNV and was able to prove large integrated safety reserves in terms of both seismic and flood safety.

The modernisation of safety solutions includes the best available technological solutions and follows international practice (e.g. Switzerland, Belgium, Sweden, and France). This applies in particular to the reliable cooling of the core in order to ensure the integrity of the containment, management of severe accidents and cooling of spent fuel.

NEK's spent fuel pool and the reactor core are the major potential sources of radiological hazards to the surrounding environment in the event of a nuclear accident. The spent fuel storage strategy changed due to the latest events and findings from the Fukushima accident, and because of the revised Resolution on the National Program for Radioactive Waste and Spent Fuel Management for the Period of 2016 –2025 [32]. In 2023, the project to construct dry spent fuel storage will be completed [35]. It will further enhance nuclear safety and minimise the risk of potential accidents in the spent fuel pool.

On the basis of its own analyses and the recommendations of international organisations and administrative bodies, NEK adopted certain short-term and long-term projects. One of the short-term projects involved purchasing specific mobile equipment (e.g.: diesel generators of different powers, air compressors, water pumps, a vehicle for towing). Different systems in the plant have been fitted with appropriate connections for mobile equipment. As part of the long-term actions and based on the URSJV Decision [65], a thorough analysis was carried out [64] and a comprehensive upgrade program for the prevention of severe accidents and mitigation of their consequences was elaborated – NEK Safety Upgrade Program [21]. The program also includes proposals which the plant did not place in the action plan stemming from [48]. Arising from the additional WENRA requirements ([50] and [51]) certain technical solutions developed in comparable European and global industries, NEK performed additional analyses ([52], [53], [54], [63] and [64]), to prove that its technical solutions are suitable and comprehensive enough for an acceptable level of severe accident prevention and mitigation. The NEK

Safety Upgrade Program will be completed in 2021, with the exception of the construction of dry storage and the relocation of SF (first campaign), which will be carried out in the first half of 2023.

3.4. Periodic Safety Review (PSR)

The Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1, Official Gazette of RS, Nos. 76/17 and 26/19) [45] requires, in Article 112, the operator of a radiation or nuclear facility to "ensure regular, comprehensive and systematic assessment and monitoring of the radiation or nuclear safety of a facility in periodic safety reviews".

More details about the frequency, content, scope, duration and method of performing periodic safety reviews, and the method of reporting on such reviews is defined in the JV9 Rules [70]. A successfully carried out PSR is a precondition for extending the operational lifetime by ten years.

The aim of the periodic safety review is for the operator of a radiation or nuclear facility to:

- review the overall impacts of plant aging, the impacts of modifications to the facility, operational experience, technical development, impacts of changes on the site and any other potential impacts on radiation or nuclear safety, and to determine the compliance with the design bases, based on which the operating licence was issued, with international safety standards and international practice, thereby confirming the facility is at least as safe as projected during the design phase and that it continues to be fit for safe operation;
- use the latest relevant, systematic and documented methodology based on deterministic as well as probabilistic approaches to analyses and assessments of radiation and nuclear safety;
- eliminate, at the earliest opportunity, any deviations from the design of the facility established during a periodic safety review, taking into account their significance for nuclear safety;
- examine and organise knowledge of the facility and processes, as well as the complete set of technical documentation;
- identify and evaluate the significance for safety of deviations from applicable standards and best international practice;
- carry out all appropriate and reasonable modifications resulting from the periodic safety review;
- carry out modifications in such a way that a written assessment of the state of each item of content is compiled, documented and supported by relevant analyses.

In keeping with requirements NEK successfully carried out two periodic safety reviews, the first one in 2003 [23], and the second one in 2013 [24], and they were approved by the URSJV with its decisions. The comprehensive safety assessments, which are part of the PSR, confirmed that the power plant is safe and that it is capable of operating safely in the period until the next PSR. The third periodic safety review is currently in progress [73] and will be completed in 2023.

3.5. Independent International Expert Reviews of Nuclear Power Plant Operation

NEK participates in a number of independent international expert reviews (missions), which examine in detail all aspects of safe and reliable operation of the power plant. Reviews are carried by different organisations: IAEA – International Atomic Energy Agency, WANO – World Association of Nuclear Operators and others.

The aim of the missions is to promote improvements concerning nuclear safety and reliability of nuclear power plants through the exchange of information between foreign experts and NEK, and to promote communication and comparisons between WANO members. A comparison of one's own practices with the global experience and an objective assessment of the operation status are directed towards achieving the highest standards of nuclear safety, availability and excellence in the operation of nuclear power plants.

The auditors compared NEK with high operational standards as defined by the nuclear industry in the field of safety culture and human behaviour, organisation and administration, improvements in efficiency and operational experience, operation, maintenance, chemistry, work process management, engineering, configuration control, nuclear fuel efficiency, equipment reliability, radiological protection, training and qualifications, fire protection, occupational health and safety, organisation and measures in the event of an emergency, and implementation of international recommendations. The observers also observe the operational shift scenarios to assess the response of operating personnel to potential unplanned events.

In the mid-1990s, analyses of selected accident scenarios that go beyond design basis accidents were also performed as part of the Level 2 probabilistic safety analyses for the power plant. These analyses included situations with reactor core damage and containment failure, known as severe accident analyses. These analyses provided a platform for the preparation of Severe Accident Management Guidelines (SAMG). Furthermore, equipment was inspected and some modifications were made to allow a more appropriate response both from the equipment and personnel in the event of such accidents. Some examples include: the strategy of flooding the space under the reactor vessel (wet cavity) in the event of the reactor vessel meltdown, replacement of the recirculation sump strainer in the containment and thermal insulation of the containment piping. After purchasing a simulator for operator training and preparing the SAMG, NEK is able to perform emergency preparedness drills for accidents that go beyond design basis accidents too. During the trainings, the functionality of the SAMG procedures was also tested.

Upon the invitation of the URSJV, the RAMP mission organised by the IAEA was held at NEK in 2001. The mission reviewed the scope and adequacy of the aforementioned analyses and guidelines for severe accident management. The RAMP recommendations were partially implemented in the post-review period, while the remaining recommendations required additional and in-depth analyses, which were carried out by NEK in the framework of the action plan for the first periodic safety review (e.g. generation, distribution of hydrogen and risk management for the case of hydrogen explosion in the containment in the event of a severe accident). As part of the action plan for the periodic safety review, NEK also prepared specific grounds for emergency operating procedure (EOP) instructions, and revised the set-points on the basis of analyses for these instructions. All of the actions from this action plan were completed (reviewed and approved also by the URSJV as part of different administrative procedures).

As part of the stress tests a review of severe accident management (equipment, procedures, organisation etc.) was also carried out. Alongside the IAEA and WANO reviews in 2017 and 2019, a review of the suitability of organisation for managing accidents was also carried out. In 2018 the validation of the new SAMG on the NEK simulator was successfully carried out.

3.6. Aging Management Program (AMP)

The Aging management program was drawn up as part of the Periodic Safety Review (PSR1) and with the actions that stemmed from the concluding report of the PSR1.

NEK has completed all actions that were part of its periodic safety review that referred to the plant's extended operational lifetime. In the administrative procedure, the URSJV approved the amendments to the NEK safety report (USAR), and NEK technical specifications (NEK TS) referring to the extension of NEK's operational lifetime (URSJV Decision No. 3570-6/2009/28 of 20 April 2012 and URSJV Decision No. 3570-6/2009/32 of 20 June 2012) and approved the entire Aging Management Program (AMP).

The NEK Aging Management Program is based on US legislation NUREG-1801, Generic Aging Lessons Learned, Revision 2. The AMP program thus covers all passive and long-life systems, structures and components. The European AMP program, prepared by the IAEA (International Generic Aging Lessons Learned (IGALL) for Nuclear Power Plants) foresees that the aging program also addresses active components. NEK monitors active components in accordance with the so-called Maintenance Rule (10 CFR 50.65) and Environmental Qualification Program (10 CFR 50.49).

The review of the aging of active components and the maintenance itself were prepared on the basis of:

- 10 CFR50.65 – Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, Regulatory Guide 1.160,
- "Monitoring the Effectiveness of Maintenance Rule at Nuclear Power Plants" Rev. 3 and NUMARC 93-01,
- "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants", Rev. 4A.

An important part of the AMP program consisted of the time-limited safety analyses (TLAA analyses), among which the AMP-TA-10 analysis "Update of USAR Chapters 11 and 15" should be highlighted, as it has shown that extending NEK's operational lifetime does not change the existing status and lead to new environmental hazards and burdens.

The compliance and integrity of the aging program was reviewed in a number of missions:

- 2014, WANO Peer Review mission at NEK (AMP),
- 2017, IAEA OSART + LTO + PSA mission,
- 2017, NEK actively participated in the preparation of the national ENSREG Topical Peer Review (TPR) on Aging Management,
- 2019, WANO Peer Review of the NEK AMP.

A special program for aging management was drawn up for the dry storage project.

All missions (including the 2017 OSART mission) and the URSJV review along with the decision, issued in the procedure described above, demonstrated the compliance of the aging program with international recommendations and the JV9 Rules [70].

Besides, in 2021 the NEK AMP will be reviewed and evaluated as part of the IAEA mission pre-SALTO (Safety Aspects of Long Term Operation). The pre-SALTO mission will carry out a thorough review of the aging management programs and their implementation on the basis of IAEA standards and the best international practices. The aging program will, however, be evaluated comprehensively and systematically as part of the third Periodic Safety Review (PSR3), in accordance with the program approved by the URSJV with decision no. 3570-7/2020/22 on 23 December 2020 [73].

3.7. Management system

The external framework for NEK's operation and business is determined by legislation, the Interstate Treaty, nuclear industry standards and the standards for the effective management of companies.

The internal organisation of the company is designed to include all functions, which comply with nuclear industry standards and the regulations necessary for the quality implementation of work processes. At the same time, the specific role of the company is taken into account, which, in addition to the operational function, also comprises engineering and corporate functions, including independent nuclear safety monitoring. The NEK MD-2 management system, being one of the key documents, systematically outlines the basic organisational features and defines the responsibilities of the management, key and supporting processes, and independent monitoring of nuclear safety.

The integrated management system, described in the NEK MD-2 – Management System – Process Organisation is in compliance with the requirements set out in the Ionising Radiation Protection and Nuclear Safety Act, ZVISJV-1, Official Gazette of RS nos. 76/17, 26/19 [45] and in more detail in the JV5 Rules [69]), (Official Gazette of RS No. 74/16) in Chapter 5 (Management System). The program also complies with the General Safety Requirements No. GSR Part 2, Leadership and Management for Safety, 2016.

A constituent part of the integrated management system is the Quality Assurance Program as part of the independent monitoring of nuclear safety, which complies with the demands of Slovenian legislation and the American code 10CFR50 Appendix B Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants. This program prescribes the monitoring of activities which affect nuclear safety and the preparedness of nuclear fuel, structures, systems and components (SSC) as well as the quality of related services.

An integral part of the management system is also the environmental management system, which at NEK was introduced in accordance with the ISO 14001:2004 standard in 2008. In November 2017, a recertification audit of the environmental management system and a successful transition to the new issue of the ISO 14001:2015 standard were performed. Certificate no. SL22114E according to ISO standard 14001:2015 was issued on 14 December 2017 and was valid until 18 December 2020. Certificates are issued for a three-year period so after two follow-up audits in October 2020 a recertification audit was successfully completed. NEK obtained a new ISO 14001:2015 certificate no. SI008072 [17] for the next three-year period (until the end of 2023).

The occupational safety and health system according to the BS OHSAS 18001:2007 standard was introduced in 2011. After the new standard was issued for occupational health and safety in 2018, changes and amendments necessary for transition from the BS OHSAS 18001:2007 to the ISO 45001:2018 standard were gradually introduced to the occupational health and safety management system. In October 2020, the transition to the new standard was thoroughly audited and confirmed in the recertification audit by the external certification organisation Bureau Veritas. NEK was issued with the ISO 45001:2018 certificate for a period of three years [18].

3.8. The power plant's key safety characteristics in 2021

Thanks to NEK's prudent and focused safety upgrades in the past ten years, especially the implementation of the safety upgrade program, the safety level is improving on an on-going basis, as shown inFigure 7, which shows the core damage frequency due to all potential internal and external events (equipment failure, pipe breaks, fires, earthquakes, floods etc.).

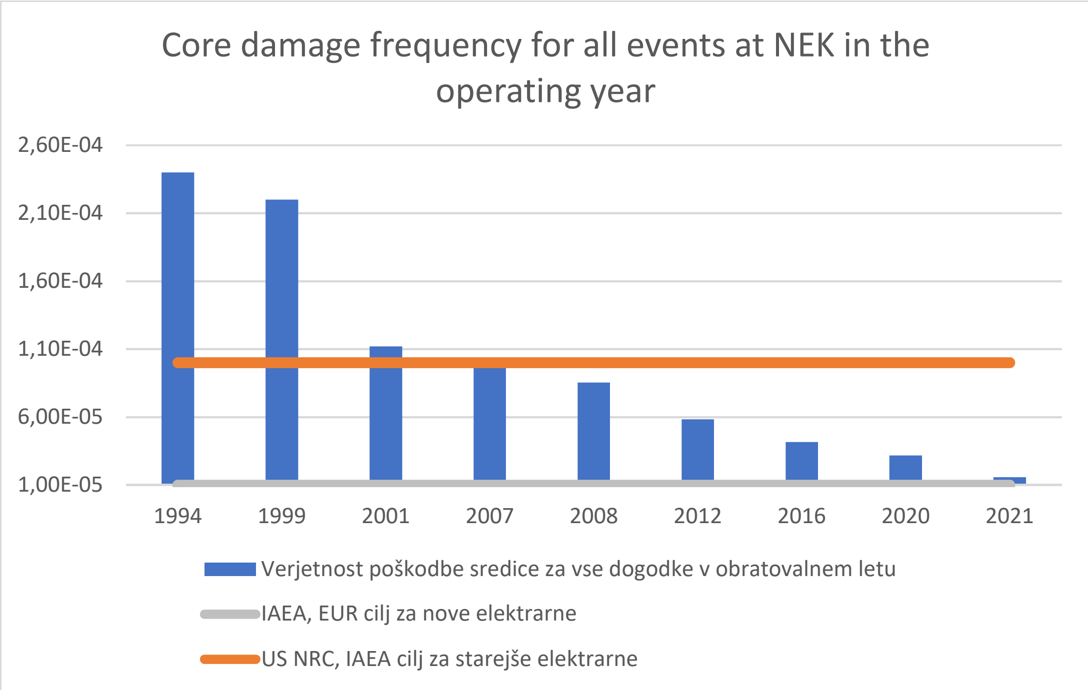


Figure 7: Safety level measured with core damage frequency per operating year (CDF/yr)

Verjetnost poškodbe sredice za vse dogodke NEK v obratovalnem letu	Core damage frequency for all events at NEK in the operating year
Verjetnost poškodbe sredice za vse dogodke v obratovalnem letu	Core damage frequency for all events in the operating year
IAEA, EUR cilj za nove elektrarne	IAEA, EU target value for new power plants
US NRC, IAEA cilj za starejše elektrarne	US NRC, IAEA target value for old power plants

Figure 7 shows core damage frequency for all events at NEK in the operating year by comparing operating history with the target values of US NRC and the IAEA for 2nd generation nuclear power plants, indicated with the orange line, and target values of the IAEA and EU for new 3rd generation power plants, indicated with the grey line, as defined in the NEA/CSNI/R (2009)16. Core damage at NEK complies with the definition of the US NRC 10 CFR 50.46, Section 1b. It is clear from the graph that during the past 20 years core damage frequency has significantly reduced, which is the result of large investments in safety upgrades in the power plant. Essential upgrades were made in the areas of earthquake hazard, flood protection, measures to mitigate the consequences of fires, provision of additional power supply sources in the event of an emergency or loss of off-site power supply, and others. As an example we can list alternative possibilities for heat removal with the new DEC systems (ASI tank, AAF tank and well [7]), which ensure the power plant's long term cooling. A decrease of risk in the past years and the planned decrease in 2021 are the result of the NEK Safety Upgrade Program [25].

3.8.1. Major Modifications in the Primary Circuit

Replacement of steam generators

The replacement of steam generators was carried out as part of the power plant modernisation. The modernisation comprised a number of subprojects. The first one involved the design, manufacture, finishing, assembling, testing and transporting of the new steam generators. The second one dealt with safety analyses and obtaining permits for the replacement. The third one, which was completed when the outage began, involved building a comprehensive personnel training simulator and analysing the power plant response in different situations. The replacement of the steam generators and the installation of the simulator took place in 2000.

Introduction of a new system for measuring the temperature of the primary circuit

The temperature measurement system for the primary coolant had a bypass installed on the A and B coolant loops that was connected to the hot, cold and intermediate legs and had a total of 30 valves. Due to the difficultly of maintenance and the possibility of leaks, all valves and bypass lines were removed during the 2013 outage, whereas the temperature measuring sensors were installed directly in the primary coolant pipe. This solution reduces the number of operational and maintenance interventions and the risk of primary coolant leaks.

Upgrade of reactor coolant pump motors

Both original electric motors of the reactor coolant pump were renewed and upgraded, and a new spare one was acquired at the same time. The control panel and visual indicators for monitoring bearing temperature, oil levels in bearings and motor vibrations have also been modernised. The upgrade took place in 2007 and 2010.

Replacement of the reactor vessel closure head

On the basis of operational experience in the industry, the reactor vessel closure head was replaced. Materials with better corrosion-resistant properties and improved manufacturing processes ensure safer and more reliable operation of the power plant. The reactor vessel closure head was replaced in 2012.

3.8.2. Major Modifications in the Secondary Circuit and electric systems

Replacement of the low-pressure turbines

NEK replaced both low-pressure turbines, as they were worn-out and the production of electricity needed optimisation. The new low-pressure turbines have a higher internal efficiency compared to the old turbines. The replacement took place in 2006.

Replacement of the stator and rotor of the main generator

The modification involved the replacement of the stator part of the generator (outer and inner housing, core, winding, main connections with bushings, hydrogen coolers), stator cooling water system, hydrogen temperature control valve, local alarm panel, installation of a new hydrogen dryer and the modernisation of control instrumentation with data transfer to the main control room.

NEK decided to replace the rotor of the main generator, taking into account the estimate that all generator subcomponents are designed and manufactured for a 30-year operational life span under normal operation conditions and reliability. The generator rotor was replaced with a new one that has better characteristics in terms of efficiency and reliability.

The stator and rotor of the main generator were replaced in 2010 and 2012.

Replacement of the turbine control and protection system (turbine operating and monitoring system)

The old digital electrohydraulic system (DEH) of the turbine control system was replaced with a new programmable digital electrohydraulic system (PDEH), manufactured by the original supplier.

The installation of the new PDEH turbine operating and monitoring system also involved replacing the turbine emergency trip system (ETS), control systems for steam superheating and moisture separation, and the relocation of the operating and testing controls for twelve valves of the steam separation system from the autonomous panel to the new PDEH-system. The replacement took place in 2012.

Replacement of the exciter, voltage regulator and main generator switch

The third project concerned with upgrading the generator system involved replacing the exciter and the voltage regulator of the main generator.

The replacement of the main generator switch is one of the performed upgrades of the generator system to enhance the reliability of the nuclear power plant operation. The project involves replacing the main generator switch with all its associated equipment and the replacement of overvoltage protection. As the new generator switch requires neither water cooling nor compressed air for its functioning, both the existing compressor plant and the cooling system of the old generator switch were removed. The system was replaced in 2016.

Renewal of the switchyard and the replacement of the 400-kilovolt system buses

In accordance with the Agreement on Technical Aspects of Investments, the switchyard was thoroughly refurbished in cooperation with the system operator ELES. The refurbishment has already begun in the 2010 outage and continued in the 2012 and 2013 outages when all the primary equipment including circuit breakers, isolators and buses, and measuring and control systems was replaced.

Some of the 400-kilovolt buses with insulating supports and portals were replaced in the section stretching from the double fence between NEK and the Krško RTP (distribution substation) to the NEK transformer field. The replacement of buses is the first phase of the joint project of NEK and ELES in reconstructing the 400-kilovolt switchyard.

Installation and connection of the energy transformer

NEK replaced the main transformer (400 MVA rated power) with a new 500 MVA one. The bottleneck in electricity distribution to the grid is eliminated and the basic configuration of the power plant with two transformers of equal power is restored. The replacement took place in 2013.

3.8.3. Major Modifications in the Tertiary Circuit and Subsystems

Extension of the cooling tower system

The design modification is the result of changes in the power plant and the environment. The cooling system of the NEK tertiary circuit was improved with carefully chosen technical solutions. Four new cooling cells (a new cooling tower – CT3) were installed, and all the electrical equipment of the cooling tower system was replaced. The replacement took place in 2008.

Reconstructions due to the construction of the Brežice HPP

Due to Brežice HPP, the level of the Sava near NEK has been raised by 3 m to 153.20 m.a.A.s.l. As a result of these changed hydraulic circumstances, it was necessary to reconstruct certain systems on the NEK site so that they could still operate inside the existing design bases following the Sava's rise in level, and at the same time it has been made possible to maintain the affected systems and structures the normal way.

Modification to the dam's hydraulic system

The modification required all the necessary mechanical, construction, electric and I&C activities that are needed on the NEK dam due to the construction of Brežice HPP. Due to hydraulic alterations on the Sava, upstream and downstream of the NEK dam, it was necessary to carry out the following interventions:

Construction part:

- providing access to and arranging the dam surroundings,
- expansion of the repository for the outage floodgates,
- raising the pillars of the spillways and building a new bridge for the crane,
- reconstruction of the downstream foundation with an additional steel crest,
- installation of additional guides on the dam's side walls,
- extension of the foundations of the crane tracks and
- an additional embankment to complete the plateau of the expanded repository.

Mechanical part:

- supply and installation of downstream outage segmental floodgates (6 new elements);
- supply and installation of upstream outage floodgates (2 new rolling segments);
- supply and installation of new mobile lifting frames, 2 x 100 kN for manipulating the downstream outage floodgates on the water channels using the crane track;
- supply and installation of lifting tongs for grabbing and releasing elements of the downstream outage floodgates; they hang from the mobile lifting frame;
- supply and installation of load transfer mobile hydraulic device for transporting the downstream outage floodgates from the mobile lifting frame to the depot for the floodgates with crane track;
- supply and installation of equipment for the disposal site of the downstream outage floodgates, which encompasses a set of bases for installing the floodgates; and
- reconstruction of the hydraulic lifting equipment of the radial floodgates, which includes electric, motor and hand-powered hydraulic units, hydraulic cylinders and piping with flexible pipes for flexible connections.

Electrics and control:

The current system for control and monitoring of the equipment on the NEK dam, which includes the regulation of the height of the Sava by taking measurements of flows and levels, was replaced by a new system. Two-way data connections with the control equipment of the Brežice HPP and Krško HPP were also set up, which enable the joint control of these dams together with the NEK dam.

Reconstruction on the Circulating Water (CW) system

To ensure the power plant's normal and safe operation after the Sava's level increased with the construction of Brežice HPP, the Circulating Water System also required certain reconstructions including:

- the installation of extra stop logs for isolating the CW inflow facilities, enabling maintenance of the coarse screens and travelling screens and CW pumps;
- reconstruction and modernisation of CW treatment plants;
- new device for cleaning the screen racks (two new and more powerful machines);
- CW 105TSC-001 travelling screens, -006 modernisation (increased speed of movement of the screens, modification of the safety valves);
- installation of an extra pump for flushing the screens and extra nozzles for each screen;
- replacement of the electrical cabinets and modification of the control system, upgrading of measurements of water level differences on the coarse screens and travelling screens;
- reconstruction of the CW deicing piping to prevent the accumulation of ice in the CW;
- installation of a new pump to meet the requirements of the functioning of the deicing system;
- modification of the nozzles on the deicing piping (extra nozzles on the CW de-icing piping);
- renewal of the manipulation surfaces.

Reconstruction on the Essential Supply Water (SW) system

Due to the construction of Brežice HPP it also became necessary to carry out a reconstruction on the tertiary safety cooling system (the SW system). The reconstruction included:

- the installation of extra barriers and the requalification of the existing ones,
- alterations to the SW pumps control system,
- installation of new working platforms,
- upgrading or replacement of the existing sediment removal system,
- modernisation of the system for measuring the silt level in the intake basin,
- adaptation of the system of cathode protection for underwater structures and pipelines.

Reconstruction on the Pretreatment Water (PW) and Sanitary Drain Systems

Due to the construction of Brežice HPP it was also necessary to carry out a reconstruction on the system of underwater wells, rainwater drainage and sewerage pipes:

- Underground wells:
  In order to keep the water table at the same level as before construction, three underground wells are built inside the diaphragm wall [6], with accompanying connecting piping to the existing pretreatment building.
- Rainwater drainage system:
  Demolition of the existing pumping station for rainwater drainage and the construction of a new one at the same location.
- Faecal sewage system:
  - construction of a new gravitational discharge above the future elevation of the Brežice HPP dam at 153.50 m.a.A.s.l.
  - The replacement of two existing submersible pumps.

3.8.4. Other design-related modifications to improve safety

Improvement of the AC safety power supply (DG3)

Activity means improving the power plant's AC safety power supply was improved by providing an alternative source in the event of loss of the complete AC power supply (Station Blackout - SBO). The upgrade of the safety power supply included the installation of an additional diesel generator (DG3) with a power of 4 megawatts (6.3 kV, 50 Hz, start-up time less than 10 seconds), which is connected to the MD1 or MD2 safety buses via a new 6.3-kilovolt bus (MD3). The upgrade took place in 2006 and 2013.

3.8.5. NEK Safety Upgrade Program

Following the completion of the Safety Upgrade Program, NEK [25] is ready for severe accidents as demanded by ZVISJV-1, Official Gazette of RS, Nos. 76/17, 26/19 [45] and the Rules on radiation and nuclear safety factors [69]. The PNV was reviewed and approved by the URSJV in February 2012 with Decision No. 3570-11/2011/09. Already in 2012, NEK began to prepare project documentation for the PNV and in 2013 it also filed applications for the implementation of the first two safety upgrade modifications (installation of a passive autocatalytic system for hydrogen recombination and the installation of a passive containment filtered venting system). These two modifications represent key solutions for severe accidents and were approved by the URSJV in October 2013.

Phase 1

Installation of passive autocatalytic hydrogen recombiners in the containment

The installation of passive autocatalytic hydrogen recombiners limits the concentration of explosive gases (hydrogen and carbon monoxide) in the containment in the event of a severe accident. The installed equipment does not require a power supply for its operation and therefore works even if the AC power supply to the power plant completely fails. The safety upgrade ensures the integrity of the containment in the event of a severe accident. The installation of autocatalytic recombiners took place in 2013.

Construction of the system for filtered venting of the containment

The installation of passive venting (relief) of the containment ensures a minimum release (less than 0.1%) of radioactive fission products of the core (with the exception of noble gases), which are released into the containment in the event of a severe accident, when the pressure in the containment rises above the design-basis level. In this way the integrity of the containment as a barrier preventing the uncontrolled release of radioactive material into the environment is preserved. The system consists of five aerosol filters in the containment, an iodine filter in the auxiliary building, piping with a rupture disc, valves, an orifice, a nitrogen plant, a radiation monitor and the necessary instrumentation. The primary objective of the modification is to maintain the integrity of the containment by preventing it from collapsing in the event of severe accident that could result in uncontrolled pressure increase. The system was installed in 2013.

Phase 2

Flood safety of NEK facilities

In 2012, design solutions were prepared to ensure flood safety of NEK facilities up to an elevation of 157.530 m above sea level, including in the event that the downstream and upstream embankments of the Sava collapsed. Design solutions include passive and active flood protection elements. Passive elements include the watertight external walls of buildings, the replacement of external doors with watertight ones and the replacement of seals on penetrations through the external walls with watertight ones. Active flood protection will be ensured with the installation of water barriers and check valves on the drainage systems. The new NEK flood protection is designed and dimensioned so as to provide functional protection even in case of earthquake of 0.6 g ground acceleration. The project was completed in 2017.

Construction of an emergency control room

The main reason for the construction of the emergency control room is to provide an alternative control location, which allows safe shutdown and cooling of the power plant if the main control room is evacuated and control of the status in the containment in the event of a severe accident with core damage. The construction of the control room was completed in 2019.

The new emergency control room provides an alternative location for shutdown and cooling of the power plant (if the main control room is lost); NEK is thus equal to comparable nuclear power plants in northern Europe, which built similar bunkered emergency control rooms in the 1990s. More recent nuclear power plants already have this solution integrated in the basic design.

The emergency control room has additional instrumentation installed that operates independently of the main control room and is used for control of the power plant in the event of a severe accident.

Upgrade of the technical and operating support centres

Along with the construction of the emergency control room, an upgrade in the new technical support centre (referred to as: TPC) was also carried out. The capacity of the existing underground shelter has been increased while the new operating support centre (OPC) building provides the conditions necessary for the long-term work and stay of a team of up to 200 people, even in the event of extreme earthquakes, floods and other unlikely emergencies. In addition to extra air filters, the building has a new diesel generator which will provide the centre with an independent power supply source. The upgrade was completed in 2021.

Alternative cooling of the spent fuel pool

The project included the installation of a new spray system (fixed distribution of nozzles for spraying the spent fuel pool), a pool cooling system with a mobile heat exchanger (a new mobile heat exchanger for alternative cooling of the spent fuel pool) and a pressure relief damper in the fuel handling building (FHB). The upgrade of the system was completed in 2020.

Installation of bypass motor-operated relief valves of the primary system

This modification provides a flow path for the controlled relief of the primary system in design extension conditions if the existing relief valves are not available. Implementing the strategy for the coordinated relief and feed of the primary system ensures cooling of the core, thereby preventing damage to the core. The design modification was completed in 2018.

Alternative cooling of the reactor cooling system and the containment

The main aim of the design modification was to install an alternative system for long-term residual heat removal. The primary function of the new system will be to remove residual heat from the reactor cooling system in design extension conditions by removing the coolant from the hot leg of the reactor cooling system, cooling via the heat exchanger and returning the coolant to the cold leg of the reactor cooling system, and removing the residual heat from the reactor cooling system by recirculating water from the containment sump back to the reactor cooling system. It is also possible to cool the containment by spraying. The design modification was completed in 2021.

Phase 3

Construction of the reinforced bunkered building (BB2) with additional water tanks for removal of residual heat from reactor

The upgrade includes the construction of a new bunkered building 2 (BB2) with auxiliary systems and the connection of various new systems within the new building to the existing NEK systems, buildings and components. The BB2 building is designed to accommodate alternative safety injection system (ASI), an alternative auxiliary feedwater system (AAF) and safety power supply to the BB2 building. For the construction of this building including all the installed systems (AAF, ASI etc.) a special building permit (No. 35105-68/2018/8 1093 and 35105-29/2018/6 1093-04 dated 24 July 2018) was obtained. Construction was completed in 2021.

Alternative Auxiliary Feedwater (AAF)

This upgrade is part of the third phase of the safety upgrade program and includes the installation of an additional pump for filling the steam generators including all piping and valves which will allow the new system to be connected to the existing auxiliary feedwater system. The new alternative system for filling the steam generators will in design extension conditions or in the event of the loss of existing auxiliary feedwater system, provide an alternative source of cooling water for one or both steam generators, allowing heat to be removed from the primary circuit and cooling of the reactor. The design modification was completed in 2021.

Alternative safety injection (ASI)

This upgrade, also part of Phase 3 of the PNV, includes the installation of an alternative safety injection system for injection of borated water into the reactor coolant primary circuit. The system installed in the new bunkered building BB2 consists of a tank containing 1,600 m^3 borated water, a high-pressure pump and the main motor-operated valve, the accompanying piping connected to the existing NEK system and the equipment to support the system operation and control. The project was completed in 2021.

Spent fuel dry storage (SFDS)

The dry spent fuel storage brings a technological and safety upgrade within the existing NEK energy complex. In addition to the passive cooling method, better radiation safety and robustness, dry SF storage also has other benefits, above all better protection against intentional and unintentional negative human influences or acts. Spent fuel dry storage is a temporary and safer form of storing SF during NEK's operation and also after its shutdown, however, it is not intended for permanent final spent fuel storage.

The dry spent fuel storage is located in the technological part of NEK, west of the present spent fuel pool location. The external appearance of the dry spent fuel storage will be adapted to the existing facilities in the NEK complex, which is already integrated into the physical environment and is recognisable in the broader area around Krško. The dry storage is under construction and is expected to be completed in the first half of 2023.

Installation of high-temperature seals in the reactor coolant pump

The installation of a new sealing insert in the reactor coolant pumps with high-temperature seals (HTS). The HTS enable the power plant to better respond to a potential loss of complete AC power supply in case of disruptions in the supply of sealing and cooling water for the reactor coolant pump seals, leading to leaking of the primary coolant. Installation of HTS thus prevents the loss of primary coolant. The project was completed in 2021.

3.8.6. Monitoring of Experiences, Research and Development in Science and Technology

Operational experience (OE) from other nuclear power plants is a valuable source of information for learning about and improving the safety and reliability of any nuclear facility. At NEK, the experiences gained by other nuclear power plants are systematically reviewed and studied in terms of their applicability to NEK, the potential use of the recommendations and probability that similar events may occur at NEK. Corrective actions for the identification of weaknesses are determined and implemented in the NEK Corrective Action Program. The processes in this regard are well defined and documented.

There are various programs for sharing operational experience conducted by the IAEA, WANO, the Institute of Nuclear Power Operations (INPO), various nuclear owner groups (PWROG, WOG), as well as numerous publications by regulatory authorities, correspondence with suppliers and architects/engineers, EPRI and the Nuclear Energy Agency at OECD. The OE program at NEK determines that it shares analyses and events with the industry. NEK personnel participate in various activities, such as the OSART delegation (INPO), the WANO delegation and in a number of EPRI activities. The information acquired is a valuable source of operational experience. Many activities are also included in the WANO/INPO information programs, the Nuclear Operation and Maintenance Information System (NOMIS) and the Nuclear Maintenance Experience Information System (NUMEX).

The Independent Safety Engineers Group (ISEG) conducts independent assessments of regulatory issues, industrial warnings, licence event reports, and other sources of power plant design- and operation-based information, including similarly designed power plants where areas for safety improvement could be identified.

The entire array of WANO SOER recommendations had been reviewed and approved by the power plant, and appropriate corrective measures have been determined for timely implementation and follow-up activities until their completion.

NEK participates in numerous research projects and participates in many international conferences in various domains. They include:

- participation in PWROG project groups (research in PAR autocatalytic plate testing),
- development of a dispersion model – Lagrangian model of nuclide dispersion in the environment,
- annual co-funding of applied research projects from the tender by the Slovenian Research Agency (ARRS),
- participation in the U.S. NRC CAMP and CSARP programs,
- cooperation in international projects under the auspices of the International Atomic Energy Agency (IAEA), etc.

In accordance with the demands of ZVISJV-1 and the JV9 Rules, NEK carries out Periodic Safety Reviews (PSR) every 10 years, which includes the verification and assessment of compliance with valid international standards and the best international practice. The PSR also assesses compliance with experience gained from a plant's own operation as well as from abroad, new findings acquired in technical studies and progress, and through the management of other radiation or nuclear facilities.

4. Description of the expected state in 2043

4.1. Starting points

4.1.1. Basic and technical characteristics of the review

In annex 1 to the Decree on activities affecting the environment that require an environmental impact assessment [41] under reference D.II (Nuclear energy), there is a list of interventions in the environment for which the environmental impact assessment (EIA) and the preliminary procedure (PP) are compulsory. Possible interventions are listed under references D.II.1 to D.II.7 inclusive, and include the following:

- nuclear power plants and other nuclear reactors, including their dismantling or removal;
- nuclear research installations for the production and conversion of fissionable and fertile materials whose maximum power exceeds 1 kW continuous thermal load;
- other nuclear research installations for the production and conversion of fissionable and fertile materials;
- installations for the production or enrichment of nuclear fuel;
- installations for the processing of irradiated nuclear fuel or high-level radioactive waste or the reprocessing of irradiated nuclear fuel;
- deep drilling for the storage of nuclear waste material;
- permanent repositories for spent fuel or solely for radioactive waste;
- storage installations designed solely for the long-term storage (planned for more than ten years) of spent fuel or radioactive waste at a different site other than the production site.

The extension of NEK's operational lifetime:

- does not change the position or location of the nuclear power plant area;
- does not change the dimensions and technical design of the power plant;
- does not change the production capacity of the power plant and its operation mode;
- means that the facility's operational lifetime is extended by 20 years, i.e. from 40 to 60 years;
- does not foresee the construction of new structures or facilities that would change the physical characteristics of NEK.

By the end of the foreseen extended operational lifetime (2043), NEK will have operated as to date, i.e. reliably, safely and in keeping with the limits on emissions into the environment. Safety culture, the proficiency of employees and their responsibility will continue to be the guiding principle and core element of the organisational and business structure of NEK, and will be an assurance for the continued safe and environmentally-friendly operation of NEK. As before, the necessary safety and other improvements will be introduced regularly and on time. NEK will regularly maintain all its technical systems, especially those connected with safety, and will regularly upgrade them in compliance with operating experience in Slovenia and globally.

NEK will maintain all control systems listed in section 3.8, and will regularly upgrade them. All physical persons and legal entities working at NEK will be informed about environmental policies, and interested parties will be able to have an insight into environmental management policies. All risks connected with NEK's operation have been significantly mitigated through a comprehensive upgrade of safety systems [25] in accordance with Slovenia's nuclear legislation.

The extension of NEK's operational lifetime from 40 to 60 years until 2043 does not change NEK's existing environmental permit [4]. NEK's existing water permits [5], [6], [7] will also not require changes.

An Environmental Impact Assessment will have to be made for: the extension of NEK's operational lifetime from 40 to 60 years, i.e. until 2043. The environmental impact assessment includes impacts on the surroundings of the facilities according to the Decree on the Environmental Impact Assessment Report for the parcel numbers shown in figure (Figure 1).

4.1.2. Preliminary information – ZVO-1

In accordance with Article 52 of the ZVO-1, NEK [40] filed an application in November 2020 for the issuing of preliminary information about the scope and content of the report about the environmental impact of the activity. In compliance with the third paragraph of Article 52 of ZVO-1, the Ministry of the Environment and Spatial Planning has requested the ministries and other organisations which, with regard to the project, are responsible for individual issues of environmental protection, the protection or use of natural goods or the protection of cultural heritage or human health protection, to state which information is to be contained in the report on environmental impact so as to allow them to submit their opinion on the environmental impact of the project from the aspect of their area of competence.

In a letter [68] from the end of 2020 ARSO submitted opinions on the information that the report on environmental impact should contain according to paragraph 3 of Article 52 of the ZVO-1 for the intended activity based on the draft of the PROJECT. The details are partially included in this document and will appear in their entirety in the report on environmental impacts.

4.1.3. Existing valid permits; operation and environment

NEK operates in accordance with the open-ended operating licence (URSJV Decision No. 3570-8/2012/5, amendment of NEK's operating licence of 22 March 2013) [3], which is directly related to the NEK Updated Safety Analysis Report (USAR) - rev. 26 [2] and defines the conditions and limits for the power plant's safe operation. NEK is technically capable of operating for at least another 20 years, provided that, in accordance with the applicable legislation, it performs a periodic safety review (PSR) every 10 years (according to the ZVISJV-1, a periodic safety review).

The construction of NEK began in 1974, the supplier of the nuclear power plant being Westinghouse from the United States. NEK was spatially located in accordance with the location permit [8] and the legislation in force at the time. On 17 July 1989, NEK obtained operating permit No. 351-02/89-15 from the Republic's Committee for Industry and Civil Engineering.

4.1.4. Operating license

In May 1981, after obtaining a special licence, the nuclear fuel was inserted into the reactor for the first time. The nuclear power plant was synchronised with the electricity grid in October of the same year. During the trial operation, it reached full power in August 1982. With Decision No. 31-04/83-5 of 6 February 1984, issued by the Republic's Energy Inspectorate in Ljubljana [3], NEK obtained special permission to begin operating (operating licence). The administrative procedure was carried out on the basis of the NEK preliminary and final safety report taking into account the regulations of the supplier country and with assistance from the missions of the International Atomic Energy Agency. On 17 July 1989, NEK obtained operating permit No. 351-02/89-15 dated 17 July 1989 from the Republic's Committee for Industry and Civil Engineering. The design of all safety equipment at NEK complies with the requirements of the US Nuclear Regulatory Commission from 1973. Westinghouse, as the main contractual partner, was responsible for the implementation of these requirements in design, construction and testing phases. To enhance safety, many modifications to the equipment have already been made during operation. In accordance with the URSJV Decision No. 390-2/2004/1/13 of

8 July 2004, NEK was classified as a nuclear facility. NEK is entered in the register of radiation and nuclear facilities under No. 1.

4.1.5. Environmental permit

In 2006, NEK filed an application at the Ministry of the Environment and Spatial Planning (MOP) and the Environmental Agency of the Republic of Slovenia (ARSO) for the issuance of an environmental permit for the operation of NEK. On 30 June 2010, the MOP issued Decision No. 35441-103/2006-24, Environmental Permit for the Operation of NEK regarding Emissions into Waters [4], which defined special conditions for the operation of the facility. On 4 June 2012 and 10 October 2013, Decisions Nos. 3544-103/2006-33 and 35444-11/2013-3, which introduced modifications in paragraphs determining the operating conditions of the facility, were issued [4]. NEK operates in compliance with the valid environmental permit [4].

4.1.6. Water permit

NEK operates in compliance with the valid water permits for water use for technological purposes. The initial partial water permit was issued on 15 October 2009, No. 35536-31/2006-16 [5], and was amended due to a change in the amount of water taken from the Sava by Decision No. 35536-54/2011-4 of 8 November 2011 and Decision No. 35530-7/2018-2 of 22 June 2018 [5]. In the last two years, water permits for the new wells were also issued: water permit no. 35530-100/2020-4 of 14 November 2020 [6] and water permit no. 35530-48/2020-3 of 9 September 2021 [7].

4.1.7. Amendment to the Operating Licence - Unlimited Operation

In 2012, the Slovenian Nuclear Safety Administration (URSJV) confirmed and approved with Decisions Nos. 3570-6/2009/28 and 3570-6/2009/32 the amendments to the NEK safety report (USAR) [2] and the accompanying documentation, which until then limited NEK's operational lifetime to 40 years. The confirmed changes now ensure NEK can operate for another 20 years, i.e. a total of 60 years. NEK's operation has thereby been extended from the expected year 2023 to 2043, provided that periodic safety reviews in 2023 and 2033 will be successfully completed. Based on the URSJV decisions, the Republic of Slovenia and the Republic of Croatia as the owners of NEK on the basis of the Interstate Treaty [30] gave their support to the decision to extend NEK's operational lifetime until 2043 [31].

4.1.8. Integrated National Energy and Climate Plan of the Republic of Slovenia – NECP

The NECP is a strategic document which must define goals, policies and actions up to 2030 (with an outlook to the year 2040) for the five dimensions of the Energy Union:

1. decarbonisation (greenhouse gas emissions (GHG) and renewable energy sources (RES)),
2. energy efficiency,
3. energy security,
4. internal energy market and
5. research, innovation and competitiveness.

The projects and measures set out in the NECP will, in terms of energy and climate policy, in accordance with the Energy Act, be in the public interest.

The following scenarios of future energy use and supply were discussed and analysed as part of the NECP:

- a scenario with the existing measures – further development is based on continuing the implementation of all measures adopted already by 1 October 2018,
- the NECP scenario.

The scenario with the existing measures serves for comparison purposes and envisages minimal additional investments in large facilities. It envisages the completion of the chain of hydroelectric power plants on the lower Sava, but no other investments in renewable energy sources (RES). It is further assumed that, upon obtaining appropriate environmental consent, the existing NEK will operate until the end of the extended operational lifetime (in 2043).
The development-oriented NECP scenario envisages an increase in the production of electricity from hydropower, as well as wind and solar power, which are both considered dispersed power sources, in combination with electricity storage facilities. The NECP scenario deals with two options: one based on the use of synthetic gas, and the other which plans a new nuclear power plant. Both options maintain the existing NEK until 2043, subject to obtaining the appropriate environmental consent.

A strategic environmental impact assessment of the NECP implementation was carried out in parallel with the preparation of the NECP [14]. As part of the NECP preparation and its comprehensive assessment, the complexity of goals and contributions for the period until 2030 was discussed. The extensive and well-founded expertise-based discussion provided the platform for reaching an agreement of the widest possible stakeholder circle regarding demanding yet feasible goals Slovenia wishes to achieve by 2030, which will take into account important national circumstances and will be an appropriate step ahead towards a climate-neutral Slovenia by 2050.

From the point of view of the NECP, Slovenia's goals are:

- decarbonisation of the energy sector,
- to ensure a reliable and competitive energy supply,
- to maintain a high level of electricity interconnection with neighbouring countries,
- at least 75% electricity supply from sources in Slovenia by 2030 and by 2040, and ensuring an adequate level of reliability of electricity supply,
- to continue to exploit nuclear energy and maintain excellence in the operation of nuclear facilities in Slovenia,
- to reduce fossil fuel import dependency,
- to increase the resilience of the electricity distribution network to disruption – increase the share of the underground medium-voltage network from the current 35% to at least 50%.

It is clear from the above that the operation of NEK has a significant role in the implementation of the NECP goals.

The updates in work processes, upgrades in technology, and the 18-month fuel cycle and employee commitment ensure stable and increased production of electricity. At present, when the world as a whole and Europe in particular are developing energy strategies to tackle climate change, such results substantially contribute to the understanding that nuclear energy is of strategic importance in the transition to a low-carbon society; nuclear energy will maintain the energy independence of countries, give the economy a competitive edge and citizens access to affordable electricity.

The figure (Figure 8) shows the increase in electricity production from the beginning of NEK's operation.

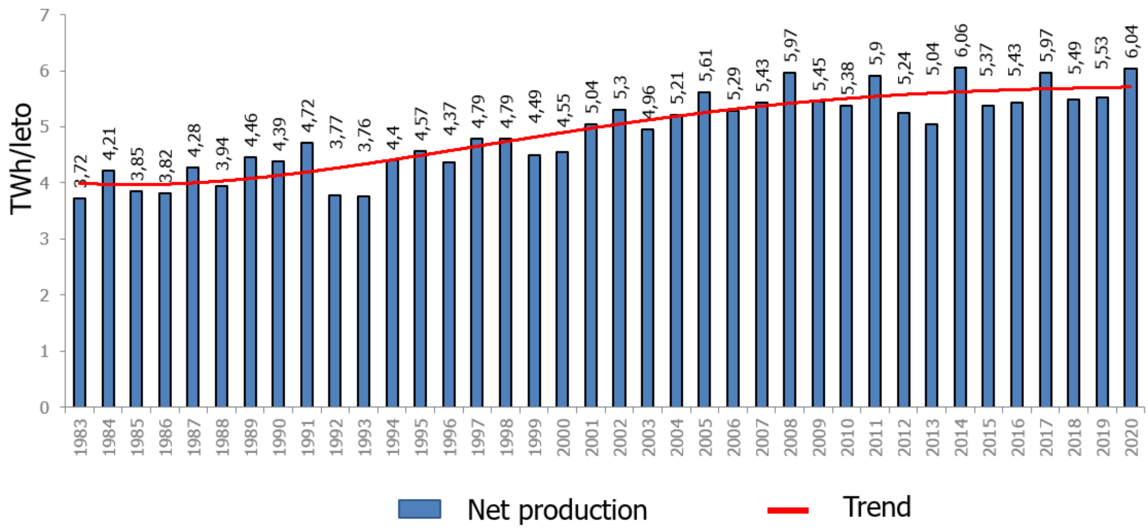


Figure 8: Net electricity generation through the years

TWh/leto	TWh/year

4.2. Design Bases for NEK's Long Term Operation

On the basis of a series of studies and analyses, the Slovenian Nuclear Safety Administration confirmed with its Decision no. 3570-6/2009/32 of 20 June 2012 that the state of the equipment at NEK is suitable, despite aging, and that all safety margins and operating functions are guaranteed.

The ability to extend operational lifetime is based above all on the following facts:

1. The power plant has built-in materials and equipment that provide sufficient safety reserves;
2. All equipment that affects the reliability of operation has been replaced;
3. The operation of the power plant is stable;
4. A safety upgrade has been carried out to comply with the ZVISJV-1 requirement and the lessons learnt from all major nuclear accidents to date, which is reflected in ENSREG, the Slovenian national post-Fukushima plan [48], [28];
5. NEK has a comprehensive Aging Management Program (AMP) in place to monitor aging of all passive structures and components (reactor vessel, concrete, underground piping, steel structures, electrical cables etc.).

With the above activities the power plant has attained modern safety standards.

4.2.1. Description of the activity entailing NEK's long term operation

The scope of the intended activity is the continued operation of NEK with the existing operating characteristics after 2023 and does not foresee the construction of new structures or facilities that would change the physical characteristics of NEK.

On 2 October 2020, the ARSO (Slovenian Environment Agency) issued decision no. 35405-286/2016-42 [1], which requires the entity responsible for the intended activity NEK to carry out an environmental impact assessment for the intended activity 'extension of NEK's operational lifetime from 40 to 60 years, i.e. until 2043' and to acquire environmental consent.

The Ministry carried out screening ex officio in accordance with the first paragraph of Article 8 of the Decree on the activities affecting the environment for which an environmental impact assessment [41] is required. In the process of screening referred to in the first paragraph of Article 51a of the ZVO-1 [40], the criteria regarding the characteristics of the intended activity in the environment, its location and the characteristics of possible impacts of the activity on the environment were taken into account.

It has been established that the intended activity foresees a modification affecting the essential feature of the ongoing activity, since NEK's operational lifetime is extended until 2043. The impacts arising therefrom would significantly increase, and/or a significant increase in environmental impacts can be expected due to the intended modification. Furthermore, it was established that the planned activity was functionally and economically related to at least another planned activity, i.e. the construction of a spent fuel dry storage building. The Ministry established that the obligation of performing an environmental impact assessment to extend the operation of the nuclear power plant also arises from the case law of the Courts of Justice of the European Union [46].

Based on the established facts, the Ministry concluded that the intended activity required an environmental impact assessment and also environmental consent, as already imposed by the aforementioned decision.

5. Bases for assessing the impact of NEK's long term operation on the environment

5.1. Basic explanations about the activity

The extension of NEK's operation from 40 to 60 years will have certain impacts on the environment.

- A greater number of spent fuel elements;
- A greater quantity of LILW;
- Up to 6 TWh/year of electricity produced (in total up to 120 TWh – the Slovenian share being 60 TWh);
- Up to 4.8 million tonnes fewer CO_2 emissions per year due to NEK's operation (in total: 97 million tonnes of CO_2 less);
- Regular maintenance and the replacement of systems with safer ones;
- Regular replacement of systems with more effective and reliable ones;
- Cleaning of the Sava using different types of screens.

The extension of NEK's operational lifetime **does not foresee the construction** of new buildings or facilities that would change the physical characteristics of NEK.

5.2. Possible impacts of the intended activity on the environment

The impacts of NEK's extended operation must be assessed in accordance with the Espoo convention, Annex 1 and 2 [42].

The Decree on the method of drafting and on the content of the report on the effects of planned activities affecting the environment (Official Gazette of RS, Nos. 36/09 and 40/17), stipulates that it must be determined, which content will be dealt with and what is important for assessment. Below are the bases for such an expert assessment. Most of the activities will remain the same in terms of scope, however, the number of spent fuel elements and the amount of low and intermediate level radioactive waste will increase. All the impacts are defined with respect to the situation in 2020. The extension of NEK's operational lifetime from 40 to 60 years does not foresee any extra airborne releases. The types and concentrations/activities of the foreseen emissions remain unchanged. The expected amount of annual emissions will remain unchanged and within previous limits as prescribed in the NEK TS [9] and RETS [11].

5.2.1. Greenhouse gas emissions

There will be no extra greenhouse gas releases into the atmosphere due to the extended operation.

5.2.2. Emissions of substances and heat into waters

The Extension of NEK's operational lifetime from 40 to 60 years does not foresee any new releases into waters. The types and concentrations/activities of the foreseen releases of substances into waters remain unchanged. The amount of annual releases of substances and heat into waters will be UNCHANGED and within the limits set by the OVD [4] and RETS [11].

5.2.3. Disposal/release of substances into the ground

No disposal or release of substances into the ground is foreseen due to the extended operation. Wastewater from precipitation, technology and municipal wastewater will be disposed of in compliance with the valid environmental permit.

5.2.4. Noise

No new noise sources are foreseen due to the extended operation, so there will be no increase in noise levels in the natural and living environment. Noise emissions will be identical to the present ones.

5.2.5. Ionising radiation - Normal operation

The extension of NEK's operational lifetime from 40 to 60 years does not alter the types and annual estimated doses of radiation. The estimated radiation doses remain UNCHANGED and within USAR [2] and RETS limits [11].

The annual dose on the NEK perimeter fence will not exceed the limit of 200 µSv as a result of the extension of operational lifetime [11]. The dose rate will not exceed the limit of 3 µSv/h, as defined in the fourth point of the first paragraph of Article 4 of the Rules on radiation protection measures in controlled and monitored areas [74], which defines the limiting average dose rate within eight hours for controlled areas. Neither will the dose rate surpass the limit from the first paragraph of Article 7 of the above Rules [74] for monitored areas, which is 0.5 µSv/h.

In addition to NEK's measurements of all releases into the air and waters, independent radiological monitoring is also carried out by authorised institutions from Slovenia (Jožef Stefan Institute, Institute of Occupational Safety, MEIS Storitve za okolje) and Croatia (Ruđer Bošković Institute). The aim of radiological monitoring is to keep a check on the power plant's operation and assess impacts on the environment and the population, and the plant's compliance with the prescribed limits. The external authorised institutions measure samples from the environment primarily in a 12 km radius around NEK.

In the area surrounding the power plant there are 13 automatic radiation measuring stations, which can detect changes in natural radiation levels due to precipitation as well as possible changes due to the nuclear facility.

The Sava is monitored downstream to a distance of 30 km from the power plant, also by independent authorised institutions.

The effect of NEK's radiation on the environment is so low that it actually cannot even be measured. However, it can be calculated with the help of models for the most exposed population group and the annual dose can be compared to the dose due to natural and other radiation sources.

The results of measurements in the environment are dealt with in more detail in special reports that can be seen on the NEK website (https://www.nek.si/sl/novinarsko-sredisce/porocila/letno-porocilo-o-meritvah-radioaktivnosti-v-okolju). The results of measurements confirm that all impacts on the environment are far below the administrative limits.

It is not expected that the extension of NEK's operational lifetime will increase impacts on the environment. All environmental and radiological conditions and limits, as they are listed in NEK's existing valid operating licence [3] remain unchanged with the extension of NEK's operational lifetime from 40 to 60 years.

5.2.6. Ionising radiation - State of emergency

As stated in section 3.2.7, NEK has studied design basis accidents and design extension conditions. Design basis accidents are described in the NEK safety report [2]. The impact on the environment, i.e. at the outer edge of the controlled area (500 m) is within the limits stipulated in the US 10 CFR 100 regulation. For a series of design basis accidents the calculated doses at 0.5 km and 1.5 km from the plant are given in NEK's safety report [2]. The estimated dose burdens due to accidental releases of radioactive substances into the atmosphere for greater distances are given in the FER-MEIS report: "Calculation of Doses at Certain Distances for Design Basis Accidents (DBA) or Beyond Design Basis Conditions (BDB) at NPP Krško" [56].

The analysed beyond design basis accidents also include more serious, but considerably less likely, core damage. In most of these cases it is expected that the containment remains intact. In a specific, small portion of accidents, releases through the passive containment filtering vent system (PCFVS), illustrated in the figure, are expected (Figure 4). The estimated doses at different distances from NEK in the event of beyond design basis accidents area also described in the FER-MEIS report "Calculation of Doses at Certain Distances for Design Basis Accidents (DBA) or Beyond Design Basis Conditions (BDB) at NPP Krško" [56].

5.2.7. Generation of waste

The extension of NEK's operational lifetime from 40 to 60 years does not alter the types and dynamics of the expected generation of waste. The total amount of waste will increase (for the additional 20 years of operation).

The dynamics of waste generation remain UNCHANGED and compliant with the provisions of the USAR [2] and RETS [11]. The quantity of waste on 31 December 2020 is given in the table (Table 11).

Table 11: Inventory of processed LILW, located in the Storage Building on 31 December 2020

Waste stream	Waste type	No of packages	Total volume of packages [m³]	Gross weight of packages [t]
Evaporator	Evaporation residues	14	10.8	15.8
	Evaporation residues in silicate concrete	1,465	1,261.9	3,172
	Dried concentrate	125	102.6	124.1
	Dried sludge/concentrate	11	8.9	10
Spent ion rasins	Primary ion exchangers in silicate concrete	795	234.9	439.7
	Ion exchangers from the primary systems	71	61	127.9
	Ion exchangers from the BD system	15[1]	12.4	11.2
Spent filters	Filters in concrete	140	44.2	147.4
Compressible waste	Compresisible combustible waste	7[2]	1.5	0.7
	Compacted waste	759	375.7	431.4
	Incineration products	83[3]	25.9	34.9
Non-compressible	Other non-compressible waste	7[4]	1.5	1
	SC non-compactable waste	234	151.2	222.4
Specific waste	SC active charcoal	12	10.4	9.9
Total	**-**	**3,738**	**2,302**	**4,748[5]**

In the 13th meeting of the Intergovernmental Commission for Monitoring the Execution of the Treaty between the Governments of Slovenia and Croatia on the regulation of status and other legal relations connected with investments, exploitation and decommissioning of NEK (MDP) held on 30 September 2019, a decision was made, based on the report from the Coordination Committee, that a joint solution for the LILW waste repository is not possible.

The total quantities of LILW to be shared between the Slovenian and Croatian parties, determined on the basis of the waste inventory in the NEK storage facility and the estimates of future LILW generation during NEK operation and decommissioning, are shown in the following table (Table 12).

[1] Additional 53 packages located in the Decontamination building ready for incineration (10.6 m³; 11.7 t)
[2] Additional 393 packages located in the WMB and DB, ready for incineration (82.0 m³; 40 t)
[3] Additional 19 packages located in Decontamination building (4.0 m³; 6.2 t)
[4] Additional 28 packages of other waste (4.0 m³; 6.2 t)
[5] Additional 80 ingots located in Decontamination building (8.8 m³; 49.5 t)

Table 12: Total amount of LILW to be shared between the Slovenian and Croatian parties.

Period of LILW generation	Data source	Mass (t)	Volume (m^3)	Activity (Bq)[6]
1983 – 2018[7]	inventory	4,877.4	2,294.9	5.98 E13
2018 – 2023	estimate	264	163.4	1.44 E13
Up to 2023	**estimate**	**5,141.4**	**2,458.3**	**7.42 E13**
2024 – 2043	Estimate	883.7	546.6	4.83 E13

Each party will manage its half of LILW in accordance with national strategies and programs addressing radioactive waste management [55].

Under the basic scenario, the Slovenian half of the waste should be disposed in Vrbina in two phases: in the first phase, from 2023 to 2025, disposal of the currently stored LILW from operation and other sources; in the second phase, from 2050 to 2061, disposal of the remaining LILW from NEK's operation together with the LILW from decommissioning, at which time the procedures for the final closure of the repository will also be initiated. The LILW from other sources refer to the LILW that meets the acceptance criteria for waste disposal and originate from the central storage facility for radioactive waste.

The Croatian scenario envisages that the Croatian part of the operational LILW will be transported to Croatia to the centre for radioactive waste management (CRAO), which will be built in compliance with the Strategy. The priority location of the CRAO centre is Čerkezovac, the location of the military logistics complex, which the army does not intend to use in the future. Čerkezovac is located in the municipality of Dvor on the southern slopes of the Trgovska Gora massif.

5.2.8. Spent fuel

All spent fuel at NEK is currently stored in the spent fuel pool, where 1,694 cells are available in storage racks. There was therefore a total of 1,323 fuel elements stored in the spent fuel pool at the end of 2020, including two special containers with fuel rods and a fission chamber from 2017. If NEK operated until the end of 2023, a total of 1,553 elements of spent fuel would be generated. If NEK operates until the end of 2043, a total of 2,281 spent fuel elements are estimated to be generated. Due to the extension of the operational lifetime from 2023 to 2043, it is expected that there will be an extra 728 elements of spent fuel at NEK.

The spent fuel elements will be relocated from the spent fuel pool to the storage in four campaigns, as listed in the table below (Table 13) [35].

Table 13: Campaigns for the transfer of SF from the pool to dry cask storage

Relocation campaigns:	Execution	Approximate number of fuel elements
Campaign I	2023	592 fuel elements
Campaign II	2028	592 fuel elements
Campaign III	2038	444 fuel elements
Campaign IV	2048	remaining fuel elements

[6] **Value excluding radioactive decay.**
[7] **Until 2020 some of the waste was further processed.**

5.2.9. Electromagnetic radiation

Electromagnetic radiation is limited to the NEK site. The extension of NEK's operational lifetime from 40 to 60 years does not alter the intensity of electromagnetic radiation and it remains limited to the NEK site.

5.2.10. Light emitted into the surroundings

Light does not shine outside the NEK site. The extension of NEK's operational lifetime from 40 to 60 years does not alter the intensity of light shining into the surroundings and remains limited to the NEK site.

5.2.11. Warming of air/water

The extension of NEK's operational lifetime from 40 to 60 years does not foresee any warming of the air and no additional warming of water. The size of the parameter temperature rise of the Sava (delta T) remains unchanged. The extent to which water will be heated will remain UNCHANGED and within the limits of OVD [4].

The effect of heating on the air is a minimal increase due to the dry storage of spent fuel. This impact has been analysed in the PVO for the acquisition of the OVS for the project of dry storage of spent fuel [35].

5.2.12. Foul odours

NEK does not produce foul odours or smells in the course of its operation.

5.2.13. Visibility

NEK's visibility will not change physically as a result of its operational lifetime being extended from 40 to 60 years.

5.2.14. Vibrations

NEK is an insignificant source of vibrations for its surroundings. All the machinery in the facilities that could be a source of vibrations is installed in such a way as to prevent the spread of vibrations inside and outside the facility. There will be no impact due to vibrations during the operating period.

5.2.15. Change in land use

The intended and actual land use will not change as a result of the planned operation extension.

5.2.16. Change in vegetation

There will be no changes in the surrounding vegetation due to NEK's extended operation.

5.2.17. Explosions

NEK does not use explosives for its operation. This will remain the case in the future.

5.2.18. Physical change/transformation of surfaces

NEK will not implement physical changes or transform surfaces as a result of its extended operation.

5.2.19. Water consumption

Water status

The extension of NEK's operational lifetime from 40 to 60 years does not foresee any changes in water use. Water use will remain UNCHANGED and within the limits of water permits [5], [6] and [7].

Water consumption

The extension of NEK's operational lifetime from 40 to 60 years does not foresee any changes in water use. Water consumption will remain UNCHANGED and within the limits of water permits [5], [6] and [7].

5.2.20. Miscellaneous

The extension of NEK's operation from 40 to 60 years does not change or contravene any of the currently legally defined protection areas, such as Natura 2000, water protection areas, or other legally defined conservation areas and cultural heritage.

5.3. Baseline and outline of further development in the event of no lifetime extension (zero variant)

Energy, system, environment protection, social and economic studies have shown that the extension of NEK's operational lifetime constitutes the most favourable alternative to all other technologies that are suitable for the production of electricity in the base-load mode and had matured for commercial use by 2020.

Its advantages are particularly significant in terms of:

- assuming the role of a support point for the 400 kV network in normal operating conditions and in the event of disruptions;
- the positive impact on Slovenia's international obligations regarding CO_2 emissions as it does not produce these emissions, whereas other technologies that use fossil fuels would put Slovenia far off from fulfilling the demands of the Paris Agreement, the European Green Deal, the Resolution on Slovenia's Long-Term Climate Strategy until 2050 etc.,
- land use, as it does not require any new development of land, and
- economics, as its operating costs are considerably lower than any of the alternative technologies, or the purchasing of energy on the market.

The non-extension of the operational lifetime of NEK would threaten Slovenia's energy independence. The deficit in energy would have to be produced using other sources or by purchasing electricity from other countries. The consequences would be economical, political and ecological.

The consequences of the zero variant are described in detail in the study Energy, Systemic, Economic and Ecological Aspects of the Operational Lifetime Extension of the Krško NPP, EIMV, Ljubljana, 2021 [15].

5.3.1. Economic consequences of the zero variant

Alongside the direct negative impact of the zero variant for the owner, the zero variant has an even greater negative macroeconomic impact on Slovenia [63]. NEK's operation, like the operation of all other energy sectors, has both a direct and indirect impact on Slovene society as a result of its tight connections with it. The negative macroeconomic effects presented in Table 14 have been calculated for 2019 on the basis of findings of the results of analyses carried out by the Economic Institute of the Faculty of Law in 2008 [63].

If NEK was shut down, this would cause a drop in electricity production amounting to 5.526 TWh (data from 2019), 2.763 TWh of this electricity being for Slovene requirements. This loss of electricity required for the domestic market would in the medium term largely be replaced by increased imports. The direct effect of NEK being shut down would mean the loss of EUR 267 million in income per year. Through its operation and purchasing of materials and services, NEK creates demand from suppliers, thereby increasing their income and added value. If NEK was shut down indefinitely, Slovenia's GDP would immediately fall by EUR 125 million per year (0.3% GDP). If NEK was shut down, this would directly cause losses in the budget's fiscal revenues and public funds from NEK, amounting to EUR 91 million per year.

In the case of the zero variant, Slovenia would lose almost 2,200 high quality and reliable jobs. Every job, created directly at NEK, maintains a further 1.5 jobs in the economy, so altogether 2.5 jobs.

Table 14: Negative macroeconomic effects of the zero variant calculated in 2019. The estimated value in the event that NEK stops operating and producing electricity (the macroeconomic effects of decommissioning are not taken into account).

Economic and social impacts of the zero variant	Direct effect	Indirect effect	Total
Fall in production	EUR 161 million annually	EUR 107 million annually	EUR 267 million annually
Smaller GDP	EUR 600 million annually	EUR 1,600 million annually	EUR 2.2 billion annually
Negative impact on revenues for public finances	EUR 200 million annually	EUR 400 million annually	EUR 600 million annually
Number of jobs lost	2,000	3,500	5,500

Both owners of NEK (the Republic of Slovenia and the Republic of Croatia) have already invested in the modification and replacement of equipment as a safety upgrade. Besides lost investments, both owners would have to provide the missing funds for NEK's decommissioning and radioactive waste disposal in the next 10 years. If NEK operates for another 20 years, these financial resources will be collected as levies in both funds earmarked for NEK's decommissioning.

The additional economic analysis has demonstrated that the eligibility criterion for continued operation has been met [31].

5.3.2. Ecological consequences of the zero variant

The zero variant's main negative impact on the environment is the shift away from decarbonisation, which is the main goal of the NECP document [14], adopted in 2020.

In several places the NECP defines the development of nuclear energy as the fundamental technology for achieving a low-carbon society, i.e. for reaching the targets to reduce emissions of greenhouse gases. It thereby follows the guidelines of Slovenia's 2030 development strategy and Slovenia's Vision.

Strategic documents, both on an international level and in Slovenia, show that considerable efforts will be necessary to significantly reduce CO_2 emissions, abandon the use of fossil fuels and protect our atmosphere as far as possible.

The project to extend NEK's operating licence can do much to help provide a safe and reliable source of electricity. NEK's energy:

- according to international methodology is a local source of energy, which reduces energy import dependence,
- is a competitive source of energy, with an acceptable, foreseeable and stable price of electricity,
- represents the optimal solution for environmental demands and standards, reduced CO_2 emissions on a national basis – nuclear energy has very low CO_2 emissions throughout its operating period, and besides it does not produce CO_2 emissions during operation,
- fulfils the highest international safety demands and standards,
- supports positive effects on economic development and living standards, and therefore also highly qualified jobs.

Climate

When taking into account the impact of a technology on the climate, an important statistic is the amount of greenhouse gas emissions in the entire life cycle (i.e. from the construction of the power plant, the acquisition of fuel, operation, decommissioning and disposal of waste). According to information from the UN Intergovernmental Panel on Climate Change (IPCC) [reference IPCC 2014], the greatest impact on the environment, throughout their life cycle, is exerted by thermal power plants, which release the largest amount of emissions into the atmosphere while producing electricity. The internationally acknowledged value of emissions when burning black coal is 0.82 kg CO_2 eq/kWh, while according to data from the Statistical Office of the Republic of Slovenia, for Slovenian lignite the value is 1.2 kg CO_2 eq/kWh (because it has a poorer heating value and the power plant is therefore less efficient).

NEK produces a net 696 MW of electricity. In the event of NEK's shutdown, energy would have to be replaced with other sources.

Data for the emissions of different technologies are taken from the IPCC, which operates as a UN body [reference IPCC 2014]. IPCC values are also used in all analyses by other relevant international agencies (e.g. the IEA at the OECD), as well as EU bodies and institutions. Throughout its life cycle (construction, operation, decommissioning, uranium ore mining and processing), a nuclear power plant releases 0.012 kg of CO_2 into the atmosphere per each kWh of electricity generated.

According to internationally acknowledged data, a coal-fired thermal power plant produces 0.82 kg CO_2 for every kWh of electricity produced (this is the case for thermal power plants using black coal; power plants using brown coal or lignite have even greater CO_2 emissions per kWh). Gas power plants of the same output power produce about half as much CO_2 emissions.

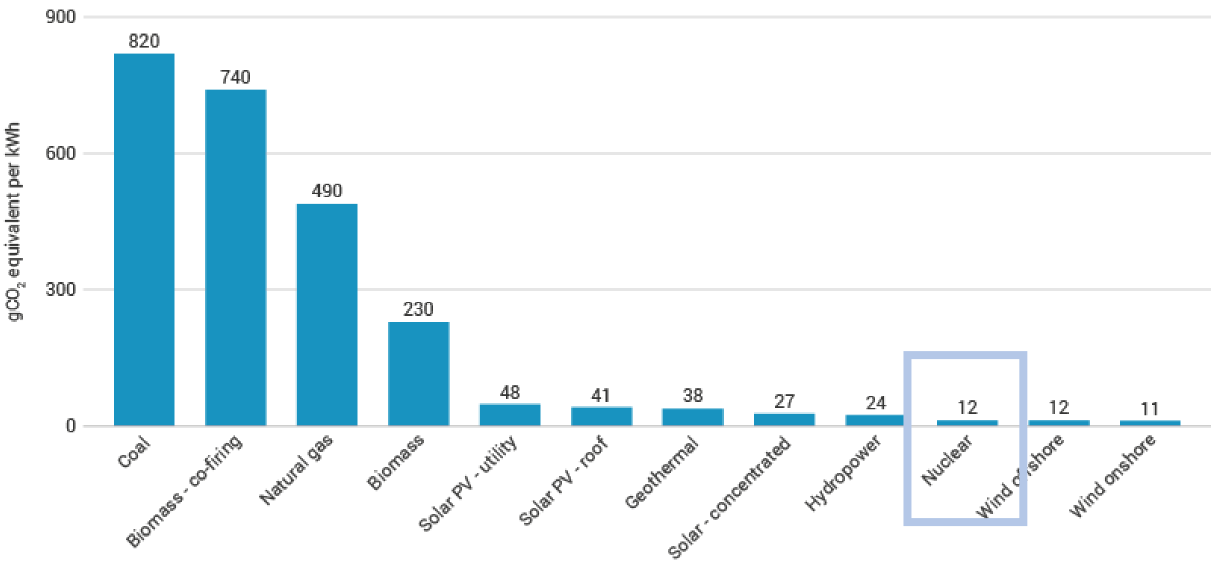


Figure 9: Average emissions of carbon dioxide equivalents in a life cycle of different electricity producers (Source: IPCC)

The greatest environmental impact would, in the event that NEK was shut down, be caused by the release of greenhouse gases, as there are no other sources with NEK's capacity, reliability and economy that could cover the electricity deficit.

Land use

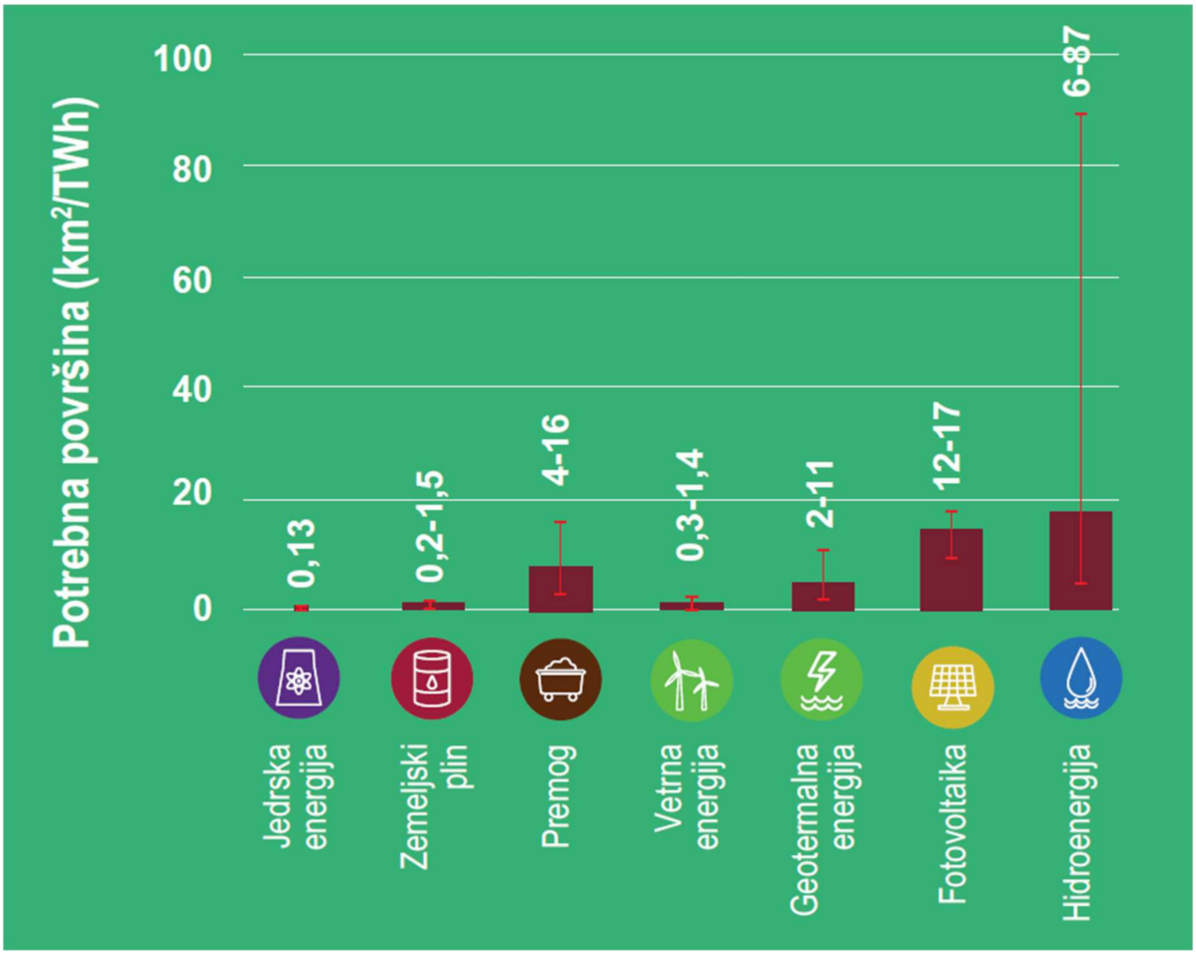


Figure 10: Land use with regard to production source of electricity Source: "Energy Sprawl Is the Largest Driver of Land Use Change in United States", A.M.Trainor PLOS ONE | DOI:10.1371/journal.pone.0162269 8 September 2016

Potrebna površina (km^2/TWh)	Required surface area (km^2/TWh)
Jedrska energija	Nuclear energy
Zemeljski plin	Natural gas
Premog	Coal
Vetrna energija	Wind power
Geotermalna energija	Geothermal energy
Fotovoltaika	Solar photovoltaic
Hidroenergija	Hydropower

On the assumption that Slovenia wants to replace the existing production capacities, the graph (Figure 10) shows that nuclear energy has the smallest possible footprint on land use compared to other production sources. With new energy facilities, not only use of land for the facilities themselves, but also the required construction of new transmission line infrastructure for connection of the facilities to the grid must be taken into account.

It should be further emphasised that power plants of the same power installed do not produce the same annual output, e.g. solar power plants do not operate at night and operate at a lower capacity in cloudy weather, the output of wind power plants changes over time, as wind power plants do not operate without wind or at extremely high wind speeds, and even hydroelectric power plants rarely produce electricity at rated power. It is therefore important to what extent the power plant is made use of. The power plant's utilisation factor is calculated as the relationship between the energy produced by the power plant if it operated at full power all the time, and the electricity actually produced. It must be taken into account that renewable energy sources have a priority in the grid and they submit all the electricity they produce into the grid, while other power plants must conform to demand and do not provide electricity all the time, but only when the grid requires energy. The image below shows the utilisation factor of all of Slovenia's power plants in 2019. (Source: Report on the situation in the energy sector in Slovenia in 2019, Energy Agency of RS, Maribor, 2020).

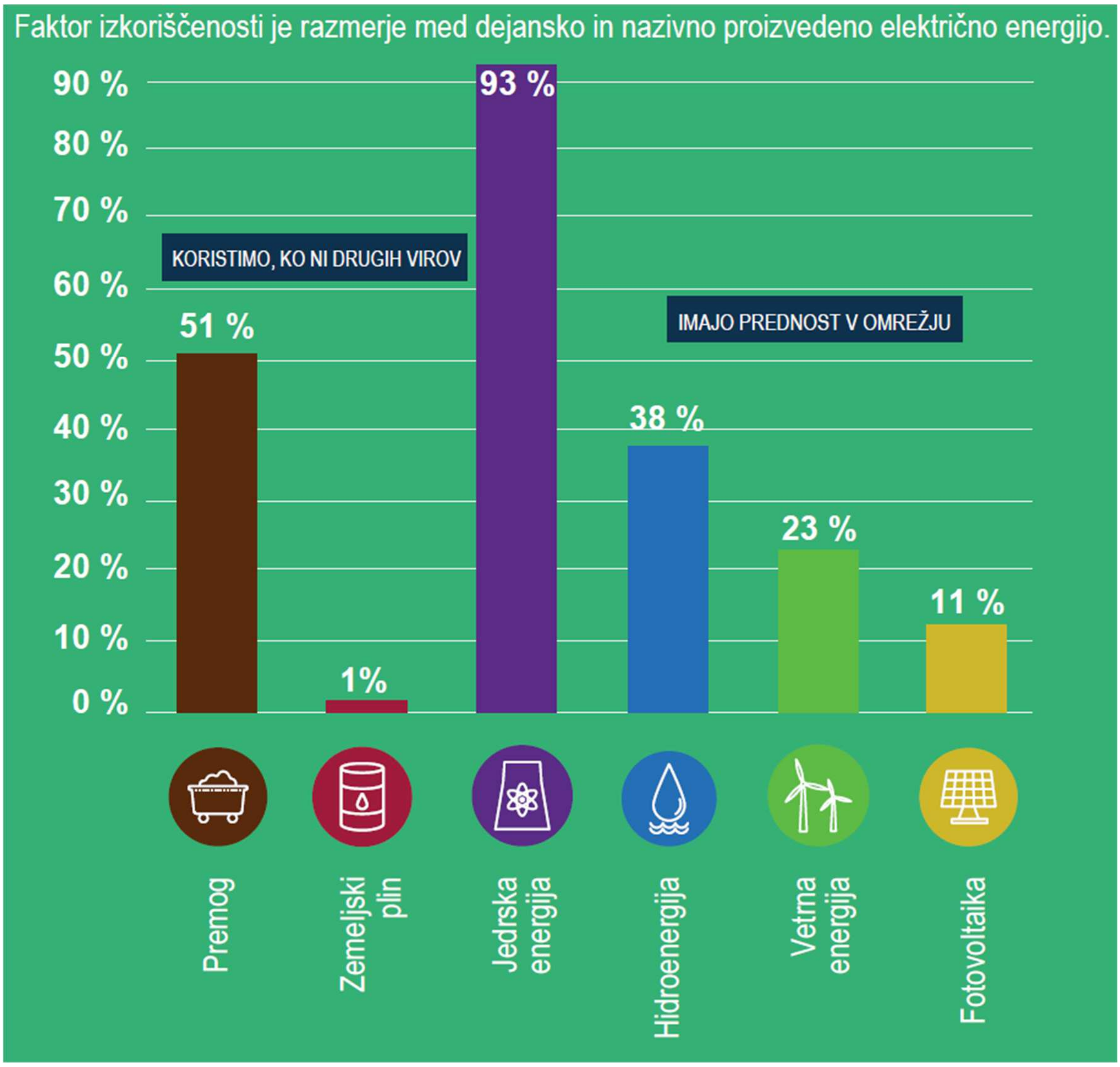


Figure 11: Annual electricity production (output) with regard to installed power. Source: "Report on the situation in the energy sector in Slovenia in 2019, Energy Agency of RS, Maribor, 2020"

Faktor izkoriščenosti je razmerje med dejansko in nazivno proizvedeno električno energijo.	The utilisation factor is the ratio between actual and nominal production of electricity.
KORISTIMO, KO NI DRUGIH VIROV	WE USE WHEN THERE ARE NO OTHER SOURCES
IMAJO PREDNOST V OMREŽJU	THEY HAVE PRIORITY IN THE GRID
Premog	Coal
Zemeljski plin	Natural gas
Jedrska energija	Nuclear energy
Hidroenergija	Hydropower
Vetrna energija	Wind power
Fotovoltaika	Solar photovoltaic

6. Facility decommissioning program

International standards and Slovenian legislation (ZVISJV-1 [45]) set strict demands regarding access to decommissioning and handling of waste for all nuclear facilities, with NEK in first place.

As sufficient experience has been accumulated on decommissioning old pressurised water nuclear power plants, there is cumulative generic data on quantities of radioactive waste from decommissioning and on decommissioning costs. This data has been collected for all OECD member states for over 20 years by the OECD NEA and is periodically published in reports on decommissioning approaches, strategies and costs [27]. Reports of decommissioning costs and methods are periodically upgraded. In the international environment, the decommissioning of nuclear facilities is a mature and developed industrial branch with different providers, who also appear in international markets.

The decommissioning of NEK, the disposal of radioactive waste and spent fuel are the joint responsibility of the contracting parties, the Republic of Slovenia and the Republic of Croatia, as determined in the Joint Convention from the preamble of the Treaty [30].

The two countries agree to provide an efficient joint solution for decommissioning and for disposal of radioactive waste and spent fuel in terms of economy and environmental protection.

The disposal of operational and decommissioning radioactive waste and spent fuel will be carried out in accordance with the Radioactive waste (RW) and Spent Fuel (SF) Disposal Program. In cooperation with NEK d.o.o., the RW and SF Disposal Program will be prepared according to international standards by a professional organisation selected by the contracting parties.

In accordance with the Treaty [30], the first removal of Radioactive waste from NEK's LILW storage facility will take place in the 2023–2025 period. As the contracting parties failed to reach a common solution, and in accordance with the third revision of the RW Disposal Program [33], 50% of LILW will be disposed of at the Vrbina Repository, and another 50% in a long-term storage facility and later at a repository in the Republic of Croatia.

The Decommissioning Program also includes management of all radioactive and other waste arising from the decommissioning, until its removal from the NEK premises, an estimation of the cost, and deadlines for its implementation.

The first description of the Decommissioning Program was provided in the document entitled "Development of the Site-Specific Decommissioning Plan for Krško NPP, NIS Ingenieurgesellschaft mbH", April 1996 [22].

In accordance with Article 10 of the Treaty [30], a review of the decommissioning program has to be made every five years that includes the development of new findings in the field of decommissioning nuclear facilities.

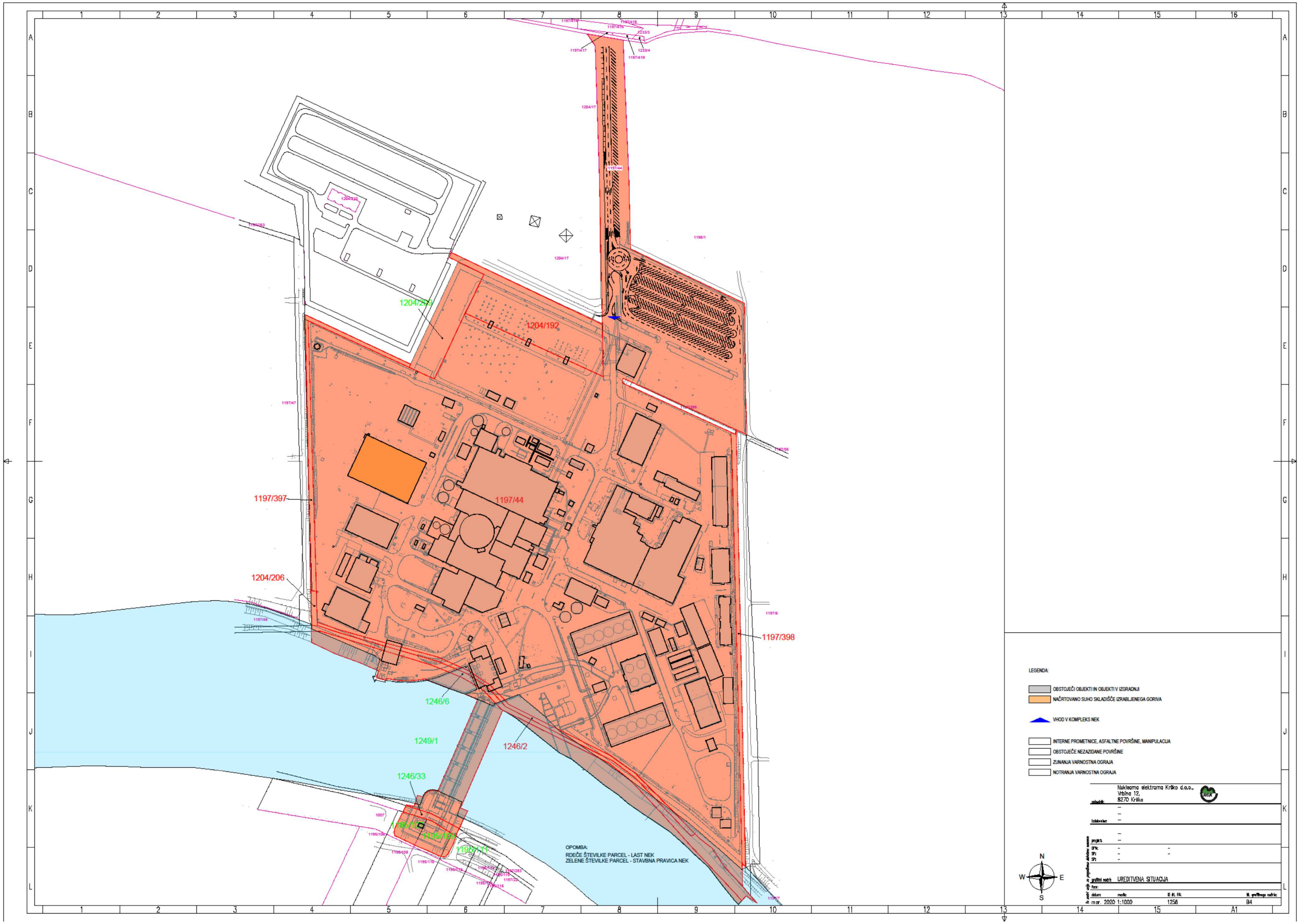
In 2019, the NEK Decommissioning Program, rev. 3 [33] and RW Disposal Program, rev. 3 [34]. In accordance with the Treaty [30] endorsed by the governments of Slovenia and Croatia, financial assets for the NEK Decommissioning Program and the RW Disposal Program are being raised in special funds. Both reports are publicly available at: https://www.sklad-nek.si/porocila-o-poslovanju [38] and http://www.fond-nek.hr/en/financial-assets/annual-reports/17 [39].

The aim of periodic reviews of the NEK Decommissioning Program and the Decommissioning Plan is to regularly review and reasonably implement new international standards while applying the best practices throughout the power plant's operation. These reviews are necessary to estimate the costs of the future decommissioning and management of radiological waste and spent fuel, and they form a basis for decommissioning funds in Slovenia and Croatia. All the studies carried out in the past used the limiting conditions for NEK's operation until 2023. In 2013, NEK received the URSJV Decision on the Modification of the Operating Licence [3], which means that all subsequent studies took into consideration the extended operational lifetime until 2043.

The impact of the facility's decommissioning will be described in more detail and assessed in a special administrative procedure in compliance with the Decommissioning Program [33] and in compliance with ZVO-1, the Decree on activities affecting the environment that require an environmental impact assessment [40]; annex 1, section D.II and ZVISJV-1 [45], Article 109.

7. Graphic Displays

1. Site Layout


1204/203
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1197/397
1197/44
1204/206
1197/398
1246/6
1249/1
1246/2
1246/33
OPOMBA:
RDEČE ŠTEVILKE PARCEL - LAST NEK
ZELENE ŠTEVILKE PARCEL - STAVBNA PRAVICA NEK
LEGENDA:
OBSTOJEČI OBJEKTI IN OBJEKTI V IZGRADNJI
NAČRTOVANO SUHO SKLADIŠČE IZRABLJENEGA GORIVA
VHOD V KOMPLEKS NEK
INTERNE PROMETNICE, ASFALTNE POVRŠINE, MANIPULACIJA
OBSTOJEČE NEZAZIDANE POVRŠINE
ZUNANJA VARNOSTNA OGRAJA
NOTRANJA VARNOSTNA OGRAJA
Nuklearna elektrarna Krško d.o.o.,
Vrbina 12,
8270 Krško
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OPOMBA:	NOTE:
RDEČE ŠTEVILKE PARCEL – LASTNIK	RED PARCEL NUMBERS – OWNER
ZELENE ŠTEVILKE PARCEL – STAVBNA PRAVICA NEK	GREEN PARCEL NUMBERS – NEK SUPERFICIES
LEGENDA:	KEY:
OBSTOJEČI OBJEKTI IN OBJEKTI V IZGRADNJI	EXISTING FACILITIES AND FACILITIES UNDER CONSTRUCTION
NAČRTOVANO SUHO SKLADIŠČE IZRABLJENEGA GORIVA	PLANNED DRY STORAGE FOR SPENT FUEL
VHOD V KOMPLEKS NEK	ENTRANCE TO THE NEK COMPLEX
INTERNE PROMETNICE, ASFALTNE POVRŠINE, MANIPULACIJA	INTERNAL ROADS, PAVED SURFACES, MANIPULATION
OBSTOJEČE NEZAZIDANE POVRŠINE	EXISTING UNDEVELOPED AREAS
ZUNANJA VARNOSTNA OGRAJA	EXTERNAL SECURITY FENCE
NOTRANJA VARNOSTNA OGRAJA	INTERNAL SECURITY FENCE
UREDITVENA SITUACIJA	SITE PLAN

8. Conclusions

The scope of the intended activity is the continued operation of NEK with the existing operating characteristics after 2023 and does not foresee the construction of new structures or facilities that would change the physical characteristics of NEK.

In 40 years of operation, NEK has implemented all necessary modifications, which ensure that the power plant complies with modern safety standards. By the end of the first half of 2023, the project to construct dry spent fuel storage will also be completed. This will further improve the power plant’s nuclear and radiation safety.

With the extension of NEK’s operational lifetime by 20 years, the types and dynamic of the expected generation of radioactive waste remains unchanged, only the total quantity of spent fuel that is already taken into account in the project for the construction of dry storage for spent fuel will increase, as will the amount of low and intermediate level radioactive waste.

For its operation, NEK has acquired an operating permit, which is valid for an unlimited period of time [3], as well as all the other necessary permits ([2], [9], [10], [11], [4], [5], [6], [7]), such as permits regarding emissions into the environment and permits for taking water from the environment. With the extension of NEK’s operational lifetime, all the environmental and radiological conditions and limits listed in the valid licences remain the same.

In the process of producing electricity, NEK does not release greenhouse gases into the environment, and it is for this reason that it is considered a low-carbon energy producer. This fact is particularly important especially because NEK is a key link in ensuring Slovenia has enough energy in the future.

During NEK's construction process, a minimum operational lifetime of 40 years was envisaged. During this period, however, a number of safety and other upgrades have been carried out, and numerous analyses have also been conducted. As a result of all the safety upgrades, replacements of key equipment and other modifications in the past, together with safety and probability analyses, the extension of the operational lifetime is the only prudent and globally established solution, in terms of security and cost-efficiency.

9. References

[1] ARSO decision concerning the intended activity: Extending the Operational Lifetime of NEK from 40 to 60 Years until 2043, No. 35405-286/2016-42, dated 2 October 2020

[2] Updated Safety Analysis Report (USAR), Rev. 27

[3] Operating Licence: Decision – Approval to Commence NEK Operation; Decision by the National Energy Inspectorate, No. 31-04/83-5, dated 6 February 1984, and the URSJV Decision, No. 3570-8/2012/5, Amendment to the Operating Licence for NEK, dated 22 April 2013

[4] ARSO Environmental permit: Environmental permit for NEK's operation concerning emissions to water No. 35441-103/2006-24 of 30 June 2010, which was amended and reaffirmed in three points of the operational part with Decision No. 35441-103/2006-33 of 4 June 2012 and was amended under decision No. 35441-11/2013-3 of 10 October 2013 (abbreviated to: OVD).

[5] ARSO Water permit: Partial Water Permit, No. 35536-31/2006-16 of 15 October 2009, and the Decision on the Modification of the Water Permit, No. 35536-54/2011-4 of 8 November 2011 and Decision on the Modification of the Water Permit No. 35530-7/2018-2 of 22 June 2018 (abbreviated to: VD)

[6] MOP, DRSV (2020): NEK water permit, No. 35530-100/2020-4 of 14 November 2020, Ljubljana

[7] MOP, DRSV (2021): NEK water permit, No. 35530-48/2020-3 of 9 September 2021, Ljubljana

[8] Planning permission: Decision of the Republic's Secretariat for Urban Planning No. 350/F-15/69 of 8 August 1974 and the Ordinance on NEK's development plan UN 55/87; Official Gazette of SRS No. 48/87; Amendments to the Ordinance on NEK's development plan; Official Gazette of SRS, No. 59/97 and the Amendments to the Ordinance on NEK's development plan (Official Gazette of RS, No. 21/20)

[9] NEK Technical Specifications (NEK TS), rev 183

[10] Design Extension Conditions - Technical specifications (DECTS), Rev. 8

[11] Radiological Effluents Technical Specifications (RETS), Rev. 10

[12] Monitoring radioactivity around Krško NPP, Report for the year 2020

[13] 2020 Report on Ionising Radiation Protection and Nuclear Safety in the Republic of Slovenia, URSJV, July 2021

[14] Integrated National Energy and Climate Plan (NECP) – adopted by the Government of the RS (Version 5.0), No. 35400-18/2019/22, 28 February 2020

[15] Energy, Systemic, Economic and Ecological Aspects of the Operational Lifetime Extension of the Krško NPP, a study: 2511, EIMV, Ljubljana, July 2021

[16] Environmental report following its public unveiling: Technical support for the comprehensive assessment of environmental impact for the Integrated National Energy and Climate Plan of the Republic of Slovenia Tender SRSS/C2019/048; EIMV, ZaVita, and STRITIH; Study: 219240-3-4-S, Ljubljana, February 2020

[17] Bureau Veritas: ISO 14001:2015 Certificate, dated 20 November 2020

[18] Bureau Veritas: ISO 45001:2018 Certificate, dated 20 November 2020

[19] Bureau Veritas: OHSAS 18001:2007 Certificate, dated 17 December 2014

[20] Slovenian National Report on Nuclear Stress Tests, Final Report, SNSA, December 2011

[21] Technical Summary on the Implementation of Comprehensive Risk and Safety Assessments of Nuclear Power Plants in the European Union, Brussels, 22 August 2013

[22] Development of the Site-Specific Decommissioning Plan for Krško NPP, NIS Ingenierungeselschaft mbH, April 1996

[23] URSJV Decision on the Confirmation of the First Periodic Safety Review (PSR1), No. 39000-17/2005/5/16, dated 16 August 2005

[24] URSJV Decision on the Confirmation of the Second Periodic Safety Review (PSR2), No. 3570-2/2011/97, dated 30 May 2014

[25] NEK Safety Upgrade Program (PNV), Rev. 3, January 2017

[26] URSJV Decision in the Administrative Case "Approval of the NEK Safety Upgrade Program, Rev. 3, and the Extension of the Implementation Deadline", No. 3570-11/2015/25, dated 20 January 2017 and URSJV Decision No. 3570-11/2015/32 dated 24 September 2021

[27] Decommissioning Nuclear Power Plants, Policies, Strategies and Costs, OECD NEA 2003

[28] Update of the Slovenian Post-Fukushima Action Plan (NAcP), SNSA, December 2019

[29] URSJV Decision on the Implementation of an Extraordinary Safety Review of NEK, No. 3570-9/2011/2, dated 30 May 2011

[30] Act Ratifying the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the regulation of status and other legal relations regarding investment in and the exploitation and decommissioning of Krško nuclear power plant, and the Joint Declaration at the time of signature of the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the regulation of status and other legal relations regarding investment in and the exploitation and decommissioning of Krško nuclear power plant (Official Gazette of RS – International Treaties, No. 5/03)

[31] Minutes and decisions by the Interstate Committee regarding the extension of NEK life span (PŽD NEK), dated 20 July 2015

[32] Resolution on the National Program for Managing Radioactive Waste and Spent Fuel for the Period 2016–2025 (ReNPRRO16–25); Official Gazette of RS, No. 31/2016, dated 29 April 2016

[33] 3rd Revision of the NPP Krško Decommissioning Program, Siempelkamp NIS for NPP Krško, Document No. 4520 / CA / F 010640 5 / 01, June 2019

[34] Third Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Program, ARAO – Agency for Radwaste Management, Ljubljana, Fund for financing the decommissioning of the Krško NPP, Zagreb, version 1.3, September 2019

[35] Environmental Impact Assessment Report for Upgrading the Spent Fuel (SF) Storage Technology by Introducing Dry Storage – NEK, No. 101118-dn, March 2020, amended in June 2020

[36] Environmental Impact Assessment Report Krško NPP for the Cooling System Expansion (an additional tower with four cooling cells), Ljubljana, December 2006

[37] PVO Krško NPP (decontamination facility), No. IJS DP-8190, Jožef Stefan Institute, February 2000

[38] Annual Reports of the NEK Decommissioning Fund: https://www.sklad-nek.si/porocila-o-poslovanju

[39] Annual Reports of the NEK Decommissioning Fund: http://www.fond-nek.hr/en/financijska-imovina/godisnja-izvjesca/

[40] Environmental Protection Act /ZVO-1/ (Official Gazette of RS, Nos. 39/06-ZVO-1-UPB1, 49/06-ZMetD, 66/06- Constitutional Court Decision, 112/06- Constitutional Court Decision, 33/07-ZPNačrt, 57/08-ZFO-1A, 70/08-ZVO-1B, 108/09-ZVO-1C, 48/12-ZVO-1D, 57/12-ZVO-1E, 92/13-ZVO-1F, 56/15-ZVO-1G, 102/15-ZVO-1H, 30/16-ZVO-1I, 61/17-GZ, 21/18 - ZNOrg, 84/18 – ZIURKOE, 49/20-ZIUZEOP, 61/20-ZIUZEOP-A, 158/20)

[41] Decree on activities affecting the environment that require an environmental impact assessment; Official Gazette of the Republic of Slovenia, Nos. 51/14, 57/15, 26/17 and 105/20

[42] Convention on Environmental Impact Assessment in a Transboundary Context – Espoo Convention, Official Gazette of RS – International Treaties, No. 11/98; Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context, Official Gazette of RS – International Treaties, No. 1/10, Amendments and other amendments to the Convention on Environmental Impact Assessment in a Transboundary Context (MPCVO-A), Official Gazette of RS No. 105/13

[43] Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters – Aarhus Convention (Official Gazette of RS – International Treaties, Nos. 17/04, 1/10)

[44] Nature Conservation Act (ZON); Official Gazette of the Republic of Slovenia, No. 96/04 – official consolidated text, 61/06 – Zdru-1, 8/10 – ZSKZ-B, 46/14, 21/18 – ZNOrg, 31/18 and 82/20

[45] Ionising Radiation Protection and Nuclear Safety Act Official Gazette of RS, Nos. 76/17 and 26/19 (abbreviated: ZVISJV-1)

[46] Judgement of the EU Court of 29 July 2019 in the matter C411-17, https://eur-lex.europa.eu/legal-content/SL/TXT/PDF/?uri=CELEX:62017CJ0411&from=EN

[47] Energy, Systemic, Economic and Ecological Aspects of the Operational Lifetime Extension of the Krško NPP, Rev. 1, EIMV, Ljubljana, 2007

[48] Slovenian National Post-Fukushima Action Plan, ENSREG

[49] Special Safety Review Final Report – NPP Krško, Rev.0, October 2011

[50] WENRA Reference Levels, revision 2, September 2014

[51] NEK Compliance with WENRA Safety Reference Levels, NEK ESD-TR-23/15, Rev.0

[52] RELAP5/MOD3.3 Analyses to Determine Pressure and Flow Requirements for Alternative Safety Injection Pump for DEC-A LOCA Conditions, NEK ESD-TR-17/15, Rev. 1

[53] Analysis of Containment Cooling During and After DEC-B Accidents, NEK ESD-TR-18/15, Rev. 2

[54] Water Inventory Requirements/Management for DEC-A and DEC-B Accidents, NEK ESD-TR-05/15, Rev.1

[55] Analysis of Potential Division and Takeover of Operational and Decommissioning RW from Krško NPP, Extended Contents, Enconet and Ekonerg, 2018

[56] Calculation of doses at certain distances for Design Basis (DB) and Beyond Design Basis (BDB) accidents at NPP Krško(No. FER-ZVNE/SA/DA-TR03/21-0), FER-MEIS, 2021

[57] "POSSIBLE ROLE OF NUCLEAR IN THE DUTCH ENERGY MIX IN THE FUTURE", report commissioned by the Ministry of Economic Affairs and Climate Policy of the Netherlands, September 2020

[58] Screening of External Hazards, NEK ESD-TR-18/16, Rev. 1

[59] WENRA Report - Guidance Document Issue T: Natural Hazards Head Document; 21 April 2015

[60] Annual Report on Probabilistic Safety Assessments (PSA) for 2020/2021, July 2021

[61] MD-5 – NEK Aging Management Program, Rev.5, 6. 7. 2020

[62] TD-6 – Fire Safety Program – Fire Safety Rules, Rev.3

[63] Macroeconomic impacts of the construction and operation of Krško NPP2 (JEK2), EIPF, Ljubljana, May 2008

[64] KRŠKO NPP Analyses of Potential Safety Improvements, NEK ESD-TR-09/11, Rev.0, January 2011.

[65] URSJV Decision on the Modernisation of Safety Solutions for Prevention of Severe Accidents and for Mitigation of their Consequences, No. 3570-11/2011/7, dated 1 September 2011

[66] RELAP5/MOD3.3 Analyses of Bleed & Feed Method in DEC-A Conditions using Pressuriser PORV Bypass Motor Operated Valves and ASI pump, NEK ESD-TR-03/16, Rev.1, February 2018.

[67] Evaluation of different options regarding DECTS requirements for ASI and AAF system, NEK ESD-TR-10/19, Rev.1, May 2020.

[68] ARSO letter No. 35403-33/2020-16 dated 24 December 2020, Preliminary information in compliance with Article 52 of the Environmental Protection Act.

[69] Rules on radiation and nuclear safety factors (Official Gazette of RS, Nos. 74/16 and 76/17 – ZVISJV-1); JV5 Rules.

[70] Rules on the provision of safety following the commencement of operation of radiation and nuclear facilities (Official Gazette of RS, Nos. 81/16 and 76/17 – ZVISJV-1); JV9 Rules.

[71] Rules on radioactive waste and spent fuel management (Official Gazette of RS, No. 125/21); JV7 Rules.

[72] Decree on radiation activities (Official Gazette of RS, No 19/18); UV1.

[73] URSJV Decision on the Confirmation of the Program of the Third Periodic Safety Review at NEK (PSR3 program), No. 3570-7/2020/22 dated 23 December 2020.

[74] Rules on radiation protection measures in controlled and monitored areas, (Official Gazette of RS, No. 47/18); SV8A Rules.

[75] Seismic Probabilistic Safety Assessment of Krško Nuclear Power Plant, Level 1 and Level 2, Revision 2, ABS Consulting, November 2004, Proprietary Document

[76] Assessment of capacity of the NEK to resist permanent ground deformations due to potential surface faulting, NEK ESD-TR-10/13, Revision 2, Krško NPP, July 2014, Proprietary Document

[77] Probabilistic fault displacement hazard analysis, Krško East and West sites, Proposed Krško 2 Nuclear Power Plant, Krško, Slovenia, Revision 1, Paul C. Rizzo Associates, Inc., May, 2013, Proprietary Document

[78] Revised PSHA for NPP Krško site, PSR – NEK – 2.7.2, Revision 1, University of Ljubljana, Faculty of Civil and Geodetic Engineering, Institute of Structural Engineering, Earthquake Engineering and Construction IT, January 2004, Proprietary Document

[79] Preparation of new revision of PMF study and Conceptual design package for flood protection, FGG, 2010

[80] NEKSIS-A200/081D: Krško NPP – Measures for preserving NEK's flood safety, Study of Variants, Revision B, IBE, August 2015

[81] The Protection and Rescue Plan in NEK (referred to as: NZIR), Rev. 38.

10. Appendices:

10.1. Appendix 1: List of issued building permits

1. Authorisation from the Republic's Secretariat for the Economy Ljubljana No. 352-265/73-VI/ST, 12 May 1973, for the laying of underground cables for Krško NPP's telephone connection
2. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16/75, 17 February 1975, for preparatory works for the construction of Krško NPP at Vrbina near Krško
3. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16/75-ind/SE, 26 March 1975, for construction work to excavate the construction pit
4. Building permit of Krško Municipal Assembly No. 3-351-765/74, 12 April 1975, for the next 12 housing units in the temporary workers' compound
5. Building permit of Krško Municipal Assembly No. 3-351-353/75, 27 May 1975, for preparatory works to construct a new residential neighbourhood near the pond in Krško
6. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16/75-ind/SE, 16 June 1975, for construction of Phase II – Auxiliary buildings & RHR-M-elevation 82.25
7. Building permit of Krško Municipal Assembly No. 3-351-353/75, 20 June 1975, for construction of: prefabricated housing unit, a temporary restaurant, water supply system, sewage system, electrical leads and outdoor lighting, water treatment plant, hot water network
8. Building permit of Krško Municipal Assembly No. 3-351-353/75, 7 October 1975, for the construction of prefabricated houses at the "Zazidava ob Zdolski cesti" complex
9. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-6/75-KO, 27 October 1975, for the construction of Phase 4A – foundations for the auxiliary building at elevation 94.21 and 97.26, Phase 4B – foundations of the intermediate building, Phase 11 – auxiliary building from elevation 82.85 to 89.64
10. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16/75-ind/SE, 7 November 1975, for construction of Phase III – the foundations of the reactor building
11. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-7/75-KO, 13 November 1975, for construction of Phase 29 B, Phase 44, Phase 5 A, Phase 5 C and Phase 12 A
12. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-8/75-KO, 25 November 1975 for construction of protective buildings between elevations 100.3 and 106.3 m and the containment – steel shell, according to technical documentation
13. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-9/75-KO, 27 November 1975, for construction of a meteorological tower H 70 m
14. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-10/75-KO, 16 December 1975, for construction of an auxiliary building between elevations 94.21 and 100.3 m and foundation slab for fuel handling facilities
15. Building permit of Krško Municipal Assembly No. 351-694/75, 25 December 1975, for the construction of the central depot in the customs warehouse
16. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-11/75, 16 January 1976, for construction of a meteorological station
17. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-12/76-KO, 21 January 1976, for construction of Phases 8, 13 and supplement to NP 13, 17A, 34, 35, 36 and supplement to NP 34, 35, 36
18. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-14/76-KO, 20 February 1976, for construction of a fuel handling facility and turbine building – foundation slab
19. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16/13/76-KO, 2 March 1976, for construction of access road C III, Phase 1, and a culvert for the Potočnica

20. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-20/76-KO, 7 March 1976, for construction of a command building (phase 20) and a building housing the component cooling systems (phase 23)
21. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-30/75-KO, 11 April 1976, for construction of an intermediate building (phase 19), a fuel-handling building (phase 28), turbine building, service elevation (phase 32), reactor buildings (phases 37 and 38)
22. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-15/75-KO, 14 April 1976, for the construction of a fuel-handling building (phase 25)
23. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-17/76-KO, 27 May 1976, for the construction of a neutralising pool for waste regeneration water
24. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16/19/76-KO, 18 June 1976, for the construction of an industrial siding
25. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-21/76-KO, 7 July 1976, for the construction of the turbine building (phase 31)
26. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-22/76-KO, 28 July 1976, for construction of the auxiliary building (phase 14)
27. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-18/76-KO, 6 August 1976, for construction of phases 27 and 17B
28. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16/23-76-MA, 16 August 1976, for the reconstruction of the fuel pipeline passage under access road C III in Krško
29. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-26/76-KO, 23 August 1976, for the construction of a building to house component cooling systems (phase 24)
30. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-25/76-KO, 23 August 1976, for construction of the intermediate building (phase 18)
31. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16/19/76-KO, 23 August 1976, for the construction of access road III
32. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-27/75-KO, 27 August 1976, for construction of the auxiliary building (phase 15) and command building (phase 21)
33. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-28/76-KO, 9 September 1976, for construction of the protective building (phase 9) and the turbine building (phase 32)
34. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-16/75, 5 November 1976, for the construction-enclosure of the construction pit for the dam on the Sava
35. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-31/76-KO, 22 November 1976, for construction of the control building (phase 22)
36. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-16-29/76, 10 December 1976, for the construction – excavation of a pumping station for essential water (phase 48)
37. Building permit of Krško Municipal Assembly No. 5-351-583/76, 13 December 1976, for the warehouse for gases, paints and construction elements as part of the central warehouse
38. Decision by the Republic’s Committee for Transport and Connections No. 340/F-31/76-I/MA, 23 December 1976, ŽG (Ljubljana Railways) is obliged to renew the surface of the level crossing at

km 466+409 of the Zagreb – Sežana railway line (local road Stara Vas – Krško) according to valid technical regulations

39. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-62/77, 31 March 1977, for the construction-fortification of the bridge across the Sava at Brežice
40. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-32/75, 1 April 1977, for construction of the turbine building and roof of the heating room compartment (phase 33)
41. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-2/77-KO, 13 April 1977, for construction of the turbine building – stepped towers (phase 33A) and buildings for the emergency diesel generators (phase 6)
42. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-5/77-KO, 14 April 1977, for construction of the dam across the Sava, cooling water pumping station, cooling water discharge facility, pumping station for essential supply water
43. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-21/76-KO, 14 April 1977, for the construction of tunnels for cooling water outside the turbine building (phase 44 ADD) and the protective dome (phase 10)
44. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56/8-77-KO, 23 May 1977, for construction of the building to house the emergency diesel generators between elevations 100.30 and 107.62 m
45. Building permit of Krško Municipal Assembly No. 5-351-460/75, 23 May 1977, for construction of the water supply from the main pipeline FI 250 at residential house Pirc over the military bridge to NEK
46. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-6/77-KO, 17 June 1977, for construction of the 380 and 110 kV switchyard (phase 55)
47. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-9/77-KO, 28 June 1977, for construction of flood embankments on the left bank of the Sava as part of the hydrotechnical facilities
48. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-1/77, 4 July 1977, for construction of the reactor building (phase 39)
49. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-11/77-KO, 19 July 1977, for construction of various foundations and the turbine building (phase 33/Rev)
50. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56/10-77-KO, 19 July 1977, for construction of the reactor building – internal reinforced concrete construction between elevations 96.04 and 115.55 m (phase 40)
51. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-3/77-KO, 24 August 1977, for installation of technical, auxiliary and electric systems in the auxiliary building, the fuel-handling building and the building for cooling components
52. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-12/77-KO, 29 August 1977, for construction of the internal reinforced concrete construction of the reactor building above elevation 115.55 m (phase 44)
53. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-16-30/75-KO, 6 September 1977, for construction of the reactor building + phase 37 and phase 38
54. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-15/77-KO, 10 October 1977, for the construction of cable conduits on the plateau (phase 55A)

55. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-14/77-KO, 21 October 1977, for the construction of systems as specified in the authorisation
56. Building permit of Krško Municipal Assembly No. 5-351-628/77, 25 October 1977, for setting up power lines 2x20 kV Brestanica – Roto Krško at the section Tov. Djuro Salaj Krško
57. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-6/77-KO, 5 November 1977, for construction of the 380 and 110 kV switchyard
58. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-16/77-KO, 10 November 1977, for construction of Phase 53 – architectural and construction work on the auxiliary buildings
59. Building permit of Krško Municipal Assembly No. 5-351-461/77, 9 December 1977, for the consolidation and enclosure of the expanded temporary warehouse for piping
60. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-19/77-KO, 2 January 1978, for the construction of various foundations for transformers on the NEK plateau
61. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-17/77-KO, 18 January 1978, for the incorporation of technical systems in the turbine building in the intake and discharge facility
62. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-18/78, 27 January 1978, for the construction of the water decarbonisation facility
63. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-20/78-KO, 28 February 1978, for the construction of the auxiliary boilerhouse
64. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56/21-78-KV, 31 May 1978, for construction of the administrative building and service workshops, and the safety fence as part of NEK's construction
65. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-22/77-IND/KV, 26 June 1978, for the construction of the industrial siding on the NEK plateau
66. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-23/78-MA, 8 September 1978, for construction of Car park Phase 1 and the gatehouse with entrance to NEK
67. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56/24/78-KO, 18 September 1978, for construction of the five-year warehouse for radioactive waste
68. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-18/78-KO, 25 September 1978, for construction of the water decarbonisation facility according to the updated technical documentation
69. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-25/78-KO, 10 November 1978, for construction of electricity connections between the NEK facilities
70. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56/23-78-KO, 12 November 1978, for construction of the outdoor platform lighting and the electrics in the gatehouse
71. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 351/B-56-26/78-KO, 22 November 1978, for construction of the fuel warehouse for the auxiliary boilerhouse and the emergency diesel generators
72. Authorisation from the Republic's Secretariat for Industry Ljubljana No. 16/79-KO, 19 February 1979, for construction-security of NEK

73. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56-27/79, 20 February 1979, for construction of the potable water system and the decarbonised technical water on the NEK plateau
74. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/28-77/KO, 27 February 1979, for construction of the cooling water systems between the cooling towers and the Sava
75. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/31-77-KO, 4 March 1979, for construction of the sewage system on the plateau
76. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/30-77-KO, 27 March 1979, for the construction of installations in the administrative building and service workshops
77. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56-33/79-KO, 20 April 1979, for construction of the power plant’s main earthing
78. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56-32/78-KO, 20 April 1979, for construction of the cooling towers
79. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/34-77/KO, 17 May 1979, for construction of transformer stations TP 1 and TP 3
80. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/35/77-8, 26 June 1979, for construction of NEK’s external hydrant network
81. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/38-77-8, 9 July 1979, for construction of the flood embankment along the Potočnica
82. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/31-77-82, 11 August 1979, for the construction of rainwater drainage with a pumping station
83. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/29-78-KO, 3 December 1979, for the construction – external fitting with communications on the NEK plateau
84. Authorisation from the Republic’s Secretariat for Industry Ljubljana No. 351/B-56/40-79-8, 28 January 1980, for construction of foundations for the warehouse for cylinders with hydrogen, oxygen and nitrogen, the plateau for cleaning barrels and wagons, and the plateau for mobile air compressors
85. Authorisation from the Republic’s Committee for Energy, Industry and Construction No. 351/B-48/4-80-8, 7 February 1980, for the construction of a lift that can carry 13 persons, load capacity of 1,000 kg
86. Authorisation from the Republic’s Committee for Energy, Industry and Construction No. 351/B-48/5-80-8, 12 February 1980, for the construction of a correct time system
87. Authorisation from the Republic’s Committee for Energy, Industry and Construction No. 351/B-48/5-80-8, 9 March 1980, for the construction of a water supply system 110/70 oC from the heating substation TS 100 to 1 m outside the turbine section
88. Authorisation from the Republic’s Committee for Energy, Industry and Construction No. 351/B-48/7-80-8, 11 May 1980, for the construction of a condensation cleaning installation
89. Authorisation from the Republic’s Committee for Energy, Industry and Construction No. 351/B-48/2-80-8, 6 June 1980, for the construction of a well on the right bank of the Sava
90. Authorisation from the Republic’s Committee for Energy, Industry and Construction No. 351/B-48/1-80-8, 6 June 1980, for the construction of transformer station TP 2/1000 kVA 6.3/0.4 kV

91. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/3-80-8, 18 June 1980, for construction of heating station TS 100
92. Building permit of Krško Municipal Assembly No. 5-351-526/79, 4 August 1980, for the setting up of a local telephone cable from the Agrokombinat Krško coldstore to the NEK facility
93. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/3-80-8, 28 August 1980, for the construction of the hot water pipe system on the NEK plateau
94. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/6-80-8, 19 September 1980, for construction of the 380 and 110 kV switchyard according to the altered technical documentation
95. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/11-81, 17 March 1981, for construction of the PA system on the NEK plateau
96. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/13-80-8, 25 May 1981, for the construction of a warehouse with flammable liquids and gases, and a compressor station
97. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/15-80-8, 10 July 1981, for the construction of the administrative complex Phase 2, and bunkers according to the projects stated in the decree
98. Decision of Krško Municipal Assembly No. 5-351-460/75, 10 July 1981, for the construction of water piping from the main pipe FI 250 to NEK, in compliance with the amendments
99. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-7/81-8, 23 July 1981, for construction of the microwave barrier FTR 200 G
100. Authorisation from the Republic's Committee for Energy, Industry and Construction No. 351/B-48/14-80-8, 23 July 1981, for the construction of the carbonate sludge reservoir
101. Building permit of Krško Municipal Assembly No. 5-351-43/75, 10 August 1981, for the reconstruction of access road II
102. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/82-5-8, 17 May 1982, for the construction of the administrative complex Phase 2, according to the projects in the decision
103. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/82-5-8, 30 June 1982, for the construction of the administrative complex Phase 2, according to the projects stated in the decree
104. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/82-192, 1 December 1983, for construction of the generator installation
105. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/83-425, 16 December 1983, for construction of the butane station
106. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/84-654, 7 December 1984, for adaptation of the cold water pumping station
107. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/85-80, 30 July 1985, for construction of a garage for emergency vehicles, a mechanical workshop and premises for the security services
108. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/84-654, 10 October 1985, for installing weak and strong current fittings in the cooling water pumping system

109. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/85-270, 26 November 1985, for construction of a radiological protection building
110. Authorisation from the Republic's Committee for Industry and Construction No. 351-05/85-259, 2 June 1986, for construction of two canopies next to the warehouse for flammable liquids
111. Authorisation from the Republic's Committee for Industry and Construction No. 351-01/89-83, 5 October 1989, for the construction of a warehouse for spare parts and equipment
112. Authorisation from the Republic's Committee for Industry and Construction No. 351-01/90-390, 4 June 1990, for the construction of a warehouse for waste oils
113. Authorisation from the Republic's Committee for Industry and Construction No. 351-01/89-83, 5 July 1991, for the installation of lifts in the spare parts and equipment warehouse
114. Authorisation from the Republic's Committee for Industry and Construction No. 351-01/92-1008, 19 May 1992, for the construction of an extension for the existing gatehouse
115. Notification of the Ministry for Economic Activities No. 351-01/159-93/DR, 10 April 1993, for the setting up of a seismological observatory is noted
116. Ministry of the Environment and Spatial Planning building permit No. 351-01-23/95, 28 March 1995, for the construction of cable line 2xKB 20 kV+PE02-2x50 RTP 110/20 kV Krško – TP Carinarnica – RTP 400/110 kV Krško
117. Ministry of the Environment and Spatial Planning building permit No. 351-01-36/97, 21 July 1997, for the reconstruction of workshops on the ground floor, kitchen, restaurant with accompanying program and the clinic within the NEK complex
118. Ministry of the Environment and Spatial Planning single permit No. 350-03-63/97-MD/TŠ, 14 October 1998, for the construction of the simulator building
119. Ministry of the Environment and Spatial Planning single permit No. 350-03-63/97-MD/TŠ, 4 January 1999, for the construction of a decontamination building
120. Single permit given by Brežice Administrative Unit No. 35102-254/99-152, 11 May 1999, for the construction of a constant sampling station
121. Ministry of the Environment and Spatial Planning single permit No. 350-03-63/97-TŠ,JK, 13 May 1999, for the construction of a car park and access road
122. Ministry of the Environment and Spatial Planning single permit No. 350-03-64/99-TŠ, 18 February 2000, for the external arrangement of the decontamination building
123. Ministry of the Environment and Spatial Planning building permit No. 351-01-97/99, 20 March 2000, for the reconstruction – replacement of NEK's steam generators
124. Ministry of the Environment and Spatial Planning building permit No. 335105-41/2010-TŠ,HČ, 11 August 2010, for the construction of building DG3
125. Ministry of the Environment and Spatial Planning building permit No. 35105-110/2011/4-TŠ,HČ, 1 December 2011, for the reconstruction of hangar 07 to contain offices and workshops
126. Ministry of the Environment and Spatial Planning building permit No. 35105-3/2012/2-TŠ,HČ, 23 January 2012, for the reconstruction of the building housing mobile equipment
127. Ministry of Transport building permit No. 35105-11/2012/TŠ,HČ, 28 March 2012, for the reconstruction of switchyard RTP Krško 400/110 kV
128. Ministry of Transport building permit No. 35105-25/2014/5-01031383 TŠ, GB, 16 June 2014, for the construction of the WMB building (Phases 1 and 2)
129. Ministry of the Environment and Spatial Planning building permit No. 35105-10/2015/6 1093-08 VC,HČ, 18 June 2015, for the construction of the Operative Support Centre

130. Building permit issued by Krško Administrative Unit No. 351-290/2015/17, 4 September 2015, for the construction of the outage container complex
131. Partial building permit issued by the Ministry of the Environment and Spatial Planning No. 35105-13-2016-14 1093-04 TŠ, 30 May 2016, for the reconstruction of the NEK dam
132. Building permit issued by the Ministry of the Environment and Spatial Planning No. 35105-52/2016/5 1093-04 TŠ, 3 August 2016, for the construction of cable connections between buildings AB-MHE30 and BB1 at NEK
133. Building permit issued by Krško Administrative Unit No. 351-329/2016/10, 26 September 2016, for the reconstruction of the rainwater and sewage pumping station at NEK
134. Partial building permit issued by the Ministry of the Environment and Spatial Planning No. 35105-13/2016/17 1093-04 TŠ, VML, 3 February 2017, for the reconstruction of the NEK dam
135. Partial building permit issued by the Ministry of the Environment and Spatial Planning No. 35105-70/2017/5 1093-04 TŠ, 8 September 2017, for the reconstruction and extension of BB1 and the fitting of cable connections between buildings BB1 and AB at NEK
136. Partial building permit issued by Krško Administrative Unit No. 351-254/2017/30, 8 November 2017, for the reconstruction or extension of the protective wall along the Potočnica
137. Building permit issued by Krško Administrative Unit No. 351-129/2018/14, 21 May 2018, for the removal of part of hangar 71, the construction of a warehouse for equipment Phase 2 and external arrangement
138. Ministry of the Environment and Spatial Planning building permit No. 35105-68/2018/8 1093-04 TŠ,HČ, 24 July 2018, for construction of building BB2
139. Ministry of the Environment and Spatial Planning building permit No. 35105-29/2018/6 1093-04 TŠ,HČ, 24 July 2018, for Phase 1 of the construction of the BB2 building – construction pit
140. Ministry of the Environment and Spatial Planning building permit No. 35105-63/2018/6 1093-04 TŠ,HČ, 9 August 2018, for the replacement of the above-ground fuel tank for the auxiliary steam system, Phases 1 and 2
141. Ministry of the Environment and Spatial Planning building permit No. 35105-11/2019/9 1096-05, 14 May 2019, for the za new construction of a building foundation with collection container and pit for transformer T3 at NEK
142. Ministry of the Environment and Spatial Planning building permit No. 35105-25/2020/57, 23 December 2020, for the dry storage of spent fuel facility on the NEK site