ENVIRONMENTAL IMPACT ASSESSMENT REPORT

EXTENSION OF KRŠKO NPP'S OPERATIONAL LIFETIME FROM 40 TO 60 YEARS – NUKLEARNA ELEKTRARNA KRŠKO D.O.O.

No.: 100820-dn

Ljubljana, October 2021, amended 8 November 2021, 10 January 2022

E-NET OKOLJE d.o.o. | Linhartova cesta 13 | SI-1000 Ljubljana | Slovenija
t +386 (0)1 2321 360 | f +386 (0)1 2321 361 | e info@e-net-okolje.si

TITLE:	**ENVIRONMENTAL IMPACT ASSESSMENT REPORT ON THE EXTENSION OF KRŠKO NPP'S OPERATIONAL LIFETIME FROM 40 TO 60 YEARS – NUKLEARNA ELEKTRARNA KRŠKO D.O.O.**
DATE:	**October 2021, amended 8 November 2021, 10 January 2022**
NUMBER:	**100820-dn**
CLIENT:	**IBE d.d.** **Hajdrihova ulica 4, 1000 Ljubljana**
Order no.:	**Contract no 9K-104/20-B056/298A**
DRAFTED BY:	**E-NET OKOLJE d.o.o.** **Linhartova cesta 13, 1000 Ljubljana**
Director:	**Jorg Jurij Hodalič** E-NET OKOLJE E-NET OKOLJE d.o.o. Linhartova cesta 13 SI-1000 Ljubljana, Slovenija
Head of report drafting:	**Dr Domen Novak**
DEVELOPER:	**Nuklearna elektrarna Krško, d.o.o.** **Vrbina 12, 8270 Krško**
Person responsible for performing the activity at NEK:	**Stanislav Rožman, President of the NEK Management Board** **Saša Medaković, Member of the NEK Management Board**

NUKLEARNA ELEKTRARNA KRŠKO, d.o.o. 1

PARTICIPANTS IN THE DRAFTING OF THE REPORT:

Jorg Hodalič

E-NET OKOLJE d.o.o.
Linhartova cesta 13, 1000 Ljubljana

- (legislation)

Manca Magjar

E-NET OKOLJE d.o.o.
Linhartova cesta 13, 1000 Ljubljana

- (ground, waste)

Dr Gregor Omahen

ZVD Zavod za varstvo pri delu d.o.o. | Chengdujska cesta 25, 1260 Ljubljana

- (ionising radiation)

Martin Žerdin

Aquarius d.o.o.
Cesta Andreja Bitenca 68, 1000 Ljubljana
(nature, nature annex)

Dr Maja Sopotnik

Aquarius d.o.o.
Cesta Andreja Bitenca 68, 1000 Ljubljana

- (nature, nature annex)

Helena Lap

IBE, d.d., svetovanje, projektiranje in inženiring

Hajdrihova ulica 4, 1001 Ljubljana

- (landscape, cultural heritage)

Boštjan Duhovnik

IBE, d.d., svetovanje, projektiranje in inženiring

Hajdrihova ulica 4, 1001 Ljubljana

- (technology)

Samo Hrvatin

IBE, d.d., svetovanje, projektiranje in inženiring

Hajdrihova ulica 4, 1001 Ljubljana

(nuclear technology and nuclear safety)

Dr Andrej Širca

IBE, d.d., svetovanje, projektiranje in inženiring

Hajdrihova ulica 4, 1001 Ljubljana

(flood safety and thermal water pollution)

Dr Franc Sinur

IBE, d.d., svetovanje, projektiranje in inženiring

Hajdrihova ulica 4, 1001 Ljubljana

(earthquake safety)

Dr Vladimir Jelavić

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (air, water, climate change)

Gabrijela Kovačić

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (water, climate change)

Brigita Masnjak, PR

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (transboundary impacts)

Elvira Horvatić Viduka

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (climate change)

Veronika Tomac

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (climate change)

Filip Opetuk

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (air, cooling towers)

Iva Švedek

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (greenhouse gases)

Mirela Poljanac

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (air)

Maja Jerman Vranić

EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (QA/QC, air)

Emeritus Professor Božidar Biondić

External associate – EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (groundwater)

Professor Ranko Biodić

External associate – EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (groundwater)

Dr Damir Dodig

External associate – EKONERG d.o.o., institut za energetiku i zaštitu okoliša

Koranska 5, 10000 Zagreb

- (transboundary impacts, human health impact)

Professor Davor Grgić

Department of Energy and Power Systems

Faculty of Electrical Engineering and Computing (FER) – Univers Zagreb

- (transboundary impacts)

Associate Professor Siniša Šadek

Department of Energy and Power Systems

Faculty of Electrical Engineering and Computing (FER) – University Zagreb

- (transboundary impacts)

Dr Paulina Dučkić

Department of Energy and Power Systems

Faculty of Electrical Engineering and Computing (FER) – University of Zagreb

- (transboundary impacts)

Dr Marija Zlata Božnar

MEIS storitve za okolje d.o.o.

Mali Vrh pri Šmarju 78, 1293 Šmarje-Sap

- (transboundary impacts)

Dr Primož Mlakar

MEIS storitve za okolje d.o.o.

Mali Vrh pri Šmarju 78, 1293 Šmarje-Sap

- (transboundary impacts)

Dr Boštjan Grašič

MEIS storitve za okolje d.o.o.

Mali Vrh pri Šmarju 78, 1293 Šmarje-Sap

- (transboundary impacts)

STATEMENT BY THE HEAD OF REPORT DRAFTING

Head of report drafting:

Dr Domen Novak

By signing, I confirm that:

- the report has been drafted with expertise and professionalism;
- the data given in the report is accurate;
- the content of the report complies with the Decree on the content of the report on the effects of the intended activity on the environment and the method of its preparation (Official Gazette of RS, Nos. 36/09, 40/17);
- with due regard to the legal and technical limitations, the preparation of the report took into account and used the latest scientific findings, the methods applied were adequate, and use was made of information on other relevant environmental analyses.

Ljubljana, 10 January 2022

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Terms:

Abbreviation	Slovenian term	English term
AAF	alternativni sistem za polnjenje uparjalnikov	Alternative Auxiliary Feedwater
ADR	Evropski sporazum o mednarodnem prevozu nevarnih snovi po cesti	European Agreement concerning the International Carriage of Dangerous Goods by Road
AMP	Program staranja opreme	Aging management programme
AB	zgradbe in zunanje površine	Buildings and Grounds
AOX	adsorbljivi organski halogeni	Adsorbable organic halides
ARSO	Agencija Republike Slovenije za okolje	Environmental Agency of the Republic of Slovenia
ASI	alternativno varnostno vbrizgavanje	Alternative Safety Injection
BAT-LCP	najboljša razpoložljiva tehnologija - velike kurilne naprave	Best available technology - large combustion plants
BB1, BB2	utrjena zgradba 1 in 2	Bunkered building 1 or 2
BDE	bromirani difenil etri	Brominated diphenyl ethers
BHRNEK	Zakon o ratifikaciji Pogodbe med Vlado Republike Slovenije in Vlado Republike Hrvaške o ureditvi statusnih in drugih pravnih razmerij, povezanih z vlaganjem v Nuklearno elektrarno Krško, njenim izkoriščanjem in razgradnjo in Skupne izjave ob podpisu Pogodbe med Vlado Republike Slovenije in Vlado Republike Hrvaške o ureditvi statusnih in drugih pravnih razmerij, povezanih z vlaganjem v Nuklearno elektrarno Krško, njenim izkoriščanjem in razgradnjo (UL RS - **Mednarodne pogodbe**, št. 5/03)	Act Ratifying the Treaty between the Government of the Republic of Slovenia and the government of the Republic of Croatia on the regulation of the status and other legal relations regarding investment, exploitation and decommissioning of the Krško NPP and 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 the status and other legal relations regarding investment, exploitation and decommissioning of the Krško NPP
BPK	biološka potreba po kisiku	Biochemical Oxygen Demand
BS OHSAS 18001:2007	sistem vodenja varnosti in zdravja pri delu po standardu	Occupational health and safety management system according to the Standard
BSS	Direktiva o določitvi temeljnih varnostnih standardov za varstvo pred ionizirajočim sevanjem	European Basic Safety Standards Directive
CC	sistem za hlajenje komponent	Component cooling system
CCB	zgradba za hlajenje komponent	Component cooling building
CCTV	nadzorni sistem s televizijo zaprtega kroga	Closed-circuit television
CDF	pogostost poškodbe sredice	Core Damage Frequency
CDP	dokument projektne zasnove, izdelan v skladu s postopkom NEK ESP-2.601.	Conceptual Design Package, doc. in accordance to NEK procedure ESP-2.601
CIS	skupna strategija izvajanja	Common Implementation Strategy
CT	sistem hladilnih stolpov	Cooling Tower System
CTF	prekladalni prostor -Poglobljen prostor v zgradbi DSB, ki je del sprejemnega prostora, kjer se izvaja premeščanje polnega MPC iz enega plašča v drugega	Canister Transfer Facility (pit - CTF); lowered part of acceptance area in DSB where MPCs are transfer from HI-TRAC to HI-STORM (or the other way around)
CT3	hladilni stolp, hladilne celice	Cooling Towers
CW	hladilna voda	Cooling water
DB	projektna nezgoda	Decontamination BuildingDesign Basis Accident
DBF	projektna poplava	Design Basis Flood

Abbreviation	**Slovenian term**	**English term**
DD	sistem deionizirane vode	Deionized water system
DEC	razširjene projektne osnove	Design Extension Conditions
DEC TS	tehnične specifikacije za razširjene projektne osnove	Design Extension Conditions Technical Specification
DEH	digitalni elektro-hidravlični (nadzorni sistem parne turbine)	Digital Electro Hydraulic (control system of steam turbine)
DG1, DG2	sistem dizelskega generatorja 1, 2	Diesel Generator 1, Diesel Generator 2
DG3	sistem dizelskega generatorja 3	Diesel Generator 3
DMMT	ionska izmenjava	Waste monitor tank demineralizer
DMP	dokument za izvedbo projekta, izdelan v skladu s postopkom NEK ESP-2.602.	Design Modification Package, doc. in accordance to NEK procedure ESP-2.602
DMWC	ionski izmenjevalnik kondenzata	Waste evaporator condensate demineralizer
DP	Program razgradnje NEK	NPP Krško Decommissioning Programme
DR	sistem drenaž	Floor and equipment drain system
DSB	zgradba za suho skladiščenje izrabljenega goriva	Dry Storage Building
EDI	elektrodeionizacija	Electrodeionization
EE	sistem za izmenično napajanje	Electrical system miscellaneous AC distribution
EKS	energetski koncept Slovenije	Energy concept of Slovenia
EMEP	Program sodelovanja za monitoring in vrednotenje prenosa emisij snovi, ki onesnažujejo zrak na velike razdalje v Evropi	Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe
ENSREG	Skupina evropskih regulatorjev za jedrsko varnost	The European Nuclear Safety Regulators Group
ENTSO-E	Evropsko združenje sistemskih operaterjev prenosnega omrežja	European Network of Transmission System Operators for Electricity
EOP	navodila za ravnanje ob izrednem dogodku	Emergency Operation Plan
IEA	ekološko pomembno območje	Important ecological area
ESW	sistem varnostne oskrbne vode	Essential Service Water System
ETS	sistem trgovanja s pravicami do emisij toplogrednih plinov v Evropski uniji	Emissions Trading System
EU	Evropska unija	European Union
EVWD	izparilnik sistema (ravnanja s tekočimi RAO)	Waste evaporator
EVRE	izparilnik sistema za recikliranje bora	Boron Recycle System evaporator
FD	sistem talnih drenaž	Floor drain system
FDT	tank za zbiranje talnih drenaž	Floor drain tank
FHB	zgradba za gorivo	Fuel Handling Building
FP	sistem varstva pred požarom	Fire protection system
FV	fizično varovanje; Pravilnik o fizičnem varovanju jedrskih objektov, jedrskih in radioaktivnih snovi ter prevozov jedrskih snovi UL RS, št. 17/13, 76/17-ZVISJV-1	Security; Rules on security of nuclear facilities and materials
GWP	potencial globalnega segrevanja	Global warming potential
HAEA	Madžarska agencija za atomsko energijo	Hungarian Agency for Atomic Energy
HE	hidroelektrarna	Hydropower plant
HERCA	Združenje direktorjev upravnih organov s področja varstva pred sevanji	Heads of the European Radiological Protection Competent Authorities
HCLPF	velika gotovost za malo verjetno napako	High Confidence Low Probability Failure

Abbreviation	Slovenian term	English term
HI-STORM FW	skladiščni plašč za večnamenski vsebnik z vloženim izrabljenim gorivom	HI-STORM FW – Storage overpack
HI-TRAC	transferni plašč za večnamen. vsebnik z IG	HI-TRAC VW - Transfer overpack
HT	habitatni tip	Habitat type
HTS	visokotemperaturna tesnila	High Temperature Seals
IAEA	Mednarodna agencija za jedrsko energijo, glej MAAE,	International Atomic Energy Agency
ICPD	območje dolgoročnih zaščitnih ukrepov (ODU), v oddaljenosti 25 km od NEK	Ingestion and commodities planning distance
IDDS	sistem za sušenje v sodu	In-drum drying system
IB	vmesna zgradba	Intermediate building
IDZ	idejna zasnova (ZGO)	Conceptual design document
IED	Direktiva o industrijskih emisijah	Industrial Emissions Directive
IG	izrabljeno gorivo	Spent fuel (SF)
IIE	notranji začetni dogodki	Internal Initiating Events
IPCC	Medvladni odbor za podnebne spremembe	The Intergovernmental Panel on Climate Change
ISO 14001:2015	standard za sistem ravnanja z okoljem	Environmental management system standard
ISO 45001:2018	standard za sisteme vodenja varnosti in zdravja pri delu	Occupational health and safety management systems standard
JV5	Pravilnik o dejavnikih sevalne in jedrske varnosti, UL RS, št. 74/16 in 76/17 – ZVISJV-1)	Rules on radiation and nuclear safety factors
COD	kemijska potreba po kisiku	Chemical Oxygen Demand
LCA	ocena življenjskega kroga	Life-cycle assessment
LERF	pogostost velikega zgodnjega izpusta	Large Early Release Frequency
LHST	tank za zbiranje vode iz pralnice in sobe za osebno dekontaminacijo	Laundry And Hot Shower Tank
LOCA	nesreča z izgubo hladila	Loss of Coolant Accident
LOD	meja detekcije	Limit of detection
LOQ	meja določljivosti	Limit of quantification
LRTAP	čezmejno onesnaževanje zraka na velike razdalje	Long-range Transboundary Air Pollution
LTO	dolgoročno obratovanje	Long term operation
MAAE	Mednarodna agencija za atomsko energijo, glej IAEA	International Atomic Energy Agency
MCR	glavna komandna soba	Main control room
MD1, MD2	varnostne zbiralke 1, varnostne zbiralke 2	Busbar 1, Busbar 2
MKČN	mala komunalna čistilna naprava	Small urban wastewater treatment plant
MM	merilno mesto	Measuring location
m n.v.	metrov nadmorske višine	Meters above Adriatic sea level
MOP	Ministrstvo za okolje in prostor	Ministry of the Environment and Spatial Planning
MP	sistem za odvajanje meteorne vode	Rainwater discharge system
MPC	večnamenski vsebnik	Multi-purpose canister
NEC	nacionalne zgornje meje emisij onesnaževal	National emission ceilings
NECP	NEPN	National Energy and Climate Plan
NEK	Nuklearna elektrarna Krško	Krško Nuclear Power Plant (Krško NPP)

Abbreviation	Slovenian term	English term
NEK MD-2	sistem vodenja – procesna organizacija	Management system - process organisation
NEPN	Celoviti nacionalni energetski in podnebni načrt Republike Slovenije	National Energy and Climate Plan of Slovenia
NMVOC	nemetanske hlapne organske spojine	Non-methane volatile organic compounds
NSR	ni pomembno za jedrsko varnost	Non-safety related
NSRAO	nizko- in srednjeradioaktivni odpadki	Low and intermediate-level radioactive waste
RBMP	Nadzor učinkovitosti vzdrževanja	Maintenance Effectiveness Monitoring
RBMP3	Načrt upravljanja voda na vodnem območju Donave za obdobje 2022-2027	Danube River Basin Management Plan 2022-2027
NV	naravna vrednota	Natural value
NziR	načrt(i) zaščite in reševanja	Protection and rescue plan(s)
ODV	Okvirna direktiva EU o vodah	The Water Framework Directive (WFD)
MSP	Občinski prostorski načrt	Municipal Spatial Plan
OSART	Revizijska skupina za operativno varnost pri MAAE	Operational Safety Review Team
OV	odpadna voda	Wastewater
RES	obnovljivi viri energije	Renewable energy sources
OVS	okoljevarstveno soglasje	Environmental Consent
OVD	okoljevarstveno dovoljenje	Environmental Permit
PC+CCS	termoelektrarna na uplinjen premog z zajemom in skladiščenjem ogljika	Pulverized coal power plant with carbon capture and storage
PCFVS	pasivni filtrski sistem	Passive containment filtering vent system
PDEH	programabilni digitalni elektro-hidravlični (sistem)	Programmable digital electro hydraulic (system)
PE	populacijski ekvivalent	Population equivalent
PGA	maksimalni pospešek tal na površju	Peak ground acceleration
PGDP	povprečni letni dnevni promet	Annual average daily traffic
PM2,5	trdni delci manjši od 2,5 μm	Particulate matter, diameter < 2.5 μm
PM10	trdni delci manjši od 10 μm	Particulate matter, diameter < 10 μm
PMF	največja verjetna poplava	Probable Maximum Flood
PMO	prostor za mobilno opremo	Mobile Equipment Area
PNV	Program nadgradnje varnosti NEK	SUP - The Krško NPP Safety Upgrade Programme
PO3	tretja revizija programa odlaganja radioaktivnih odpadkov in izrabljenega goriva NEK	Third Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Programme
POD	podaljšanje obratovalne dobe NEK s 40 na 60 let do leta 2043	Extension of Krško NPP operating life from 40 to 60 years - until 2043
POO	posebno ohranitveno območje	Special protection area
POV	posebno območje varstva	Special area of conservation
PP	predhodni postopek (za ugotovitev potrebnosti PVO)	Screening (to determine the need for an EIA)

Abbreviation	**Slovenian term**	**English term**
PR3	tretja revizija programa razgradnje NEK	3rd Revision of the NPP Krško Decommissioning Programme
PSA	verjetnostne varnostne analize, glej VVA	Probabilistic safety assessment
PSR	občasni varnostni pregled	Periodic safety review
PVO	presoja vplivov na okolje	Environmental impact assessment
PW	sistem filtrirane vode	Water pretreatment system
PWR	lahkovodni tlačni reaktor	Pressurised water reactor
RAMP	Pregled programov za obvladovanje nesreč Pregled nesreč upravljanje programov Disaster Management Programme Overview Can't load full results	Review of Accident Management Programmes
RAO	radioaktivni odpadki	Radioactive waste
RCC	odlagalni zabojniki	Reinforced concrete container
RCP	značilni poteki koncentracije toplogrednih plinov	Representative concentration pathway
ReNPRRO16-25	Resolucija o Nacionalnem programu ravnanja z RAO in IG za obdobje 2016-25, UL RS, št. 31/16	Resolution on the National LILW and Spent Fuel Management Programme (2016–2025)
RETS	Tehnična specifikacija sevalnih vplivov NEK	Radiological Effluent Technical Specification, NEK
RH	Republika Hrvaška	The Republic of Croatia
RAO	radioaktivni odpadki	Radioactive waste
RNO	(radiološko) nadzorovano območje v skladu z ZVISJV-1	(radiation) controlled area
RS	Republika Slovenija	The Republic of Slovenia
RTP	razdelilna transformatorska postaja	Substation (transformer station)
RWSB	zgradba za hranjenje RAO	Radioactive waste storage building
SALTO	Pregled varnosti dolgoročnega obratovanja	Safety Aspects of Long Term Operation
SAMG	smernice za obvladovanje težkih nesreč	Severe Accident Management Guidelines
SF	sistem bazena za izrabljeno gorivo	Spent fuel pool system
SFDS	suho skladiščenje izrabljenega goriva (IG)	Spent fuel dry storage
SJV	sistem za zaznavanje vsiljivcev	Intrusion detection system
SK	superkompaktiranje	Supercompaction
SR	pomembno za jedrsko varnost	Safety related
SRSF	skladišče trdnih radioaktivnih odpadkov	Solid Radwaste Storage Facility
SSE	potres, pri katerem se elektrarna lahko varno ustavi	Safe Shutdown Earthquake
SSK	skupek konstrukcij, sistemov in komponent	Structures, systems and components (SSC)
SUP	PNV - Program nadgradnje varnosti NEK	The Krško NPP Safety Upgrade Programme
SV8	Pravilnik o obveznostih izvajalca sevalne dejavnosti in imetnika vira ionizirajočih sevanj, UL RS, št. 43/18	Rules on the obligations of persons performing radiation practices and holders of ionising radiation sources
SV8A	Pravilnik o ukrepih varstva pred sevanji na nadzorovanih in opazovanih območjih, UL RS, št. 47/18	Rules on radiation protection measures in controlled and monitored areas
SW (ESW)	sistem varnostne oskrbne vode	Essential service water system
ŠCZ	štab civilne zaščite	Civil protection headquarters
TB	turbinska zgradba	Turbine building

Abbreviation	**Slovenian term**	**English term**
TC	zaprt sistem hlajenja turbine	Turbine Closed Cycle Cooling System
TEB	Termoelektrarna Brestanica	Thermal Power Plant Brestanica
TEŠ	Termoelektrarna Šoštanj	Thermal Power Plant Šoštanj
TE-TOL	Termoelektrarna toplarna Ljubljana	Thermal Power Plant Ljubljana
GHG	toplogredni plini	Greenhouse gases
TP	transformatorska postaja	Transformer station
TS	Tehnične specifikacije NEK	NEK Technical Specifications
TTC	cevasti zabojnik	Tube type container
UHS	končni ponor toplote	Ultimate Heat Sink
UL RS	Uradni list Republike Slovenije	Official Gazette of the Republic of Slovenia
UN NEK (NEK development plan)	Ureditveni načrt NEK	NEK Development Plan
Uredba PVO	Uredba o posegih v okolje, za katere je treba izvesti presojo vplivov na okolje, UL RS, št. 51/14, 57/15, 26/17 in 105/20	Decree on activities affecting the environment that require an environmental impact assessment
URSJV	Uprava Republike Slovenije za jedrsko varnost	Slovenian nuclear safety administration (SNSA)
USAR	Varnostno poročilo NEK	Updated Safety Analysis Report
U.S. NRC	Upravni organ Združenih držav Amerike za jedrsko varnost	United States Nuclear Regulatory Commission
UV1	Uredba o sevalnih dejavnostih, UL RS, št. 19/18	Decree on activities involving radiation
UV2	Uredba o mejnih dozah, referenčnih ravneh in radioaktivni kontaminaciji, UL RS, št. 18/18.	Decree on dose limits, radioactive contamination and intervention levels
UV3	Uredba o območjih omejene rabe prostora zaradi jedrskega objekta in o pogojih gradnje objektov na teh območjih, UL RS, št. 78/19	Decree on areas of restricted use due to nuclear facilities and on the conditions for construction in these areas
VCT	tank za regulacijo volumna hladila	Volume control tank
VRAO	visokoradioaktivni odpadki	High-level radioactive waste
VT	vodno telo	Body of water
VVA	verjetnostne varnostne analize, glej PSA	Probabilistic safety assessment
VZD	varnost in zdravje pri delu	Occupational health and safety
W	sistem pitne in sanitarne vode	Potable and sanitary water system
WANO	Svetovno združenje operaterjev jedrskih elektrarn	World Association of Nuclear Operators
WCT	tank za zbiranje kondenzata	Waste evaporator condensate tank
WENRA	Zveza zahodnoevropskih uprav za jedrsko varnost	Western European Nuclear Regulators Association
WMB	zgradba za ravnanje z odpadki	Waste manipulation building
WMT	nadzorni odpadni tank	Waste monitoring tank
WP	sistem za obdelavo tekočih radioaktivnih odpadkov	Liquid radwaste processing system
WT	sistem priprave deionizirane vode	Water Treatment System
ZRSVN	Zavod Republike Slovenije za varstvo narave	Institute of the Republic of Slovenia for Nature Conservation
ZVISJV-1	Zakon o varstvu pred ionizirajočimi sevanji in jedrski varnosti, UL RS, št. 76/17 in 26/19	Ionising Radiation Protection and Nuclear Safety Act
ZVO-1	Zakon o varstvu okolja, UL RS, št. 39/06 – UPB, 49/06 – ZMetD, 66/06 – odl. US, 33/07 – ZPNačrt, 57/08 – ZFO-1A, 70/08, 108/09,	Environmental Protection Act

Abbreviation	Slovenian term	English term
	108/09 – ZPNačrt-A, 48/12, 57/12, 92/13, 56/15, 102/15, 30/16, 61/17 – GZ, 21/18 – ZNOrg, 84/18 – ZIURKOE in 158/20	

1. INFORMATION ABOUT DEVELOPER AND SUBMITTED REPORT

1.1 INTRODUCTION

Operator Nuklearna elektrarna Krško, d.o.o. (*hereinafter: NEK*) intends to extend NEK's operational lifetime from 40 to 60 years, i.e. from 2023 to 2043.

Title of activity:

Extension of NEK's operational lifetime from 40 to 60 years, i.e. until 2043

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.

The extension of NEK's operational lifetime means that the facility's operational lifetime is extended by 20 years, from 40 to 60 years. This:

- **does not change** the position or location of NEK;
- **does not change** the technical dimensions and design of NEK;
- **does not change** the production capacity of NEK and its operation mode.

No new activities are required for the extension of NEK's operational lifetime. The dry storage building (functional connection), which has a building permit and an environmental impact assessment (hereinafter: EIA) was also carried out for the building, is under construction and will be completed in the first half of 2023. The dry storage building will already be in operation at the beginning of NEK's extended operational lifetime in 2023, while the environmental impacts of dry storage have been discussed in this report, as an impact of the activity (see Section 5.1).

No other activities were carried out to extend the plant's operational lifetime. Safety upgrades, which are not covered by the assessment, were carried out irrespective of the extension of NEK's operational lifetime on the basis of Slovenia's Post-Fukushima Action Plan following EU stress testing.

By the end of the operational lifetime that will be extended from 40 to 60 years until 2043, NEK will have operated as to date, i.e. safely and in keeping with the limits on emissions into the environment. Safety culture and the proficiency of employees and their responsibility are a core element of the organisational and business structure of NEK, and will continue to be the guiding principle and assurance of 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.

All risks connected with NEK's operation will be significantly mitigated through a comprehensive upgrade of safety systems 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 /49/. NEK's existing water permits will also not require changes /50/, /163/,/276/.

NEK, with an output power of 696 MWe, ranks at the very top as Slovenia's largest producer of electricity (~38% of total Slovenian electricity, half of which is exported to the Republic of Croatia). In 1983, with the start of its commercial operation, NEK obtained a permit for regular operation. 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 that indicate that the extension of the operational lifetime is an appropriate and globally established solution, in terms of security and cost-efficiency. 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 /4/ that is directly related to NEK's safety report /3/, containing 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, i.e. the Slovenian Nuclear Safety Administration. 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), the water permits, the environmental permit, the NEK Technical Specifications (hereinafter: TS) /5/, the Radiological Effluent Technical Specification (hereinafter: RETS) /7/ and the Design Extension Conditions Technical Specifications (hereinafter: DECTS) /6/, 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 generation of electricity, make nuclear technology the safest way of generating electricity known to mankind /235/.

1.2 BASES

NEK, with an output power of 696 MWe generates 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 generates to the Republic of Croatia (hereinafter: RC). The generation of electricity is in the base-load mode (constant operation at 100%) and ensures the stability of the power grid. As NEK does not emit any greenhouse gases during electricity generation, it is classed as a low-carbon production facility. The Slovenian share of the electricity generated by NEK accounts for roughly one half of total low-carbon electricity in Slovenia.

NEK operates in accordance with the following decisions: an approval to commence NEK operation, the decision by the Energy Inspectorate of RS No. 31-04/83-5 of 6 February 1984, the amendment to NEK's operating licence, the decision by the Slovenian Nuclear Safety Administration (hereinafter: URSJV) No. 3570-8/2012/5 of 22 April 2013 /4/, and the NEK Updated Safety Analysis Report (hereinafter: USAR) /3/.

1.2.1 Safe, reliable and competitive generation of electricity

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 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 generation, i.e. from 4.5 TWh/year to 5.45 TWh/year. This significant increase can be attributed to multiple investments, 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 domestic electricity production without 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.

1.2.2 Nuclear safety as 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 generation 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 generation that we are aware of.

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. The inspections are carried out by the following bodies: 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.

Over the last 10 years, the following missions took place at NEK:

- a special safety review (EU stress tests) in 2012;
- IAEA's Topical Peer Review Aging Management in 2018;
- IAEA's OSART (Operational Safety Review Team) programme conducted in 2017; and
- WANO Peer Review in 2014 and 2018.

1.2.2.1 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 Programme (hereinafter: PNV) /18/.

The PNV has been approved by the Slovenian Nuclear Safety Administration /19/ and comprises a number of improvements and additional systems for managing beyond design-basis accidents. Following the implementation of the safety upgrade programme, 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.

1.2.2.2 OSART – Operational Safety Review Team led by the IAEA

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.

1.2.2.3 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.

1.2.3 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 energy in the form of electricity.

According to estimates /20/, /243/, 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). Otherwise, the energy should either be imported or provided through the construction of 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 /282/ and the UN Framework Convention on Climate Change /281/, 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)

/20/ 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 generation 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 light of the aforementioned facts, NEK's operation is gaining importance, as it does not need fossil energy sources for operation and does not emit any greenhouse gases during operation.

During the procedure to prepare the National Energy and Climate Plan (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 comprehensive assessment of environmental impact (SEA) had to be carried out, including an acceptability assessment for the nature conservation areas, and that the environmental 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, an environmental report was prepared /175/, which defined, described and evaluated 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)./20/

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, the 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 the long term use of nuclear energy.

The current EU policy framework could not attain the goals until 2050, nor could it fulfil its commitments from the Paris Agreement /282/. Projections indicate that the EU is going to achieve a 60% reduction in GHG emissions by 2050 by continuing to implement the current legislation /279/. That is why the EU has set a more ambitious goal for itself, i.e. to achieve climate neutrality by 2050, which was put in place with the European Green Deal and adopted with the Regulation establishing the framework for achieving climate neutrality /264/. In order to achieve the goal of climate neutrality by 2050, it is the EU's binding climate target to reduce the net GHG emissions (emissions after excluding sinks) by at least 55% relative to the levels from the period 1990–2030. The new proposed Effort Sharing Regulation by Member State for the non-ETS sector proposes for the Republic Slovenia to reduce its greenhouse gas emissions by 27% until the summer of 2030, relative to the level in 2005, which exceeds the current national target from the NECP (-20%) /265/.

1.3 TITLE AND PURPOSE OF ACTIVITY

Title of activity:

Extension of NEK's operational lifetime from 40 to 60 years, i.e. until 2043

Nuklearna elektrarna Krško, d.o.o., operates on the basis of the operating licence, which is directly connected to NEK's Updated Safety Analysis Report (hereinafter: USAR); /3/) and contains the conditions and limits for the power plant's safe operation. NEK has a valid operating licence that is of unlimited duration (/4/) and is technically capable of operating until 2043, provided that, in accordance with the legislation in force, it performs a Periodic Safety Review (PSR) every 10 years.

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 that indicate that the extension of the operational lifetime is a prudent and globally recognised solution, in terms of security and cost-efficiency. With these updates, 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. Safety upgrades, which are not covered by the assessment of environmental impact, would have been carried out irrespective of the extension of NEK's operational lifetime on the basis of Slovenia's Post-Fukushima Action Plan following EU stress testing.

1.4 MANDATORY ENVIRONMENTAL IMPACT ASSESSMENT

On 2 October 2020, the ARSO (Slovenian Environment Agency) issued decision no. 35405-286/2016-42, 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 activities affecting the environment that require an environmental impact assessment. In the process of screening referred to in the first paragraph of Article 51a of the ZVO-1, 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 dry storage building for spent fuel. 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 Court of Justice of the European Union /242/.

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.

- **Intended activity**

The developer plans to extend NEK's operational lifetime from 40 to 60 years.

The environmental impact assessment is mandatory in accordance with Article 2 in conjunction with Appendix 1 to the Decree on activities affecting the environment that require an environmental impact assessment (Official Gazette of RS, Nos. 51/14, 57/15, 26/17 and 105/20):

- D – Energy sector D.II – Nuclear energy:

- **D.II.1 –** Nuclear power plants and other nuclear reactors, including their dismantling or removal.

- **Ongoing activity**

At the site of the intended activity the permitted activity is already ongoing – Nuklearna elektrarna Krško, d.o.o., Vrbina 12, 8270 Krško, for which an impact assessment has already been completed three times, with respect to:

- the construction of the facility for decontamination, environmental consent no. 35405-04/99 of 26 March 1999;
- the construction of foundations by setting up a backup transformer, environmental consent no. 35405-81/00 of 1 August 2000;
- the construction of the spent fuel dry storage building, building permit no. 35105-25/2020/57 of 23 December 2020.

The Krško nuclear power plant is classed among activities listed in Section D Appendix 1 to the aforementioned decree – D.II.1 (nuclear power plants and other nuclear reactors, including their dismantling or removal). The envisaged modification (extension of the operational lifetime) does not alter the current capacity of production. However, the ongoing activity is treated in this report as related and is included in the assessment of the activity's overall impact on the environment.

1.5 DEVELOPER

1.5.1 Developer

Nuklearna elektrarna Krško d.o.o., Vrbina 12, 8270 Krško
Company registration number: 5034345000
Core activity: D35.112 (Electricity generation in thermal power plants, nuclear power plants)

Responsible persons: Mr Stanislav Rožman, President of NEK's Management Board, Mr Saša Medaković, Member of the Management Board

The signatures of the responsible persons of the entity responsible for the activity affecting the environment are presented in the introductory part of the report.

NEK is equipped with Westinghouse's light-water pressurised reactor with a thermal power of 1994 MW. Its net electrical output is 696 MW. The power plant is connected to the 400 kV network that supplies electricity to consumers in Slovenia and Croatia. It annually generates over 5 billion kWh of electricity /40/.

1.5.2 Person responsible for performing the activity at the entity responsible for the activity

Stanislav Rožman, President of NEK's Management Board

Saša Medaković, Member of NEK's Management Board

Nuklearna elektrarna Krško d.o.o., Vrbina 12, 8270 Krško

The signature of the person responsible for the activity at the entity responsible for the activity is presented in the introductory part of the report.

1.6 REPORT DRAFTED BY

1.6.1 Report drafted by

E-NET OKOLJE d.o.o., Linhartova cesta 13, 1000 Ljubljana

1.6.2 Head of report drafting

Dr Domen Novak

E-NET OKOLJE d.o.o., Linhartova cesta 13, 1000 Ljubljana

In accordance with the fourth paragraph of Article 4 of the Decree on the method of drafting and on the content of the report on the impacts of planned activities affecting the environment, a signed statement of the head of report drafting is presented in the introductory part of the report.

The references of the head of report drafting relating to the assessment of environment impacts are given in **Appendix 1**.

1.6.3 Participants in the drafting of the report

- Jorg Jurij Hodalič (all factors),
- Manca Magjar (all factors),

all employed at E-NET OKOLJE d.o.o., Linhartova cesta 13, 1000 Ljubljana.

- Dr Gregor Omahen (ionising radiation)

ZVD Zavod za varstvo pri delu d.o.o., Chengdujska cesta 25, 1260 Ljubljana

- Boštjan Duhovnik (technology, radioactive waste and SF, decommissioning),
- Helena Lap (landscape, cultural heritage),
- Samo Hrvatin (nuclear technology and nuclear safety),
- Dr Andrej Širca (flood safety, thermal pollution),
- Dr Franc Sinur (earthquake safety),

IBE d.d., svetovanje, projektiranje in inženiring, Hajdrihova ulica 4, 1000 Ljubljana

- Dr Maja Sopotnik (nature, supplement for protected areas of nature)
- Martin Žerdin (nature, supplement for protected areas of nature)

Aquarius d.o.o., cesta Andreja Bitenca 68, 1000 Ljubljana

- Dr Vladimir Jelavić (air, water, climate change)
- Gabrijela Kovačić (water, climate change),
- Brigita Masnjak (transboundary impacts)
- Elvira Horvatić Viduka (climate change)
- Veronika Tomac (climate change)
- Filip Opetuk (air)
- Iva Švedek (climate change)

- Mirela Poljanac (air)
- Maja Jerman Vranić, chemical engineering graduate, MBA in construction (air)
- Emeritus Professor Božidar Biondić (groundwater)
- Professor Ranko Biodić (groundwater)
- Dr Damir Dodig (transboundary impacts, human health)

Ekoenerg d.o.o., Institut za energetiku i zaštitu okoliša. Koranska 5, Zagreb, Croatia

- Professor Davor Grgić (transboundary impacts)
- Associate Professor Siniša Šadek, (transboundary impacts)
- Dr Paulina Dučkić (transboundary impacts)

Fakultet elektrotehnike i računarstva (FER) – University of Zagreb, Zagreb, Croatia

- Dr Marija Zlata Božnar (transboundary impacts)
- Dr Primož Mlakar (transboundary impacts)
- Dr Boštjan Grašič (transboundary impacts)

MEIS storitve za okolje d.o.o., Mali Vrh pri Šmarju 78, 1293 Šmarje-Sap

The signatures of the persons who participated in the drafting of the report are presented in its introductory part.

1.7 SUBJECT AND CONTENT OF REPORT

1.7.1 General description

In accordance with Article 2 of 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), the subject of the report are the description and analysis of the intended activity affecting the environment during its implementation, duration, decommissioning and termination in relation to the environment in which it is positioned, and the establishment and assessment of direct and indirect significant impacts of the activity on the following factors: residents and people's health, biodiversity and natural values, land, soil, water, air, climate, material goods, cultural heritage, landscape, and interactions between all these factors. Expected impacts of the activity due to the risk of severe accidents, which includes hazardous substances, nuclear accidents, and natural and other accidents, including those caused by climate change if these risks are associated with the activity, also comprise the factors referred to in the previous paragraph.

1.7.2 Subject of the report

The report discusses the extension of NEK's operational lifetime from 40 to 60 years, i.e. from 2023 to 2043, (Nuklearna elektrarna Krško, d.o.o.) located at Vrbina 12, 8270 Krško.

The third paragraph of Article 9 of 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) provides that the description and assessment of the impacts of the intended activity should also include the expected impacts that are the result of actions connected with the activity or other environmental activities, during preparation work or construction, use or operation, or during the duration, removal or termination of the activity. Due to the extension of the operational lifetime in the scope of the existing power plant complex, the report focuses on the Krško nuclear power plant in the sense of the activity's overall impact after the modification, including the dry storage building, which commences operation in 2023. The Vrbina LILW repository (see Section 5.1) is also taken into account as a connected activity with respect to impacts that form part of the activity's overall impact.

1.7.3 Factors discussed in the report

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. The dry storage building (functionally connected activity) will have already been constructed at the beginning of the extended operational lifetime in 2023 (see Section 1.1). The report also discusses the impacts of the dry storage building. In light of the above, this report **does not address** environmental impacts **during construction**.

Environmental impacts due to the extension of NEK's operational lifetime will be described and evaluated for the period of operation and also for the eventuality that the activity is terminated (see Section 2.18), considering that the activity termination **disregards** the decommissioning of the facility.

The decommissioning of the facility under the decommissioning programme /13/, which is envisaged after the cessation of operation will be subject to other administrative procedures relating to construction, nuclear safety and environmental protection, and as such the decommissioning of the facility, in the parts relating to impacts resulting from this activity's termination, is not addressed by this report.

In accordance with 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), the report discusses the direct and indirect impacts of the activity on the following factors:

- soil,
- water (underground, surface, thermal pollution, flood safety),
- air,
- land,
- landscape,
- climate impact,
- biodiversity,
- material assets,
- population and human health (noise, vibration, waste, risks for environmental and other accidents, radioactive radiation, electromagnetic radiation),

also taking into account any interaction between the listed factors.

1.7.4 Factors not discussed in the report

Note: the reference to “decree” below relates to 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).

- **Odours**

The location of the intended activity is situated in the vicinity of the existing NEK facility. There are no odour emissions at the site or its vicinity, meaning that the planned activity will not be a source of odour emissions during operation, at the time of termination or thereafter. Hence, odours were not discussed in this report.

- **Cultural Heritage**

The site of the intended activity is situated outside the registered cultural heritage units, which is also indicated in the opinion of the Institute for the Protection of Cultural Heritage of Slovenia (ZVKDS) no. 350-0051/2016-16 of 10 December 2020. The opinion cites: “After examining the materials on the web server we find that the intended activity does not affect the cultural heritage registered units, and as such the information that should be included in the Environmental Impact Assessment Report is not at our disposal. We also believe that the environmental impact assessment and the acquisition of the environmental consent for reasons of protecting cultural heritage are not required to obtain the extension of NEK's operational lifetime from 40 to 60 years." For that reason, cultural heritage is not addressed in this report.

1.8 SPATIAL PLANNING ACTS AS THE BASIS FOR THE SITING/POSITIONING OF FACILITIES

The basis for the siting of facilities is the Ordinance on NEK's development plan (Official Gazette of the SRS, No. 48/87, Official Gazette of RS, Nos. 59/97 and 21/20).

1.8.1 Spatial planning acts

- Ordinance on the municipal spatial plan (OPN) for the area of the Krško Municipality (Official Gazette of RS, No. 61/15);
- Ordinance on NEK's development plan (Official Gazette of the SRS, No. 48/87);
- Amendments to the Ordinance on NEK's development plan (Official Gazette of RS, No. 59/97);
- Amendments to the Ordinance on NEK's development plan (Official Gazette of RS, No. 21/20).

According to the spatial planning document, the site of the activity is located in an area of building land intended for:
- **E** – energy infrastructure, in spatial planning unit (EUP) **KRŠ 025**;
- **VI** – water infrastructure area, in spatial planning unit (EUP) **HJE 01**.

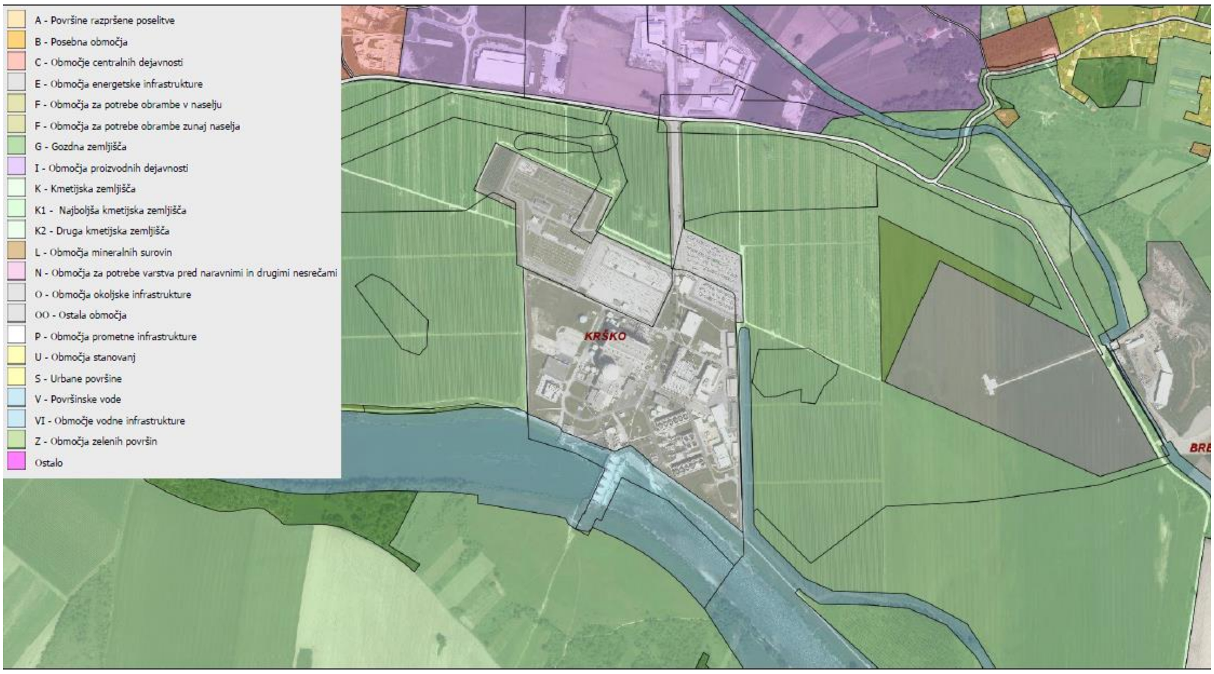


Figure 1: Intended use of land according to the municipal spatial plan (OPN) – scale 1:10,000 (source: /63/)

A – Površine razpršene poselitve	A – areas of dispersed settlement
B – Posebna območja	B - special areas
C – Območje centralnih dejavnosti	C – area of central activities
E – Območja energetske infrastrukture	E – energy infrastructure areas
F – Območja za potrebe obrambe v naselju	F – urban areas intended for defence
F – Območja za potrebe obrambe izven naselja	F – non-urban areas intended for defence

G – Gozdna zemljišča	G – forest land
I – Območja proizvodnih dejavnosti	I – areas intended for manufacturing
K – Kmetijska zemljišča	K – agricultural land
K1 – Najboljša kmetijska zemljišča	K1 – best agricultural land
K2 – Druga kmetijska zemljišča	K2 – other agricultural land
L – Območja mineralnih surovin	L – mineral raw material areas
N – Območja za potrebe varstva pred naravnimi in drugimi nesrečami	N – areas for protection against natural and other disasters
O – Območja okoljske infrastrukture	O – environmental infrastructure areas
OO – Ostala območja	OO – other areas
P – Območja prometne infrastrukture	P – transport infrastructure areas
U – Območja stanovanj	U – residential areas
S – Urbane površine	S – urban areas
V – Površinske vode	V – surface water
VI – Območje vodne infrastrukture	VI – water infrastructure area
Z – Območja zelenih površin	Z – green areas
Ostalo	Other

1.8.2 Extracted provisions from spatial planning acts (development plan)

Basic intended use:
- Energy infrastructure – Krško Nuclear Power Plant

On the basis of Article 5 of the ordinance, the development plan discusses the following use of areas inside NEK's fence:

- areas intended for development,
- undeveloped areas/land,
- areas intended for transport, and
- areas intended for infrastructure.

Article 10

Terms and conditions for urban, architectural and landscape design

In terms of urban design, in addition to the general principles of construction in industrial complexes, the planned facilities in the complex of the nuclear power plant must take into account, in particular:

The functional positioning of facilities, a clear transport connection inside the complex, adjustment of the dimensions of the facilities to the already constructed structure, technological connection, functional and rational construction of infrastructure, humane work environment and rational use of space.

The architectural design of the buildings needs to be adjusted to the existing buildings, and efforts need to be made to ensure a more uniform appearance of the entire complex. [1]

Article 11

The altitude of the plateau of 155.20 m above sea level shall be taken into account when designing structures/facilities.

There is a schematic presentation of the routes of the primary network that also adapt to the technological solutions of the planned structures and facilities.

[1] The article then cites provisions that relate to individual buildings and areas inside the complex: the safety upgrade area (spent fuel dry storage building), the entrance building, parking spaces, petrol station for motor vehicles, foundation for the backup transformer, building for preparing drums for LILW storage, security building, defrosting system on the path to the storage facility for flammable liquids, simulator building, canopy for the mobile compressor, additional cooling tower cell, area for decontamination, canopy for the handling of equipment and radioactive cargo shipments, borated water facility, green areas.

Article 12

The planned structures shall be connected to the current utilities infrastructure.
Water supply system: there is no need to increase the capacity of the water supply system for the planned structures (currently at 20 l/s).
Electricity: the final connection point of the complex will be from the planned new DTS via the cable line.
Sewerage: The new structures/facilities will be connected to the existing sewerage network.
Roads: New paved areas shall be constructed in the safety upgrade area, and the parking area in front of the entrance building shall undergo reconstruction.

Article 13

During construction, i.e. groundworks, the excavated material shall be deposited in abandoned quarries on the left bank of the Sava, with humus being used for green plots inside the power plant complex.

Article 14

The dimension tolerances of the planned facilities shall be set out when defining the individual facilities/structures in Article 10 of the ordinance.

A ±10% tolerance is permitted for all other facilities/structures and spatial arrangements.

Article 14a

The construction of the planned facilities and spatial arrangements can proceed in phases.

Article 14b

Renovations, investment maintenance and reconstruction of facilities/structures, the capacity of which cannot be changed or their ecological status impaired, shall be permitted in the area of the development plan.

After the construction of the planned facilities that are covered in this ordinance, new facilities can undergo renovations, investment maintenance and reconstructions.

Activities aimed at improvement and at increasing NEK's operational safety are permitted in the area of the development plan. However, these activities may not change the general concepts of the spatial arrangements in the development plan.

Article 14c

When preparing documentation to acquire opinions and a building permit, deviations are permitted from the functional, design and technical solutions laid down in the development plan if, after further detailed examination of the geological, geomechanical, hydrological and other conditions, technical solutions are obtained that are more suitable from the technical, design, environmental protection or safety aspects, which take account of the state of the art in techniques and that enable space to be utilised more cost-effectively.

Deviations from the functional, technical or design solutions set out in the development plan cannot impair the conditions in the area of the development plan, negatively impact neighbouring areas, nor may they run counter to the public interest. Consent must be obtained for the permitted deviations from those required to give their opinion, whose competencies are affected by those deviations, and from the Krško Municipality.

Article 15

The quality of treated water and the treatment plant must comply with the requirements set out in the issued water management opinion.

Article 18

When monitoring the thermal pollution of the Sava, the discharge (intake) rate of the Sava into the groundwater, the temperature of which cannot rise above 15 degrees Celsius, shall also be monitored. The conditions for the abstraction and discharge of cooling water from or into the Sava are laid down in the water management consent. Due to the cooling water's impact on the Sava's temperature, regular controls need to be carried out of the Sava's impact on the temperature of groundwater.

Article 19

There is a basis in place for the storage and decay-storage capacity of low- and intermediate-level radioactive waste that the annual maximum permissible dose equivalent of radiation from the entire nuclear power plant complex may not exceed 0.2 mSv at NEK's fence. Measurements shall be conducted at the security fence of the nuclear power plant, except in the area of the current and envisaged distribution transformer station - substation (hereinafter: DTS) (LN *198/86), where the measurement is carried out at the interior security fence (between the power plant and the DTS). The fence may not be moved.
The current temporary storage facility for low- and intermediate-level radioactive waste cannot be increased or any extension built therefor.
No final repository for low- and intermediate-level radioactive waste is envisaged in the area of the development plan and protection zones of the complex.

Article 20

All spatial activities must be planned so that the activities in a particular spatial arrangement area do not exceed the noise thresholds that apply to level IV noise protection (70 dB/A). If the noise thresholds are exceeded, additional noise protection barriers shall be put in place.

Article 21

An independent meteorological station is mandatory throughout the operation of NEK. The programme of measurements must be aligned with the programme of measurements and the methodology that applies to global meteorological network to which the station must be telemetrically linked. The programme of measurements shall be defined by way of a decision by the Slovenian Nuclear Safety Administration.

Article 26

The development plan does not discuss the terms and conditions of NEK's shutdown after the expiration of NEK's operational lifetime. That is the subject of special spatial implementing acts.

Article 27

The development plan does not address the final storage of spent fuel.

1.8.3 Information regarding protection and restriction zones

- The land/site is located inside the infrastructure area – airport – restricted use;
- The land is located inside NEK's protection zone: exclusion zone, narrow area of controlled use and wider area of controlled use (Decree on areas of restricted use of space resulting from a nuclear facility and the conditions applying to the construction of facilities in these areas, Official Gazette of RS, No. 78/19).[2]

[2] The exclusion zone is a circular area centred in the centre of the nuclear power plant reactor and with a radius of 500 m; the narrower area of controlled use is an area outside the exclusion zone and inside the area that is limited on the outer part by a circle centred in the centre of the nuclear power plant reactor and a radius of 650 m, and a straight line that intersects this circle in points with coordinates y = 540,010.62 m and x = 88,927.02 m and coordinates y = 540,772.11 m and x = 88,834.04 m; the wider area of controlled use is an area outside the narrower area of controlled use and inside the circle centred in the centre of the nuclear power plant reactor and with a radius of 1,500 m.

1.8.4 Requirements deriving from operating licences

- The decision – 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, and NEK Updated Safety Analysis Report (hereinafter: USAR);
- Rules on the obligations of persons performing radiation practices and holders of ionising radiation sources (SV8, Official Gazette of RS, No. 43/18);
- Rules on radiation protection measures in controlled and monitored areas (SV8A, Official Gazette of RS, No. 47/18);
- Decree on areas of restricted use due to nuclear facilities and on the conditions for construction in these areas (UV3, Official Gazette of RS, No. 78/19);
- Environmental permit no.: 35441-103/2006-24 of 30 June 2010, which was amended in three points of the operational part (points 1.1, 1.4 and 1.8 of the environmental permit). Decision no. 35441-103/2006-33 of 4 June 2012 reaffirmed the environmental permit, which was amended (point 1.5, Table 3) under decision no. 35444-11/2013-3 of 10 October 2013.

Operating licence and updated safety analysis report (USAR)

The crucial document for the operation of NEK is the operating licence which relates directly to the NEK Updated Safety Analysis Report (USAR), and contains the conditions and limits for the power plant's safe operation.

Rules on the obligations of persons performing radiation practices and holders of ionising radiation sources (SV8) / Rules on radiation protection measures in controlled and monitored areas (SV8A)

NEK's operation takes into account the Rules on radiation protection measures in controlled and monitored areas (SV8A) and the Rules on the obligations of persons performing radiation practices and holders of ionising radiation sources (SV8), which limits the dose rate at the facility's boundary (3 μSv/h), while UN NEK (development plan) limits the maximum annual permissible dose equivalent of radiation from the entire nuclear power plant at NEK's fence (0.2 mSv per year).

Decree on areas of restricted use due to nuclear facilities and on the conditions for construction in these areas (UV3)

The UV3 decree sets out the areas of restricted use, which include: the exclusion zone, area of controlled use and wider area of controlled use. The provision of the exclusion zone referred to in the first paragraph of Article 6 of the UV3 decree, which defines a 500 m radius surrounding the centre of the reactor, applies to NEK.

1.8.5 Strategic environmental impact assessment

During the strategic environmental impact assessment for the amendments and additions to NEK's development plan for the spatial arrangement of common importance, with the Krško Municipality being the entity responsible for preparing the plan, the Ministry of the Environment and Spatial Planning issued decision no. 35409-155/2019 of 14 August 2019, in which it adopted the following findings:

1. During the process of preparing and adopting the plan, i.e. Amendments and additions to NEK's development plan for the spatial arrangement of national and local importance, the strategic environmental impact assessment process has to be conducted.
2. During the process of preparing and adopting the plan, i.e. Amendments and additions to NEK's development plan for the spatial arrangement of national and local importance, the acceptability assessment process at protected zones is not required.
3. During the process of preparing and adopting the plan, i.e. Amendments and additions to NEK's development plan for the spatial arrangement of national and local importance, transboundary consultation should be conducted.

4. The plan is subject to monitoring, as defined in Article 10 of the Ordinance on NEK's development plan, point 11.

In its decision on the strategic environmental impact assessment no. 35409-155/2019/68 of 3 March 2020, the Ministry of the Environment and Spatial Planning determined the acceptability of impacts from the implementation of the plan, and stated the grounds for this as follows:
In the process of determining the acceptability of impacts from the implementation of the plan the Ministry reviewed the opinions it obtained from the ministries and organisations involved in the strategic environmental impact assessment, and the opinions of Austria and Croatia.

After examining the materials, the Ministry found that all the opinions of the ministries and organisations in Slovenia involved in the strategic environmental impact assessment were positive, and that no additional requests had been filed to restrict the planned effects on the environment in the phase of the strategic environmental impact assessment. After examining all the materials the Ministry believes that all the environmental impacts from the implementation of the plan were acceptable.

In accordance with the sixth paragraph of Article 22 of the Decree laying down the content of environmental report and on detailed procedure for the assessment of the effects on certain plans and programmes on the environment (Official Gazette of RS, No. 73/05) the decision approving the plan must also set out mitigation measures that eliminate the expected essential or devastating impacts, criteria and conditions, which must be fulfilled to enable the plan to be implemented, and the methods of monitoring the plan's implementation.

The Ministry finds that all the measures are in the plan and are explained in the environmental report, and that no additional measures have been proposed in the spatial planning phase. In accordance with the first paragraph of Article 23 of the Decree laying down the content of environmental report and on detailed procedure for the assessment of the effects on certain plans and programmes on the environment, upon approving a plan a decision also needs to be made on monitoring the plan's implementation. The monitoring of the state of the environment is carried out in accordance with sectoral regulations, and is additionally defined in Article 10 of the Ordinance on amendments and additions to NEK's development plan for the spatial arrangement of common importance.

2. TYPE AND CHARACTERISTICS OF THE ACTIVITY

2.1 GENERAL DESCRIPTION

The developer intends to extend NEK's operation from 40 to 60 years, i.e. from 2023 to 2043.

The subject of the environmental impact assessment is the extension of NEK's operational lifetime, which means that the facility's operating period is extended by 20 years, from 40 to 60 years. This:

- does not change the position or location of NEK;
- does not change the dimensions and design of NEK;
- does not change the production capacity of NEK and its operation mode.

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

Krško Nuclear Power Plant (NEK) has an output power of 696 MWe, which is ~38% of total Slovenian electricity making it one of Slovenia's largest producers of electrical energy. Half of the energy produced is exported to the Republic of Croatia.

NEK is equipped with Westinghouse's Light-water pressurised reactor with a thermal power of 1994 MW. Its net electrical output is 696 MW. The power plant is connected to the 400 kV network that provides electricity to consumers in Slovenia and Croatia.

The purpose of the whole complex is to produce electrical energy.

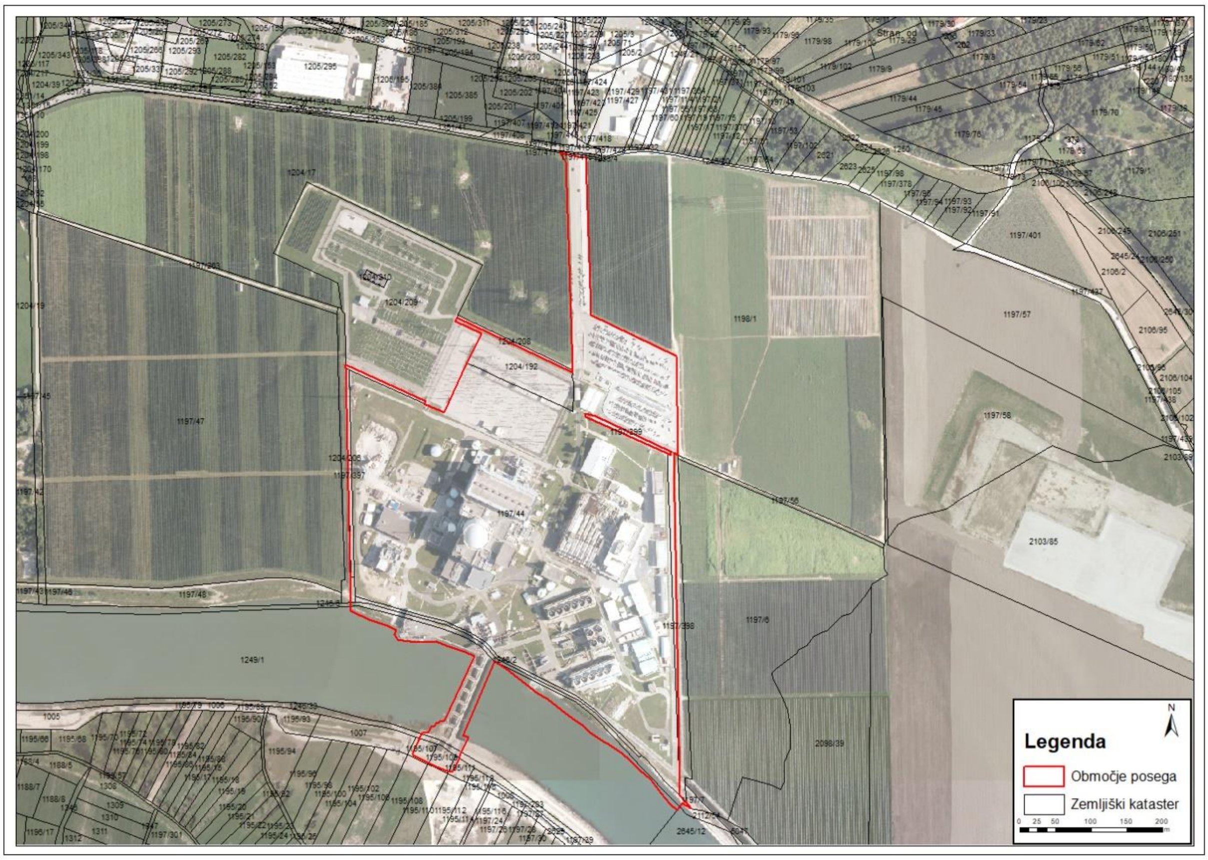


Figure 2: Map of the area concerned, scale of 1:4000 (source:/1/)

Legenda	Key
Območje posega	Area of the activity
Zemljiški kataster	Cadastral register

NEK operates at base-load mode throughout the year. Besides, as a reliable source of active and reactive power it is an important point of support in the electrical energy system as part of ENTSO-E - the European Network of Transmission System Operators for Electricity. It is an essential factor in stabilising critical operational states and voltage levels, especially during large transitional occurrences within ENTSO-E.

The operation of the power plant between two outages is called the fuel cycle. During the outage, part of the spent fuel is replaced with fresh fuel, preventive equipment inspections are carried out and parts replaced, the integrity of materials is verified, surveillance tests are made and corrective actions according to the existing state are taken.

The crucial document for the operation of NEK is the operating licence which relates directly to the NEK Updated Safety Analyses Report (USAR), and contains the conditions and limits for the power plant's safe operation. After the implementation of the dry storage system in NEK, the USAR will be expanded and supplemented with the conditions and limits for its operation.

NEK operates in accordance with the following: Approval to Commence NEK Operation, 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 (referred to as: URSJV) No. 3570-8/2012/5 of 22 April 2013 /4/, and NEK Updated Safety Analyses Report /3/ (referred to as: USAR).

NEK - as it is now and after its operational lifetime is extended - is not classified as an activity or installation that can cause large-scale environmental pollution as defined in the Decree on the types of activity and installation that could cause large-scale environmental pollution, (Official Gazette of RS, No. 57/15).

NEK - as it is now and after its operational lifetime is extended - is not classified as an installation with a higher or lower risk for the environment as defined in the Regulation on the prevention of major accidents and the reduction of their consequences (Official Gazette of RS, No. 22/16).

2.2 LOCATION OF THE ACTIVITY

2.2.1 Description of the location

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 455617.556 (north) and 153055.037 (east) in WGS-84 coordinates and by Gauss-Kruger coordinates x = 88353.76 m and y = 540326.67 m.

The immediate area of the activity location is shown on the figure in Section 11.2.

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 /4/.

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 500 m, north (buildings in Spodnja Libna) at a distance of approximately 550 m and approximately 1.4 km west (Žadovinek) from the site of the planned activity.

The nearest kindergartens (Vrtec Dolenja vas, Vrtec Krško) 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 of the planned activity.

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. (Figure 3). There are currently no installations with upper-tier or lower-tier major accident hazard (Seveso) /59/ in the area of Krško.

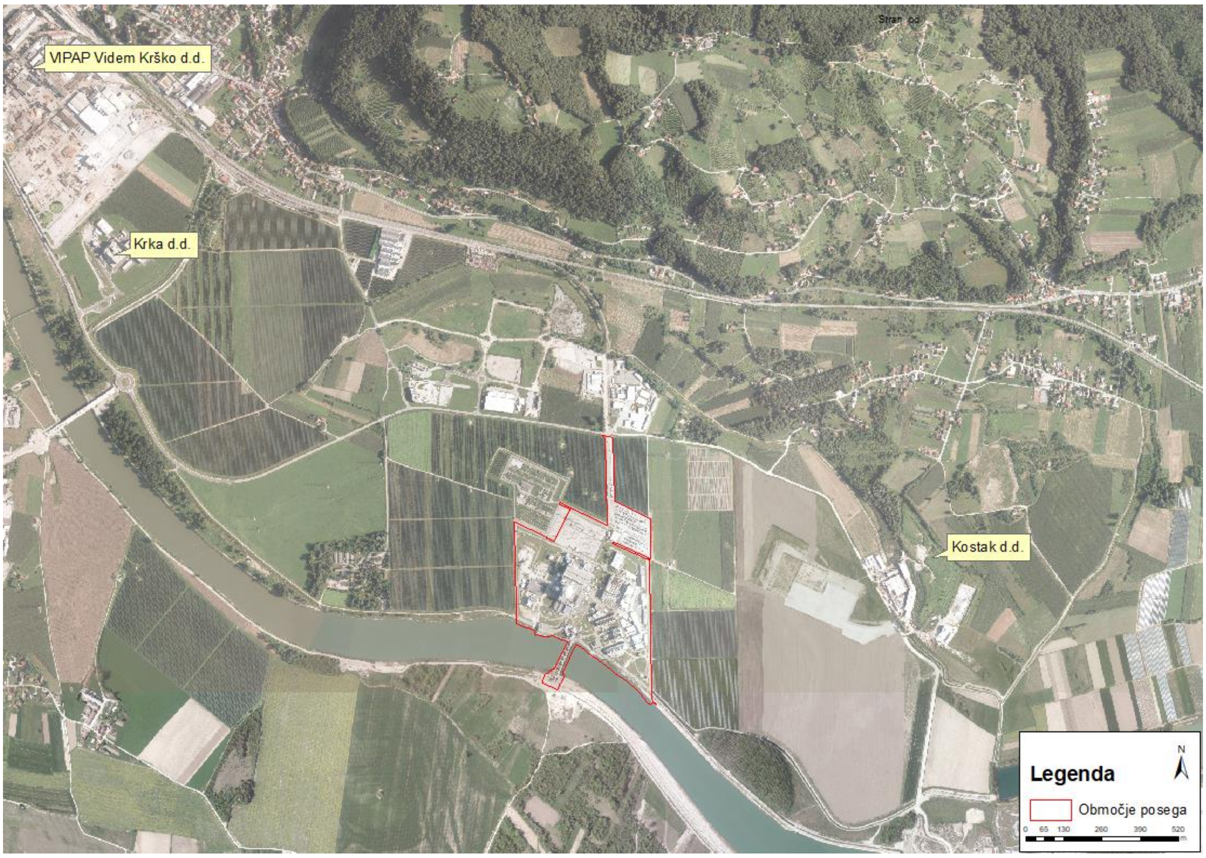


Figure 3: IED installations in the broader area of the activity, scale 1:15,000 (source: Environment atlas /60/)

Legenda	**Key**
Območje posega	Area of the activity

2.2.2 Parcel numbers

The area of the activity is located on land with the following parcel numbers:

- parcels owned by NEK: 1197/44, 1204/192, 1197/397, 1246/2, 1197/398 (partly) and 1204/206 (partly), all cadastral municipality (1321) Leskovec.
- parts of parcels, on which NEK holds building rights: 1204/209, 1246/6, 1249/1, 1246/33, 1195/107, 1195/109, 1195/111, all cadastral municipality (1321) Leskovec.

Aerial images of the site of the activity can be seen in Section 11.2, while an overview of the situation and the area of the activity are displayed in **Appendix 2**.

2.3 SIZE / CAPACITY OF THE ACTIVITY

2.3.1 Reactor power

NEK is a nuclear facility equipped with Westinghouse's pressurised light-water reactor with a thermal power of 1994 MW.

Its net electrical output is 696 MW. The power plant is connected to the 400 kV network that supplies electricity to consumers in Slovenia and Croatia.

It annually produces over 5 billion kWh of electricity, which is approximately 38% of the total electricity produced in Slovenia. Half of the energy produced is exported to the Republic of Croatia.
The extension of NEK's operational lifetime means that the facility's operational lifetime is extended by 20 years, from 40 to 60 years. This:

- **does not change** the position or location in the nuclear power plant area;
- **does not change** the technical dimensions and design of NEK;
- **does not change** the production capacity of NEK and its operation mode.

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

2.4 SPATIAL CHARACTERISTICS OF THE ACTIVITY

2.4.1 Use of space / land for the purpose of the activity

Most of the buildings connected with the operation of the power plant are inside the immediate controlled area of NEK (parcel no. 1197/44, cadastral municipality Leskovec). The detailed land use in accordance with the Municipal Spatial Plan is E – energy infrastructure.

The site is located on flat terrain at an altitude of approximately 155 m. The area of the activity can be seen in the image (Figure *2*) in chapter 2.1

2.4.2 Demands connected with infrastructural equipment

Due to the intended extension of the operational lifetime, interventions in the existing public infrastructure are not foreseen.

2.5 PROPERTIES OF NEK

2.5.1 General description

The largest and most important nuclear facility in the country is the Krško Nuclear Power Plant (NEK), whose ownership is shared by Slovenia and Croatia. NEK delivers the electrical energy it produces to the shareholders Gen Energija and Hrvatska Elektroprivreda in accordance with 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 NEK. The shareholders each take over half of the electrical energy produced. NEK operates on a non-profit basis and the costs of producing electrical energy are covered by both shareholders.

The purpose of the whole complex is to produce electrical energy.

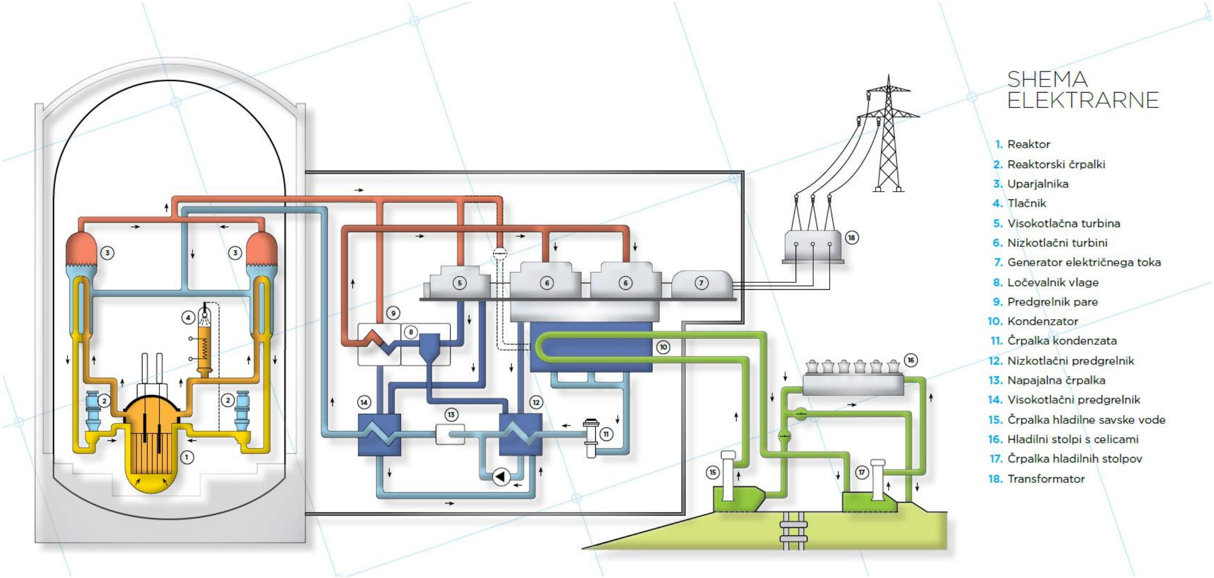


Figure 4: Constituent parts of NEK (source:/1/)

SHEMA ELEKTRARNE	A DIAGRAM OF THE POWER PLANT
1. Reaktor	1. Reactor vessel
2. Reaktorski črpalki	2. Reactor coolant pumps
3. Uparjalnika	3. Steam generators
4. Tlačnik	4. Pressuriser
5. Visokotlačna turbina	5. High-pressure turbine
6. Nizkotlačni turbini	6. Low-pressure turbines
7. Generator električnega toka	7. Electricity generator
8. Ločevalnik vlage	8. Moisture separator
9. Predgrelnik pare	9. Steam preheater
10. Kondenzator	10. Condenser
11. Črpalka kondenzata	11. Condensate pump
12. Nizkotlačni predgrelnik	12. Low-pressure preheater
13. Napajalna črpalka	13. Feed pump
14. Visokotlačni predgrelnik	14. High-pressure preheater
15. Črpalka hladilne savske vode	15. Pump for cooling water from the Sava
16. Hladilni stolpi s celicami	16. Cooling tower with cells
17. Črpalka hladilnih stolpov	17. Cooling tower pump
18. Transformator	18. Transformer

The construction of the power plant, whose supplier was Westinghouse from the USA, began in 1974. Fuel was inserted into the reactor for the first time in 1981 when the power plant was also synchronised with the grid. The power plant began commercial operations in 1983. In this period it fulfilled the basic expectations and guidelines concerning safety and stable operating, dealing with the environment, competitive production in comparison with other sources and public acceptance. By today's standards of nuclear safety and operating stability, as defined by the World Association of Nuclear Operators (WANO), NEK ranks in the first quarter of operational nuclear power plants in the world.

The Krško nuclear power plant is equipped with Westinghouse's Light-water pressurised reactor with a thermal power of 1994 MW. The nominal electrical power of the NEK generator is approximately 730 MWe, and its net electrical output is 696 MWe. It is connected to the 400 kV network and provides energy to the consumer centres in Slovenia and Croatia.

2.5.2 Buildings

All the technologically important buildings of NEK stand on a massive reinforced concrete plate that is anchored on the clay-sand layers of the Pliocene sediments of the Krško Polje plain. This plate forms a solid and earthquake-safe foundation. The buildings are designed and constructed in such a way that they can withstand the expected earthquakes in this area without suffering major damage.

The reactor building, which contains the reactor with the coolant loops and the safety systems, consists of an inner steel pressure shell and external reinforced concrete protective building. The tunnels into the reactor building for people and equipment are fitted with air locks with double doors. The penetrations through walls for piping and cables are double sealed. Alongside the reactor building there are auxiliary building, component cooling building, fuel handling building, emergency diesel generators building and the turbine building.

The cooling water and essential service water intakes are on the bank of the Sava, above the dam, which ensures a sufficient water supply in all conditions. The cooling water outlet is below the dam. In the event of insufficient water in the Sava, the condensate is cooled by cooling towers with forced draft cooling cells.

The storage space for intermediate and low-level radioactive waste is on the southwest rim of the power plant. The administrative building with workshops and the switchyard are at the northern rim, near the entrance to the power plant.

2.5.3 Reactor with coolant loops

The Westinghouse pressure reactor with two coolant loops consists of the reactor vessel with internals and closure head, two steam generators, two reactor coolant pumps, pressuriser, piping, valves and auxiliary reactor systems.

Ordinary demineralised water is used as reactor coolant, neutron moderator and solvent for boric acid. In the steam generator the reactor coolant gives off heat which on the secondary side of the steam generator heats the feedwater and turns it into steam. The coolant pressure is maintained by the pressuriser by means of electric heaters and water sprays which are fed by water from the cold leg of the reactor's coolant loop.

The neutron flux meters, indicators of reactor coolant flow and temperature, and water level
and pressure meters in the pressuriser give the required data for operating the working process and maintaining the safety of the reactor system.

The power of the reactor is controlled with control rods. The drive mechanisms of the control rods are fixed to
the reactor vessel shutter head and their absorption rods reach into the reactor core. Long-term changes in the reactivity of the core and its poisoning with fission products are compensated by changing the concentration of boric acid in the reactor coolant.

2.5.4 Nuclear fuel

The reactor core consists of 121 fuel elements. The fuel element consists of the fuel rods, the lower and upper nozzle, spacers and guide tubes for the absorption rods and instrumentation. The fuel rods consist of fuel pellets of uranium dioxide which are clad with zirconium alloys.

During outages, almost half of the fuel elements are replaced with new ones. Fresh fuel elements are dry stored. Spent fuel elements are stored under water in the spent fuel pool, where they cool down.

The technology for storing spent fuel (SF) is being upgraded with the introduction of dry storage. The construction of the SF dry storage building is being implemented within the existing nuclear facility (see Section 2.7.11).

When the fuel is changed, the fuel elements are brought along the water canal through the wall of the reactor building in the reactor pool. The fuel is loaded while the reactor is open and the space above it is filled with water. The charging machine hoists spent fuel elements from the reactor core and replaces them with fresh ones. A fuel element usually stays in the core for at least two fuel cycles. One fuel cycle lasts 18 months.

2.5.5 Turbine generator and electrical system

The steam generators produce saturated vapour, which propels the turbine. The steam in the double-flow high pressure part of the turbine expands to pressure of 0.8 Mpa, then after the moisture is removed and it is superheated it expands in the two low-pressure parts of the turbine to pressure of 5 kPa. It condensates in the four-part condenser, condensate pumps then return the condensate through the heaters into the steam generators.

When the Sava flows at more than 100 cubic metres per second, the condenser is cooled by flow cooling. If the flow rate is smaller the flow cooling is combined with cooling towers whereby a smaller quantity of water from the Sava is taken and the rest is recirculated in the cooling towers. The temperature of the Sava water, after it has been mixed with the cooling water, can rise by a maximum of 3°C.

The electricity generator produces three-phase current with power 850 MVA, cos phi 0.876 and voltage 21 kV. The rotor of the three-phase generator is cooled by hydrogen while the stator is water-cooled. The exciter does not have brushes.

Krško nuclear power plant is connected to the 400 kV electrical transmission system. Electricity flows from the generator via two transformers into the power plant's switchyard and from there via one transmission line towards Maribor, along two lines towards Ljubljana and Zagreb, and via two transformers to the 110 kV Krško distribution substation.

For its own needs the power plant uses electricity produced by its own generator or takes it from the 400 kV system. If the latter is down then it uses the 110 kV line from the Krško substation. Additional electrical energy can be provided by Termoelektrarna Brestanica (gas power plant), which is located about 7 km from NEK. Brestanica power plant can disconnect all other users and provide electricity only for NEK.

In case of loss of off-site power, NEK has three independent diesel generators (DG#1 and DG#2 producing 3.5 MW each, and DG#3 4 MW), which can provide electricity within 10 seconds. Each one can power the equipment necessary to shut down the power plant safely. NEK is also equipped with mobile generators which would be used in the event of an urgent need for electricity due to damage to the internal electrical grid.

2.5.6 Radioactive waste

The operation of NEK produces gaseous, liquid and solid radioactive waste. For the treatment of waste radioactive gases the power plant has two parallel closed loops with a compressor and catalytic incinerator for hydrogen, and six tanks for the decay and storage of compressed fission gases. Four gas tanks are used during regular operation while two are for when the reactor is not in use. The capacity of the tanks is enough to store gas for more than one month. In this period most short-lived fission gases decay, while the remaining gases go into the atmosphere when the meteorological conditions are favourable. Automatic radiation monitors in the plant ventilation stack prevent uncontrolled discharge when the concentration of radioactive gases is greater than the allowed limit /3/.

Liquid radioactive waste is treated in a system consisting of tanks, pumps, filters, an evaporator and two ion exchangers. Blowdown water from the steam generators is treated separately. The radioactivity of the wastewater released into the Sava is much lower than the permitted level. Liquid releases are dealt with in Section 4.4.7.1. The effective dose for an adult from releases into the Sava was 0.006 µSv per year (time spent on the bank and the consumption of fish) in Brežice in 2020. The calculated annual effective dose for an adult 350 m from the NEK dam is 0.014 µSv. If the average habits of the reference person were taken into account, the effective dose received would be several times lower. H-3 accounts for the biggest single share of the total effective dose (44%), with the predominant pathway being the consumption of fish.

The estimated effective doses are several 1,000 times smaller than the dose of 0.1 mSv, which is defined in Article 18 of the Decree on dose limits, reference levels and radioactive contamination (Official Gazette of RS, No 18/18), as the dose to be used to calculate the implemented concentrations for potable water.

All solid radioactive waste that is produced during the power plant's operation, and during maintenance work and repairs, is collected in the solid waste plant. Most of the waste consists of used ion exchangers, sludge from the evaporator, spent filters and other contaminated solid waste such as plastic, paper, cloths, personal protective equipment, tools and mechanical parts.

The solid radioactive waste, after having been compacted or solidified, depending on the purpose, is put into different containers: 208 l steel barrel, 200 l stainless steel barrel or 150 l stainless steel barrel with biological protection. The barrels and pressings are then placed into Tube Type Containers. The containers are temporarily stored in the power plant. During the plant's operation, the radiation dose contributed to the environment by NEK is less than 0.1% of the annual dose received from the natural background and artificial sources. This is ensured by modern cleaning devices and constant monitoring of the plant's surroundings /3/.

Radioactivity on the Krško Polje plain has been measured since 1974 at 50 different points around the power plant. At these points measurements are taken of the air, water, precipitation and biological samples also during the plant's operation. The data is compared with natural radioactivity and radioactive fallout prior to the plant's operation.
The state of the water and biotope in the Sava and the groundwater is also monitored. These measurements also continue during the plant's operation. A detailed description of the situation and radiation load on the environment is given in Section 4.4.

2.5.7 Water treatment for process purposes

There are two process water systems:

- the water filtering system (PW - Water Pretreatment System) and
- the system that produces demineralised water (WT – Water Treatment System).

The filtered (PW) and demineralised (WT) water systems are located in the Pretreatment Building. The whole process water production system is controlled by computer. It is operated remotely by means of two PLCs (Programmable Logic Controllers). The process water systems do not belong to the safety class, but the loss of these systems can nevertheless cause the automatic loss of components that require process water for their normal operation.

Raw water is drawn either from wells or the public water supply. It is collected in the raw water tank. From there it is pumped through two-layered filters, where the water steriliser (sodium hypochlorite) is added, into the PW tanks. The aim of the system that filters water is to provide all users with filtered water. The aim of the system that produces demineralised water is to produce water that is as pure as possible and provide it to consumers in the primary and secondary circuits.

A water treatment system is planned to provide filtered water for the water treatment system (WT), seal water for CW and CT pumps, and the distribution of PW water:

- during normal operation of the power plant, the system produces 45.9 m^3/h of PW water;
- in the period of increased consumption after the annual outage, the system provides 129.2 m^3/h of PW water.

The system that produces WT water includes:

- production of demineralised water,
- preparation of chemicals to support the water purification process,
- storage and distribution of demineralised water.

The aim of the system that prepares demineralised water (WT) is to prepare the required amount of water that has the prescribed quality. It also enables the storage and pumping of demineralised water (DD) to different consumers. The aim of the DD system is to distribute highly purified water from the WT system to consumers on the primary and secondary side of the power plant.

The demineralised water (DD) system is designed to provide the maximum flow rate of 70 m^3/h (308.2 gpm) into the DD tanks. The two DD tanks have capacities of 379 m^3 (10,000 gallons) and 1,000 m^3 (26,000 gallons).

2.6 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.

2.6.1 Primary Circuit

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

The heat rejected 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 generator 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 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.

2.6.2 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.

Expanded 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.

2.6.3 Tertiary Circuit

The tertiary circuit consists of:
- condenser,
- cooling pumps,
- cooling towers and piping.

The tertiary circuit is intended for cooling the condenser and removing the heat, which cannot be usefully utilised for electricity production.

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 expanded steam. Heating the river water is NEK'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 and the amount of water intake. 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.

2.6.4 Technical data about the facility

Technical data about the facility is presented in the following tables:

Table 1: 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 2: 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 3: Basic data about the reactor coolant

Chemical composition:	H_2O
Additives:	H_3BO_3
Number of cooling loops:	2
Pressure:	15.41 MPa (157.1 kp/cm^2)
Temperature at reactor inlet:	287°C
Temperature at reactor outlet:	324°C

Table 4: Basic data about the control rods

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

Table 5: Basic data about the steam generators

Material:	INCONEL 690 TT
Number of steam generators:	2
Pressure of steam leaving generator:	6.4 MPa (65.6 kg/cm^2)
Steam flow rate from both generators:	1,088 kg/s

Table 6: 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 7: 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

2.7 ENSURING NEK'S SAFE OPERATION

2.7.1 Safety systems

Safety systems **prevent** the uncontrolled release of radioactive substances into the environment. A high level of attention is paid to nuclear safety already in the phase when the reactor and power plant are 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:

1. effective reactivity control (reactor power control),
2. cooling of the nuclear fuel in the reactor, the spent fuel pool and in the spent fuel dry storage,
3. 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:

1. The **first** barrier is nuclear fuel (or fuel pellets) retaining radioactive material within itself.
2. The **second** barrier is a waterproof cladding that encloses fuel pellets and prevents leakage of radioactive substances from fuel.
3. The **third** barrier is the primary system boundary (pipe walls, reactor vessels and other primary components) that retains radioactive water for reactor cooling.
4. 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, whereas the fourth barrier prevents radioactive substances from being released directly into NEK'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.

2.7.2 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 the 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.

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 compliance with Article 19 of the Rules on radiation and nuclear safety factors (Official Gazette of RS, Nos. 74/16 and 76/17 – ZVISJV-1).

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 so-called cliff edge effect.

2.7.2.1 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 /21/. 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");
- 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.

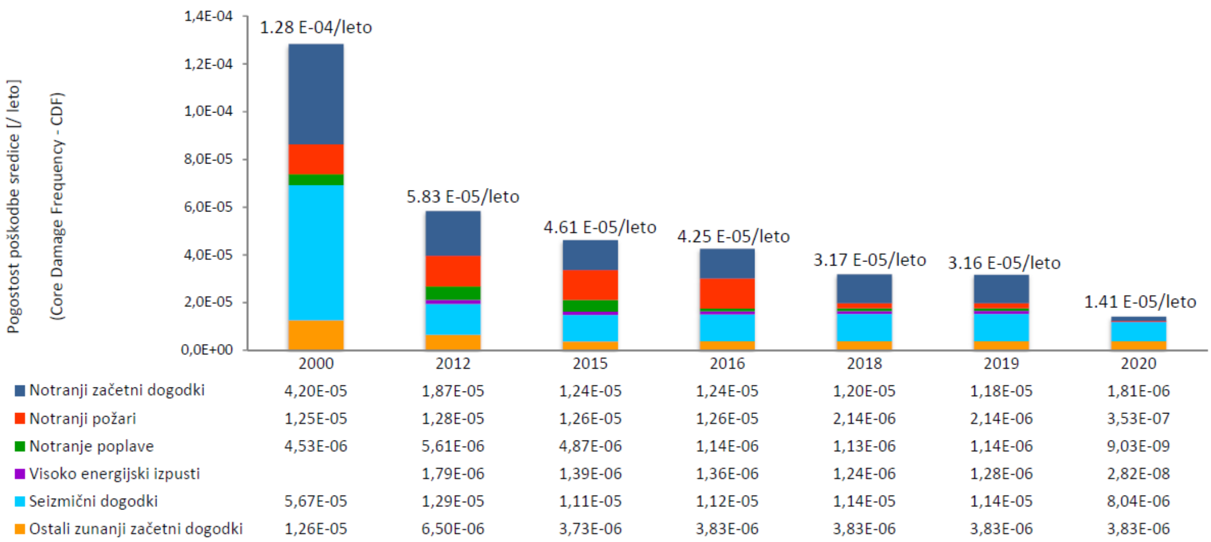


Figure 5: The history of core damage frequency due to internal initiating events, external initiating events from the power plant and external initiating events from the surroundings (source:/1/)

Pogostost poškodbe sredice [/leto]	**Core damage frequency [/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.

2.7.3 Incident and Emergency Preparedness at the Nuclear Power Plant

2.7.3.1 Protection and Rescue Plan (NZIR)

NEK has prepared a special emergency plan. The Protection and Rescue Plan in NEK (referred to as: NZIR) /224/ 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 /224/ 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 material that is accumulated in the reactor core and in spent fuel is the main hazard source for the environment.

2.7.3.2 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 /3/ design basis and DEC accidents are described. 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 (DB) and Beyond Design Basis (BDB) accidents at NPP Krško" /196/ 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 Programme (PNV), described in Section 3.4. 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 Design Basis (DB) and Beyond Design Basis (BDB) accidents at NPP Krsko " /196/.

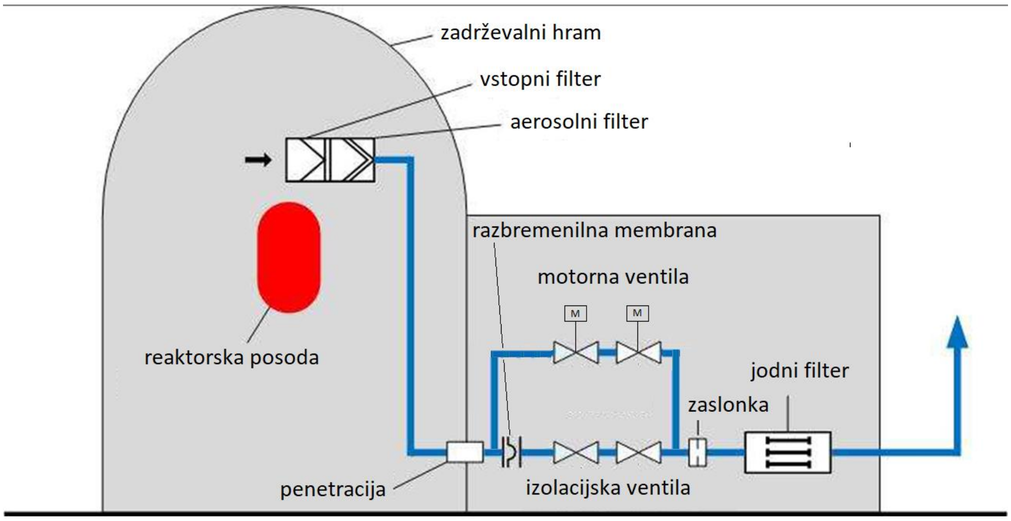


Figure 6: Schematic outline of passive containment filtering vent system (source:/1/)

zadrževalni hram	Containment
vstopni filter	Prefilter
aerosolni filter	Aerosol filter
razbremenilna membrana	Rupture disc
motorna ventila	Motor operated valves
reaktorska posoda	Reactor pressure vessel
jodni filter	Iodine filter
zaslonka	Orifice plate
penetracija	Penetration
izolacijska ventila	Isolation valves

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).

2.7.4 Aging Management Programme

NEK has established an equipment aging management programme (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 programme defines in detail the responsibilities, activities and methodology for monitoring equipment aging. The AMP programme also foresees measures to reduce or eliminate ageing impacts.

The AMP consists of various NEK programmes, 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 programme thus comprehensively covers the plant aging, including mechanical, electrical and construction SSC, with which it systematically recognizes 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 programme.

The NEK aging management programme is therefore based on 10 CFR 54 – "Requirements for Renewal of Operating Licences for Nuclear Power Plants". Other activities are controlled through the monitoring of maintenance efficiency – the so-called Maintenance Rule (10 CFR 50.56), Reliability Centred Maintenance (INPO API 913) and Environmental Qualification Programmes (10 CFR 50.49). The activities related to equipment replacement are included in the long-term investment plan and maintenance activities.

2.7.5 Fire safety

NEK has established a NEK Fire Safety Programme - Fire Safety Rules /23/, 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 programme 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 /3/ 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 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. It must be ensured that in compliance with Rules on radiation and nuclear safety factors (Official Gazette of RS, Nos. 74/16 and 76/17 – ZVISJV-1) the following are implemented:

- measures that prevent fires from occurring,
- rapid detection, control and extinguishing of any fire, and
- reducing 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.

The person responsible for the implementation of fire safety measures is the fire safety chief.

The operative and preventive work at NEK is carried out by professional firemen led by the leader of the fire unit on duty which always numbers at least three firemen. The contract between NEK and the Krško Professional Fire Unit ensures that three professional firemen from the Unit are on call at all times for a possible intervention at NEK.

Four equipment operators from the operations team can provide an additional help to professional firemen on the request of the shift supervisor.
Further help in fighting a fire at NEK can be provided by the fire safety section which consists of:

- the leader of the fire safety section who is a professional fireman;
- the deputy leader of the fire safety section who is trained to fight fires;
- two divisions (the leader of the division who is a professional fireman; each division has at least ten firemen trained in accordance with the NEK procedure).

A possible intervention begins from the mobile equipment point (PMO), which is where the firemen, the main fire office and equipment for interventions are located.

2.7.6 Seismic safety

The Reactor Site Criteria 10 CFR 100 App. A, which were applied in the design and construction of NEK, demand 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 (Rules on radiation and nuclear safety factors (Official Gazette of RS Nos. 74/16, 76/17 - ZVISJV-1)). 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 probabilistic safety analyses for earthquakes /225/.

After the end of the extensive probabilistic safety analyses for earthquakes /225/, which also involved a seismic hazard analysis of the NEK site, the studies for potential locations for LILW and 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 since 2008 /274/,/275/, 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 /271/, which was produced in the years 2002-2004 after 10 years of previous research.

The stress tests at NEK /26/ 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 programme. All new buildings and systems constructed as part of the power plant safety upgrade programme 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 /274/ 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 /26/. 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. /26/.

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, 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.

2.7.7 Physical security

Protecting NEK from terrorism is defined and described in a special document "NEK Physical Protection Plan", which is classified in compliance with ZVISJV-1 and is dealt with as a document with a classified level of confidentiality in accordance with the Classified Information Act.

The physical security of NEK is provided by the NEK Security Department in cooperation with the Police. Physical security is provided in accordance with the NEK Physical Protection Plan (NFV). This Plan is updated at least annually on the basis of a Threat assessment prepared by the Police. The content of the Plan must be agreed to by the Slovenian Nuclear Safety Administration (URSJV), and confirmed by the Slovenian Ministry of the Interior. The Plan's content and the accompanying executive procedures are classified as confidential information in compliance with ZVISJV-1 and the Classified Information Act (ZTP). Access to confidential information is limited in accordance with ZTP.

2.7.8 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 devices, 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 /26//25/. 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 (see Section 2.13.1).

2.7.8.1 <u>Design Basis Floods (DBF)</u>

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 rate 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 sea level (a.s.l.). The elevation of the plateau on which NEK stands is 155.20 a.s.l. The entrances and openings of the buildings in the middle of the site are above the elevation of 155.50 a.s.l. This ensures that water cannot enter the buildings if the embankments along the Sava fail.

2.7.8.2 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 rate 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 a.s.l. /3/. 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 return periods for flow rates of such magnitude are estimated at one million (1,000,000) years /26/.

2.7.8.3 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), 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 to a length of 1,430 m and the Potočnica to a 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 a.s.l., while the elevation of the Sava embankment measures between 158,82 a.s.l. at the new round-about and 157.18 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)" 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 flow rates, meant it was necessary to undertake additional measures to improve NEK's flood safety.

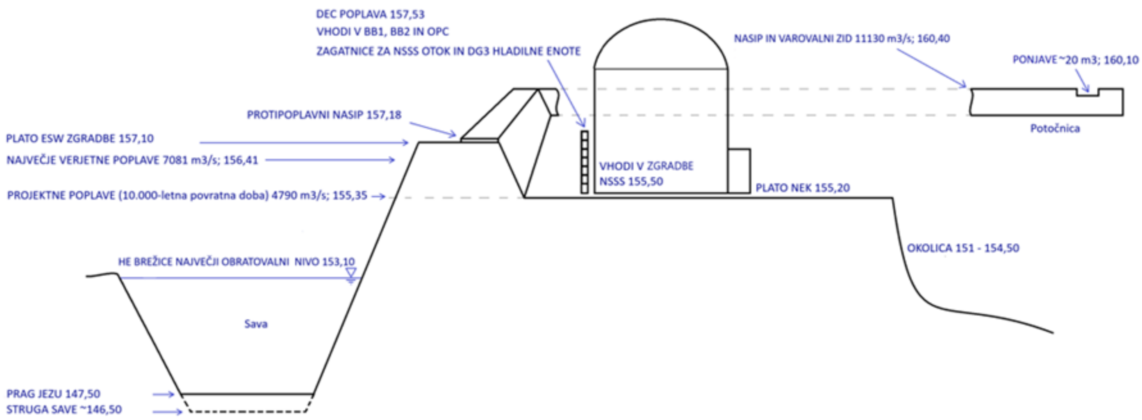


Figure 7: Flood protection

DEC POPLAVA 157,53	DEC FLOOD 157.53
VHODI V BB1, BB2 IN OPC	ENTRANCES TO BB1, BB2 and OPC
ZAGATNICE ZA NSSS OTOK IN DG3 HLADILNE ENOTE	WATER BARRIERS FOR THE NSSS ISLAND AND THE DG3 COOLING UNITS

NASIP IN VAROVALNI ZID 11130 m^3/s; 160,40	EMBANKMENT AND PROTECTIVE WALL 11,130 m^3/s; 160.40
PONJAVE ~20 m^3; 160,10	TARPAULINS ~20 m^3; 160.10
Potočnica	Potočnica
PROTIPOPLAVNI NASIP 157,18	FLOOD EMBANKMENT 157.18
PLATO ESW ZGRADBE 157,10	PLATEAU OF THE ESW BUILDING 157.10
NAJVEČJE VERJETNE POPLAVE 7081 m^3/s; 156,41	PROBABLE MAXIMUM FLOOD 7,081 m^3/s; 156.41
VHODI V ZGRADBE NSSS 155,50	ENTRANCES TO THE NSSS STRUCTURES 155.50
PLATO NEK 155,20	NEK PLATEAU 155.20
PROJEKTNE POPLAVE (10.000-letna povratna doba) 4790 m^3/s; 155,35	DESIGN BASIS FLOODS (a 10,000-year return period) 4,790 m^3/s; 155.35
OKOLICA 151-154,50	SURROUNDINGS 151-154.50
HE BREŽICE NAJVEČJI OBRATOVALNI NIVO 153,10	HPP BREŽICE MAXIMUM OPERATING LEVEL 153.10
Sava	Sava
PRAG JEZU 147,50	RIVER DAM SPILLWAY CREST 147.50
STRUGA SAVE ~ 146,50	SAVA RIVERBED ~ 146.50

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. 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 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 rate of the Sava where the water would reach the top of these raised embankments. This flow rate is 11,130 m^3/s. Before the reservoir for HPP Brežice was built, the flow rate that would overflow the embankments was 10,600 m^3/s.

2.7.9 Other Extreme Weather Conditions

NEK has prepared a technical report entitled Screening of External Hazards /34/, 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 /234/. 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 /34/, 104 external events are defined.

The design basis values, i.e. protection against significant extreme weather conditions are described in the table below (Table 8).

Table 8: 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 Weather Conditions	Design basis values
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 structures and systems are built to withstand heavy loads (from 120 kg/m^2 to 375 kg/m^2).

2.7.10 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 and this is why nuclear energy is an example of a sustainable energy source. Basic information about RAW from the point of view of ensuring safe operation is given below, meanwhile, detail information about the inventory and ways of handling RAW are given in Section 4.4.10.

2.7.10.1 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.

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 RAW. If they are not contaminated they are handed over to an organisation authorised for the collection of such waste (in compliance with legal requirements).

2.7.10.2 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 RAW.

This type of waste represents a considerable share of the total amount of RAW 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 RAW 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 RAW at NEK are listed in the table below (Table 9).

Table 9: Processes used for treating liquid RAW 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)
Filtration	All liquids with particles	Cartridge filters

2.7.10.3 Solid Radioactive Waste

Solid RAW 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 RAW 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 RAW includes solidified and encapsulated RAW (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 (Official Gazette of RS, No. 19/18) 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 (Official Gazette of RS, No. 19/18) (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 (Official Gazette of RS, No. 19/18).

In accordance with the Decree on Radiation Activities, 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. This is implemented in accordance with the following procedure: Request for the release from radiological control of waste.

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

Table 10: Processes for reducing the volume of non-solidified solid RAW /228/

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
Supercompacting 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 /3/, entitled RADIOACTIVE WASTE MANAGEMENT. The stored waste meets special storage criteria that comply with the Rules on Radioactive Waste and Spent Fuel Management (Official Gazette of RS No. 125/21). 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.

The capacity of the LILW (RWSB) storage is 11,200 drums or 3,000 tube type containers, which is the most frequent form of packaging for LILW at NEK. The warehouse's capacity suffices until, in compliance with the agreement between the Republic of Slovenia and the Republic of Croatia, the public utility services of both countries each take over half of the radioactive waste. /11/.

2.7.11 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 in the spent fuel pool (SFP) in the fuel handling building (FHB) as was foreseen in the power plant's original design. 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 analyses and 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. 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) /28/.

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, so no device, system or energy source is needed for cooling and operation. 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. 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.

After several years of cooling in the spent fuel pool (SFP), the SF is transferred to special canisters (Figure 8), that are hermetically sealed and placed in a suitable overpack (for transfer, storage or transport).

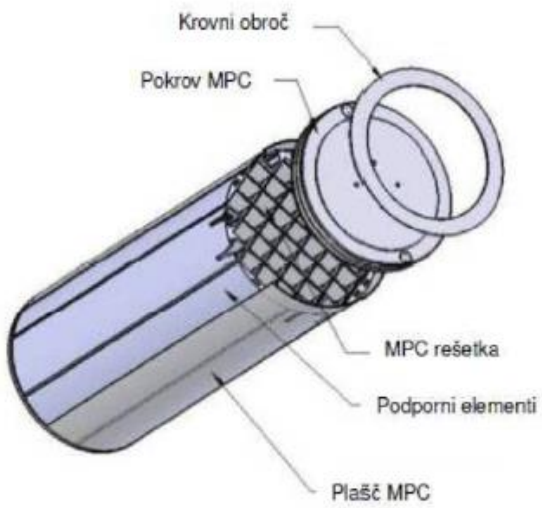


Figure 8: Spent fuel multi-purpose canister (MPC) (source: /226/)

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 9). The building is divided into several areas: manipulation, technical and storage 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. The first phase of dry storage loading follows in 2023, when the initial 592 spent fuel elements will be transferred. In the second phase in 2028, the next 592 spent fuel elements will be transferred.

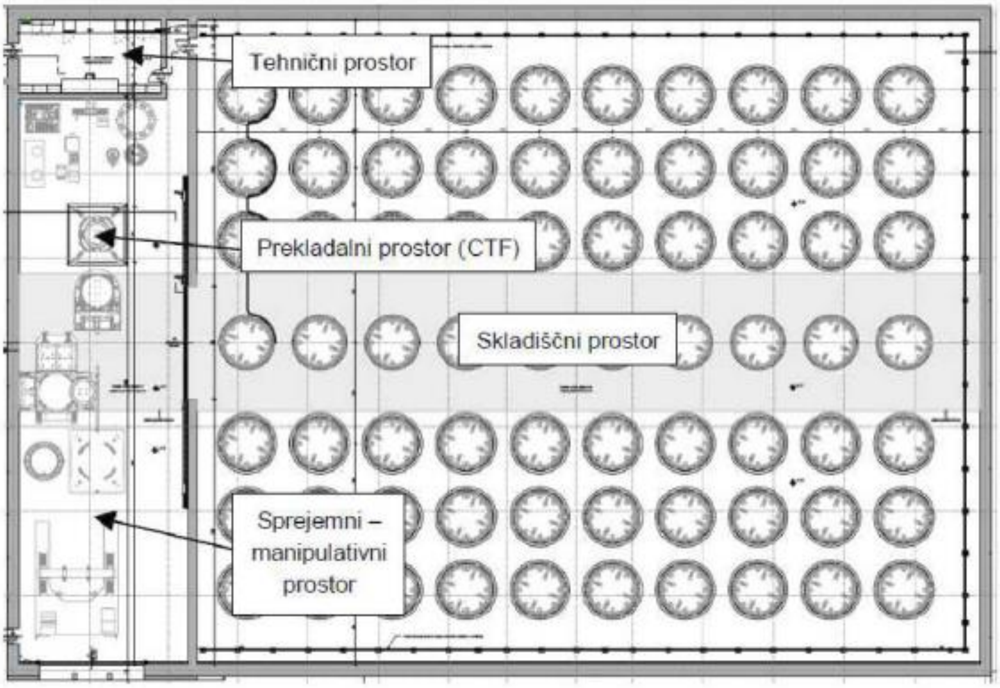


Figure 9: Floor plan of SF dry storage building (source: /226/)

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

2.7.12 Safety Upgrade Programme (PNV)

In compliance with Slovenian legislation in the field of nuclear safety (Rules on Radiation and Nuclear Safety Factors) 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 programme of safety upgrades was demanded. In its reasoning, the aforementioned decision specifically highlighted 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 /26/ to ENSREG and published it on its website. The NEK Safety Upgrade Programme is not part of the environmental impact assessment. Safety upgrades would have been carried out irrespective of the extension of NEK's operational lifetime on the basis of Slovenia's Post-Fukushima Action Plan following EU stress testing.

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 programme 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 /8/. 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.

NEK's 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 Programme for Radioactive Waste and Spent Fuel Management for the Period of 2016 –2025 /28/. In 2023, the project to construct dry spent fuel storage will be completed /2/. 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, a thorough analysis was carried out and a comprehensive upgrade programme for the prevention of severe accidents and mitigation of their consequences was elaborated which has been completed in 2021, with the exception of the completion of construction of the dry storage and the transfer of spent fuel (first campaign), which will be carried out in the first half of 2023.

2.7.13 Periodic Safety Review (PSR)

The Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1, Official Gazette of RS, Nos. 76/17 and 26/19) 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".

The frequency, content, scope, duration and method of performing periodic safety reviews, and the method of reporting on such reviews are defined in the Rules on the safety assurance of radiation and nuclear facilities (Official Gazette of RS, Nos. 87/11, 76/17). 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, and the second one in 2013. Both 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 and will be completed in 2023.

2.7.14 Independent International Expert Reviews

NEK participates in a number of independent international expert reviews (missions), which examine in detail all aspects of the power plant's safe and reliable operation. These reviews are carried out by various 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.) /26/ 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.

2.7.15 Aging Management Programme (AMP)

The Aging management programme 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 Programme (AMP).

The NEK Aging Management Programme is based on US legislation NUREG-1801, Generic Aging Lessons Learned, Revision 2. The AMP thus covers all passive and long-life systems, structures and components. The European AMP, prepared by the IAEA (International Generic Aging Lessons Learned (IGALL) for Nuclear Power Plants) foresees that the aging management programme also addresses active components. NEK monitors active components in accordance with the so-called Maintenance Rule (10 CFR 50.65) and Environmental Qualification Programme (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 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 management programme 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 programme 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 management programme with international recommendations and the Rules on the provision of safety following the commencement of operation of radiation and nuclear facilities.

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 programmes and their implementation on the basis of IAEA standards and the best international practices. The aging management programme will, however, be evaluated comprehensively and systematically as part of the third Periodic Safety Review (PSR3), in accordance with the programme approved by the URSJV with decision no. 3570-7/2020/22 on 23 December 2020.

2.7.16 Management Systems

The external framework for NEK's operation and business is determined by legislation, the Intergovernmental 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) and in more detail in the Rules on Radiation and Nuclear Safety Factors (Official Gazette of RS No. 74/16, 76/17) in Chapter 5 (Management System). The programme also complies with the IAEA 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 Programme 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 programme 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. 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 for the next three-year period (until the end of 2023)/26/.

The occupational safety and health system according to the BS OHSAS 18001:2007 standard was introduced in 2011. Its adequacy and success level are regularly audited by an external certification organisation.

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 obtained the ISO 45001:2018 certificate no. SI008176 for a period of three years /30/.

2.8 THE POWER PLANT'S KEY SAFETY CHARACTERISTICS IN 2021

Safety modifications and upgrades of NEK **are not** the subject of this assessment. We are listing them only with the aim of showing what has been done in the past to improve NEK's safe and efficient operation. All the below listed safety modifications and upgrades represent the latest state of technology at NEK in its present state.

Thanks to NEK's prudent and focused safety upgrades in the past decades, especially the implementation of the safety upgrade programme, the safety level is improving on an on-going basis, as shown below in Figure 10, which shows the core damage frequency due to all potential internal (equipment failure, pipe breaks, fires, etc.) and external (earthquakes, floods etc.) events.

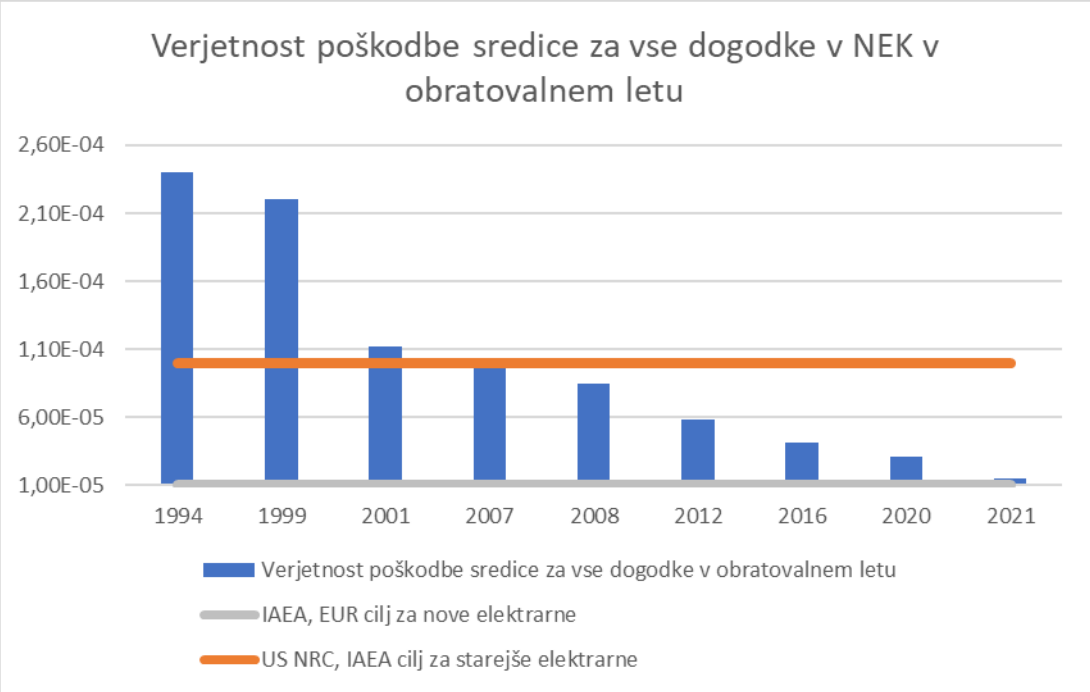


Figure 10: Safety level measured with core damage frequency per operating year (CDF/yr) (source:/1/)

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, EUR target value for new power plants
US NRC, IAEA cilj za starejše elektrarne	US NRC, IAEA target value for old power plants

The figure 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, mitigating the consequences of fires, provision of additional power supply sources in the event of an emergency or loss of off-site, and others. As an example we can list alternative possibilities for heat removal with the new DEC systems (ASI tank, AAF tank and well), 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 Programme /18/.

2.8.1 Major Modifications in the Primary Circuit

2.8.1.1 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.

2.8.1.2 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.

2.8.1.3 Upgrade of reactor coolant pump motors

Both electric motors of the reactor coolant pump were renewed and upgraded. 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.

2.8.1.4 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.

2.8.2 Major Modifications in the Secondary Circuit and electric systems

2.8.2.1 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.

2.8.2.2 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.

2.8.2.3 Replacement of the turbine regulation 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.

2.8.2.4 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 was one of the performed upgrades of the generator system to enhance the reliability of the nuclear power plant operation. The project involved 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.

2.8.2.5 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.

2.8.2.6 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.

2.8.3 Major Modifications in the Tertiary Circuit and Subsystems

2.8.3.1 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 extension took place in 2008.

2.8.3.2 Reconstructions due to the construction of the Brežice HPP

Due to Brežice HPP, the level of the Sava at the NEK site has risen by 3 m, to the level of 153.20 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.

2.8.3.2.1 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 a 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 flow rates 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.

2.8.3.2.2 Reconstruction of 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, travelling screens and CW pumps;
- the reconstruction and modernisation of CW cleaning systems – a 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.

2.8.3.2.3 Reconstruction of 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), which ensures cooling of the safety components. 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.

2.8.3.2.4 Reconstruction of 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, 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 a.s.l.
  - the replacement of two existing submersible pumps.

2.8.4 Other design-related modifications to improve safety

2.8.4.1 Improvement of the AC safety power supply (DG3)

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.

2.8.5 NEK Safety Upgrade Programme

Following the completion of the Safety Upgrade Programme /18/, NEK is ready for severe accidents as demanded by ZVISJV-1 (Official Gazette of RS, Nos. 76/17, 26/19) and the Rules on radiation and nuclear safety factors (Official Gazette of RS, No. 74/16 and 76/17 – ZVISJV-1). 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.

2.8.5.1 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.

A dry filter system was installed, consisting 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.

2.8.5.2 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 included 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 is 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 was 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 operational 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 operational 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 provides 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 is 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.

2.8.5.3 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. The construction of the BB2 building, the installation of the Alternative Safety Injection System (ASI) and the Alternative Auxiliary Feedwater system (AAF) ensures the Alternative Ultimate Heat Sink (AUHS). 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) system

This upgrade is part of the third phase of the safety upgrade programme and includes the installation of an additional pump for filling the steam generators including all piping and valves which 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 spent fuel dry 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, SF dry 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 disposal. The dry storage is under construction and is expected to be completed in the first half of 2023.

The spent fuel dry storage is located in the technological part of NEK, west of the present spent fuel pool location.

Installation of high-temperature seals in the reactor coolant pump

The upgrade includes 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. The installation of HTS thus prevents the loss of primary coolant. The project was completed in 2021.

2.8.6 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 Programme. The processes in this regard are well defined and documented.

There are various programmes 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 programme at NEK determines that it shares analyses and events with the industry. NEK personnel participate in various activities, such as the OSART delegation (IAEA), 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 programmes, 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, after which appropriate corrective measures were 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 programmes,
- 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 Rules on the operational safety of radiation and nuclear facilities (Official Gazette of RS, Nos. 81/16 and 76/17 – ZVISJV-1) 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.

2.9 HAZARDOUS SUBSTANCES AT NEK

NEK - as it is now and after its operational lifetime is extended - is **not classified** as an installation with a high or low risk for the environment as defined in the Decree on the prevention of major accidents and mitigation of their consequences (Official Gazette of RS, No. 22/16).

NEK – as it is now and after its operational lifetime is extended – is **not classified** as an activity or installation that can cause large-scale environmental pollution as defined in the Decree on the types of activity and installation that could cause large-scale environmental pollution (Official Gazette of RS, no. 57/15).

The table below features some of the more significant hazardous substances present on the NEK site.

Table 11: Significant hazardous substances at NEK /17/

Type of hazardous substance and aggregate state	Type of danger	Location	Quantity
Hydrogen (gaseous)	explosive	warehouse for gases, gas bottles	168 kg
Nitrogen (gaseous)	gas under pressure	warehouse for gases, gas bottles	8,000 kg
Boric acid (solid)	toxicity for reproduction	storage for hazardous substances	7,000 kg
Ammonium (liquid)	corrosive, toxic to aquatic organisms	storage for hazardous substances	8,000 l
Hydrazine hydrate (liquid)	toxic, corrosive, toxic to aquatic organisms	storage for hazardous substances	3,000 l
SF6 (gaseous)	gas under pressure	transformer field	240 kg
diesel fuel oil (liquid)	inflammable, poisonous	3 underground storage tanks and drums	439 m^3 + 10 m^3
extra-light heating oil (liquid)	inflammable, poisonous	5 underground storage tanks + above-ground tank	5 x 113 m^3 + 240 m^3
lubrication oil (liquid)	inflammable, poisonous	2 underground storage tanks	105 m^3 + 56 m^3
laboratory waste (solid and liquid)	corrosive	storage for hazardous substances	400 kg/year

For its normal operation, NEK requires only small quantities of hazardous chemicals. The most important hazardous substances at NEK and their average quantities are listed in table 11 /11/. Hazardous substances are stored in compliance with the Rules on technical and organisational measures for the storage of hazardous chemicals (Official Gazette of RS, No. 23/18). The different chemicals are appropriately handled, stored and used, depending on their specific properties and the demands stemming from the manufacturers' safety documents.

After the hazardous substances have been used they become hazardous waste. In compliance with legislation, this is classified according to the applicable waste classification number and is stored appropriately until it is taken away. The creation of hazardous waste is accompanied by its regular removal by organisations authorised to remove hazardous waste. This ensures a minimal amount of hazardous waste is kept on the NEK site.

As mentioned in the introduction to the section, NEK is liable neither to SEVESO nor IPPC.

2.10 THE EXISTING UTILITIES, ENERGY AND TRANSPORT ARRANGEMENT

The extension of NEK's operational lifetime **does not change** the utilities, energy and transport arrangement which remains the same as in the existing state.

2.10.1 Potable water supply

There is already a connection to the public water supply. Potable water is used for sanitary and fire safety needs (hydrants).

2.10.2 Water supply for process purposes

The cooling water and essential service water intakes are on the bank of the Sava, above the dam, which ensures a sufficient water supply in all conditions. The cooling water discharge is below the dam. In the event of there being insufficient water in the Sava, the condensate cooling water is cooled by cooling towers with forced draft cooling cells.

The developer uses water from the Sava for technological purposes, on the basis of a partial water permit no. 35536-31/2006 of 15 October 2009 and Decision no. 35536-26/2011-9 of 23 May 2013 and the Decision governing the change in water permit no. 35530-7/2018-2 of 22 June 2018, which gave the developer water rights for the direct use of water for technological purposes (the Sava and the well on the right bank) at a maximum rate of 29,000 l/s i.e. maximum 915,000,000 m^3/year, valid until 31 August 2039. In 2020 another water permit no. 35530-100/2020-4 of 14 November 2020 (valid until 31 October 2050) was acquired for three wells on the nuclear island, which can provide 3 x 5 l/s, altogether up to 3 x 70,000 m^3/year. Water permit No. 35530-48/2020-3 was issued on 9 September 2021 /276/ for the requirements of the additional filling of tanks containing borated water and demineralised water, for cleaning and testing the well pump, and in the event of an emergency. Water is pumped from well SPW006 BB2 at the maximum rate of 8.0 l/s and no more than 230 m^3/year.

Water is taken from the Sava at the location determined by the coordinates GKY=540294, GKX=88198, on land plot 1246/6, cadastral municipality 1321 Leskovec.

2.10.3 Separation of wastewaters

All wastewater (municipal, industrial, rainwater) from the NEK plant flows into the Sava via 9 discharges and 12 outlets. The developer has acquired an environmental permit concerning emissions to water no. 35441-103/2006-24 of 30 June 2010, changed by decision no. 35441-103/2006-33 of 4 June 2012 /49/, which summarises all the information about the discharges and the largest quantities and allowed flow rates in the following table.

Table 12: Existing discharges and outlets of NEK (source: OVD /49/)

Release point (MM)	Type of wastewater	Location (coordinates)	Largest annual quantity, daily and 6 hour average flow rate
V1	Industrial wastewater	GKX = 88198 GKY = 540250	26,002,500 m³/year 1,606 l/s 1,606 l/s
	of which:		of which:
V1-1 MM1	- Industrial wastewater from outlet V1-1, Discharge of essential service water	GKX = 88332 GKY = 540280	26,000,000 m³/year 1,600 l/s 1,600 l/s
V1-12 MM2	- industrial wastewater from outlet V1-12, NEK liquid waste reservoir	GKX = 88320 GKY = 540893	2,500 m³/year 1,600 l/s 6 l/s
V2	- industrial wastewater (flushing of rotating rakes)	GKX = 88199 GKY = 540231	
V3	- industrial wastewater (discharge of fire protection pumps)	GKX = 88197 GKY = 540219	
V4	- industrial wastewater (essential service water supply)	GKX = 88196 GKY = 540243	
V5	- industrial wastewater (flushing of travelling screens)	GKX = 88178 GKY = 540364	
V6	- industrial wastewater (pumping during an outage)	GKX = 88177 GKY = 540362	
V7	- cooling wastewater and wastewater from water treatment	GKX = 88103 GKY = 540438	791,000,000 m³/year 25,000 l/s 25,000 l/s
	Of which:		
V7-7 MM3	- cooling wastewater (discharge of cooling water through measuring point MM3) - in the period between October and April of the following calendar part	GKX = 88162 GKY = 540400	331,000,000 m³/year 25,000 l/s 25,000 l/s 460,000,000 m³/year 25,000 l/s 25,000 l/s
V7-10 MM4	- cooling wastewater (NEK cooling towers through measuring point MM4) - in the period between October and April of the following calendar part	GKX = 88154 GKY = 540435	52,000,000 m³/year 15,000 l/s 15,000 l/s 104,000,000 m³/year 15,000 l/s 15,000 l/s

Release point (MM)	Type of wastewater	Location (coordinates)	Largest annual quantity, daily and 6 hour average flow rate
V7-11 MM5	- Wastewater from water treatment (Discharge from the water treatment tank through the neutralisation tank through measuring point MM5) - in the period between October and April of the following calendar part	GKX = 88370 GKY = 540418	6,000 m³/year 6 l/s 6 l/s 9,000 m³/year 6 l/s 6 l/s
V8	- precipitation wastewater (during outages also cooling wastewater from the boilerhouse) pressure pipe 1 pressure pipe 2 pressure pipe 3 pressure pipe 4	GKX = 88010 GKY = 540582 GKX = 88012 GKY = 540580 GKX = 88014 GKY = 540578 GKX = 88016 GKY = 540576	
V9 MM6	- municipal wastewater from the small municipal treatment plant	GKX = 87993 GKY = 540587	10,000 m³/year 2.9 l/s 2.9 l/s

In the table discharges are marked with a V and a number (e.g. V1) and represent a release into the Sava. Outlets are marked with the number of the discharge to which they are connected, and the number of the outlet (e.g. V1-1), and mean release from NEK. Measuring points are marked with the letters MM and a number (e.g. MM1).

Large cooling system – CW 8 (Circulating Water System) (outlets 7 and 10; discharges 7 – V7-7 and V7-10)

It is intended for cooling the main condenser and the Turbine Closed Cycle Cooling (TC) system, which is in fact the system which cools the secondary components. The flow rate of CW water through the TC system is 1 m^3/s. When the Sava's flow rate exceeds 100 m^3/s, the condenser is cooled with flowing water (outlet 7, discharge 7 – V7-7). When the flow rate is smaller (less than 100 m^3/s, possibility of heating the Sava by more than 3 K) the flow cooling is combined with the cooling towers which make use of the forced cooling of the tertiary system with ventilating cooling cells (release point 7, discharge 10 – V7-10). In both cases the water flow rate through the condenser is ca. 25 m^3/s.

Before and after being pumped the water is only mechanically cleaned. Chemicals are added only to the TC system - a mixture of sodium nitrite and sodium tetraborate, in a ratio of 30/70. This system is closed and has no direct connections with outlets or discharges into the Sava.

Small cooling system – SW (essential service water supply system) (outlet 1; discharge 1 – V1-1)

The cooling water cools the Component Cooling (CC) system via heat exchangers. The CC system is intended for cooling components in the power plant's installations (pumps, exchangers). On the CC side of the heat exchangers of the CC system, molybdate (MoO_4^{-2}) is added to the water – in a concentration of 200 – 1,000 *mg/l (once or twice a year, between 300 and 400 l per year). As the system is completely closed, there can be no discharge into the River Sava. No dangerous substances are added to the small cooling system.*

Buildings and equipment for water treatment (outlet 11; discharge 7 – V7-11)

As its primary source of raw water NEK uses its own wells (Section 2.10.2). Water from the public water supply is used as a reserve source. Before the raw water enters the water treatment system it is mechanically cleaned with the Dual Media Filter (sand filter with sand grains of different sizes and added anthracite). Water purified in this way is kept in two tanks for pre-treated water (PW) and is later used for two purposes: as seal water for different pumps and as a source of water for the system for production of deionised water which begins with wet filtration on filters with filter inserts. From there the water is further purified through two-level reverse osmosis modules and continues through a softening unit (mixed ion exchanger). The final fine purification is achieved with the help of electrodeionisation (EDI).

During the periodic cleaning of the system (reverse osmosis, degassing, EDI), which NEK can perform if the system's parameters worsen (it has not been carried out in recent years), chemicals such as citric acid and hydrochloric acid are used. In this case the system is transformed in such a way that wastewater is collected first in the neutralising pool where the pH is constantly monitored and also adjusted to the neutral value before it is finally discharged (i.e. outlet 11 and discharge 7 – V7-11).

WP (L) system (outlet 12; discharge 1 – V1-12)

The waste processing (WP) system is a system intended for the treatment of liquid radioactive waste where boron in the form of boric acid acts as a neutron absorber. The absorption of neutrons controls criticality of the chain reaction. Liquid radioactive waste coming from the primary circuit is concentrated in the evaporator. The concentrate then dries and the liquid waste turns solid while the evaporated water, which still contains small quantities of boron, is discharged into the first tank for control of liquid radioactive waste. In the event that this wastewater is safe in terms of radioactivity, it is released into the Sava via outlet no. 12, which later joins with outlet no.1 - the small cooling system) and flows out through discharge no. 1.

The second source of boron is in detergents that are used in the laundry for overalls. Due to the possibility of radioactive contamination, the waste from the laundry is also collected in the second control tank for liquid radioactive waste.

The main chemical that is added is therefore boric acid. The annual quantity of boron released in 2020 was 17 kg. This data is evident from NEK's internal measurements, which are kept in the NEK archive and can also be consulted via the environment engineer. The concentration of boron is determined prior to each release. This fulfils the requirement from point 1.3 of the OVD regarding releases into water.

OTHER WASTEWATERS

Wastewater that is not measured is also created at this site (flushing of the rotating rakes, discharge from the fire protection pumps, filter cleaning, flushing of the travelling screens and emptying of the maintenance channels), sanitary wastewater produced by employees and wastewater from the water treatment.

Municipal wastewater

The small wastewater treatment plant is a biological treatment plant with an EKOROL - 22 rotating contactor. Municipal wastewater from NEK flows into the treatment plant. The plant's capacity is 700 PE, the average daily amount of wastewater measured at the intake is ca. 140 m^3. It began operating in 2001 and the discharged water goes into the Sava.

Basic technical information about the treatment plant:
WATER LINE:

- primary settling in the Emscher settler, rotating contactor - 2x, supplementary settler

SLUDGE LINE:

- anaerobic stabilisation of sludge in the "Emscher" digester (primary sludge and superfluous sludge from the supplementary settler).

Wastewater from NEK is discharged through a number of discharges, while monitoring takes place at different measuring points. The discharges and measuring points are listed below and their locations are shown on the figure below (Figure 11).
Discharge V1: essential service water (Y=540250, X=88198)
- Outlet V1-1: waste cooling water (essential service water) via measuring point MM1 (Y=540280, X=88332)
- Outlet V1-12: liquid waste tank via measuring point MM2 (Y=540893, X=88320)

Discharge V2: wastewater from flushing the rotating rakes (Y=540231, X=88199)

Discharge V3: discharge of the fire protection pumps (Y=540219, X=88197)

Discharge V4: essential service water (Y=540243, X=88196)

Discharge V5: wastewater from flushing the travelling screen (Y=540364, X=88178)

Discharge V6: pumping during an outage (Y=540362, X=88177)

Discharge V7: discharge of cooling water (Y=540438, X=88103)
- Outlet V7-7: discharge of cooling water via measuring point MM3 (Y=540400, X=88162)
- Outlet V7-10: discharge of cooling water via cooling towers via measuring point MM4
- Outlet V7-11: discharge from the water treatment tank via the neutralisation tank via measuring point MM5

Rainwater is discharged via oil separators into the rainwater sewer system which ends up (via discharge V8) in the Sava. All the oil separators have operating procedure and diary and are checked on a regular basis. There are a total of 17 oil separators on the NEK site.

Discharge V9: discharge from the wastewater treatment plant (small municipal treatment plant with a capacity of 700 PE) via measuring point MM6 (Y=540587, X=87993).

Municipal wastewater flows into the small municipal treatment plant whose discharge (V9) goes into the Sava.

Figure 11: Locations of discharges and measuring points of NEK wastewater (source:/60/)

AGENCIJA RS ZA OKOLJE	SLOVENIAN ENVIRONMENT AGENCY
ATLAS OKOLJA	ENVIRONMENT ATLAS

2.10.3.1 Treatment of wastewater from the dry storage

Rainwater during the operating period

The drainage of rainwater from the roof of the dry storage facility is foreseen via the system of vacuum drainage from two heated metal gutters running lengthwise along the long sides of the building. The vertical drainage pipes are located in the corners on the western side of the facility and lead to PEHD pool. The drainage pipes will run from the northern pool to the southern pool, and from there on to the 100 m^3 capacity reinforced concrete water tank, which is foreseen on the southern side of the facility below the western side of the manipulation area; its capacity is adapted to the capacity of NEK's unified rainwater drainage system. From the tank, rainwater will go into the rainwater drainage system.

The NEK rainwater drainage system also collects water from road surfaces and buildings. Buildings are connected either directly or via confinement ponds to the rainwater drainage system, while the water collected on the manipulation areas flows into the closest oil separator. All the rainwater drainage pipes come together in the SE corner of the NEK site and the water is pumped via the pumping station and release point V8 into the Sava.

Wastewater from casting of the storage casks

On the southern side, in front of the facility, a manipulation area of ca. 13 m x 89 m, at altitude 155.75 m is foreseen. It will be made in the form of a reinforced concrete plate with an incline of at least 1% away from the facility.

The access platform is intended for transport and access to the DSB building and serves as a manipulation area. It will occasionally be used for casting of the storage casks. The concrete will be purchased from the nearby certified concrete mixing plant.

The concrete is poured between the inner and outer cylindrical steel walls of the cask from which no cement milk can escape. A small release of cement milk is possible only in the case of overflow at the top of the storage cask.

Drainage of the access platform is enabled with appropriate longitudinal and transverse slopes. All rainwater is channelled via a linear drain on the southern side and the grit chambers that capture the larger particles, into a settler with two compartments where it settles and the solid particles sink to the bottom. Prior to each casting of HI-STORM FW concrete outers, the settlers are emptied and cleaned. The settlers are emptied and cleaned also at the end of each day on which concrete was cast.

In one day, the concrete will be cast on three casks. The wastewater that accumulates from the process of concreting these casks collects in settlers (the volume of one settler being 3.8 m^3) and after the work is done and the platform is cleaned, samples are taken and analysed. It is estimated that as much as 0.25 m^3 of wastewater can accumulate during the concreting of one cask.

If the permitted values for the water to be discharged into public waters are surpassed, the wastewater is taken for treatment to an authorised collector or processor of such waste.

If the values are not surpassed, the water is pumped into the internal rainwater drainage system and the solid particles are removed from the settler.

The vehicles that will deliver the concrete for casting the storage casks will not be cleaned on the platform, which would cause additional wastewater, but will be cleaned in the cement factory.

2.10.4 Wastewater from extinguishing fires

In the event of a fire, the water that accumulates is collected in special tanks in each building. In the facility for dry storage of spent fuel it will be kept inside the building with the help of anti-flood barriers. These protect the interior of buildings from the flood waters. The barriers are watertight and will always be fixed in front of the roller doors. The doorway for staff use is fitted with an anti-flood door. Both the barriers and the gates prevent water from moving in either direction. After the fire is extinguished, samples of the water are taken, water is pumped out of the building and handed over for treatment to the authorised organisation for treating hazardous waste.
In facilities where the water could come into contact with radioactive material, all drained water is collected in a tank whose content is analysed and cleaned before being emptied. If the quantity of firewater were to surpass the tank's capacity, it would not flow out into the environment but would all remain in the sealed building.

All other facilities of the technological part of the power plant are equipped with collecting basins into which the drains, through which the firewater would flow, lead. If the amount of firewater were to surpass the capacity of these collecting basins, it would be pumped, or in some cases gravity would make it run, into a joint external rainwater drainage system.

The firewater would also flow into this system if an outdoor fire was being extinguished. The whole rainwater drainage system runs into external collecting basins from where it is pumped out into the surroundings.
After the fire all polluted surfaces will be cleaned and sanitised. The polluted floor will be dug up and given over to an authorised collector or processor of such waste. Wastewater from cleaning and the polluted absorption materials will be given over to authorised collectors or processors of such waste.

2.10.5 Electricity

To provide electricity for users at NEK, there are several transformer stations on the site of the activity, that are managed by the developer.

2.10.6 Roads and Transport

NEK is situated on the left bank of the Sava in Krško's industrial/energy zone. A local road leads up to the power plant and connects, via a bypass road, to the regional road R1 Krško – Spodnja Pohanca. The plant also has an industrial railway track, which connects it to Krško railway station.

From its junction with the future main road to the entrance to the NEK site, the access road is 320 m long, is flanked by a railway line, and has parking spaces along it. At the end of the access road there are two car-parks, one measuring ca. 9,000 m^2 and the other ca. 5,200 m^2.

These are the existing parking spaces:
- There are 37 parking spaces parallel with the access road.
- There are 58 parking spaces arranged at an angle of 45° to the access road.
- There are 368 parking spaces at the north-eastern side of the power plant.
- There are 153 parking spaces on the eastern side of the power plant.
- There are new parking spaces on the sandy surface along the access road, ca. 60 parking spaces.

2.10.7 HEATING

The facilities are heated by means of a heating plant which prepares hot water. The heating fluid is saturated steam from the auxiliary steam heating system. The heat exchanger heats the water to 110°C, which is the outlet temperature. The return heating water at the inlet to the heat exchanger has a temperature of 70°C.

2.10.8 Cooling

For cooling the buildings in the non-technological part of NEK there is no central system. Basically each building has its own cooling unit.

2.10.9 Types and quantities of energy required

While operating at full power, NEK requires approximately 35 MW of electricity for its own use. During poor hydrological conditions the production process uses around 40 MW of electricity.

2.10.10 Number of employees

At the end of 2020 NEK had 630 employees, 46.7% of them graduates of either a technical college or university or with an academic title. Amongst the employees 12 have PhDs and 16 have Masters degrees in science.

2.10.11 Operating time

The production of electricity depends on the fuel cycles – periods of uninterrupted operation at full power. These periods are followed by outages when the power plant is stopped so the nuclear fuel is changed (part of the spent fuel is replaced with fresh fuel), preventive equipment checks are carried out and parts replaced, the integrity of materials is verified, control tests are made and corrective measures to the existing state are taken. The outage to replace fuel usually lasts up to 30 days. The 31st fuel cycle which began when the power plant was connected to the grid on 28 October 2019, is an 18-month cycle.

2.11 SAFETY SYSTEMS

2.11.1 Legal and other bases

Ensuring safety stems from current Slovenian legislation, international standards and the guidelines of the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators' Association (WENRA) as well as US legislation in the field of nuclear safety (Nuclear Regulatory Commission - US NRC) and other foundations listed below.

- The Ionising Radiation Protection and Nuclear Safety Act, ZVISJV-1 (Official Gazette of RS, Nos. 76/17 and 26/19),
- Rules on radiation and nuclear safety factors (Official Gazette of RS, Nos. 74/16 and 76/17 – ZVISJV-1),
- Rules on the safety assurance of radiation and nuclear facilities (Official Gazette of RS, Nos. 81/16 and 76/17 – ZVISJV-1)
- Rules on the Mechanical Resistance and Stability of Construction Works (Official Gazette of RS, No. 101/05),
- Transport of Dangerous Goods Act (ZPNB), (Official Gazette of RS, Nos., UPB1 33/06, 41/09, 97/10, 56/15),
- WENRA Report Waste and Spent Fuel Storage Safety Reference Levels, Report of Working Group on Waste and Decommissioning (WGWD), Version 2.2, April 2014,
- WENRA Report - Guidance Document Issue T: Natural Hazards Head Document; 21 April 2015,
- IAEA Safety Standards, External Event Including Earthquake in the Design of Nuclear Power Plants, NS-G-1.5; 2003,
- IAEA Safety Standards, Safety of Nuclear Fuel Cycle Facilities, NS-R-5, Rev 1; 2014 (superseded by SSR-4; 2017),
- IAEA Safety Guide, External Human Induced Events in Site Evaluation for NP, NS-G-3.1; 2002,
- IAEA Specific Safety Guide Storage of Spent Nuclear Fuel, SSG-15; 2012,
- IAEA Specific Safety Standard - Safety Guide Format and Content of the Safety Analysis Report for Nuclear Power Plants, GS-G-4.1; 2004,
- IAEA Safety Standards - General Safety Guide the Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste, GSG-3; 2013,
- US NRC Regulation 10 CFR 71 Packaging and Transportation of radioactive material,
- US NRC NEI 06-12 Guidelines, Section B.5.b ICM,
- IAEA Regulations for the Safe Transport of Radioactive Material, Specific Safety Requirements, No. SSR-6 (Rev.1), 2018,
- European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) (Official Gazette of the SFRJ - MP, Nos. 59/72, 8/77, Act on Notification of Succession Official Gazette of RS - MP, No. 9/92, supplementary protocol Official Gazette of RS - MP, No. 7/97),
- The Convention concerning International Carriage by Rail (COTIF) and the Regulation concerning the International Carriage of Dangerous Goods by Rail (RID) (Official Gazette of the SFRJ - MP, No. 8/84, Act on Confirmation of Succession Official Gazette of RS - MP, No. 9/92),
- ASME Boiler & Pressure Vessel Code (B&PVC) Section XI, Article IWA-2200,
- US NRC RG 1.60 Design response spectra for seismic design of nuclear power plants, Revision 1, December 1973,
- US NRC RG 1.61 Damping values for seismic design of nuclear power plants, October 1973,
- US NRC RG 1.76: Design-basis tornado and tornado missiles for nuclear power plants, Revision 1, March 2007,
- US NRC RG 1.92 Combining modal response and spatial components in seismic response analysis, Revision 2, July 2006,
- US NRC RG 1.142: Safety-related concrete structures for nuclear power plants (other than reactor vessels and containment), Revision 1, October 1981,
- US NRC RG 1.142: Safety-related concrete structures for nuclear power plants (other than reactor vessels and containment), Revision 2, November 2001,
- US NRC NUREG-0800 Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition.

2.12 SYSTEMS AND COMPONENTS FOR PREVENTING AND MITIGATING THE CONSEQUENCES OF ACCIDENTS

To prevent nuclear accidents and mitigate their consequences the following systems have been installed in NEK (USAR /3/):

- safety systems,
- engineered safety features,
- confinement systems,
- emergency power supply.

The common task of all these safety systems is to prevent an uncontrolled release of radioactive substances into NEK's surroundings in all operating conditions and types of accident.

The task of safety systems is to detect deviations from the normal operating states of the power plant, to alert operators and activate all other safety systems if the power plant's safety parameters surpass the set limit values. The most important automatic measures in such cases are:

- emergency reactor shutdown,
- start of the emergency core cooling,
- isolation of the containment,
- start of the diesel generators.

The technical safety devices are intended above all to cool the fuel in all the power plant's emergency states. Nuclear fuel is a constant source of heat and radiation because of the buildup of fission products that arise from the burnup of uranium and which are all radioactive until they decay into stable atoms. That is why fuel must always be cooled so it does not overheat and become damaged because of the residual heat. Immediately after the reactor is shut down, its heat is still at some percentage of the power on which the reactor was operating before it was shut down because of the heat still present in the fuel. There are three systems for the safety injection of water into the reactor to ensure the fuel elements in the reactor are cooled even in the event of an accident which would cause a loss of primary coolant (pipe break, blocked open valve, etc):

- in the accumulators there are 70 m^3 of borated water,
- two high-pressure pumps can pump 0.088 m^3/s of borated water,
- two low-pressure pumps can pump 0.28 m^3/s of borated water into the reactor.

An additional pump was also installed as part of the PNV, which enables water to be injected from the supplementary tank containing borated water directly into the reactor. In order to ensure the integrity of the primary circuit, a special water tank and special pump, which can pump water into both steam generators and thereby ensure the long term cooling of the core and removal of residual heat, were also installed in the same building.

The diversity of systems for cooling the reactor in an emergency and their redundancy ensure the temperature of the fuel in the reactor is kept below the critical temperature at which excessive damage would start to occur on the cladding of the fuel rods due to oxidation or even melting of the ceramic fuel itself.

The confinement systems at NEK retain gaseous and liquid radioactive substances and prevent their uncontrolled release into the power plant's surroundings. The most important confinement systems are:

- the containment consisting of a steel and concrete shell which surrounds the whole primary system including the reactor and the steam generators. A constituent part of the containment are all the air-tight inlets and penetrations with isolation valves,
- air filters, which retain radioactive dust and radioactive iodine, in all the ventilation systems,
- decay tanks for radioactive gases,
- ion exchangers and steam generators for cleaning liquid radioactive substances from the power plant's wastewater,

- sprays, hydrogen recombiners, air filters and air coolers in the containment for spraying, cleaning and cooling the atmosphere in the containment in the event of the loss of primary coolant from the reactor.

The functioning of confinement systems is important both in normal and in emergency states of NEK. In this sense, the most important aspect is the functional and structural integrity of the containment so that in all events its leakage rate remains below its permitted design value of 0.1%, or 0.2% at increased pressure in the containment per 24 hours.

Emergency power supply systems must ensure availability of electricity to all safety systems in all emergencies encountered by the power plant. These are some of the most important emergency power supply systems: two 3.5 MW diesel generators, one 4 MW diesel generator and batteries.

In the event of the complete failure of the external power supply and the simultaneous failure of all forms of cooling the core, including the loss of the operating crew, core meltdown could occur and result in a rise in pressure in the containment. In order to ensure the integrity of this pressure barrier, the Safety Upgrade Programme (PNV) included the installation of a passive depressurisation filter system, which enables containment depressurisation. The system is designed in such a way that it retains more than 99.99% of fission products in particle form (e.g. Cs-137, Sr-90 etc.) and more than 90% of all isotopes of radioactive iodine (e.g. I-131).

Additional equipment and systems for controlling beyond design conditions ensure that even unlikely emergencies are managed with strategies that were not considered in the power plant's initial design. This includes a passive autocatalytic system for eliminating flammable gases (hydrogen and carbon monoxide) from the containment, a passive filter system for ventilating the containment, mobile equipment (pumps, generators, compressors, transformers, transport vehicles, fire-fighting equipment) and equipment for setting up flood barriers.

The power plant possesses the instrumentation and systems necessary to evaluate the operating state and the nuclear safety and for managing emergencies. This includes process instrumentation, systems for radiological control, sampling systems, meteorological instrumentation, seismic instrumentation, fire-detection systems, information and communication systems, protective and other equipment and an emergency control room and centres for managing emergencies, which are located in the technological area, both on and off the power plant site. The power plant possesses operative procedures for normal operation, for controlling abnormal states (AOP), emergencies (EOP) and severe accident states (SAMG) of the power plant.

2.13 CLASSIFICATION OF POWER PLANT STATES

Quoted directly from the document: Threat assessment – revision 6, DCM-RP-051, NEK, September 2021 /17/.

The states of the power plant are, considering the probability of their occurrence per year of the reactor's operation, the scale of the radiological consequences for the environment and the reliability of the operation of safety systems, divided into three groups:

- Operating states which can be divided into the following two categories:
  - (1) normal operation
  - (2) operation with transients

- Nuclear incident states which can also be divided into two categories:
  - (3) expected operating events
  - (4) less probable operating events

- Nuclear accident states which can be divided into three categories:
  - (5) design basis accidents
  - (6) design extension conditions nuclear accidents

- (7) severe nuclear accidents

For the needs of planning protection and rescue measures, both from the point of view of emergency classification as well as the probability of the onset of individual emergencies or nuclear accidents, past experience and the theoretical calculations of probability show that the threat level increases from category to category by a factor of 10, while the probability of an event occurring falls by a factor of 10 with each category. These factors are a little smaller only between the first and second categories and perhaps between categories 6 and 7.

In the operation category with **transients**, which also includes annual outages and the replacement of fuel in the reactor, releases from the power plant are a little larger because it is necessary to clean the considerably greater quantities of wastewater, air from the containment, filters and other systems which must be prepared for the outage. However, in most cases these releases remain at the level of 1% the annual dose received by people living close to NEK from natural radiation. In this category, the power plant's employees receive considerably larger doses, which in the case of some special outage tasks reach over half the legally defined limit annual dose for professional workers, which is 20 mSv.

An incident is any undesired situation the consequences of which are not negligible from the point of view of radiation or nuclear protection. An incident may be caused by an inappropriate human action or inadequate functioning of the system or a component. An incident requires that the defect be identified, eliminated or subjected to a corrective action /Rules on Radiation and Nuclear Safety Factors (Official Gazette of RS, Nos. 74/16 and 76/17–ZVISJV-1)/. The **expected operating event** category includes all states of NEK which we must expect with near certainty in the power plant's lifetime, regardless of whether their origin is in the power plant (equipment failure, power cuts, small fires that can be extinguished rapidly, accidents and errors by operators or maintenance staff) or outside the power plant (external power cut, collapse of the electricity transmission system, flood, minor earthquake).

This category also allows for minor single faults in the safety systems, however, no such fault may cause the failure of the affected safety system or the loss of its function. The most common faults in this category, which cause the release of radioactive substances into the environment, occur in the auxiliary reactor building where all the auxiliary reactor systems, the systems for cleaning primary cooling water, the waste gas tanks and systems for treatment of radioactive waste are located. Minor pipe leakages in the steam generators are also possible, resulting in the active primary cooling water coming over onto the secondary side where it is mixed with the feedwater and then goes with the steam into the turbine and condenser, from where it can also escape into the environment. However, all these releases do not cause doses in the environment that are greater than 1/10 of the dose due to natural radiation and they are mostly several times smaller.

Rare operating events include primarily major equipment failure, large-scale fires in the power plant, ruptures of small diameter pipes in the primary cooling system, complete loss of electrical power, major failure of safety system components, but still without loss of their safety function. This category can also include ruptures of pipes in the steam generator resulting in a major release of radioactively contaminated steam into the environment through discharge and safety valves on the main steam pipe. For this category of emergencies we must expect doses in the vicinity of the NEK site that reach the annual dose due to natural radiation.

A **nuclear accident** is by definition only an event that can cause releases of radioactive substances into the power plant's surroundings that are so great that they demand urgent measures to protect the lives and health of local inhabitants. Releases of such magnitude are possible only in cases where one or more causes bring about the failure of several consecutive barriers which confine the radioactive material to the nuclear fuel, combined with the failure of at least some of the essential safety systems. The nuclear accident category determines how many safety systems fail. The manner and scale of the failure are also important as they affect the scale and period during which radioactive substances are released into the environment. The category of nuclear accidents includes design basis accidents and also beyond-design-basis accidents and severe-design-basis accidents.
A design extension condition is an accident caused by design extension event. A beyond-design-basis event is an event or combination of events that has an extremely small likelihood of occurrence, has

more severe consequences than design-basis events or involves more failures than are postulated in the nuclear installation's design bases. There are two categories of design extension event:

- Category A design extension event in which damage to fuel in the reactor or the spent fuel storage facility can be prevented, and they do not lead to a severe nuclear accident;
- Category B design extension events in which severe design extension damage to the fuel is anticipated.

In terms of consequences, a severe nuclear accident exceeds a Category A design extension condition and results in damage/meltdown of the core or spent fuel and a threat to the environment, or that could irradiate or contaminate human beings or the environment. A severe accident may arise as a result of recurring failures, such as the loss of all branches of the safety systems, or as a result of an extremely unlikely event for which the power plant was not designed. Core damage is the uncovering and heating of the reactor core to the point where increased oxidisation and severe damage to the fuel elements across a large section of the core can be expected.

Sufficient quantities of radioactive substances to cause a **nuclear accident** are located only in the nuclear fuel in a reactor which has been operating for at least a few months and in the spent fuel in the spent fuel pool. For sufficient quantities of these substances to escape from the ceramic tablets, the fuel must overheat, thereby causing most of the gaseous and evaporative radioactive substances to escape. The cladding of the fuel rods must also suffer damage, which is possible only if the regular cooling of the fuel elements fails, as well as if the emergency cooling of the reactor fails for a limited length of time, either due to the failure of safety systems or operator error. The failure of all fuel cooling for an extended period of time causes gradual melting of the ceramic tablets due to the residual heat in the fuel. This results not only in the complete release of all gaseous and evaporative substances, but also in the evaporation of less volatile substances and the fuel itself in a melt with the construction materials. The probability of the core melting is extremely small.

2.13.1 Probabilistic Safety Assessment - level 1

The probabilistic safety assessment - level 1 assesses the probability of core damage and meltdown due to initiating events. An initiating event is an event that can trigger a sequence of events (scenario), which can lead to core damage.

Initiating events are divided into:

- internal initiating events – failures in the technological process (e.g. primary coolant system piping break, break on the secondary side, transients, failure of support systems, loss of all AC power, transients without automatic reactor scram);
- external initiating events in the power plant and/or internal hazards (e.g. internal floods, internal fires and high energy releases).
- external initiating events coming from the surroundings, or external hazards (e.g. earthquakes, strong winds, aeroplane crashes, floods).

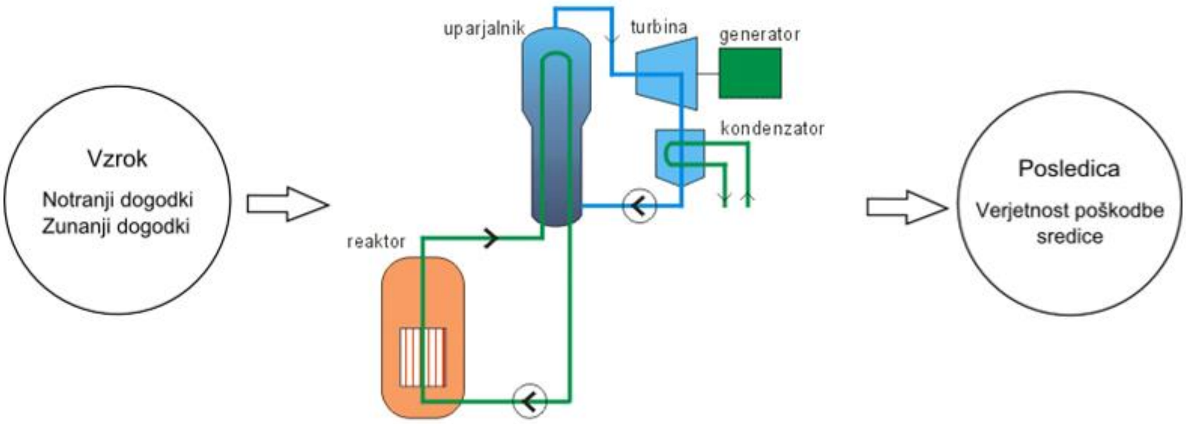


Figure 12: Diagram of PSA level 1

Vzrok	Cause
Notranji dogodki	Internal events
Zunanji dogodki	External events
uparjalnik	steam generator
turbina	turbine
generator	generator
kondenzator	condenser
reaktor	reactor
Posledica	Consequence
Verjetnost poškodbe sredice	Core damage probability

There are no production facilities or warehouses within a 1.5 km radius from NEK whose activity could threaten the environment or where the consequences of events (accidents, fires, explosions), whose probability should reasonably be considered, could have an effect on NEK's safe operation. A plant belonging to Krka d.d. is located 2 km from NEK and it stores large quantities of hazardous chemicals. Analyses show that in the event of an emergency – the release of hazardous substances from the Krka plant, technical solutions would prevent any impact on NEK's safety and operation. In Brestanica, at a distance of ca. 7 km from NEK, the Brestanica thermal power plant has 3 D2 reservoirs, which can store 19,500 m^3 of fuel oil. The railway line Ljubljana - Zagreb runs 1.08 km from NEK, and the motorway Ljubljana—Novo mesto—Zagreb runs approximately 3 km south of the site. Trucks carrying up to 30,000 litres of gas or petroleum use the Ljubljana—Zagreb motorway. Hazardous chemicals and explosives are often transported on the Ljubljana—Zidani most—Zagreb railway line; it should, however, be mentioned that the maximum quantities of these substances which can be transported at one time are limited by regulations. Road or railway accidents resulting in spills or explosions of the substances being transported are estimated to have a negligible effect on NEK.

In Cerklje ob Krki, ca. 6 km from NEK, there are military barracks and an airport. NEK's safety evaluations include the risk due to the crash of a military or commercial flight near NEK, taking into consideration all flights over the NEK site and not just those connected with the airport in Cerklje. The total evaluated core damage frequency due to a plane crashing into NEK is less than 2 E-7/year and the early release frequency due to the same cause is 1 E-8/year /254/.

The Sava is not navigable in the vicinity of NEK. Upstream of NEK on the Sava there are 7 hydroelectric power plants and one downstream. The probability of an effect on the safe operation of NEK due to dam failure at the hydroelectric power plants is evaluated in Section 2.4.4 of the USAR NEK. The consequences of the simultaneous (or serial) failure of several dams are taken into consideration, assuming that a 25-year flood occurs at the same time. The circumstances on the NEK site are analysed on the basis of 2D modelling. In the event of the simultaneous failure of all dams, the flood level for the NEK is not reached, so the safety of the power plant is assured. In the event of a downstream dam failing, an adequate heat sink is assured allowing for a safe shutdown of the power plant.

2.13.2 Probabilistic Safety Assessment - level 2

The Probabilistic Safety Assessment - level 2 (PSA - level 2) also took into account the response of the containment and the accompanying safety systems (sprays, containment isolation system, passive filter system, passive autocatalytic elements for the combustion of hydrogen, flooding of the chambers under the reactor pressure vessel, etc.).

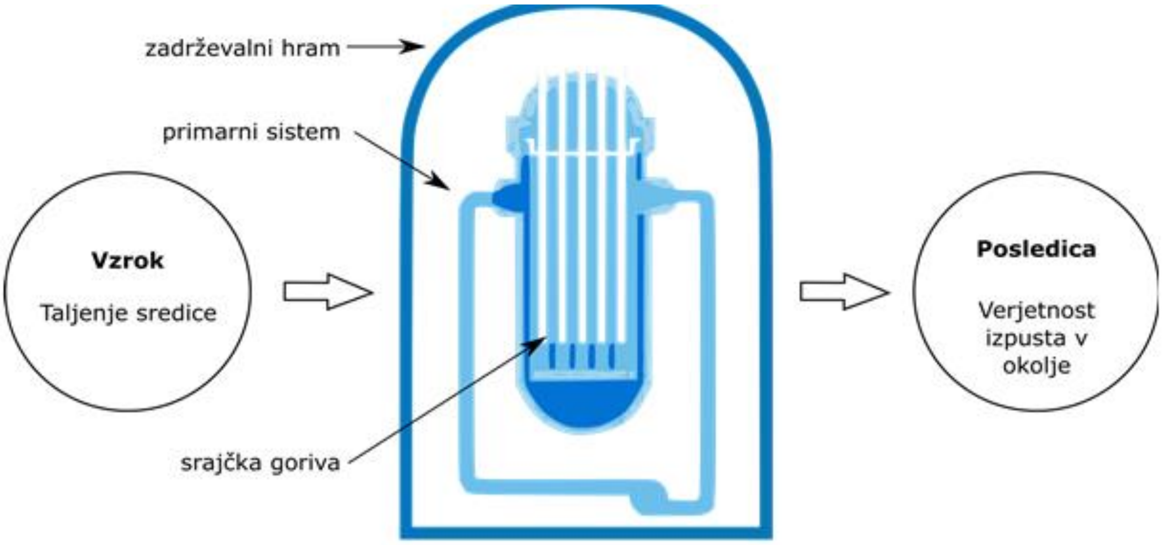


Figure 13: Diagram of PSA level 2

Vzrok	Cause
Taljenje sredice	Core meltdown
zadrževalni hram	containment
primarni sistem	primary system
srajčka goriva	fuel cladding
Posledica	Consequence
Verjetnost izpusta v okolje	Probability of release into the environment

PSA - level 2 estimates the probability of releases from the containment and the timeline and quantity of radioactive substances released. For this purpose, all possible states which already take into account the response of the containment and its safety systems, are grouped together into a manageable number of so-called accident states and a reference accident is determined for each of them.

In the PSA - level 2 analysis, the event tree is divided into four time windows, primarily with the aim of describing the time dependence of events. Events are deterministic by nature (e.g. a hydrogen explosion in the containment). For a deterministic event to be placed on the accident tree, it must occur in the time frame described by the event tree and it must fulfil at least one of the criteria listed below:

- it can have a direct effect on the integrity of the containment or affect the form and size of the release;
- it can affect events listed further down (after the present event) on the accident tree;
- it represents the function of a system, which is not explicitly defined by the state of failure of the power plant and can seriously affect events (this allows us to carry out a sensitivity analysis and evaluate the influence of individual systems which are not part of the existing project)

In PSA - level 2 NEK the time windows (periods) of the containment's failure are defined as follows:

a) the first time period (containment failure prior to reactor pressure vessel failure) - is the time between the beginning of an intense reaction between water and zirconium, and the moment just before the reactor pressure vessel fails;
b) the second time period (failure of the containment when the reactor pressure vessel fails) - runs from the moment just before the reactor pressure vessel fails to the end of the dynamic response of the containment to the reactor pressure vessel failure;
c) the third time period (the containment does not fail – medium-term release through the PFCV in less than 24 h) – is defined from the end of the containment's dynamic response (reaction between the melt and the coolant outside reactor pressure vessel) to 24 hours after the beginning of the incident;
d) the fourth time period (the containment does not fail, late release through the PFCV after 24 h) - is defined from 24 hours onwards.

The main deterministic phenomena or events that are dealt with in the event tree are the following:

a) Release with "bypass" of the containment;
b) failure of the primary circuit due to high temperature;
c) manner of release from the containment (release via layers of water, direct release, penetration through the containment foundations);
d) manner in which the reactor pressure vessel fails;
e) solidification of the melt following reactor pressure vessel failure;
f) interaction of the melt and the concrete;
g) hydrogen burning or exploding;
h) integrity of the containment in an individual time period.

Release categories
The definition of release categories must include key elements of incident progression, which affect the composition and size of the release. This means the following elements must be taken into account: containment status (integrity ensured, containment isolation fault, containment function bypassed, containment integrity upset in one of the time slots);

- either the melted core and concrete interact;
- or the release is reduced due to layers of water through which the radioactive substance must pass;
- or a stable state has been established - cooling, solidification of the core in the reactor pressure vessel and the reactor pressure vessel did not fail.

This is how we can define the release categories (RC), which appear in the table below (Table 13):

Table 13: Release categories (source: /17/)

	Category of release	Description
1	**RC1**	The melt remains in the reactor pressure vessel and the reactor pressure vessel and containment do not fail.
2	**RC2**	Containment does not fail.
3	**RC4**	Penetration of containment foundations.
4	**RC6**	Early failure of the containment (in the first and second time period).
5	**RC7A**	Loss of containment integrity, no interaction between melt and concrete.
6	**RC7B**	Loss of containment integrity, interaction between melt and concrete.
7	**RC8A**	Release past the containment - release reduced due to layers of water through which radioactive material must pass; ("scrubbed release").
8	**RC8B**	Release past containment - direct release; ("unscrubbed release").
9	**RCV3**	Passive filtered relieving of the containment in the fourth time period
10	**RCV5**	Passive filtered relieving of the containment in the third time period, no interaction between melt and concrete.

For each group of initiators the large early release frequency (LERF) following core damage is calculated by adding together all the categories of large releases (RC6, RC7A, RC7B, RC8A and RC8B).

2.13.3 Emergency classification

The emergency classification is based on predetermined emergency levels and a methodology and instructions on how to classify an incident according to its actual or foreseen consequences in the power plant and its environment.

There are four emergency levels:

- a) emergency level 0 or unusual event;
- b) emergency level I or alert;
- c) emergency level II or site area emergency;
- d) emergency level III or general emergency.

In the table on the next page (Table 14) the different emergency levels are defined, what it means if they are declared and the main measures to be taken by the power plant and its surroundings after each emergency level is declared.

Table 14: Definitions of emergency levels (source: /17/)

Purpose of declaration	Measures in the power plant	Measures in the surroundings
Unusual events This is an emergency level in which the origin or development of events causes a state, which in the event of incorrect implementation of operative measures or the continued uncontrolled development of events could lead to a reduction in the nuclear safety of the power plant or in which events show a possible threat to the physical safety of the power plant. There is no release of radioactive substances at a scale which would demand the implementation of radiological monitoring and protective measures in the surroundings.		
1. Ensure the organised control of the emergency and appropriate first response in the event of circumstances deteriorating; 2. Ensure appropriate readiness of the power plant's operational personnel in the event of the circumstances deteriorating; 3. Ensure systematic identification, recording and analysis of this emergency level.	1. Inform of the onset and then continuously inform competent authorities in the surroundings on the state of the emergency, until the end of emergency is declared; 2. If necessary provide additional support to staff in the shift; 3. Evaluate the situation and act correctively; 4. Declare a higher emergency level if the situation deteriorates or declare the end of the emergency when the conditions to declare the end of the emergency are fulfilled.	1. If necessary, ensure additional support to the power plant (e.g. fire-fighters, medical help, police); 2. In the event of the situation deteriorating, transition to a higher level of readiness; 3. State of readiness until the end of the emergency is declared.
Alert This is an emergency level in which the origin or development of events leads to or causes a considerable reduction in the power plant's nuclear safety or in which hostile activity increases the level of danger for personnel or equipment in the power plant. There is the possibility of a limited release of radioactive substances which can surpass the limitations of radiological technical specifications, but not to an extent that would necessitate protective measures in the power plant's surroundings. To remedy the situation in the power plant requires automatic or somewhat more demanding manual action.		
1. Ensure full availability of forces to manage the emergency if the situation deteriorates or if the need for implementing radiological monitoring emerges; 2. Provide appropriate organs and institutions in the surroundings with constant information about the state and course of the emergency.	1. Immediately inform the competent authorities in the surroundings about the onset and cause of onset of the level of emergency; 2. Activate all the power plant's technical support and operational support centres, and ensure an appropriate state of readiness of the power plant's external support centre and other key personnel in the power plant; 3. Analyse the situation in the power plant and act correctively; 4. Provide protective measures for the personnel in the power plant; 5. Allocate teams for radiological monitoring around the power	1. If necessary, ensure additional support to the power plant (e.g. fire-fighters, medical help, police); 2. Be in a state of readiness, in keeping with the plans for protection and rescue; 3. Ensure the readiness of key personnel to organise protection, rescue and help in the vicinity, including teams for radiation monitoring, and establish appropriate communication; 4. Ensure radiation monitoring in the surroundings and evaluate doses due to radiation exposure along the food chain if radioactivity is released into the environment to an extent that considerably surpasses the power plant's limitations in operating conditions and limits;

Purpose of declaration	Measures in the power plant	Measures in the surroundings
	plant and set up a suitable communications system; 6. Provide appropriate organs in the vicinity with constant information about the state and course of the emergency in the power plant; 7. Constantly monitor the meteorological conditions and if radiation is released into the environment, evaluate the dose in the environment and inform the appropriate organs in the vicinity; 8. Declare a higher emergency level if the situation deteriorates or declare the end of the emergency when the conditions to declare the end of the emergency are fulfilled.	5. Transition to a higher emergency level if necessary; 6. Maintain readiness at this emergency level until such time as the emergency passes or a lower level is declared.
Site area emergency This is an emergency level at which the origin or development of events causes failure of the power plant's safety function or there is a high probability that such a failure could occur, or where hostile activity could endanger personnel or equipment in the power plant or access to equipment and systems important for the plant's safety is prevented. There is the possibility that radioactive substances are released to such an extent that protective measures must be introduced on the power plant site and in exceptional cases also in the direct vicinity of the power plant.		
1. Ensure that all centres, forces and means of protection, rescue and help are activated in accordance with plans for protection and rescue; 2. Ensure radiation monitoring teams are deployed; 3. Ensure full state of readiness of protection, rescue and help forces responsible for carrying out evacuations in the direct vicinity of the power plant if necessary in the event of the situation deteriorating; 4. Establish communication between the power plant and relevant external bodies and institutions; 5. Continuously inform local and state centres and the public about the onset and state of the emergency.	1. Immediately inform the competent local and state authorities about the onset and cause of the site area emergency; 2. Activate all forces and centres for controlling and monitoring emergencies (technical support centre, operational support centre and the power plant's external support centre); 3. Analyse the situation in the power plant and act correctively; 4. Ensure protective measures are carried out for the personnel in the power plant including evacuation; 5. Deploy teams and carry out radiation monitoring on the power plant site and its surroundings, and set up suitable communications; 6. Provide appropriate organs and institutions in the vicinity	1. Provide additional support to the power plant; 2. If taking refuge in a fallout shelter is recommended as a protective measure in the direct vicinity of the power plant, ensure the population living in a radius of 3 km from the plant is suitably informed; 3. Provide instructions and information to the population living around the power plant concerning the level of threat; 4. Activate all protection and rescue services on a local and state level; 5. Act in compliance with protection, rescue and help plans, including the deployment of teams for monitoring radiation in the environment and establishing suitable communications; 6. Ensure appropriate readiness of forces to carry out evacuations in the vicinity of the power plant if necessary;

Purpose of declaration	Measures in the power plant	Measures in the surroundings
	with constant information about the state and course of the emergency in the power plant; 7. Establish communication between the power plant and relevant bodies and institutions in the vicinity; 8. Constantly monitor the meteorological conditions, evaluate doses in the environment and suggest to the Civil Protection Units (ŠCZ) in the surroundings to prepare protective measures for the population in the area under threat; 9. On the basis of the situation in the power plant and the expected developments provide information to nearby ŠCZ regarding the current and predicted scale and type of release of radioactive substances into the environment; 10. Declare a higher emergency level if the situation deteriorates or declare the end of the emergency when the conditions to restore the normal situation are fulfilled.	7. Exchange and evaluate different results of radiation monitoring in the environment; 8. Constantly evaluate information about the state of the power plant and the results of radiation monitoring in the environment and on this basis decide on the suitability of protective measures being implemented and whether they should be changed, and on the deployment of forces to carry out evacuation if necessary; 9. Inform the population in areas where a state of readiness is being planned and carry out the necessary protective measures; 10. Inform the public and prepare press conferences together with the power plant; 11. In the event of the situation deteriorating, declare the level of general emergency; 12. Maintain readiness at this emergency level until such time as the normal situation is restored or a lower level is declared.
General emergency This is the emergency level in which the origin or development of events have brought about core damage or meltdown and the loss of the containment's integrity, or there is a great danger of this occurring, or where the development of events due to hostile activity could lead to the loss of physical control of the power plant. There is the possibility of large-scale radioactive releases surpassing the intervention levels for the introduction of protective measures in the surroundings.		
1. Provide population with preventive protection; 2. Ensure constant evaluation of the situation on the basis of information from the power plant and measurements in the surroundings; 3. Considering the level of actual or foreseen releases of radioactive material, carry out additional protective measures for the population; 4. Establish communication between the power plant and relevant bodies, institutions	1. Immediately inform the relevant local and state authorities about the onset and cause of the general emergency; 2. Activate all forces and centres for controlling and monitoring emergencies (technical support centre, operationalve support centre and the power plant's external support centre) if they have not already been activated; 3. Analyse the situation in the power plant and act correctively;	1. Provide additional support to the power plant; 2. Activate the system which immediately informs the population about the threat in the areas where protective measures are planned and constantly inform the population about the threat level; 3. As a basic protective measure recommend the immediate evacuation of the population within a 3 km radius and determine whether this protective measure should be implemented in a larger area. Make a decision concerning the use of KI pills (in a 10 km radius or more);

Purpose of declaration	Measures in the power plant	Measures in the surroundings
and protection, rescue and help forces in the vicinity; 5. Constantly inform the public about the state of the emergency.	4. Ensure protective measures are carried out for the personnel in the power plant including evacuation, if this has not already been done; 5. Deploy teams and carry out radiation monitoring on the power plant site and its surroundings, and set up suitable communications; 6. Provide appropriate organs and institutions in the vicinity with constant information about the state and course of the emergency in the power plant; 7. Establish communication between the power plant and relevant bodies and institutions in the vicinity; 8. Constantly monitor the meteorological conditions, evaluate doses in the environment and suggest to the Civil Protection Units (ŠCZ) in the surroundings to prepare protective measures for the population in the area under threat; 9. On the basis of the situation in the power plant and the expected developments provide information to nearby ŠCZ regarding the current and predicted scale and type of release of radioactive substances into the environment; 10. Declare the end of the emergency when the conditions to restore the normal situation are fulfilled.	4. Activate all protection, rescue and help forces on a local and state level; 5. Act in compliance with protection, rescue and help plans, including the deployment of teams for monitoring radiation in the environment and establishing suitable communications; 6. Ensure full state of readiness of all protection and rescue forces within a 10 km radius around the power plant and the readiness of all other forces outside this area if needs arise; 7. Exchange and evaluate different results of radiation monitoring in the environment; 8. Constantly evaluate information about the state of the power plant and the results of radiation monitoring in the environment and on this basis decide on the suitability of protective measures being implemented and whether they should be changed, and on the deployment of forces to carry out evacuation if necessary; 9. Inform the population in areas where protective measures are being planned and carry out the necessary protective measures; 10. Recommend the use of dry fodder for dairy cattle in a radius of 25 km around the power plant and decide about the enlargement of this area; 11. Inform the public and prepare press conferences together with the power plant; 12. Maintain readiness at this emergency level until such time as the normal situation is restored.

2.13.4 Emergency planning zones

Four areas for planning protective measures (Emergency Planning Zones - EPZ) are defined around NEK:

1. The Preventive measures zone (PMZ) - an area encompassing a 3 km radius from NEK, where protective measures are carried out immediately due to the direct vicinity. The PMZ includes entire housing estates even if they extend outside the 3 km radius. Protective measures in the

PMZ are immediate and alimentary in nature, with an emphasis on taking refuge in fallout shelters, evacuation and reception and care for the evacuated population from the PMZ. The implementation of protective measures must begin immediately after the general emergency is declared.

2. The immediate preventive measures zone (IPMZ) - an area encompassing a 10 km radius from NEK. For easier planning and implementation of protective measures the whole IPMZ is divided up into residential areas covered by a network of 16 sectors (circular segments), the axis of the first one going towards the north. Protective measures in the IPMZ are immediate and alimentary in nature, with an emphasis on evacuation and reception and care for the population evacuated from the IPMZ.
3. The long-term preventive measures zone (LPMZ) is an area encompassing a 25 km radius from NEK. Protective measures in the LPMZ are implemented on the basis of the results of models and radiation measurements. For easier planning and implementation of protective measures the whole LPMZ is divided up into residential areas covered by a network of 16 sectors, each measuring 22.5x°. Protective measures are long-term, alimentary and also immediate.
4. The general readiness zone covers the whole of Slovenia – protective measures in the whole country are implemented on the basis of the results of models and radiation measurements. Protective measures in the whole of Slovenia are long-term, alimentary and also immediate.

The table below (Table 15) shows information about the number of people living in the EPZ around NEK. Distribution of the population by sector and distance from NEK in the area of planned immediate protective measures and in the area of planned long-term protective measures is shown in the figures below (Figure 14, Figure 15). Meteorological and other data important for planning protective measures in the surroundings are monitored and are published in the USAR NEK.

Table 15: Population numbers for the area surrounding NEK (source: /37/, /17/)

Radius	Population	Average density (no. inhabitants. / km^2)
0-3 km	9,087	321
3-10 km	29,303	103
10-25 km	136,191	84
Total 0-10 km	38,390	122
Total 0-25 km	174,581	89
References: Statistical Office of the Republic of Slovenia as at 1 January 2020 Croatian Bureau of Statistics, Population census 2011		

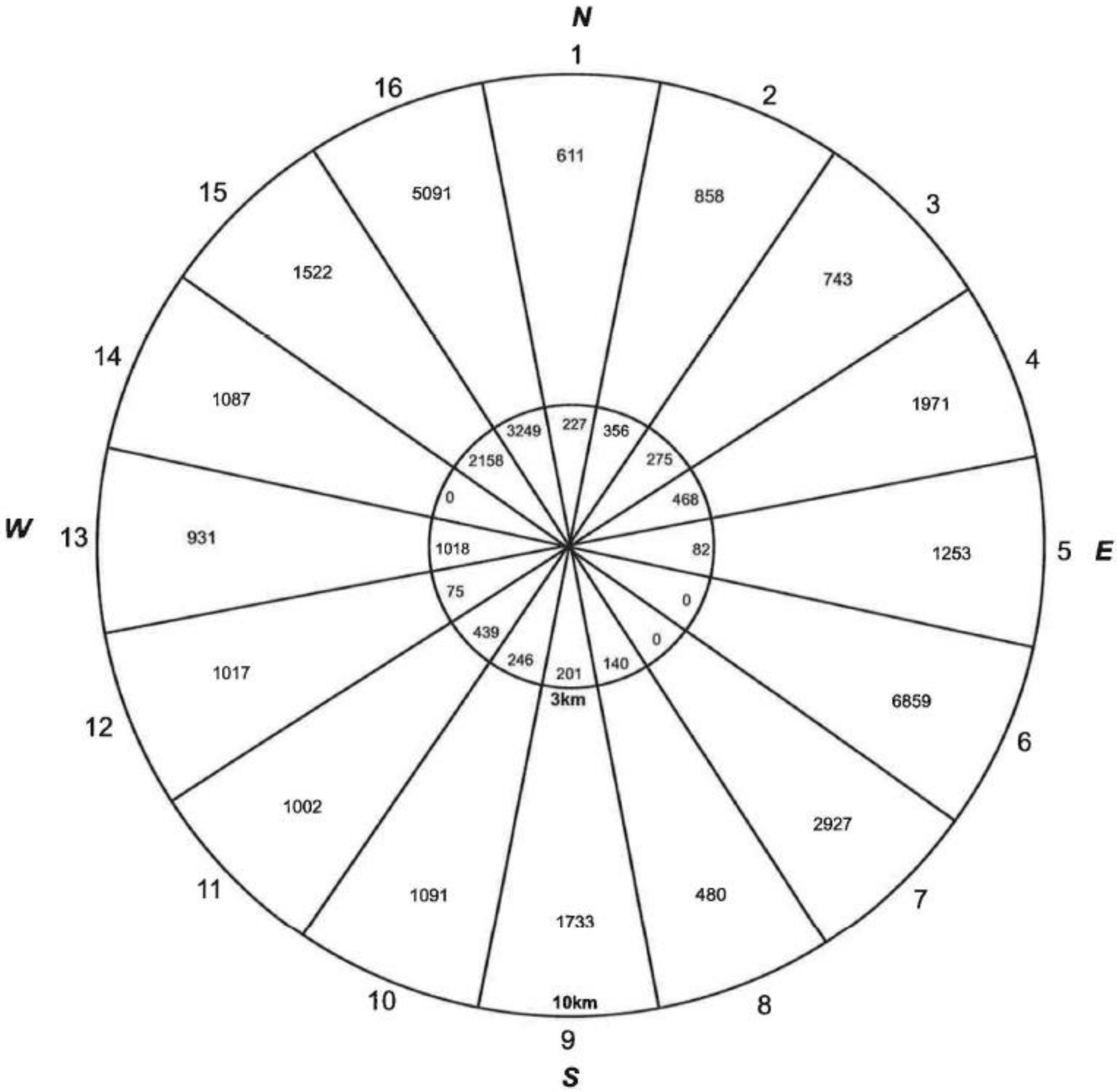


Figure 14: Population distribution – 10 km radius around NEK (source:/17/)

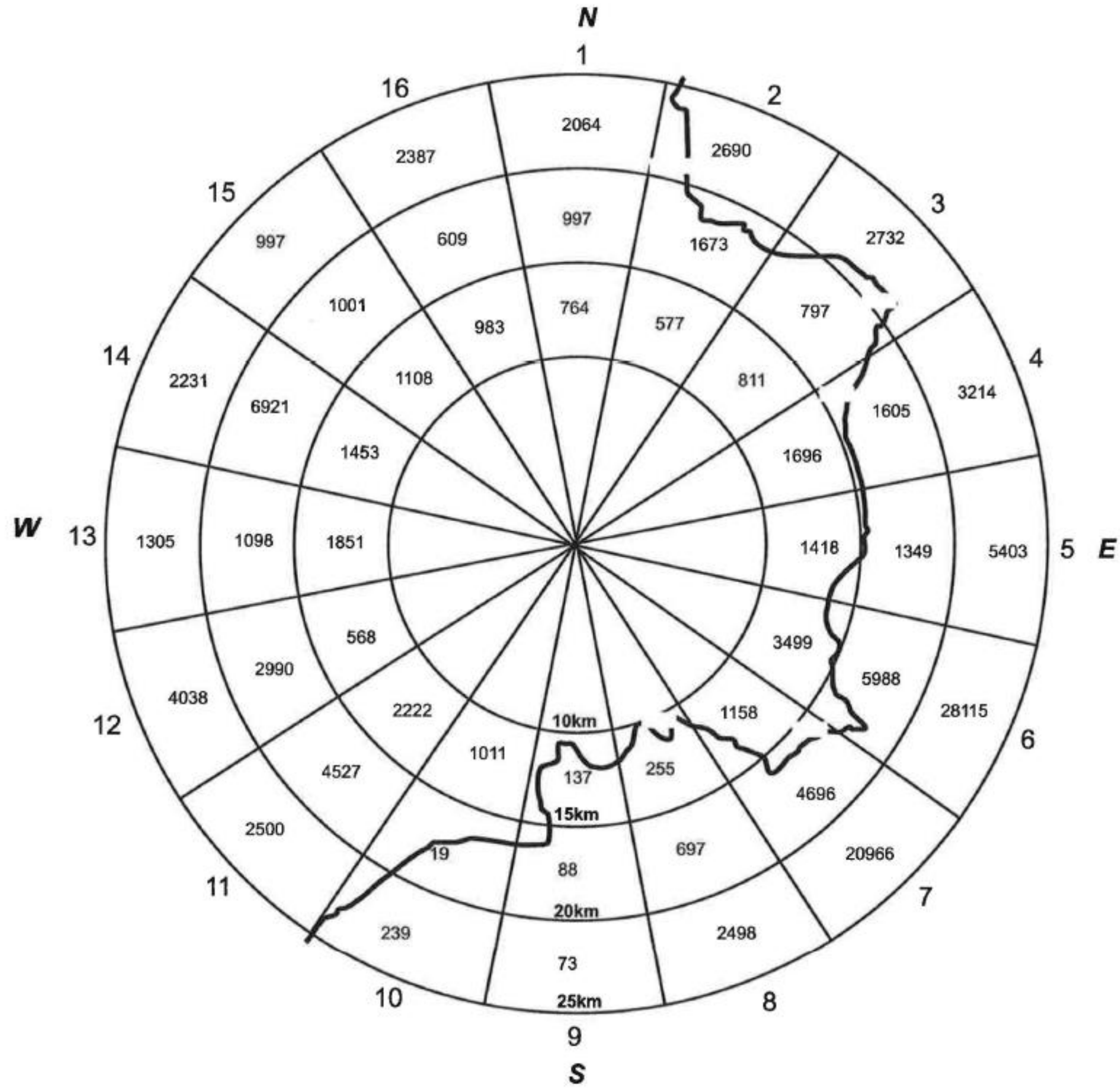


Figure 15: Population distribution – area between 10 km and 25 km around NEK (source:/17/)

2.13.5 Help to be provided to the power plant in case of emergency

In the case of the worst possible accidents it is possible that the power plant is left without a power supply and without sources of cooling water to cool the reactor and spent fuel. For such cases NEK possesses mobile equipment to provide power, cooling and technological air for longer periods. NEK is capable of handling the most serious emergencies with the equipment on the plant site and its shift staff without any external support in means or personnel for the first 24 hours after the onset of such an event, and 7 days without any large-scale equipment.

Support for the power plant in handling the emergency is provided by contractual support organisations, equipment suppliers and engineering companies, and international expert organisations and associations. Support for the power plant from supporting institutions is ensured with contracts concluded in advance which are regularly renewed. The help of international expert organisations and associations is ensured through NEK's membership of these institutions. Additional support for the power plant is ensured by the state through its national Plan for protection and rescue in the event of a nuclear or radiation accident, from the national reserves in the event of natural and other accidents or from the national commodity reserves and through international help based on international agreements.
Support to be provided to the power plant in case of emergency includes primarily:

- expert technical, design and engineering support;
- fire extinguishing and the provision of fire protection;
- interventions for handling hazardous substances, pumping, setting up flood barriers;
- help in implementing mobile strategies for handling beyond design basis accidents;
- rescue, help and medical care for casualties in the power plant;
- radiological monitoring and measurements in the vicinity of the power plant;
- informing the power plant about events and conditions in the surroundings which could affect its safety;
- the provision of premises for the operation of an external support centre and other off-site locations of the power plant important for handling the emergency;
- logistical support (food, transport).

2.14 EXISTING LICENCES

NEK operates in accordance with the open-ended operating licence (Slovenian Energy Inspectorate Decision No. 31-04/83-5, URSJV Decision No. 3570-8/ 2012/5, amendment of NEK's operating licence of 22 March 2013) /4/, which is directly related to the NEK Updated Safety Analysis Report (USAR) - rev. 26 /3/ 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. NEK, constructed with building permits issued by the Republic's Secretariat for Industry SRS Ljubljana, obtained operating permit No. 351-02/89-15 from the Republic's Committee for Industry and Civil Engineering dated 17 July 1989. The supplier of the nuclear power plant is Westinghouse from the United States. NEK was spatially located in accordance with the location permit and the legislation in force at the time.

2.14.1 Operating licence

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, 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.

2.14.2 Environmental permit for the emission of substances into water

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 /49/, which defined special conditions for the operation of the facility. On 4 June 2012 and 10 October 2013, Decisions Nos. 35441-103/2006-33 and 35444-11/2013-3, which introduced modifications in paragraphs determining the operating conditions of the facility, were issued. NEK operates in compliance with the valid environmental permit.

2.14.3 Water permits

NEK also operates in compliance with the water permits for water use for technological purposes. The initial partial water permit was issued on 15 October 2009, No. 35536-31/2006-16 /50/, which 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. 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 and water permit no. 35530-48/2020-3 of 9 September 2021 /276/.

2.14.4 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) /3/ 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.

The operation of NEK was thus extended from the projected year 2023 to 2043, provided that it successfully passes the periodic safety reviews in 2023 and 2033. Based on the URSJV decisions, the Republic of Slovenia and the Republic of Croatia as the owners of NEK on the basis of the Intergovernmental Treaty /11/ gave their support to the decision to extend NEK's operational lifetime until 2043 /33/.

2.15 INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN OF THE REPUBLIC OF SLOVENIA – NECP

The NECP /20/ is a strategic document which defines 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 are, in terms of energy and climate policy, in accordance with the Energy Act 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 environmental consent.

A strategic environmental impact assessment of the NECP implementation was carried out in parallel with the preparation of the NECP. 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 take into account important national circumstances and are 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 below (Figure 16) shows the increase in electricity production from the beginning of NEK's operation.

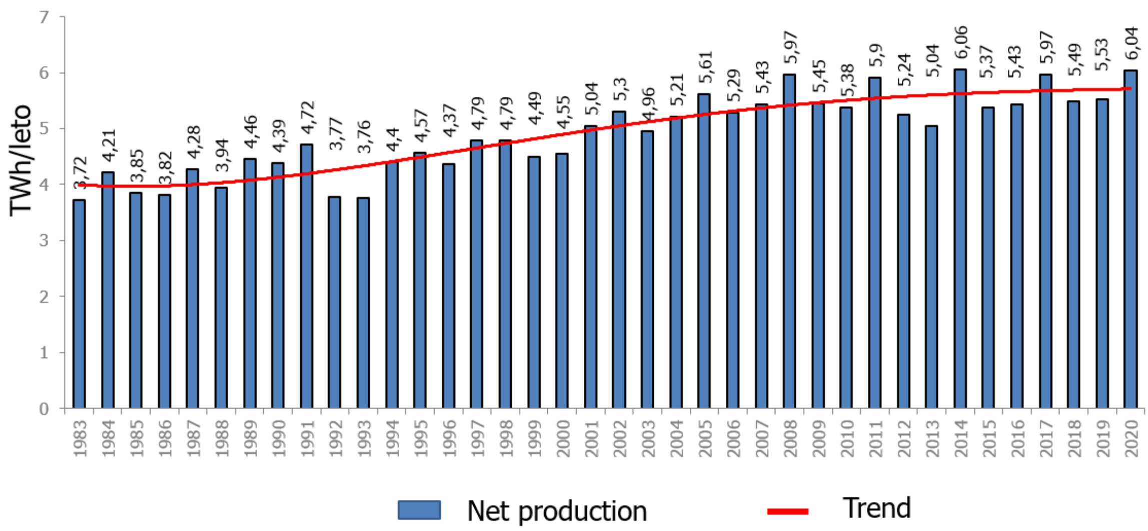


Figure 16: Net electricity production from 1984 to 2020 (source:/1/)

TWh/leto	TWh/year

2.16 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 the 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; and
5. NEK has a comprehensive Aging Management Programme (AMP) in place to monitor aging of all passive structures and components (reactor vessel, concrete, underground piping, steel structures, electrical cables etc.). An effective preventive maintenance programme also monitors the aging of active components.

The above actions have already established the technical preconditions necessary for the extension of the operational lifetime.

2.17 EXISTING ACTIVITIES IN THE AREA AND CONNECTIONS WITH THE LIFETIME EXTENSION (LTE)

On the site of the LTE, NEK operates on the basis of an operating licence /4/ that is directly related to the NEK safety analysis report /3/, containing all the conditions and limits for the safe operation of the power plant. 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, i.e. the Slovenian Nuclear Safety Administration. NEK is obliged to ensure all aspects of the power plant's safe operation.

The developer intends to extend NEK's operational lifetime by 20 years, i.e. from 2023 to 2043.

The construction of a LILW repository is planned in the vicinity of NEK at Vrbina, Krško. An environmental impact assessment was carried out for the intended activity and environmental consent no. 35402-29/2017-169 of 30 June 2021 acquired. Supplementary decision no. 35402-29/2017-172 of 5 July 2021 was also acquired.

2.18 ACTIVITIES CONNECTED WITH THE TERMINATION OF THE ACTIVITY AND AFTER IT IS OVER

Termination of activity or cessation of operations is defined as the cessation of the nuclear power plant's regular operation, meaning that:

- no more electricity is produced,
- fuel is no longer in the reactor, but is stored safely in the spent fuel pool and/or in the dry storage for spent fuel.

When the activity is terminated, the process of decommissioning the nuclear facility will **not have begun**.

In this period (of termination) it is still necessary to ensure nuclear materials are kept under control and provide active cooling for the spent fuel in the pool.

The termination of activity is followed by decommissioning of the entire facility, in compliance with the decommissioning programme /13/.

The decommissioning of the facility is **not the subject** of this assessment and will be subject to other administrative procedures relating to construction, nuclear safety and environmental protection, and as such the decommissioning of the facility, in the parts relating to impacts resulting from this activity's termination, is **not addressed** by this report.

In the period when the activity is terminated, the impact on the environment does not change significantly as this is still a nuclear facility, which must provide almost all functions as in the time of regular operation.

Environmental impacts due to the extension of NEK's operational lifetime are therefore described and evaluated for the period of operation and the activity's termination. We must emphasise once again that the activity termination **does not include** the decommissioning programme for the reasons described in the beginning of this section.

2.18.1 General information about decommissioning[3]

The decommissioning of a nuclear facility includes all the steps taken to bring a facility into a state in which it no longer needs to be monitored according to the provisions of nuclear and radiation safety regulations, and when the facility can make the transition to unrestricted use. Decommissioning includes procedures of decontamination, demolition and removal of structures, the dismantling of systems and appliances, and the removal of radioactive waste and spent fuel from the facility.[4]

In accordance with the final edition of the NEK Decommissioning programme /13/, the decommissioning will take place in **two** phases.

In **phase one**, after NEK ceases operating, the energy-producing part of NEK will be decommissioned so that radioactive material will be removed from all facilities except for the dry storage. For most of the facilities and surfaces this will mean that a state is reached in which the requirements for nuclear

[3] The decommissioning of the facility is not the subject of this assessment and will be subject to other administrative procedures relating to construction, nuclear safety and environmental protection.

[4] Taken from the Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1 (Official Gazette of RS, Nos. 76/17 and 26/19)), Article 3, paragraph 1, point 85.

facilities are no longer valid (brown field). Only the dry storage and structures, systems and components necessary for the operation of the dry storage facility (power supply, security, temperature control, radiation and humidity monitoring, and fire protection) will remain in operation.

In **phase two** of decommissioning, radioactive materials will also be removed from the dry storage facility. The dry storage building will be demolished, together with all other buildings on the NEK site, resulting in the complete remediation of the site and the possibility of unlimited use (green field). Additionally, the 4th Revision of the NPP Krško Decommissioning Programme will assess the option in which the fuel handling building (FHB) remains available for repairing multi-purpose containers after other NEK facilities have been decommissioned.

The decommissioning activities will begin after the end of NEK's operation in 2043 and will last until the dry storage facility for SF is fully decommissioned, which according to the baseline scenario will operate until 2103, and according to the sensitivity case scenario until 2075.

2.19 ENVIRONMENTAL CHARACTERISTICS OF THE LIFETIME EXTENSION

2.19.1 Use / consumption of natural resources

According to the Environmental Protection Act (ZVO-1), a natural resource is part of the environment when it is the subject of commercial exploitation, while elements of the environment include soil, mineral raw materials, water, air and animal and plant species, including their genetic material.

2.19.1.1 Operation

The use of natural resources by NEK includes the use of water (potable water from the public water network, water from the wells and river water from the Sava for process purposes). Potable water is used for sanitary and fire protection purposes while the river and well water are for process purposes. The current annual water use is indicated in the table below. The use of water does not increase with the intended LTE.

Table 16: Water used in 2020 (source: /237/)

Water source	**2020 (1,000 m^3/year)**
From the public water supply	31
From a private source	204
Other	768,622
Water supply – total	**768,857**
Water consumption	
Cooling wastewater	190
Municipal wastewater	10
Industrial wastewater	768,626
Evaporated water	30
Water losses due to system failures	1
Water consumption – total	**768,857**

2.19.1.2 Cessation of operations

In the event of operations ceasing, the use/consumption of natural resources will be considerably reduced. The spent fuel pool and some other safety components will still have to be cooled - water will be withdrawn and returned to the Sava at the rate of approximately 1.6 m^3/s.

2.19.2 By-products and managing them

There will be no by-products resulting from the LTE.

2.19.3 Emissions of ionising radiation

2.19.3.1 Operation

By extending the operational lifetime the emission of radioactive substances into the environment will be equal to or smaller than the existing rate. NEK is continuously upgrading and improving its safety and process systems, which means that the environmental burden is constantly decreasing. On the basis of the present state, the estimated annual effective dose from NEK to the critical member of the public is 0.1 µSv at most. This is approximately 0.005% of the natural background.

When the dry storage facility for spent fuel comes into use, the dose on the NEK fence near the storage facility will increase. However, the annual effective external radiation dose on the NEK fence following the storage of spent fuel will not exceed the 200 µSv limit (RETS 3.11.7).

The dose rate on the outside wall of the dry storage building will not exceed the limit of 3 µSv/h, as defined in point 3.2.b.2.1 of specification SP-ES5104 or the fourth point of the first paragraph of Article 4 of the Rules on radiation protection measures in controlled and monitored areas - SV8A (Official Gazette of RS, No. 47/18), which defines the limiting average dose rate within eight hours for controlled areas. The surroundings of the dry storage building therefore do not need to be declared as a controlled area.

2.19.3.2 Cessation of operations

After NEK ceases operating, the fuel will no longer be in the reactor, but stored safely in the spent fuel pool and/or in the dry storage for spent fuel. Ionising radiation due to the dry storage will be present on the NEK fence, as evident in the table (Table 127), in Section 5.11.1, while the gaseous and liquid effluents will be considerably smaller or completely non-existent.

2.19.4 Waste types and quantities and how it is managed

The types and annual quantities of waste (including radioactive) generated by NEK will not change substantially due to its extended operational lifetime. The rate at which waste is generated will remain the same.

2.19.4.1 Operation

Radioactive waste
The dynamics of waste generation remain **unchanged** and compliant with the provisions of the USAR /3/ and RETS /7/. Due to the extension of the operational lifetime from 2023 to 2043, there will be an extra 547 m^3 or 884 t of low- and intermediate-level radioactive waste.

The quantity of LILW on 31 December 2020 is given in the table below (Table 17).

Table 17: Inventory of processed LILW, located in the Storage Building on 31 December 2020[5] (source: NEK data, /227/)

Type of waste	Reference	No of packages	Gamma activity [Bq]	Alpha activity [Bq]*	Volume [m³]
incineration products	A	[1]70	$5.14 \cdot 10^{9}$	$1.14 \cdot 10^{8}$	14.6
dried spent ion-exchange resins from the secondary cycle	BR	[2]1	$8.80 \cdot 10^{8}$	$1.33 \cdot 10^{6}$	0.2
compressible waste	CW	[3]7	$1.95 \cdot 10^{8}$	$3.34 \cdot 10^{5}$	1.5
dried evaporator concentrate	DC	9	$1.75 \cdot 10^{9}$	$1.70 \cdot 10^{5}$	1.8
dried sediment	DS	1	$3.39 \cdot 10^{7}$	$6.30 \cdot 10^{3}$	0.2
evaporator concentrate	EB	2	$2.28 \cdot 10^{8}$	$1.19 \cdot 10^{5}$	0.4
spent filters	F	117	$1.10 \cdot 10^{11}$	$4.74 \cdot 10^{7}$	24.3
other waste	O	[4]7	$3.56 \cdot 10^{8}$	$1.28 \cdot 10^{6}$	1.5
dried spent ion-exchange resins from the primary cycle	PR	1	$1.43 \cdot 10^{10}$	$9.69 \cdot 10^{6}$	0.15
supercompacted waste from 1988 and 1989	SC	617	$1.29 \cdot 10^{10}$	$2.09 \cdot 10^{8}$	197.4
spent ion-exchange resins	SR	689	$1.87 \cdot 10^{12}$	$3.75 \cdot 10^{9}$	143.3
TTCs containing compressed waste from 1994 and 1995, and pressings from ongoing supercompaction (2006, 2007, 2008, 2010, 2011, 2012, 2013 and 2014).	ST	1853	$5.32 \cdot 10^{11}$	$6.73 \cdot 10^{8}$	1601.0
TTC, into which standard noncompacted drums are inserted	TI	364	$1.23 \cdot 10^{13}$	$1.93 \cdot 10^{10}$	316.2
Total		**3,738**	**$1.49 \cdot 10^{13}$**	**$2.41 \cdot 10^{10}$**	**2,302.6**

* Alpha activity is determined on the basis of activity ratios of alpha emitters and radionuclide 137Cs, as was found in the reference samples.

[1] Additional 19 packages located in the Decontamination building will be relocated to the NEK LILW storage facility (4.0 m³)
[2] Additional 53 packages located in the Decontamination building ready for incineration (10.6 m³)
[3] Additional 393 packages located in the WMB and DB, ready to be sent for incineration (81.7 m³)
[4] Additional 28 packages located in WMB prior to measurements and storage in RWSB (5.8 m³)
[5] Additional 80 ingots located in Decontamination building (8.8 m³)

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[5] 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 18).

[5] The decommissioning of the facility is not the subject of this assessment and will be subject to other administrative procedures relating to construction, nuclear safety and environmental protection.

Table 18: Total amount of LILW to be shared between the Slovenian and Croatian parties /36/.

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
total by 2023	estimate	5,141.4	2,458.3	7.42 E13
2024 – 2043	estimate	883.7	546.6	4.83 E13
decommissioning of NEK	PO3[8]	2,860	2,842	/
dismantling of the SF dry storage facility	PO3	392	407	/

Each party will manage its half of LILW in accordance with national strategies and programmes addressing radioactive waste management/36/.

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 2058, 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.

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.

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 19).

Table 19: Campaigns for the transfer of SF from the pool to dry storage

SF 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

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 will be generated.

[6] Value excluding radioactive decay.
[7] Until 2020 some of the waste was further processed.
[8] Third Revision of the NEK Radioactive Waste and Spent Fuel Disposal Programme, version 1.3, September 2019, ARAO - Agency for Radwaste Management, Ljubljana, Fund for financing the decommissioning of the NEK, Zagreb (PO3), Table 4-17

Due to the extension of the operational lifetime from 2023 to 2043, an extra 728 spent fuel elements will be generated.

Management of other waste

The table below shows data from the official records of the Slovenian Environment Agency about the types and quantities of waste generated in 2020. Above all construction waste and some other forms of waste were generated because of construction works and are not part of NEK's normal operation.

Table 20: Types and quantities of waste generated in 2020 (source: /132/)

Serial No.	Waste No.	Waste	2020 Quantity (kg)
	08	WASTES FROM THE MANUFACTURE, FORMULATION, SUPPLY AND USE (MFSU) OF COATINGS (PAINTS, VARNISHES AND VITREOUS ENAMELS), ADHESIVES, SEALANTS AND PRINTING INKS	
	08 01	Wastes from MFSU and removal of paint and varnish	
1	08 01 11*	Waste paint and varnish containing organic solvents or other hazardous substances	100
	12	WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTICS	
	12 01	Waste from shaping and physical and mechanical surface treatment of metals and plastics	
2	12 01 09*	Machining emulsions and solutions free of halogens	564
3	12 01 12*	Spent waxes and fats	91
	12 03	Waste from water and steam degreasing processes (except for 11)	
4	12 03 02*	Steam degreasing wastes	202
	13	OIL WASTES AND WASTES OF LIQUID FUELS (except edible oils, and those in Sections 05, 12 and 19)	
	13 01	Waste hydraulic oils	
5	13 01 10*	Mineral based non-chlorinated hydraulic oils	89
	13 02	Waste engine, gear and lubricating oils	
6	13 02 05*	Mineral-based non-chlorinated engine, gear and lubricating oils	3.143
	13 03	Waste insulating and heat transmission oils	
7	13 03 10*	Other insulating and heat transmission oils	148
	13 07	Liquid fuel waste	
8	13 07 01*	Fuel oil and diesel	431
	15	WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED	
	15 01	Packaging (including separately collected municipal packaging waste)	
9	15 01 10*	Packaging containing residues of or contaminated by hazardous substances	3,175
	15 02	Absorbents, filter materials, wiping cloths and protective clothing	
10	15 02 02*	Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by hazardous substances	657
	16	WASTES NOT OTHERWISE SPECIFIED IN THE LIST	
	16 01	End-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)	
11	16 01 07*	Oil filters	249
12	16 01 14*	Antifreeze fluids containing hazardous substances	30
	16 05	Gases in pressure containers and discarded chemicals	
13	16 05 04*	Gases in pressure containers (including halons) containing hazardous substances	5

Serial No.	Waste No.	Waste	2020 Quantity (kg)
14	16 05 06*	Laboratory chemicals, consisting of or containing hazardous substances, including mixtures of laboratory chemicals	155
15	16 05 07*	Discarded inorganic chemicals consisting of or containing hazardous substances	127
	16 06	Batteries and accumulators	
16	16 06 01*	Lead batteries	2,450
	16 09	Oxidising substances	
17	16 09 02*	Chromates, e.g. potassium chromate, potassium or sodium dichromate	481
	17	CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)	
	17 01	Concrete, bricks, tiles and ceramics	
18	17 01 01	Concrete	1,546,880
	17 02	Wood, glass and plastic	
19	17 02 03	Plastic	27,120
	17 03	Bituminous mixtures, coal tar and tarred products	
20	17 03 02	Bituminous mixtures other than those mentioned in 17 03 01	321,300
	17 04	Metals (including their alloys)	
21	17 04 05	Iron and steel	18,100
22	17 04 11	Cables other than those mentioned in 17 04 10	230
	17 05	Soil (including excavated soil from contaminated sites), stones and dredging spoil	
23	17 05 04	Soil and stones other than those mentioned in 17 05 03	234,200
	17 08	Gypsum-based construction materials	
24	17 08 02	Gypsum-based construction materials other than those mentioned in 17 08 01	15,960
	17 09	Other construction and demolition wastes	
25	17 09 04	Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	28,040
	19	WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTEWATER TREATMENT PLANTS AND THE PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION AND WATER FOR INDUSTRIAL USE	
	19 08	Wastes from wastewater treatment plants not otherwise specified	
26	19 08 09	Grease and oil mixture from oil/water separation containing only edible oil and fats	2,000
	19 09	Wastes from the preparation of water intended for human consumption or water for industrial use	
27	19 09 05	Saturated or spent ion exchange resins	9,240
	20	MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS	
	20 01	Separately collected fractions (except 15 01)	
28	20 01 08	Biodegradable kitchen and canteen waste	43,425
29	20 01 21*	Fluorescent tubes and other mercury-containing waste	120
30	20 01 25	Edible oil and fat	2,185
31	20 01 33*	Batteries and accumulators mentioned in 16 06 01, 16 06 02 or 16 06 03, and unsorted batteries and accumulators containing these batteries	180
32	20 01 36	Discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35	880
33	20 01 38	Wood other than that mentioned in 20 01 37	36,280
34	20 01 40	Metals	2,720

Serial No.	Waste No.	Waste	2020 Quantity (kg)
	20 02	Garden and park wastes (including cemetery waste)	
35	20 02 01	Biodegradable waste	1,040
	20 03	Other municipal wastes	
36	20 03 07	Bulky waste	280

Key:
* hazardous waste

All the waste in the above table was handed over to another entity (authorised contractor) in Slovenia.

2.19.4.2 Cessation of operations

After the cessation of operations, the maintenance and emptying of fluid systems, and the decontamination of appliances and facilities will produce the same form and quantity of radioactive waste as during operation.
Due to the extension of the operational lifetime from 2023 to 2043, there will be an extra 547 m^3 or 884 t of low- and intermediate-level radioactive waste.

Due to the extension of the operational lifetime from 2023 to 2043, an extra 728 spent fuel elements will be generated.

2.19.5 Emissions of soil pollutants

2.19.5.1 Operation

There will be no emissions of soil pollutants during operation. All wastewater from the existing NEK plant flows into the Sava following suitable treatment. All waste is appropriately stored and does not present a danger for soil contamination.

2.19.5.2 Cessation of operations

There will be no emissions of soil pollutants during the cessation of operations of NEK.

2.19.6 Emissions of water pollutants

2.19.6.1 Operation (thermal pollution)

According to the definition from the Decree on the emission of substances and heat when discharging wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14, 98/15) the emission of heat into water is the emission of heat that accompanies the discharge of wastewater from a facility directly into the water.

NEK discharges wastewater into the Sava in compliance with environmental permit no. 35441-103/2006-24 of 30 June 2010, which was amended in three points of the operational part (points 1.1, 1.4 and 1.8). Decision no. 35441-103/2006-33 of 4 June 2012 reaffirmed the environmental permit, which was amended (point 1.5, Table 3) under decision no. 35444-11/2013-3 of 10 October 2013 /49/.

A description of the impact of thermal pollution in the existing state can be found in Section 4.1.4.1.

2.19.6.2 Operation (surface water)

The extended operational lifetime will not cause any new wastewater discharges. The quantities of discharged pollutants will remain the same as in the present state, which is described in more detail in Section 4.4.4.1 Emissions of substances and heat from NEK in 2020.

There are other facilities operating at the NEK site alongside the primary activity (the production of electricity) which we consider to be sources of wastewater:

- large cooling system,
- small cooling system,
- buildings and components for water treatment and
- the WP system (treatment of liquid radioactive waste).

The water permit /50/ allows water abstraction for process purposes (the Sava and the well on the right bank), the annual total being as much as 915,000,000 m^3 (29,000 l/s).

A more detailed description of the discharging of wastewater can be found in Section 2.10.3.

2.19.6.3 Cessation of operations

The cessation of operations means there will be no more need for cooling water for the technological process of electricity production. After NEK ceases to operate, there will be no more thermal load on the Sava from this address.

The spent fuel pool and some other safety components will still have to be cooled. It is estimated that water will be withdrawn and returned to the Sava at the rate of approximately 1.6 m^3/s.

When NEK ceases to operate there may be temporary small quantities of wastewater as a result of the cleaning of facilities and they will be taken to the small municipal water treatment plant.

The sampling and analysis of gathered liquid discharges and further handling thereof will consider (alongside the radiological parameters), the Rules on the first measurements and operational monitoring of wastewater (Official Gazette of RS, Nos. 94/14, 98/15), the Decree on emissions of substances and heat when discharging wastewater into water and public sewage system (Official Gazette of RS, Nos. 64/12, 64/14, 98/15) and the Decree governing the discharge and cleaning of municipal and rain wastewater in the Municipality of Krško (Official Gazette of RS, Nos. 73/12, 84/13), or the appropriate regulations according to the valid legislation.

In the event of radiological pollution, the wastewater will be suitably treated in the existing NEK systems.

If the water is not contaminated with radiation but the parameter values surpass the limit values for discharging into the watercourse according to the valid legislation, then these waters will not be discharged into the sewer system which flows into the Sava, but will be handed over to an authorised collector or processor of such waste.

2.19.7 Emissions of air pollutants

2.19.7.1 Operation

The emission of substances into the air will be the same as in the present state. Emissions of substances that affect air quality are very small (see table: Table 84) and are the consequence of combustion of fossil fuels on the site. They come from: emergency diesel electricity generators (DG1, DG2 and DG3), an auxiliary boiler room, on-site goods transport, cars in the carpark.

Another source of air pollutants is also the traffic on public roads - the cars of employees and goods vehicles.

2.19.7.2 Cessation of operations

Following the cessation of NEK's operations, pollutants will temporarily be released into the air from the auxiliary boiler room, which will be used for heating premises and for safety purposes (to prevent freezing). The total quantity of fuel used will be reduced as heat will no longer be needed for the production of supplementary steam. Temporary emissions will occur as a result of the testing of the diesel generators, which will remain on site as an emergency source of electricity.

2.19.8 Greenhouse gas emissions

2.19.8.1 Operation

A nuclear power plant does not emit greenhouse gases in the process of producing electricity. This will remain the case during the extended operational lifetime.

The LTE will generate very small emissions of greenhouse gases which are the result of the use of fuel oil in the emergency power supply diesel generators (three diesel engines, emissions from the auxiliary boiler room (technical details in Section 4.4.5.6)). The diesel engines are in operation only when the facility is being tested, and the boilerhouse is an emergency heat source for when the power plant is not operating and/or when steam is needed for heating the system when the power plant is started up. Emissions are calculated using IPCC methodology and emission factors from the Slovenian National Inventory Report 2021 /152/, for fuel oil CO_2 EF = 74.1 t/TJ, CH_4 EF = 0.003 t/TJ and N_2O EF = 0.0006 t/TJ. Greenhouse gas emissions from NEK amount to 0.609 ktCO$_2$-eq/year, as the average of the last seven years (Table 21). Emissions will not change due to the LTE and will remain the same until 2043. Small variations are, however, possible.

Table 21: *Emissions of greenhouse gases by NEK (average in the period from 2014 to 2020)*

	ktCO$_2$-eq/year
Diesel generator emissions	0.223
Auxiliary boiler room emissions	0.386
Total	0.609

In 2019 Slovenia's greenhouse gas emissions amounted to 17,065 ktCO$_2$-eq, of which 4,576 ktCO$_2$-eq were from the sector of public electricity and heat production/152/. The greenhouse gases emitted by NEK account for 0.003% of Slovenia's emissions and 0.013% of the emissions from the public electricity and heat sector.

The Decree on the use of fluorinated greenhouse gases and ozone-depleting substances (Official Gazette of RS, No 60/16) also defines the operator's obligation to report stationary equipment, and the obligation of the operator, maintenance provider and authorised company to report the use, capture, and delivery of waste fluorinated greenhouse gases and waste ozone-depleting substances to the waste collector. NEK has informed ARSO of the presence of stationary equipment containing fluorinated greenhouse gases (F-gases) and SF6 gas. F-gases are present in the equipment for cooling, air-conditioning and the heat pumps, and the fire-extinguishing equipment, while SF6 gas is present in the circuit breakers and switchgear. The F-gases used include gases with the industrial names for mixtures R134a, R407c and R410a, and the gas with high global warming potential SF6 (22,800). SF6 gas has extremely high insulation strength, and its use means reductions in the size of equipment, so it is nowadays used as standard in new plants. These gases are potential sources of emissions. Emissions would occur if gases leaked from equipment. To display the size of a potential emission, the emissions of all gases are calculated, assuming average leakage from equipment using the emissions factor from /152/. The total potential emission of F-gases from the process is 0.323 ktCO$_2$-eq, SF6 0.135 ktCO$_2$-eq, and from non-process sources 0.043 ktCO$_2$-eq, altogether 0.501 ktCO$_2$-eq.

2.19.8.2 Cessation of operations

Following the cessation of NEK's operations, greenhouse gases will temporarily be released into the air from the auxiliary boiler room, which will be used for heating premises and for safety purposes (to prevent freezing). Temporary emissions will occur as a result of the testing of the diesel generators, which will remain on site as an emergency source of electricity.

F-gases remain in the cooling and air-conditioning equipment, heat pumps and fire-extinguishing equipment. SF6 gas remains also in the circuit breakers and switchgear. The above are possible sources of greenhouse gas emissions so this equipment must be regularly maintained and monitored in compliance with the Decree (Official Gazette of RS, No. 60/16).

2.19.9 Noise emissions

2.19.9.1 Operation

No new sources of noise emissions, such as ventilating or cooling devices, are foreseen due to the extended operational lifetime.

Noise emissions during the operating period will be the same as the existing ones (described in Section 4.4.12). Due to climate change, there could be an increase in the operation of cooling towers.

2.19.9.2 Cessation of operations

There will be no noise emissions after NEK ceases to operate, or there will be only some temporary noise due to activities connected with the termination of the activity.

2.19.10 Electromagnetic radiation

2.19.10.1 Operation

No new sources of electromagnetic radiation are foreseen (e.g. transformer stations) due to NEK's extended operational lifetime.

Emissions of electromagnetic radiation will be the same as the present ones (see description in Section 4.4.14).

2.19.10.2 Cessation of operations

There will be no more sources of electromagnetic radiation once NEK ceases to operate.

2.19.11 Light emissions

2.19.11.1 Operation

The extension of the operational lifetime does not change the effect of light shining out into NEK's surroundings. Light emissions into the environment will be identical to the present ones.

As NEK's external lighting is an integral part of the technical systems for ensuring physical protection, NEK is not bound by the Decree on limit values for light pollution (Official Gazette of RS, Nos. 81/07, 109/07, 62/10, 46/13), but by the Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13, 76/17 [ZVISJV-1]).

2.19.11.2 Cessation of operations

After NEK ceases operating, light emissions into the environment will be identical to the present ones as the facility will still be subject to security control.

2.19.12 Risks associated with protection against environmental and other accidents

According to the Environmental Protection Act (ZVO-1), an environmental accident is an uncontrolled or unforeseen event which arises as the result of an intervention in the environment and which has an immediate or delayed consequence of directly or indirectly endangering human life or health or the quality of the environment. An environmental accident is also an ecological disaster pursuant to the regulations on protection against natural and other disasters.

Other accidents defined by the Protection Against Natural and Other Disasters Act (ZVNDN) (Official Gazette of RS, Nos. 51/06-ZVNDN-UPB1, 97/10, 21/18-ZNOrg), may include accident in road, rail and air traffic, fire and other ecological and industrial accidents caused by man's actions.

2.19.12.1 Operation

NEK operates on the basis of an operating licence /4/ that is directly related to the NEK safety analysis report /3/, 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, i.e. the Slovenian Nuclear Safety Administration. NEK is obliged to ensure all aspects of the power plant's safe operation.

NEK operates in accordance with the decision/approval to commence the operation of NEK, decision no. 31-04/83-5 of 6 February 1984 issued by the Energy Inspectorate of the Republic of Slovenia, with an amendment to the NEK operating licence, decision no. 3570-8/2012/5 of 22 April 2013 issued by the Slovenian Nuclear Safety Administration (URSJV), and the Updated Safety Analysis Report (hereinafter: USAR) for NEK.

NEK is not classified as an activity or installation that can cause large-scale environmental pollution (Decree on the types of activity and installation that could cause large-scale environmental pollution; Official Gazette of RS, No. 57/15) nor as a plant with a high or low risk for the environment (Decree on the prevention of major accidents and mitigation of their consequences; Official Gazette of RS, No. 22/16).

How safety functions are ensured for the power plant's operation can be seen in Sections 2.11, 2.12 and 2.13. Various different emergency scenarios have been studied on the basis of which solutions and design bases have been foreseen which ensure safe operation.

2.19.12.2 Cessation of operations

After NEK ceases operating (see Section 2.18), the fuel will no longer be in the reactor, but stored safely in the spent fuel pool and/or in the dry storage for spent fuel. No particular risks are expected regarding protection against environmental and other accidents.

2.20 ENVIRONMENTAL PROTECTION REGULATIONS

Regulations from the field of environmental protection and related fields that are taken into account in the Environmental Impact Assessment Report and refer to this activity:

- **General description**
  - 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);
  - Protection Against Natural and Other Disasters Act (ZVNDN)(Official Gazette of RS, Nos. 64/94, 33/00 - Constitutional Court Decision, 87/01 - ZMatD, 41/04 - ZVO-1, 28/06, 97/10, 21/18 - ZNOrg);
  - Decree on activities affecting the environment that require an environmental impact assessment (Official Gazette of RS, Nos. 51/14, 57/15, 26/17, 105/20);

- 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, 40/17);
- Convention on Nuclear Safety (MKJV), (Official Gazette of RS – MP, No. 16/96);
- Convention on Early Notification of a Nuclear Accident (Official Gazette of SFRY-MP, No. 15/89);
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (MKVIGRO), Official Gazette of RS – MP, No. 3/99;
- IAEA Incident Reporting System (IAEA-IRS), (Official Gazette of SFRY- MP, No. 1/87);
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, (Official Gazette of SFRY-MP, No. 4/91);
- Convention on the Physical Protection of Nuclear Material, (Official Gazette of SFRY-MP, No. 33/73); Amendment to Convention on Physical Protection of Nuclear Material (UL RS – MP, No. 14/09);
- Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (MKOTJE), UL RS – MP, No. 18/00; Protocol on the amendment to the Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (MPSKOJE), UL RS – MP, No. 4/10; Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (MSPDKPK), Official Gazette of RS – MP, No. 22/94;
- Treaty establishing the European Atomic Energy Community dated 25 March 1957 – consolidated version (OJ C 203, 7 June 2016, pp. 1–112);
- Convention on Biological Diversity Safety (MKBR), Official Gazette of RS – MP, No. 7/96;
- Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters – Aarhus Convention (Official Gazette of RS – MP, Nos. 17/04, 1/10)
- Convention on Environmental Impact Assessment in a Transboundary Context – Espoo Convention, Official Gazette of RS – MP, No. 11/98; Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context, Official Gazette of RS – MP, 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.
- Act ratifying the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Official Gazette of RS – MP, Nos. 17/04, 27/04, 1/10 – MSKIVOZ)

- **Nature conservation**
  - Nature Conservation Act (Official Gazette of RS, No. 96/04 – official consolidated text, 61/06 – ZDru-1, 8/10 – ZSKZ-B, 46/14, 21/18 – ZNOrg, 31/18 and 82/20);
  - Decree on Special Protection Areas (Natura 2000 Areas) (Official Gazette of RS, Nos. 49/04, 110/04, 59/07, 43/08, 8/12, 33/13, 35/13 – corrigenda, 39/13 – Constitutional Court Decision, 3/14, 21/16 and 47/18);
  - Decree on important ecological areas (Official Gazette of RS, Nos. 48/04, 33/13, 99/13 and 47/18);
  - Decree on the categories of valuable natural features (Official Gazette of RS, Nos. 52/02 and 67/03);
  - Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 96/08, 36/09, 102/11, 15/14, 64/16 and 62/19);
  - Decree on protected wild plant species (Official Gazette of RS, Nos. 46/04, 110/04, 115/07, 36/09 and 15/14);
  - Decree on habitat types (Official Gazette of RS, Nos. 112/03, 36/09, 33/13);
  - Decree on types of measures for remediation of environmental damage (Official Gazette of RS, No. 55/09);
  - Rules on the content defining environmental damage (Official Gazette of RS, No. 46/09);
  - Rules on the assessment of the acceptability of effects caused by the execution of plans and activities affecting nature in protected areas (Official Gazette of RS, Nos. 130/04, 53/06, 38/10 and 3/11);

- Rules on the inclusion of endangered plant and animal species in the red list (Official Gazette of RS, Nos. 82/02, 42/10) ("Red list" in the text);
- Rules on the designation and protection of natural values (Official Gazette of RS, Nos. 111 /04, 70/06, 58/09, 93/10, 23/15 and 7/19);
- Rules on forest protection (Official Gazette of RS, Nos. 114/09, 31/16);
- Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version) (OJ L No. 20 of 26 January 2010, p. 7), last changed by Council Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of environment, by reason of the accession of the Republic of Croatia (OJ L No. 158 of 10 June 2013, p. 193) (Birds Directive);
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206 of 22 July 1992, p. 7), as last amended by Council Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of environment, by reason of the accession of the Republic of Croatia (OJ L 158 of 10 June 2013, p. 193) (Habitats Directive);
- Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species (OJ L 317 of 4 November 2014, p. 35–55);
- Biodiversity Conservation Strategy of Slovenia (adopted by RS government on 20 December 2001);
- Programme of managing Natura 2000 areas (2015-2020) (adopted by RS government on 9 April 2015, two appendices amended 28 May 2015 and 24 March 2016).

- **Air**
  - Decree on ambient air quality (Official Gazette of RS, Nos. 9/11, 8/15, 66/18);
  - Decree on Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in the Ambient Air (Official Gazette of RS, No. 56/06);
  - Decree on the Emission of Substances into the Atmosphere from Stationary Sources of Pollution (Official Gazette of RS, Nos. 31/07, 70/08, 61/09 and 50/13);
  - Decree on the emission of substances into the atmosphere from medium-sized combustion plants, gas turbines and stationary engines (Official Gazette of RS, Nos. 17/18 and 59/18);
  - Decree on the emission of substances into the atmosphere from small combustion plants (Official Gazette of RS, No. 46/19);
  - Decree on inspections, cleaning and measurements of small combustion units (Official Gazette of RS, No. 77/17);
  - Rules on Initial Measurements and Operational Monitoring of the Emission of Substances into the Atmosphere from Stationary Pollution Sources and on the Conditions for Their Implementation (Official Gazette of RS, No. 105/08);
  - Rules on criteria and methodology for revision of basic requirements for small combustion units (Official Gazette of RS, No. 12/18);
  - Rules on loading and securing cargo in road traffic (Official Gazette of RS, No. 70/11);
  - Order on the classification of zones, agglomerations and subzones according to ambient air pollution (Official Gazette of RS, Nos. 38/17, 3/20);
  - Ordinance on the determination of subzones for the management of ambient air quality (Official Gazette of RS, Nos. 67/18, 2/20);

- **Greenhouse gases**
  - Energy Act (EZ-1) (Official Gazette of RS, Nos. 17/14, 81/15, 43/19, 65/20);
  - Decree on greenhouse gases, activities and installations for which a greenhouse gas emissions permit is required or monitoring of greenhouse gas emissions must be implemented (Official Gazette of RS, Nos. 55/11, 1/13);
  - Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006;
  - Decree on the implementation of the Regulation (EC) on certain fluorinated greenhouse gases (Official Gazette of RS, No. 32/07);
  - Decree on the use of fluorinated greenhouse gases and ozone-depleting substances (Official Gazette of RS, No. 60/16);

- Decree implementing Regulation (EC) on substances that deplete the ozone layer (Official Gazette of RS, No. 57/11).

- **Ionising radiation**
  - The Ionising Radiation Protection and Nuclear Safety Act, ZVISJV-1 (Official Gazette of RS, Nos. 76/17, 26/19);
  - Rules on radiation and nuclear safety factors (Official Gazette of RS, Nos. 74/16 and 76/17 – ZVISJV-1);
  - Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13 and 76/17 – ZVISJV-1);
  - Rules on the obligations of persons performing radiation practices and holders of ionising radiation sources, SV8 (Official Gazette of RS, No. 43/18);
  - Rules on radiation protection measures in controlled and monitored areas, SV8A (Official Gazette of RS, No. 47/18);
  - Rules on Radioactive Waste and Spent Fuel Management (Official Gazette of RS, No. 125/21);
  - 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);
  - Resolution on the National Programme for Managing Radioactive Waste and Spent Fuel for the Period 2016–2025 (ReNPRRO16–25) (Official Gazette of RS, No. 31/61);
  - Decree on dose limits, reference levels and radioactive contamination, UV2 (Official Gazette of RS, No 18/18);
  - Decree on radiation activities, UV1 (Official Gazette of RS, No. 19/18);
  - Decree on the safeguarding of nuclear materials, UV6 (Official Gazette of RS, Nos. 34/08 and 76/17 – ZVISJV-1).

- **Soil**
  - Decree on limit values, alert thresholds and critical levels of dangerous substances in the soil (Official Gazette of RS, Nos. 68/96, 41/04 - ZVO-1);
  - Decree on the burdening of soil with waste spreading (Official Gazette of RS, Nos. 34/08 and 61/11);
  - Rules on soil status monitoring (Official Gazette of RS, Nos. 66/17, 4/18).

- **Waters**
  - Water Act /ZV-1/ (Official Gazette of RS Nos. 67/02, 110/02-ZGO-1, 2/04-ZZdrl-A, 41/04-ZVO-1, 57/08-ZV-1A, 57/12-ZV-1B, 100/13-ZV-1C, 40/14-ZV-1D, 56/15-ZV-1E, 60/17-ZDMHS, 49/20-ZIUZEOP, 65/20, 80/20-ZIUOOPE);
  - Decree on the emission of substances and heat when discharging wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14, 98/15);
  - Decree on the emission of substances in the discharge of rainwater from public roads (Official Gazette of RS, No. 47/05);
  - Decree on the emission of substances in the discharge of wastewater from cooling facilities and steam and hot water generating facilities (Official Gazette of RS, Nos. 28/00, 41/04-ZVO-1);
  - Rules on initial measurements and operational monitoring of wastewater (Official Gazette of RS, Nos. 94/14, 98/15);
  - Rules on groundwater status monitoring (Official Gazette of RS, Nos. 66/17, 4/18, 77/19);
  - Rules on the Criteria for the Designation of a Water Protection Zone (Official Gazette of RS, Nos. 64/04, 5/06, 58/11 and 15/16).
  - Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L No. 327, of 22 December 2000, p. 1), last amended by Council Directive No. 2013/64/EU of 17 December 2013 amending Council Directives 91/271/EEC and 1999/74/EC, and Directives 2000/60/EC, 2006/7/EC, 2006/25/EC and 2011/24/EU of the European Parliament and of the Council, following the amendment of the status of Mayotte with regard to the European Union (OJ L No. 353 of 28 December 2013, p. 8), (hereinafter: Directive 2000/60/EC);
  - Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (OJ L No. 288 of 6 November 2007, p. 27).

- Decree on the discharge and treatment of urban wastewater (Official Gazette of RS, Nos. 98/15, 76/17, 81/19 and 194/21)

- **Noise**
  - Decree on the assessment and management of environmental noise (Official Gazette of RS, Nos. 121/04, 59/19);
  - Decree on limit values for environmental noise indicators (Official Gazette of RS, Nos. 43/18, 59/19);
  - Rules on Initial Assessment and Operational Monitoring of Sources of Noise and Conditions for the Implementation of Monitoring (Official Gazette of RS, No. 105/08);
  - Rules on noise emissions from machinery used in the open air (Official Gazette of RS, Nos. 106/02, 50/05, 49/06 and 17/11-ZTZPUS-1).

- **Waste**
  - Decree on waste (Official Gazette of RS, Nos. 37/15, 69/15, 129/20);
  - Decree on management of waste arising from construction work (Official Gazette of RS, No. 34/08);
  - Decree on the burdening of soil with waste spreading (Official Gazette of RS, Nos. 34/08 and 61/11);
  - Decree on the management of batteries and accumulators and waste batteries and accumulators (Official Gazette of RS, Nos. 3/10, 64/12, 93/12, 103/15, 84/18, 101/20);
  - Decree on waste oils (Official Gazette of RS, No. 24/12);
  - Decree on the management of packaging and packaging waste (Official Gazette of RS, Nos. 84/06, 106/06, 110/07, 67/11, 68/11 – corr., 18/14, 57/15, 103/15, 2/16 – corr., 35/17, 60/18, 68/18, 84/18 – ZIURKOE and 54/21);
  - Decree on waste electrical and electronic equipment (Official Gazette of RS, Nos. 55/15, 47/16, 72/18, 84/18, 108/20);
  - Decree on the implementation of Regulation (EC) on shipments of waste (Official Gazette of RS, Nos. 78/16, 94/21);
  - Commission Decision of 18 December 2014 amending Commission Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council (2014/955/EU);
  - Decree on biodegradable kitchen waste and garden waste management (Official Gazette of RS, No. 39/10):

- **Electromagnetic radiation**
  - Decree on electromagnetic radiation in the natural and living environment (Official Gazette of RS, Nos. 70/96, 41/04-ZVO-1);
  - Rules on the first measurements and operational monitoring for sources of electromagnetic radiation and the terms for its implementation (Official Gazette of RS, Nos. 70/96, 41/04-ZVO-1, 17/11-ZTZPUS-1).

- **Light**
  - Decree on limit values due to light pollution of the environment (Official Gazette of RS, Nos. 81/07, 109/07, 62/10 and 46/13).

- **Cultural Heritage**
  - Cultural Heritage Protection Act (ZVKD-1, Official Gazette of RS, Nos. 16/08, 123/08-ZVKD-1A, 8/11, 30/11-Constitutional Court Decision, 90/12-ZVKD-1B, 111/13-ZVKD-1C, 32/16-ZVKD-1D, 21/18-ZNOrg);
  - Rules on the Registry of Types of Heritage and Protection Guidelines (Official Gazette of RS, No. 102/10);
  - Rules on archaeological research (Official Gazette of RS, No. 3/13).

- **Hazardous substances (chemicals)**

- Chemicals Act /ZKem/ (Official Gazette of RS, Nos. 110/03-ZKem-UPB1, 47/04-ZdZPZ, 61/06-ZBioP, 16/08, 9/11-ZKem-C, 83/12-ZFfS-1);
- Decree on the storage of hazardous liquids in fixed storage facilities (Official Gazette of RS, Nos. 104/09, 29/10 and 105/10);
- Rules on technical and organisational measures for the storage of hazardous chemicals (Official Gazette of RS, No. 23/18);
- Rules on the classification, packaging and labelling of dangerous substances (Official Gazette of RS, Nos. 35/05, 54/07, 88/08, 6/14, 43/19);
- Rules on the classification, packaging and labelling of dangerous preparations (Official Gazette of RS, Nos. 67/05, 137/06, 88/08, 81/09, 6/14, 43/19);

2.21 EU DOCUMENTS (BREF)

There are no reference documents of best available techniques (BREF) that should be taken into account in this activity. The above applies to the whole plant as a technical solution (nuclear power plant).

Although devices for producing nuclear energy are not part of the fields of application of Annex I to the IED Directive[9], this document takes into account environmental techniques, which refer to the cooling systems of the ordinary part of these devices. Of the horizontal BREF guidance documents, connected with individual systems, BREF is used for industrial cooling systems.

There follows an analysis of the situation from the point of view of the demands in the "Reference Document on the application of Best Available Techniques to Industrial Cooling Systems, December 2001 (BREF ICS)".

1. Process and location

   The once-through cooling system is more effective than the recirculating system. Choosing the once-through cooling system, when large quantities of water are available on the site, is considered BAT (best available technology). For the once-through cooling system, the temperature increase following mixing according to the BAT is 3-5°C. NEK uses a combined cooling system: the once-through cooling system using river water from the Sava and the recirculating system using mechanical cooling towers, which keeps the average daily temperature increase of the Sava below 3°C (00:00-24:00). In the years 2010-2019 the ΔT°C amounted to 1.95°C, which is 65% of the maximum permitted heat removal. NEK does not use groundwater for cooling, which is BAT.

2. Reducing direct energy consumption and renewing energy

   The cooling towers have three batteries with altogether 16 ventilator units, enabling the gradual increase of cooling power and the optimisation of energy use. By means of the programme for the preventive maintenance of pumps, gear transmissions and the secondary system cooling towers, a high level of the entire system's operational reliability is maintained.

3. Reducing water use and reducing thermal emission into water

   By means of the combined cooling system, using both the once-through cooling system and the cooling tower recirculating system, which is usually engaged when the flow is less than 100 m^3/s, enables the average daily temperature increase of the Sava to be kept below 3°C. Of the 25 m^3/s cooling water required for cooling using the Sava, the cooling towers can take over 15 m^3, so when the Sava has a low flow rate it provides only 10 m^3/s. **When the Sava has a high flow rate, the cooling towers are engaged with the aim of reducing water consumption and thereby depositing impurities on the CW cleaning systems.**

4. Reducing the intake of organisms

[9] DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

Water is taken from the Sava at the rate of 25 m^3/s (maximum up to 27.4 m^3/s), the minimal rate being 10 m^3/s. This allows the free migration of organisms in the watercourse. The CW inlet screen is 8 cm wide and 1 m high or more, while the travelling screens are ca. 5x5 mm, preventing the intake of large organisms.

5. Reducing emissions of chemicals into water

   The condenser pipes are made of stainless steel so there is no need for an anti-corrosive coating and protection. Cleaning is carried out mechanically using Taprogge, a system that uses rubber balls in constant circulation. The short-term controlled application of biocides is no longer used for cleaning. For a number of years NEK has not been using biocides for cleaning its cooling system.

6. Reducing emissions by means of optimised treatment of cooling water

   All that is released from the cooling towers is moist air and tiny droplets. Evaporation depends on the ambient conditions – air humidity, temperature etc.

7. Reducing the impact of the discharge and microbiological risks

   Water from the Sava is used in an open system without prior mechanical or chemical treatment (except for filtration on the CW strainer and the application of biocides if deemed necessary), so there is a small risk of microbiological organisms accumulating, smaller than in closed cooling systems.

8. **Waste**

   During an outage, silt from the cooling water tank is cleaned mechanically and removed as solid waste.

Considering the above, we can conclude that the NEK cooling system is in line with the conclusions of the BAT/BREF document for cooling systems.

3. ALTERNATIVE SOLUTIONS CONNECTED WITH THE ACTIVITY

3.1 BASES

The Integrated National Energy and Climate Plan (NECP)[10] is a strategic document which defines goals, policies and actions up to 2030 (and outlook to the year 2040) for the five dimensions of the Energy Union: decarbonisation (greenhouse gas emissions and renewable energy sources), energy efficiency, energy security, the internal energy market and research, innovation and competitiveness.

For more details on the climate and energy policy and the role of nuclear energy see5.5.1.

Large electricity producing facilities are crucial for ensuring a reliable power supply as they cover the difference due to production from diffuse sources and the necessary production for ensuring a reliable supply. Both the scenario with the existing measures and the NECP scenario, which is development-oriented and envisages a greater generation of electricity from renewable energy sources, include the operation of the existing NEK until the end of the extended operational lifetime (2043) upon obtaining appropriate environmental consent.

As part of the NECP preparation and its strategic assessment for impact on the environment, 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 take into account important national circumstances and are an appropriate step ahead towards a climate-neutral Slovenia by 2050.

Energy, system, environment protection 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 generation of electricity in the base-load mode and will have matured for commercial use by 2023.

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 management of international obligations regarding CO_2 emissions, as it produces minimal CO_2 emissions, whereas other technologies that use fossil fuels would put Slovenia far off from fulfilling the requirements 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 spatial developments; 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 Life Extension of the Krško NPP, EIMV, Ljubljana, July 2021 /243/.

3.2 ENVIRONMENTAL CONSEQUENCES OF THE ZERO VARIANT

For a description of the zero variant see Section 4.5

[10] The Slovenian Government adopted the NECP on 27 February 2020, after receiving a decision concerning the acceptability of the implementation's effects on the environment. The NECP was also forwarded to the European Commission in compliance with EU Regulation 2018/1999 on the Governance of the Energy Union and Climate Action.

3.2.1 Climate

NEK produces a net 696 MW of electricity. In the event of NEK's shutdown, energy would have to be replaced with other sources. The IPCC study from 2006 estimated that throughout its life cycle (construction, operation, decommissioning, uranium ore mining and processing), a nuclear power plant discharges 0.012 kg of CO_2 into the atmosphere per each kWh of electricity generated.

On average, the estimate shows that 8.3 t of CO_2 is generated every hour in the operation of a power plant of the same power output as NEK (direct and indirect emission).

According to extremely conservative assumptions, a coal-fired thermal power plant produces 0.82 kg of CO_2 per each kWh of electricity generated. This means that a 696 MW thermal power plant generates no less than 570,720 kg of CO_2 every hour, releasing it into the atmosphere.

Gas power plants of the same output power produce about half as much CO_2 emissions or 341,040 kg of CO_2 per hour of operation.

Section 5.5.1 provides a detailed comparison of GHG emissions of various technologies.

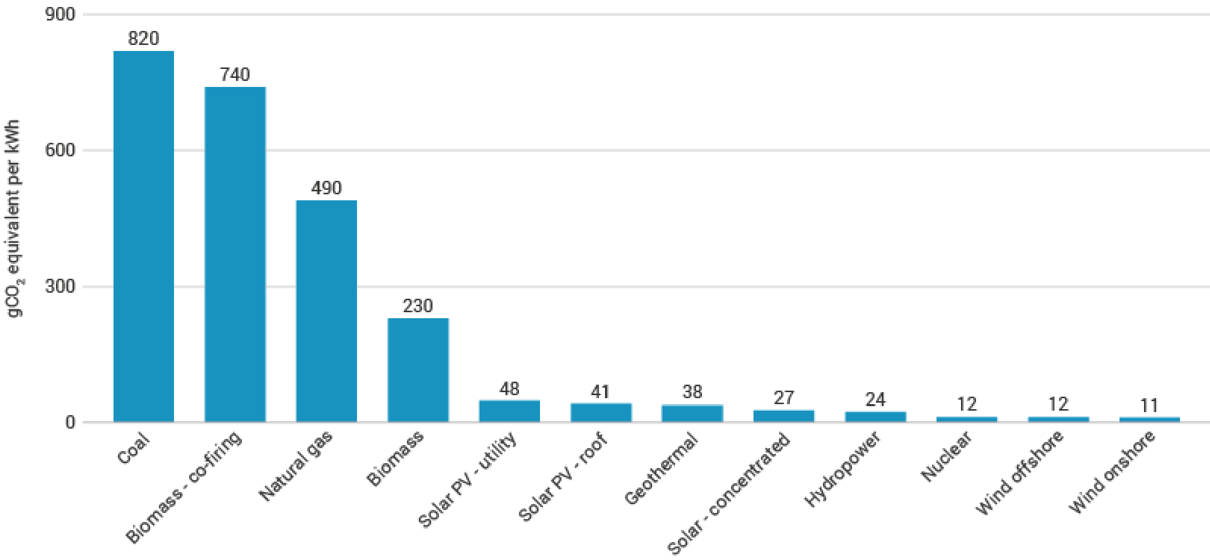


Figure 17: Average emissions of carbon dioxide equivalents in a life cycle of different electricity producers (source: IPCC, /1/, /176/)

The greatest environmental impact would be caused by the release of greenhouse gases, as there are no other sources whose capacity, reliability and economy could cover the electricity deficit.

3.2.2 Land use

On the assumption that Slovenia wants to replace the existing production capacities, the graph in the figure below 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 noted that power plants of the same power installed do not necessarily 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.

On average, NEK in total produces 5,900 GWh of electricity in the years with no outages. On average, the annual production (output) of the Brežice hydroelectric power plant (HPP) is 161 GWh, meaning that 36 comparable hydroelectric power plants or 18 for the Slovenian half of the annual output would be required to replace NEK's annual generation of electricity. If we take account of the annual output of Slovenia's largest hydroelectric power plant, the Zlatoličje HPP (577 GWh per year) /221/, five of these hydroelectric power plants would be required to replace the Slovenian half of NEK's annual output. The Zlatoličje HPP reservoir is 6.5 km in length and covers ca. 1.14 km^2 or 114 ha in area.

The wind turbine with rated power of 2.3 MW in Dolenja vas pri Senožečah has an annual energy output of 4.5 GWh /222/, meaning that we would require 655 wind turbines of that size to replace Slovenia's portion of NEK's annual output. The spacing of ca. seven rotor diameters between wind turbines is recognised globally, which given the size of this wind turbine (rotor diameter of 71 m) would correspond to the spacing of ca. 500 m between turbines and the use of ca. 25 ha of land per turbine. A total of 655 wind turbines could be installed in total in an area of 163.75 km^2.

The annual output of a large solar plant within the Lauingen Energy Park complex in Bavaria with a rated power of 25.7 MW, which extends across 63 ha, is ca. 27 GWh /223/. Comparable solar plants to replace the Slovenian portion of NEK's output would cover ca. 6,883 ha or 68.83 km^2 in area.

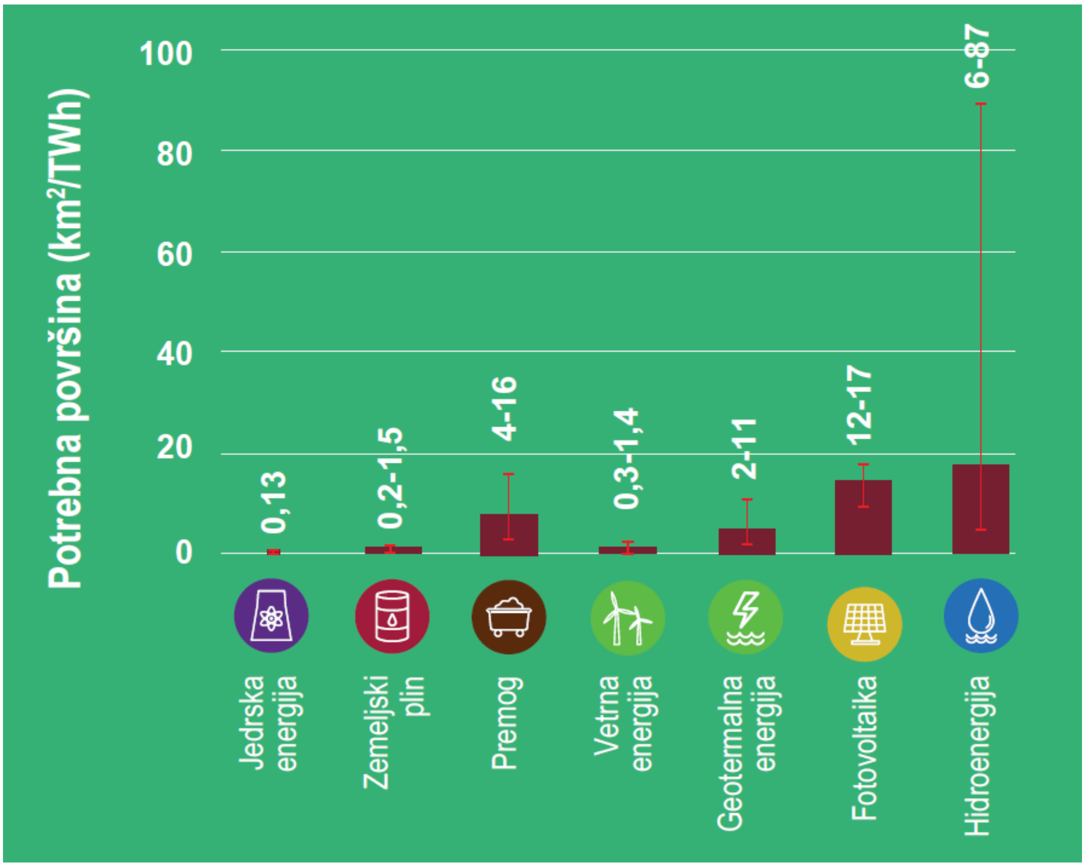


Figure 18: Land use with regard to production source of electricity (Source: /236/)

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

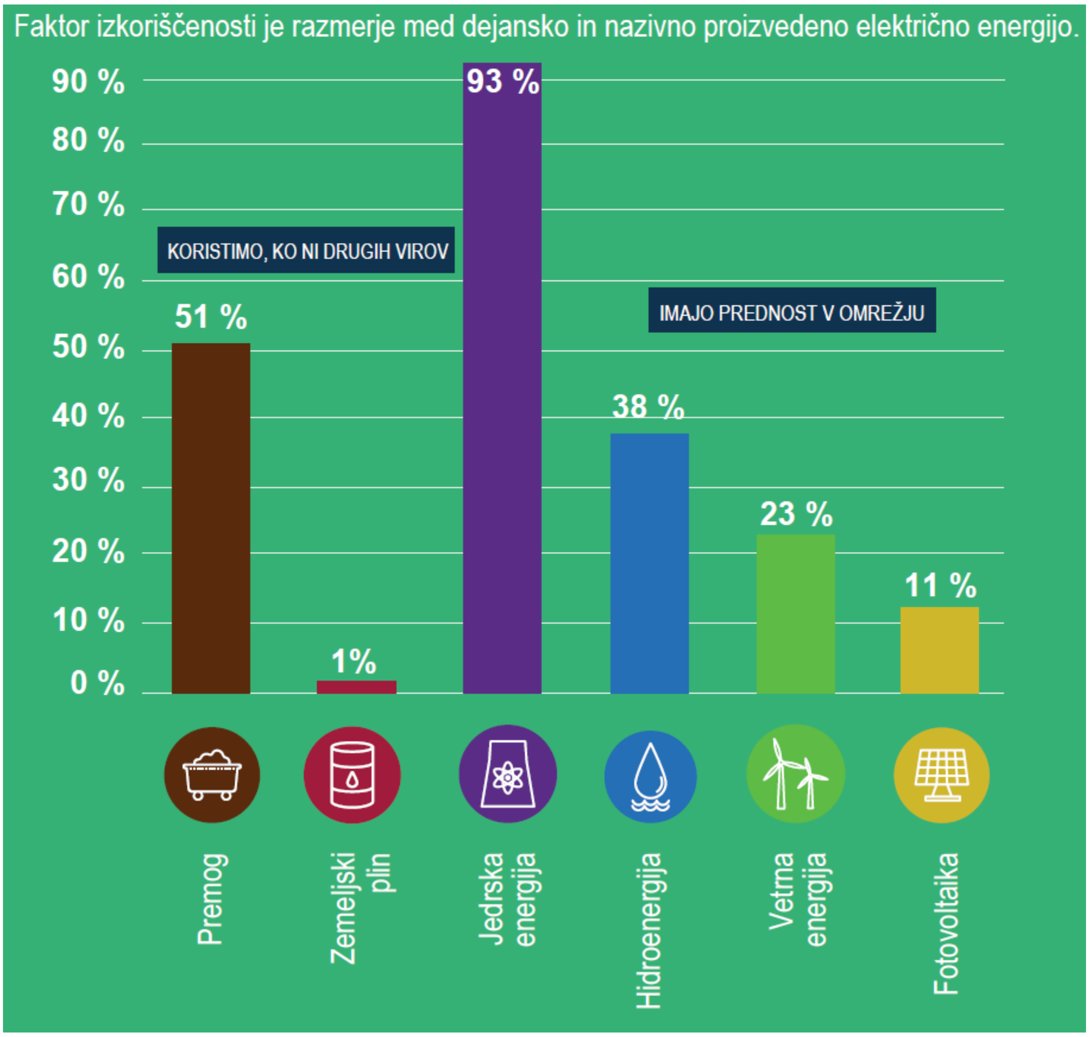


Figure 19: Projected average annual electricity generation with regard to installed power (Source: /236/)

Faktor izkoriščenosti je razmerje med dejansko in nazivno proizvedeno električno energijo.	The utilisation factor is the ratio between actual and nominal generation 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

3.2.3 Other impacts

One of the objectives of Slovenia's Integrated National Energy and Climate Plan (NECP, 2020) in terms of energy safety is to continue to exploit nuclear energy and maintain excellence in the operation of nuclear facilities in Slovenia. In terms of decarbonisation (zero-carbon society), one of the crucial targets is to reach at least 27% of renewable energy sources in final energy consumption by 2030, of which 43% is produced by the electricity sector. It can therefore be concluded that in the event of the non-extension of NEK's operational lifetime, we can expect the missing output to be generated with imports, at least in the initial stage, and from renewable energy sources in the medium term.

In addition to positive impacts, all energy sources also have adverse effects on the environment. The type and intensity of impacts differ depending on the technology used, geographic location and on a number of other factors. While much is known to the professional and general public regarding the effects of non-renewable sources on the environment, certain renewable sources of energy are often treated as completely unproblematic in terms of their environmental impacts. The impact of environmental burdens arising from renewable energy sources is largely or completely overlooked (solar energy: production and decommissioning of solar panels and energy storage units – batteries, wind energy: low-frequency noise and birds, hydro power plants: invasion of natural habitats and excessive growth of algae).

A brief overview of the potential negative environmental effects of renewable sources is given below.

Table 22: Summary of potential adverse effects of renewable sources of energy (Source: /119/, /120/)

Renewable energy sources (RES)	Potential adverse effects
Production of biomass: centralised systems	adverse effects characteristic of vast plantations: degradation of land, use of water, impairment of water quality, adverse effects on the ecosystem, etc.
	decreasing the land area earmarked for the production of food, rise in food prices
Production of biomass: dispersed systems	impoverishment of forests, disruptions to the natural environment due to human activity
Burning (combustion) of biomass	air pollution, release of CO_2 (for now, wood is the most effective form of long-term storage of CO_2)
Solar energy: centralised systems	degradation of vast areas – covered by solar panels
	resulting in the loss of habitats in these areas
	indirect pollution during the production of solar panels and energy storage units
	generation of hazardous pollutants during decommissioning
Solar energy: dispersed systems	in urban areas the heating of installed panels can contribute to the heat island phenomenon
	interference with treetops around buildings with the installed solar panels – removal of trees that cast shade on the panels
	possibility of fire
Wind power: centralised systems	noise from turbines (low-frequency, infra)
	visual degradation and casting shade (locally)
	interference with the flight path of birds
	adverse impact on the ecosystem due to lower wind speeds behind the turbines
	TV signal disruptions
	pollution due to oil spills in case of accidents
	additional occupation of space/area with access routes and transmission lines
Hydropower: centralised systems	loss/destruction of habitats (forests, meadows)
	impairment of water quality
	greenhouse gas emissions due to the decay of accumulated vegetation
	obstacle in the river course, altered hydrodynamics
	change in living conditions for aquatic organisms, suspending contact between populations
	possibility of barriers collapsing or embankments giving way
	change to the local micro climate
Hydropower: small HPP and micro HPP	similar effects as with larger systems
Ocean thermal energy conversion (OTEC)	impact on marine ecosystems: change in water temperature
	change in the chemical composition of the water
	eutrophication and algal bloom

Renewable energy sources (RES)	Potential adverse effects
	application of biocides
Geothermal energy	land in use / nuisance
	subsidence / sinking of ground, micro earthquakes
	noise
	thermal pollution
	air pollution (hydrogen sulphide, methane, ammonia, radon)
	water contamination
Waste incineration	air pollution (especially dioxins, furans and toxic metals), production of hazardous and non-hazardous waste

3.3 ECONOMIC CONSEQUENCES OF THE ZERO VARIANT

Both owners of NEK have already invested in the modification and replacement of equipment as a safety upgrade. Besides discouraging investments, both owners (the Republic of Slovenia and the Republic of Croatia) would have to provide the missing funds for NEK's decommissioning and radioactive waste disposal in the coming 10-year period.

If NEK operates for another 20 years, these financial resources will be collected as levies in both funds earmarked for NEK's decommissioning.

Even if NEK's generation of electricity is replaced by other energy sources, these sources cannot be replaced directly after NEK's lifetime expires due to the protracted siting procedures and also due to an additional period required for the construction of the replacement facilities. This means that initially, directly after 2023, the Republic of Slovenia and the Republic of Croatia would have to completely compensate for the missing portion of energy (on average 5,900 GWh in total in the years with no outages) by leasing electricity from other countries.

A description of the zero variant is presented in Section 4.5 Baseline and outline of likely further development without the activity - lifetime extension (zero variant)

3.4 SITING (SPATIAL POSITIONING)

The planned activity for the extension of the operational lifetime of NEK does not change the position or location of the facilities or transmission line connections, meaning that there is no solution in terms of siting that would be more appropriate.

4. DESCRIPTION OF THE PRESENT STATE OF THE ENVIRONMENT

4.1 BASIC CHARACTERISTICS OF THE SITE OF THE ACTIVITY

4.1.1 Location and geographical characteristics of the area

The site of the activity is located on the Krško plain, which constitutes the southernmost part of the Pannonian Plain in Slovenia. In the north, the Krško plain borders the Pannonian Bizeljsko and Krško Hills, in the west the Dinaric Novo Mesto region, in the south the Dinaric Gorjanci hills, and in the east it reaches Sotla, which runs along the border with Croatia. Most of the Krško plain lies at an altitude between 100 and 200 m. It has the lowest average height above sea level (161 m) in Slovenia. Three quarters of the area are flat with an incline of below 2° (with an average of 1.6°). There are three major rivers in the Krško plain: Sava, Krka and Sotla. As much as a third of the Krško plain are flood zones. The plain is flooded by all three major rivers and most of their tributaries, especially those from the Krško and Bizeljsko hills. Along the Sava, the flood zone is split between Krško and Brežiško Polje, and from Brežice onward it runs along the edge of the Gorjanci hills before reaching the Sotla flood zone at the border with Croatia. The composition of the vegetation in the Krško plain is relatively simple: willow, alder and poplar grow on all deposits along watercourses, as well as on the sandy deposits in the higher parts of the flood plains, oak and hornbeam grow on clay deposits, and hornbeam predominates on all deposits above the flood plains. Due to the extensive forests and flooding, the Krško plain was populated later than the drier and sunnier hills on its outskirts. The flood zones were first cultivated in the Roman era. The largest settlement in the Krško plain is Krško, followed by Brežice and Šentjernej.

The site of the activity is located at the edge of the Krško Polje alluvial plain, on the left bank of the Sava. The narrow area of the site is also located within the Vrbina floodplain, which is the transition point between the eastern edge of the Krško Polje and the western edge of the Brežiško Polje /133/.

Krško Polje is a gravel valley criss-crossed by meadows and fields, the southern edges of which are traversed by the winding Krka river. In the north, across the Sava, Krško Polje borders the forest-covered slope of Bohor. Krško Polje is surrounded by low hills, covered with orchards and vineyards, and ends in the south at the foot of the Gorjanci hills, covered with beech forests, which are home to many game species. To the west, the valley extends into the Krakovski primeval forest, a protected area harbouring several rare and endangered animal and plant species.

NEK is located in the Municipality of Krško, 2.5 km southeast of the town of Krško, at an altitude of between 154 m and 155 m.

4.1.2 Meteorological characteristics of the area, climate data

4.1.2.1 Climate

Krško is located in a temperate continental climate zone. The wider Krško area is characterised by relatively hot summers and mild winters. Average January temperatures are below zero and average July temperatures reach up to 20°C /107/.

4.1.2.2 Climate data

The nearest meteorological station for which climate data is available is Bizeljsko (46° 1' N, 15° 41' E, 174 m a.s.l.), located 16 kilometres northwest of NEK (Figure 20). According to its programme of meteorological measurements, Bizeljsko is a climatological station. Meteorological measurements of temperature and relative humidity and cloud observations are carried out daily at 7 am, 2 pm and 9 pm, while measurements of precipitation and snow depth are carried out daily at 7 am. The description of winds is based on the data obtained from anemometer measurements on the meteorological tower in the radius of NEK.

Climate is defined as the average weather in a particular area over a long period of time. Following the World Meteorological Organization guidelines, climate data (e.g. average annual air temperature, average annual precipitation, etc.) are calculated in 30-year periods. The following shows the Bizeljsko station climate averages[11] for the 1981–2010 period. The annual course of air temperatures and precipitation amounts is shown in the chart (Figure 20), and an overview of the monthly values of climate parameters is shown in the table (Table 23).

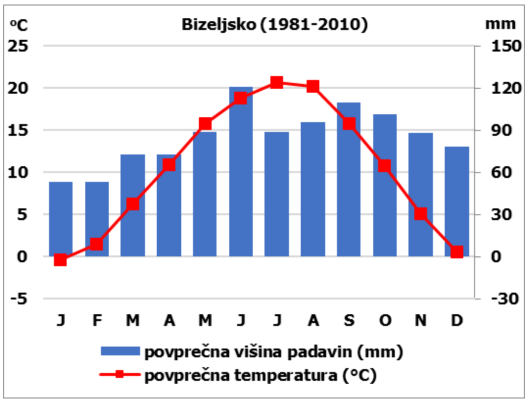


Figure 20: Location of the Bizeljsko climate station and a climate graph for 1981–2010 (source: /106/)

povprečna višina padavin (mm)	**average amount of precipitation (mm)**
povprečna temperatura (°C)	**average temperature (°C)**

The average annual air temperature for Bizeljsko in the 1981–2010 period was 10.5 °C. The coldest month was January, with an average temperature of -0.4 °C, and the warmest was July, with an average temperature of 20.7 °C. In the 1981–2010 period, the absolute lowest air temperature of -26.5 °C was recorded in January, while the absolute highest air temperature of 39.4 °C was recorded in August. In the 1981–2010 period, there were on average:

- 18 ice days between November and February, with the highest number in January (7);
- 92 cold days between October and April, with the highest number in January (24);
- 81 warm days between April and October, with the highest number in July (23);
- 24 hot days between May and August, with the highest number in July (10).

In the 1981–2010 period, the annual precipitation in Bizeljsko averaged 1,024 mm. On average, the highest precipitation was in June (121 mm). This annual maximum precipitation is characteristic of the continental precipitation regime. September (101 mm) and October (110 mm) also stand out in terms of precipitation. In the 1981–2010 period, there was an average of 125 precipitation days per year (days with precipitation above 0.1 mm). There were on average 35 days per year with precipitation above 10 mm, with the highest number (4) in June and September.

In the 1981–2010 period, there were on average 57 clear days per year (cloud cover 2/10 or less) and 113 mostly cloudy days per year (cloud cover 8/10 or more). July and August are the months with the highest number of clear days (9) and the lowest number of cloudy days (4). December is the month with the highest number of cloudy days (17), followed by November and January (15). In addition to December, October and November also have the lowest number of clear days per year (2).

In the 1981–2010 period, snowfall occurred at the Bizeljsko meteorological station from November to March. There were on average 40 days with snow cover. On average, the highest number of snow days was in January (13).

[11] Climate averages is the term used for climate data for precisely defined 30-year periods, starting from the 1901–1930 period.

Table 23: Climate data for Bizeljsko, 1981–2010 (source: /106/)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
average temperature (°C)*	-0.4	1.5	6.2	10.9	15.8	18.8	20.7	20.2	15.8	10.8	5.1	0.6	10.5
average highest daily temperature (°C)*	3.3	6.5	12.1	17.3	22.8	25.8	28.1	27.6	22.5	16.4	9.1	3.8	16.3
average lowest daily temperature (°C)*	-3.6	-2.9	1.0	5.2	9.9	13.1	14.9	14.5	10.8	6.5	1.7	-2.2	5.7
absolute maximum temperature (°C)	17.6	21.8	26.2	29.8	33.6	36.0	38.0	39.4	31.6	27.0	22.2	20.6	39.4
absolute minimum temperature (°C)	-26.5	-23.0	-15.2	-5.4	0.2	4.2	6.6	4.6	1.6	-4.8	-16.2	-18.6	-26.5
average number of days with maximum temp. <0°C	7	3	0	0	0	0	0	0	0	0	1	6	18
average number of days with minimum temp. < 0°C	24	21	11	2	0	0	0	0	0	2	11	21	92
average number of days with maximum temp. > 25°C	0	0	0	1	9	16	23	22	8	1	0	0	81
average number of days with maximum temp. > 30°C	0	0	0	0	1	5	10	8	0	0	0	0	24
average relative humidity at 7 a.m. (%)	89	89	87	87	87	88	89	91	92	93	92	91	90
average relative humidity at 2 p.m. (%)	73	60	53	50	50	53	51	52	57	64	72	79	59
average relative humidity at 9 p.m. (%)	86	80	74	72	75	78	77	80	85	88	88	89	81
average cloud cover at 7 a.m. (in tenths)	7.5	6.5	6.3	6.0	5.4	5.4	4.5	5.2	7.4	8.1	8.0	8.2	6.5
average cloud cover at 2 p.m. (in tenths)	6.6	5.6	6.0	6.1	5.7	5.5	4.5	4.4	5.3	5.7	7.0	7.2	5.8
average cloud cover at 9 p.m. (in tenths)	6.2	5.1	4.9	5.0	4.4	4.8	3.8	3.3	4.1	4.7	6.4	6.7	4.9
average number of clear days (cloud cover 2/10 or less)	3	5	5	4	6	6	9	9	3	2	2	2	57
average number of cloudy days (cloud cover 8/10 or more)	15	9	9	8	6	6	4	4	8	10	15	17	113
average precipitation (mm)*	53	53	73	73	89	121	89	96	110	101	88	78	1,024
average number of days with at least 0.1 mm of precipitation	8	8	10	12	12	13	10	10	10	10	11	12	125
average number of days with at least 1 mm of precipitation	7	7	8	10	10	11	8	8	9	8	9	9	105
average number of days with at least 10 mm of precipitation	2	2	2	2	3	4	3	3	4	3	3	2	35
average number of days with snow cover at 7 a.m.	13	10	3	0	0	0	0	0	0	0	3	10	40

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
average depth of snow cover at 7 a.m. (cm)*	5	5	1	0	0	0	0	0	0	0	1	3	1.2
maximum depth of snow cover at 7 a.m. (cm)	45	59	45	7	2	0	0	0	0	0	35	56	59
daily fresh snow depth (cm)*	16	17	5	1	0	0	0	0	0	0	7	16	61

Figure 21 shows the wind rose at a height of 10 m above ground based on measurements from the meteorological tower in a radius around NEK from 2001 to 2019. In the Krško area, weak winds from the southwestern quadrant are prevalent (directions: SW – 9.9%, WSW – 10.3%, and W – 8%), followed by wind from the northeast (ENE – 10.6%). Winds with speeds above 5 m/s are rare (1.1% per year) and come from the southwestern quadrant (directions: SW, WSW and W). The north-northeast wind has the highest average speed (2.0 m/sec), followed by the south-southwest wind (1.8 m/s). Calm periods with winds of less than 0.3 m/s are a common occurrence at the NEK site. In the 2001–2019 period, the average annual incidence of calm periods was 7.4%.

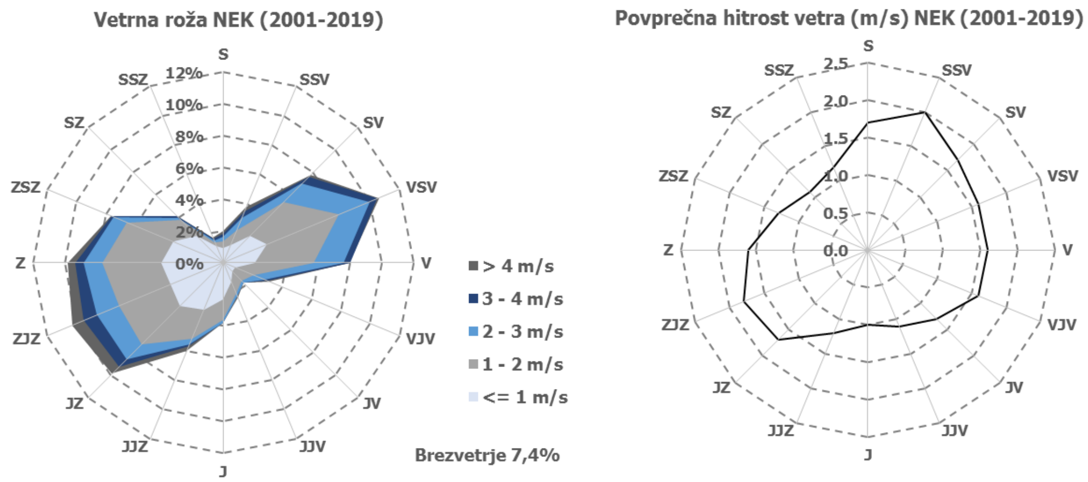


Figure 21: Wind rose (left) and average wind speeds by direction (right) at the NEK meteorological tower (10 m above ground) for the 2001–2019 period (Source:/107/, processing: EKONERG)

Vetrna roža NEK (2001-2019)	Wind rose for NEK (2001–2019)
S	N
SSV	NNE
SV	NE
VSV	ENE
V	E
VJV	ESE
JV	SE
JJV	SSE
J	S
JJZ	SSW
JZ	SW
ZJZ	WSW
Z	W
ZSZ	WNW
SZ	NW
SSZ	NNW
Brezvetrje 7,4%	Windless periods 7.4%
Povprečna hitrost vetra (m/s) NEK (2001-2019)	Average wind speeds (m/s) for NEK (2001–2019)

4.1.2.3 Observed climate change

The 2019 global average temperature was 1.1 ± 0.1°C above pre-industrial levels. The year 2019 was the second-warmest since measurements began, and the last decade (2010–2019) has been the hottest on record. Since the 1980s, each successive decade has been warmer than any preceding decade /67/.

Human activities are estimated to have so far caused a global increase in temperature, i.e. global warming, of approximately 1°C compared to the pre-industrial period. If the current trend continues, global warming is expected to reach 1.5°C between 2030 and 2052 /68/.

Average annual air temperatures from 1961 to 2020 in Slovenia, shown in Figure 22, indicate a strong increase in temperatures at the end of the 20th and the beginning of the 21st century.

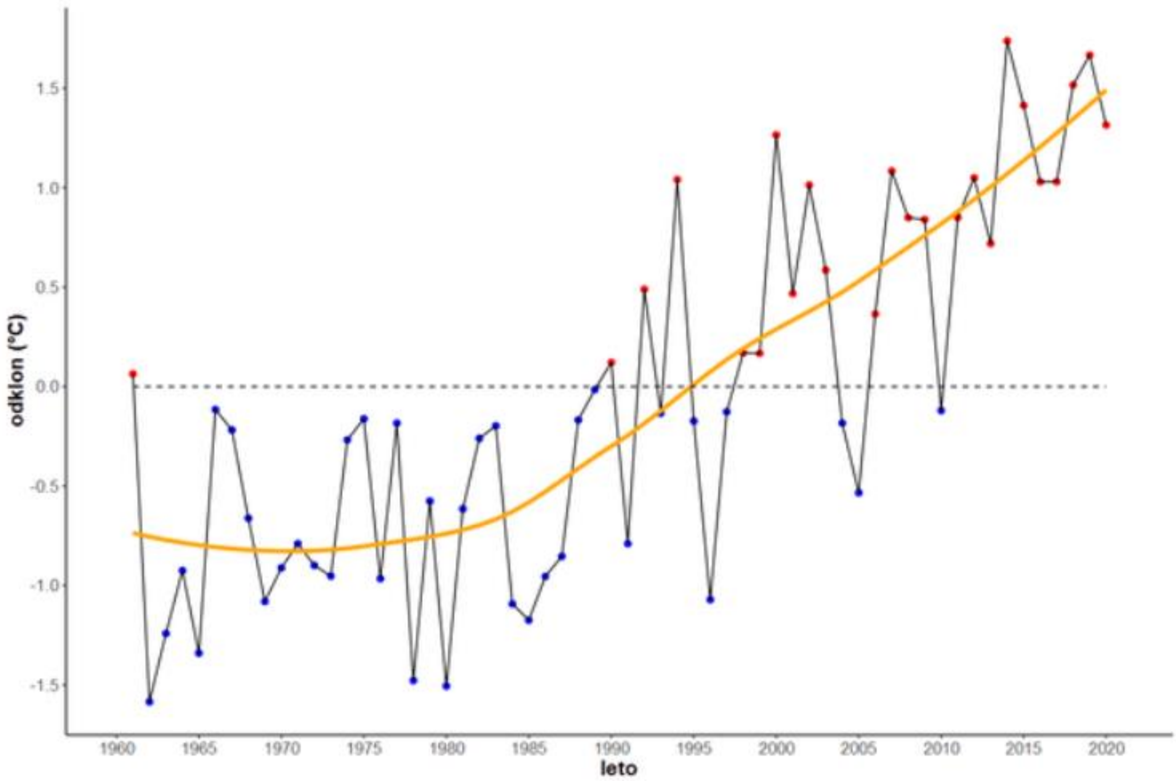


Figure 22: Deviation in average annual air temperatures from the average for the 1981–2010 period (source: /68/).

odklon (°C)	deviation (°C)
leto	year

From 1961 to 2011, the following climate-change characteristics were recorded in Slovenia /70/:

- The average air temperature increased by 1.7°C.
- The trend of increase in air temperature is slightly more pronounced in the eastern compared to the western half of the country.
- Greatest warming was observed in spring and summer, slightly lesser in winter. Autumns did not show any significant change.
- The annual amount of precipitation decreased by around 15% in the western half of the country, and slightly less (10%) in the eastern half of the country, where the changes are not statistically significant.
- The greatest decrease in the amount of precipitation was observed in spring (across the country) and summer (in the southern half of the country).

- The total depth of the snow cover decreased by around 55%.
- The depth of fresh snow decreased by 40%.
- The annual duration of sunshine increased on average by 10%, mostly due to the increase in spring and summer. The duration of sunshine thus increased by 30–40 hours per decade.
- Evaporation increased by around 20% since 1971, mainly as a result of an increase in spring and summer.
- Annual air pressure increased by 1.5 hPa on average.
- The greatest increase in air pressure was observed in winter, slightly less in spring. The increase in air pressure is significantly lower in summer and the lowest in autumn.
- Water temperature increased by 0.2°C per decade for surface waters (1953–2015) and 0.3°C per decade for groundwater (1969–2015).

Figure 23 shows average annual air temperatures and annual precipitation at the Bizeljsko meteorological station in the 1961–2011 period. There is a clear increase in air temperatures and a decrease in precipitation over the period of observation, although it should be noted that the variability of precipitation is naturally significantly higher than the variability of air temperature. The trend of changes in monthly air temperatures was +0.39°C per decade, while the decrease in precipitation was -2.34 mm per decade, as shown in Figure 24.

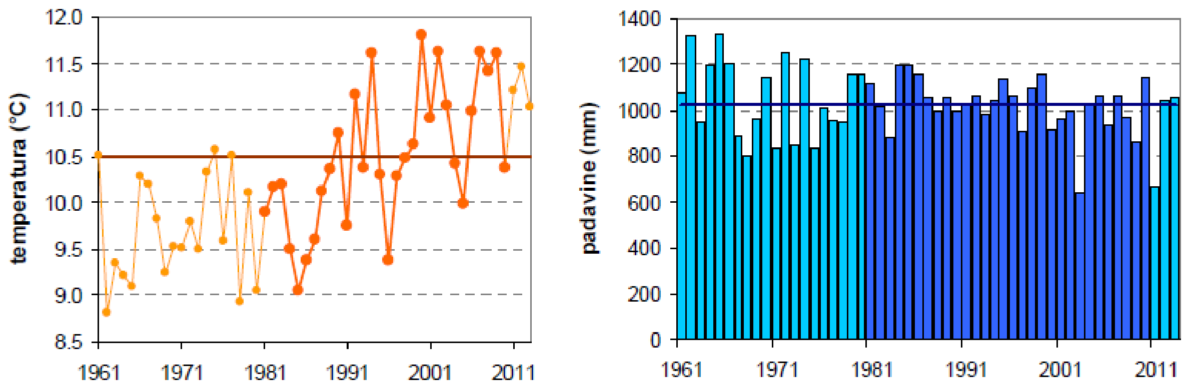


Figure 23: Average annual air temperatures and annual precipitation for Bizeljsko in the 1961–2011 period (source: /106/

temperatura (°C)	temperature (°C)
padavine (mm)	precipitation (mm)

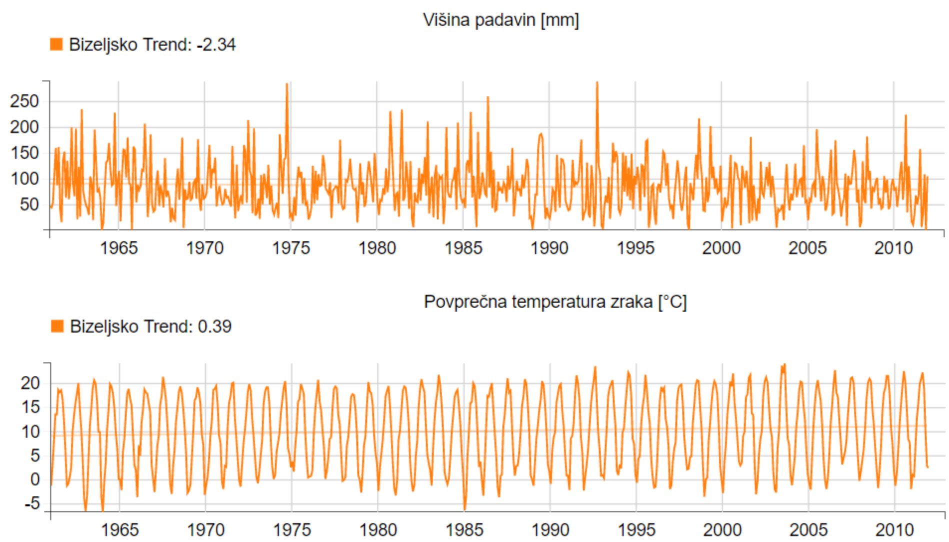


Figure 24: Precipitation and temperature trends at the Bizeljsko climate station in the 1961–2011

period

Bizeljsko Trend: -2.34	Bizeljsko trend: -2.34
Višina padavin [mm]	Amount of precipitation [mm]
Bizeljsko Trend: 0.39	Bizeljsko Trend: 0.39
Povprečna temperatura zraka [°C]	Average air temperature [°C]

In the 1961–2011 period, average annual air temperatures at all meteorological stations near NEK increased by around 0.4°C per decade, while precipitation decreased by around 20–40 mm or 2–4% per decade (Figure 25). An increase in temperatures was recorded in all seasons, with the highest increases in summer. The decrease in annual precipitation was mainly due to a decrease in spring and summer precipitation /73/.

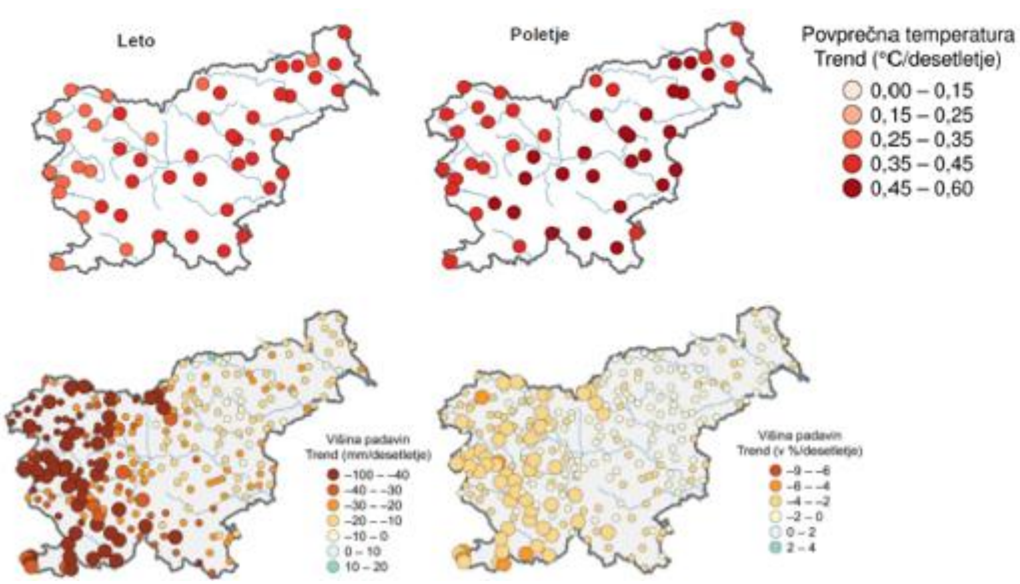


Figure 25: Trend of changes in temperatures and precipitation (source: /72/)

Leto	Year
Poletje	Summer
Povprečna temperatura Trend (°C/desetletje)	Average temperature Trend (°C/decade)
Višina padavin Trend (mm/desetletje)	Amount of precipitation Trend (mm/decade)
Višina padavin Trend (v %/desetletje)	Amount of precipitation Trend (in %/decade)

Climate change, which affects precipitation and the flow and temperature of the Sava river, is addressed in the Periodic Safety Review, i.e. at least once every ten years. The impact of the changes on the Sava basin (e.g. the construction of Brežice hydroelectric power plant) and of changes to the use of space in the surrounding area is evaluated before the changes take effect. Measurements of the profiles of the Sava channel are taken periodically at least every five years or after markedly high water levels that exceed the 50-year return period (3,060 m^3/s).

4.1.2.4 Expected climate change in the 21st century

The future course of climate change depends on actual greenhouse gas emissions, which are described by different scenarios of possible greenhouse gas concentration, or Representative Concentration Pathways (RCP). The scenarios are based on human activity-related emissions of CO_2, CH_4, N_2O and other air pollutants. Each of the scenarios depends on global socio-economic factors such as population growth, gross domestic product and technological development in the 21st century, which directly affect the consumption of primary energy resources and oil, as well as changes in land use. The scenarios can be distinguished by the numerical designation of the sum of radiative forcing, which is a general measure of the increase in the greenhouse effect compared to the pre-industrial period and is expressed in watts per square meter (W m^{-2}). The most optimistic scenario, RCP2.6, envisages active climate change mitigation and low greenhouse gas emissions that are expected to peak in the early 21st century and then gradually decline, with a radiative forcing of 2.6 Wm^{-2} at the end of the century. The stabilisation scenario RCP4.5, considered moderately optimistic based on the current situation, envisages a gradual reduction of emissions and stabilisation of radiation forcing at 4.5 W m^{-2} by 2100. Similarly, the stabilisation scenario RCP6.0 foresees a value of 6.0 W m^{-2} in 2100 and stabilisation shortly after. The most pessimistic scenario, RCP8.5, foresees no climate change mitigation actions and projects high emissions and a resulting increase in their concentration beyond 2100, with radiative forcing reaching 8.5 W m^{-2} at the end of the century. For the purposes of the analysis of future climate, the 21st century is divided into three projection periods: 1st period from 2011 to 2040 (central year 2025), 2nd period from 2041 to 2070 (central year 2055), and 3rd period from 2071 to 2100 (central year 2085). To account for spatial differences, six smaller spatial regions within Slovenia were addressed in accordance with the following climate classification: High mountains, wet hilly region, northeast region, southwest region, central region, and hilly transition region /74/.

Climate projections are simulations of the Earth's climate in future decades using climate models. Results of climate modelling are typically expressed as a deviation from a reference period. Given that climate projections are mainly derived on the basis of calculations using several climate models, the results often indicate a range of values (minimum and maximum), in addition to the expected (median) value.

Figure 26 shows the range of climate projection values for air temperature and precipitation changes under three climate projection scenarios for Slovenia and the "central region" in which NEK is located. The lines represent the smoothed median of model projections, while the envelopes represent the maximum and minimum values for each model projection. Projections for the "central" region differ slightly from the average climate projection values for the territory of Slovenia.

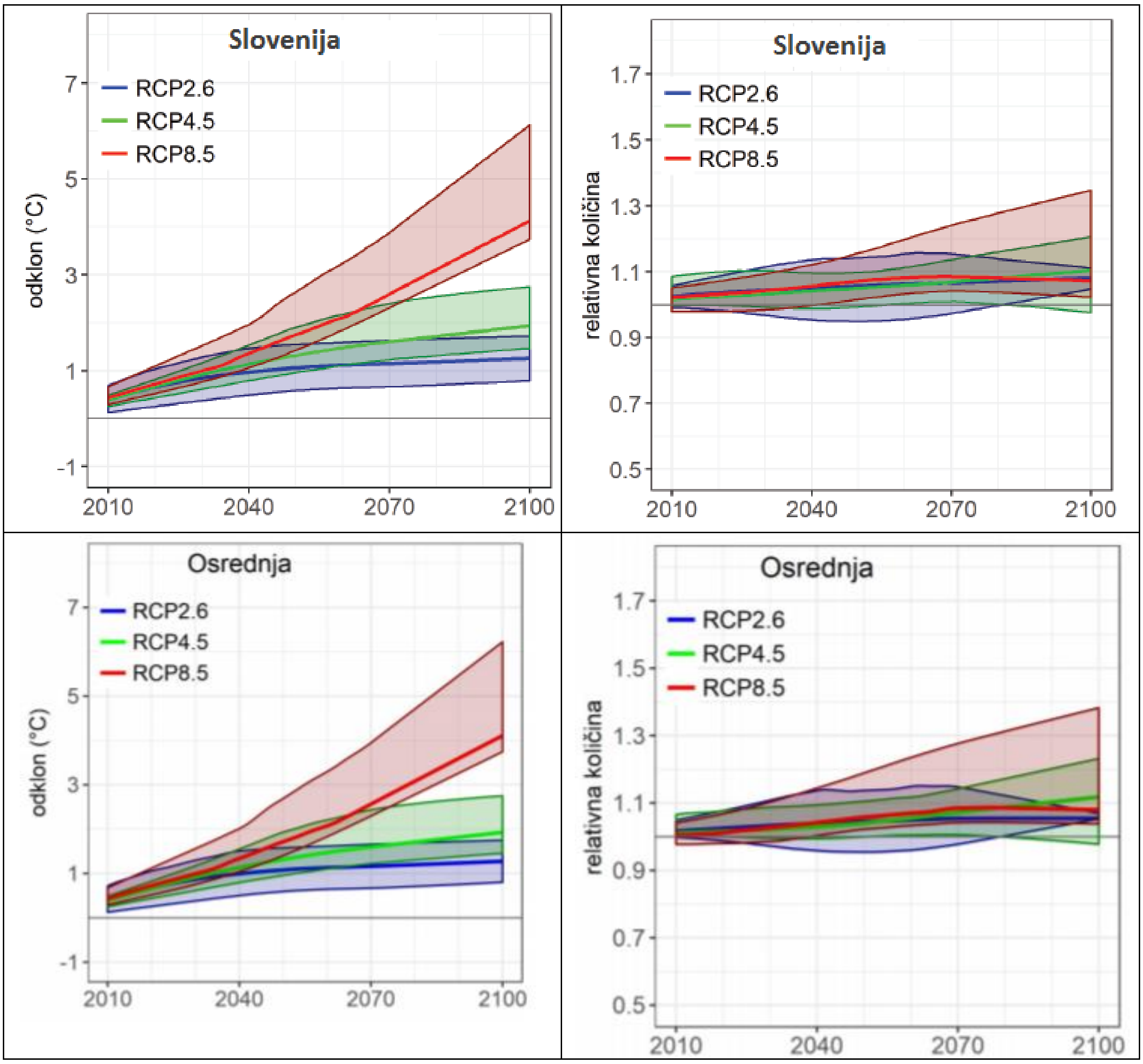


Figure 26: Changes in average annual air temperatures and precipitation during the 21st century compared to the reference period of 1981–2010 for scenarios RCP2.6, RCP4.5, and RCP8.5, including possible deviation ranges (source: /74/)

odklon (°C)	deviation (°C)
Slovenija	Slovenia
RCP2.6	RCP2.6
RCP4.5	RCP4.5
RCP8.5	RCP8.5
relativna količina	Relative amount
Osrednja	Central

The greater the radiative forcing, the greater the expected changes in the climate system. Stabilisation scenario RCP4.5, which, based on the current situation, is considered moderately optimistic and most likely in the next century, envisages a gradual reduction of emissions and stabilisation of the radiative forcing at 4.5 W m^{-2} by 2100.

By 2100, the RCP4.5 scenario foresees an increase in air temperatures of about 2°C; temperatures will initially rise and stabilise at the end of the 21st century. While Slovenia will experience significant temperature changes in all seasons, warming in winters is expected to be more pronounced than average annual warming at the end of the century. In the Alpine region, the northeast and central Slovenia, the rise in winter temperatures will be even steeper. Warming will be the least pronounced in the spring. In contrast to temperature, precipitation change scenarios are less reliable due to the greater temporal and spatial variability of precipitation. There are significant differences between precipitation change signals under different emission scenarios, particularly in the second half of the 21st century. In the case of the moderately optimistic scenario RCP4.5, no significant annual changes are expected initially, though the signals intensify further on in the future. With the beginning of the second period, the area of increasing annual precipitation will begin to spread from east to the west of Slovenia. By 2100, the average annual precipitation in Slovenia, with the exception of the northwest, is expected to increase by around 10% compared to the 1981–2010 period. At a seasonal scale, the precipitation change signal is slightly more pronounced; in the case of the moderately optimistic scenario RCP4.5, the increase in precipitation will be most pronounced in winter. Compared to the 1981–2010 average, summers are expected to be drier during the first two projection periods, while at the end of the century they are expected to be wetter. The values of the seasonal changes in precipitation strongly depend on the future course of greenhouse gas emissions. Thus, in the case of the RCP4.5 scenario, summer precipitation first decreases, then increases at the end of the century. Winter increase in precipitation does not imply an increased probability of snowfall, as the simultaneous rise in air temperatures suggests that snowfall is likely to become less frequent.

The following is a summary of climate scenarios for the first (2011–2040) and second (2041–2070) 30-year period under the moderately optimistic scenario RCP4.5 that assumes significant emission mitigation actions, compared to the 1981–2010 average.

- Air temperature changes:
  - 2011–2040: on average, Slovenia will warm by 1°C at the annual scale. A temperature rise of approximately 1 degree is expected in all seasons except spring, where the projected rise is under 0.5°C;
  - 2041–2070: by the middle of the 21st century, Slovenia will warm by 2°C at the annual scale. As in the previous 30-year period, this period shows a fairly steady rise in summer, autumn, and winter temperatures, and a slightly less pronounced rise in spring temperatures;
- Changes in precipitation:
  - 2011–2040: no significant changes in annual precipitation are expected, although there are slightly more pronounced precipitation change signals at the seasonal scale. The most significant change is projected for winters, when an increase in precipitation is likely;
  - 2041–2070: by mid-century, changes in precipitation will intensify. At the annual scale, precipitation is projected to increase in the eastern half of the country, while for the western half of the country the precipitation increase signal is weaker. Changes at the seasonal scale are expected to be greater than those at the annual scale. The winter precipitation increase signal will continue to strengthen relative to the preceding 30-year period, and the eastern half of the country is also expected to experience more precipitation in the autumn. For summer, the precipitation change signal shows a decrease, particularly in the southern half of the country, whereas in spring, the signal is the least pronounced, indicating a slight increase in precipitation in the western part of the country;
- Changes in potential evapotranspiration:
  - 2011–2040: major changes in potential evapotranspiration are not expected in the near future, with the clearest change signal indicating an increase in potential evapotranspiration in autumn;
  - 2041–2070: by mid-century, changes in potential evapotranspiration will be more pronounced. An increase at the annual scale is projected, which will be most pronounced in the southwest of the country. At the annual scale, changes will be primarily driven by the increase in potential evapotranspiration in summer and autumn, while the increase in spring and winter will be less significant.

According to climate projections for the 21st century, the following changes in hydrological conditions can be expected in Slovenia /74/:

- Under all emission scenarios, no major changes in mean annual flow rates are expected in Slovenia compared to the 1981–2010 period, with the exception of the northeast, where flow rates could increase by up to 30% by the end of the century under the moderately optimistic scenario (RCP4.5).

Under the pessimistic emission scenario (RCP8.5), the increase in the northeast of Slovenia could reach up to 40% by mid-century.

- Compared to the 1981–2010 period, mean annual peaks will rise throughout the country, on average from 20 to 30% under all emission scenarios. This increase will intensify from the near future towards the end of the century. The increase in peaks will be most significant in the northeast of the country, reaching up to around 30% under the moderately optimistic emission scenario. Under the pessimistic emission scenario, the increase will range from 20 to 40% at almost all gauging stations at the end of the century. Under the moderately optimistic and pessimistic scenarios, changes in moderate low flow rates are spatially uneven, showing a significant increase of around 20% only in parts of the northern half of Slovenia.
- Under all emission scenarios, an increase in annual 100-year-flood levels is expected for all periods in the future relative to the 1981–2010 period, throughout the majority of the country. Under the RCP2.6 emission scenario, the largest increase is projected in the eastern part of the country and the rivers of the Adriatic basin. Under the RCP4.5 and RCP8.5 emission scenarios, the increase in 100-year-flood levels is not as significant as in RCP2.6 scenario. Larger increases are expected in the northeast of the country.

Table 24 shows climate projections of temperature and precipitation in the "central region" for 2025 (as the central year of the 2011–2040 period) and 2055 (as the central year of the 2041–2070 period). Included are the projections for all three climate scenarios (RCP2.6, RCP4.5, RCP8.5), shown as deviation from the 1981–2010 reference period. For ease of comparison, Table 24 does not include minimum and maximum values, but only the median values of climate projections.

All climate projections show a warming trend in the 21st century, with a particularly steep rise in temperatures in the second half of the century under the RCP8.5 scenario. In addition to the increase in average and maximum daily air temperatures, warming in the 21st century is also reflected in an increase in the heat indices (number of warm days, number of hot days, number of tropical nights), and a decrease in cold indices (number of cold days, number of ice days), as can be seen in Table 24 and Table 25.

The trend of precipitation change is not unequivocal across all models, as can be seen in Figure 26, where values less than 1 indicate a decreasing trend, while values greater than 1 indicate an increasing precipitation trend. Although most climate projections point to an increase in precipitation, some also predict a decrease, especially in the middle of the 21st century under the RCP2.5 scenario. Median values of the projections under all climate scenarios indicate an increase in average precipitation and maximum daily precipitation, as well as an increase in the number of days with precipitation exceeding 10 mm. Unlike temperature indices, which show a clear warming trend, precipitation indices do not show a clear decreasing trend in the duration of consecutive dry days (CDD) and an increase in the duration of consecutive wet days (CWD), as evident from Table 24.

Table 24: Climate projections of temperature and precipitation changes for the "central" region expressed as deviations from the 1981–2010 period (source: /75/, /76/)

	2011–2040 PERIOD for the central year 2025			2041–2070 PERIOD for the central year 2055		
	RCP2.6	RCP4.5	RCP8.5	RCP2.6	RCP4.5	RCP8.5
Average temperature (°C)	0.8	0.8	0.8	1.1	1.4	1.8
Highest daily average temperature (°C)	0.8	0.8	0.8	1.1	1.4	1.7
Lowest daily average temperature (°C)	0.9	0.8	0.8	1.2	1.4	1.8
Number of warm days (SU)	11.4	10.5	11.2	13.9	19.9	22.5
Number of hot days	7.7	5.9	6.4	7.6	12.7	14.3
Number of tropical nights (TR)	1.3	1.6	1.7	2.3	5.0	7.7
Number of frost days (FD)	-10.9	-9.0	-9.3	-16.2	-16.7	-23.5
Number of ice days (ID)	-3.1	-3.6	-3.9	-4.9	-7.4	-9.4

	2011–2040 PERIOD for the central year 2025			2041–2070 PERIOD for the central year 2055		
	RCP2.6	RCP4.5	RCP8.5	RCP2.6	RCP4.5	RCP8.5
Amount of precipitation (%)	4	4	3	7	6	10
Maximum 1-day precipitation amount (Rx1day) (%)	3.0	4.8	4.4	6.9	9.3	12.4
Annual number of days with precipitation above 10 mm (R10mm)	1.2	0.8	0.2	2.1	1.5	2.6
Annual maximum consecutive dry days (CDD) (number of days)	-1.1	-0.3	0.3	-1.2	0.3	-0.5
Annual maximum consecutive wet days (CWD) (number of days)	0.0	-0.1	-0.1	0.3	0.0	-0.1

Changes in the mean annual flow rate of the Sava in the 21st century do not show significant differences across individual emission scenarios /70/. Table 25 gives an overview of changes in hydrological indicators for all three climate scenarios (RCP2.6, RCP4.5, RCP8.5) over two climate periods (2011–2040 and 2041–2070), as well as their statistical significance. Changes in low flow rates range from -5% to 5% under all three scenarios (RCP2.5, RCP4.5, RCP8.5) in both climate periods (2011–2040 and 2041–2070) and are not statistically significant. The following changes in the 2041–2070 period were assessed as statistically significant: an increase in the average flow rate of up to 20% under the scenario RCP8.5, and an increase in high water flow rates of up to 20% under scenarios RCP4.5 and RCP8.5.

Table 25: Climate projections of hydrological variables for the Sava – Čatež location (source: /77/)

	2011–2040 PERIOD			2041–2070 PERIOD		
	RCP2.6	RCP4.5	RCP8.5	RCP2.6	RCP4.5	RCP8.5
Moderate flow rate	**-5% – +5%**	**-5% – +5%**	**-5% – +5%**	+5% – +20%	+5% – +20%	+5% – +20%
High flow rate	5% – +20%	5% – +20%	5% – +20%	5% – +20%	5% – +20%	5% – +20%
Moderate low flow rate	**-5% – +5%**	**-5% – +5%**	**-5% – +5%**	**-5% – +5%**	**-5% – +5%**	**-5% – +5%**

Key:
- A low degree of reliability indicates significant differences across climate models, which produce conflicting results.
- The "no change" degree of reliability denotes that the combination of applied models shows a small, statistically insignificant change, which is probably masked by the natural variability of the climate.
- A high degree of reliability denotes that changes in a certain direction are highly probable.

4.1.3 Geological and hydrogeological characteristics of the area

4.1.3.1 Geological characteristics

The site of the activity is located in the area of Krško Polje. In geotectonic terms, the wider Krško area lies on the NW edge of the sinistral strike-slip Mid-Hungarian zone, near the SE margin of the Sava tectonic wedge characterised by the E–W oriented Sava folds. The principal (leading) structures in the Mid-Hungarian zone are the NE trending ("Balaton") strike-slip faults. The leading (principal) structure of this sinistral strike-slip zone is the Sveta Nedelja fault, on the southern margin of the Gorjanci hills, and the Zagreb fault running along the southern margin of Mt Medvednica. The Sveta Nedelja fault represents a continuation of the Zagreb fault. The Orlica fault is the northwestern-most of the Balaton faults and exhibits post-Badenian sinistral strike-slip activity. It is therefore considered an external margin of the Mid-Hungarian strike-slip zone. The frequency of the Balaton faults increases from Orlica fault towards the SE.

The Krško syncline is the most prominent plicative structure in the marginal part of the Mid-Hungarian zone. According to the data from seismic and gravimetric surveys and numerous boreholes, the Krško syncline has a NE trend in the central part of the Krško Basin, turning in an E–W direction towards the west, where it approaches the SW continuation of the Orlica fault. The central and eastern parts of the

Krško syncline are not parallel to the Balaton faults, since the angle between them is around 30°. Taking into account the sinistral strike-slip character of the Balaton faults, the Krško syncline may represent a "fault-flank depression" between (or related to) the Orlica and Artiče faults to the north, and the set of sub-parallel Balaton faults south of the syncline, observed in the Gorjanci hills /82/.

The wider area around the site is part of the Krško Basin, where Mesozoic sediments of unknown thickness lie below the Krško syncline of Tertiary sediments. The oldest Tertiary sediment is Ottnangian clay silicate-gravel with coal. Its granularity is medium to very thick. Above this is erosionally and irregularly placed solid Badenian limestone, covered in places with limestone Sarmatian resediments. These sediments are then covered in the Krško Basin by a 1,000-metre-thick layer of Sarmatian fine-grained clastites (well-consolidated clayey carbonate sludge, silt, sandy silt and fine-grained sand) of Pannonian and Pontian age. The last and youngest unit of this area is a covering of Plio-Quaternary clastites: medium- to coarse-grained Sava gravel of varying thickness. The last Quaternary Sava layer is fairly shallow (up to 15 m).

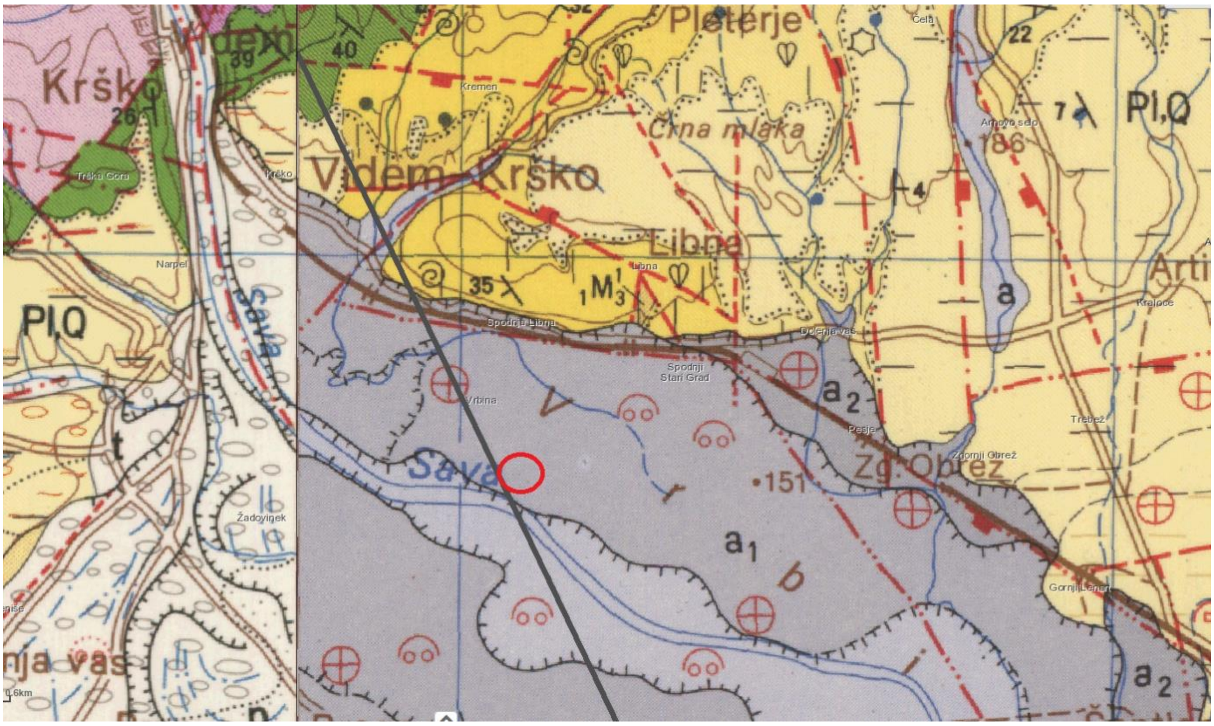


Figure 27: Excerpt from the basic geological map, 1:100,000, with the marked site of the activity (source: /79/)

4.1.3.2 Geological characteristics at the site of the activity

Geological conditions at the planned site are summarised after the "Geological–Geotechnical Report For Dry Storage Building – DSB" (IRGO) /80/.

The upper layer (IG0b) of the artificial embankment, designated NA, is medium to very dense sandy gravel.

This is followed by a thin layer (1 to 2-metre-thick) of Quaternary clay deposits (IG1a) underlaying the artificial embankment. This layer is classified as CL, SM (low-plasticity clay and silt).

Beneath the clay layer is a very thin layer of silt and sand (IG1b) classified as SM. This is followed by a relatively thick layer of gravel with sand (IG1c) – GW, GM – that is medium to densely compacted.

The base layer consists of Miocene clays and silt deposits (IG2a) of very firm to very dense (ML) consistencies.

4.1.3.3 Hydrogeological characteristics

NEK is located at the northwestern edge of the Krško Polje/Brežiško Polje, on the left bank of the Sava, a few kilometres downstream from the town of Krško. In geological terms, this region is a complex boundary zone between the Dinarides, Alpine structures, and the Pannonian Basin. The oldest dated rocks on the terrain surface are from the Permian and Triassic periods and form the cores of the anticlines along the edges of the Krško Polje/Brežiško Polje /154/.

The Krško Polje/Brežiško Polje depression formed in the early Neogene as part of the Paratethys in the wider Pannonian Depression on the northeast of the Dinaric platform, which divided the former Tethys sea into the Pannonian and Adriatic Basins. Since the Krško Polje/Brežiško Polje was part of the Pannonian sedimentary area in the Neogene, Neogene strata can be observed continuously in the direction of the Hrvatsko Zagorje from the Krško–Brežice depression towards the northeast. The carbonate and clastic strata at the edges of the depression are partially covered by Neogene strata which have transgressed over the older substrates.
The Neogene strata (M, Pl) are lithologically predominantly clastic, starting with sandy and clayey Miocene layers. The total thickness of the Neogene strata is estimated at 700 m /158/.

The transition to the Quaternary is marked on the surface by eroded remains of Plio-Quaternary strata in the upper part of the Libna ridge. These are silicate silty-sand layers, distributed throughout the Krško Polje/Brežiško Polje in different thicknesses, depending on the morphology of the sedimentation basin at the transition from the Neogene to the Quaternary. Forming of depressions with surface tributaries with direct catchment areas and the forming of closed lakes – wetlands – are characteristic of the end of the Neogene and the beginning of the Quaternary in the Dinarides. The increase in the amount of water in the interglacial period resulted in an intensified process of fragmentation, expansion of river basins, and the forming of connections between karst water systems through water infiltration and its re-emergence at the lower levels of the basin. A similar process took place during the Pleistocene in the Krško Polje/Brežiško Polje, where Plio-Quaternary sediments filled the depressions in the relief.

In the Holocene, a significant increase in surface waters in the Sava and Krka basins caused an intrusion of their water flows from parts of the basin that are today remote; the so-called third river terrace was thus formed by the deposits of both rivers. The second river terrace runs along most of the course of the Sava, while the first runs along its entire course. These are mainly gravelly-sandy sediments 7 to 20 m thick, with an average thickness of around 12 m /158/.

The tectonics is very complex due to the contact of two macrostructural forms of the Alps and the Dinarides /156/. The opening of the Pannonian Basin began at the transition from the Oligocene to the Early Miocene with the rising of the carbonate platform of the Dinarides, separating the Adriatic and Pannonian Basins. An important role in the opening of the "large" Pannonian Basin and local basins was played by the regional movement of structural blocks in the northeast direction along the Medvednica fault. A sedimentation basin thus opened in the Middle Miocene stretching from Novo Mesto towards the Hrvatsko Zagorje, and the Krško Polje/Brežiško Polje also lies in this zone.

The hydrogeological relations are directly related to the geological characteristics of the terrain – the lithological and tectonic relations. In the wider area of the Krško Polje/Brežiško Polje and further downstream towards the Zagreb aquifer in the Republic of Croatia, three basic groups of rocks and sediments of different hydrogeological characteristics can be found. These are moderately to poorly permeable rocks with fissure porosity in the surrounding hills, completely impermeable fine clastic Neogene sediments and permeable clastic Quaternary sediments.

The rocks of the surrounding hills form a base of Neogene, predominantly clastic sedimentary rocks of the Pannonian Basin. On the southeastern side of the Krško–Brežice basin, this is the anticline of the Gorjanci hills, in the lithological sense of alternating clastites, dolomite, and a smaller amount of limestone, on the basis of which this complex can be classified as moderately to poorly permeable rocks. Consequently, there are no large karst springs along the right bank of the Krka river, which flows across the Krško Polje/Brežiško Polje along the northern edges of the Gorjanci hills. The northwestern side of the Krško Polje/Brežiško Polje has a similar geological structure as the southeastern side. Anticlines with a core of Triassic dolomite dominate, stretching from Krško towards Bizeljsko, where they gradually "sink" under the Neogene strata of the Pannonian Basin. These are rocks with fissured porosity, the permeability of which is limited due to the large amount of clastic rocks, which also affects the formation of active aquifers. There are no strong groundwater sources in this area and most drainage of the precipitation takes place on the surface, via torrential streams flowing into the Sava /154/, /157/.

Geophysical research has established that the Krško Polje/Brežiško Polje depression is filled with fine clastic strata of Neogene age with a total thickness exceeding 700 m /158/. Hydrogeological surveys and other interventions carried out as part of water supply management have determined that the majority of the Neogene clastic strata, with the exception of Lithothamnion limestones, constitute an impermeable layer. Pumping experiments carried out near NEK as part of a hydraulic conductivity study have determined hydraulic conductivity of Neogene strata at around $3x10^{-7}$ m/s /159/.

Plio-Quaternary and Quaternary clastic strata were formed by sediments deposited by the Sava and Krka. In lithological terms, Plio-Quaternary strata comprise a mixture of gravel, sand, silt, and clay and mainly fill depressions in the relief formed by Neogene sediments. They were formed by erosion and run-off from the local basins of the Krško–Brežice depression, as well as sedimentation of aeolian material, resulting in the higher clay content in the sediment with relatively low hydraulic conductivity values of $1x10^{-6}$ to $1x10^{-8}$m/s. The strata of Quaternary age (Holocene) are the result of the Sava "breaking through" from the precipitation-rich Alpine area to reach Krško Polje/Brežiško Polje and further downstream the Danube. In terms of lithology, this layer can be characterised as a classic gravelly alluvial deposit, created by the Sava and partly its right-side tributary Krka in the area of Brežice, with a thickness of between 7 and 20 m. The hydraulic conductivity of the Sava alluvial deposit is high, ranging from $1x10^{-1}$ to $1x10^{-3}$ m /160/.

The consequence of the geological and hydrogeological conditions of the Krško–Brežice Depression described above is that the only active aquifer system is tied to the alluvial deposits of the Sava and the river itself, which is the main water conduit from the remote, precipitation-rich Alpine region, as well as the main drainage point for maintaining a balance in the local groundwater system in the Krško Polje/Brežiško Polje. The Sava also has a significant impact on the impermeable fine clastic strata of Neogene age, which was confirmed by simultaneous measurements of groundwater levels in deep Neogene and shallow Quaternary strata conducted in 2009 and 2010. The measurements demonstrated a comparable groundwater storage potential in both aquifers /159/, which does not directly affect the overall hydrogeological picture of the area.

In the Krško area, the Sava enters a wide valley before reaching Brežice, then narrows again after the confluence with the Krka. After Brežice, the river opens towards Čatež and further downstream towards the Samobor basin in Croatia and the narrower aquifer between Medvednica and Samoborska Gora /160/.

From a hydrogeological point of view, the two aquifers are interconnected, with downstream extensions from Krško and across Čateško Polje towards the Samobor and finally Zagreb aquifers, where the Sava and its connected underground aquifers function as a kind of corridor between the Krško–Brežice and Zagreb aquifers. Numerous water pumping wells are in operation along this aquifer corridor in both Slovenia and Croatia.

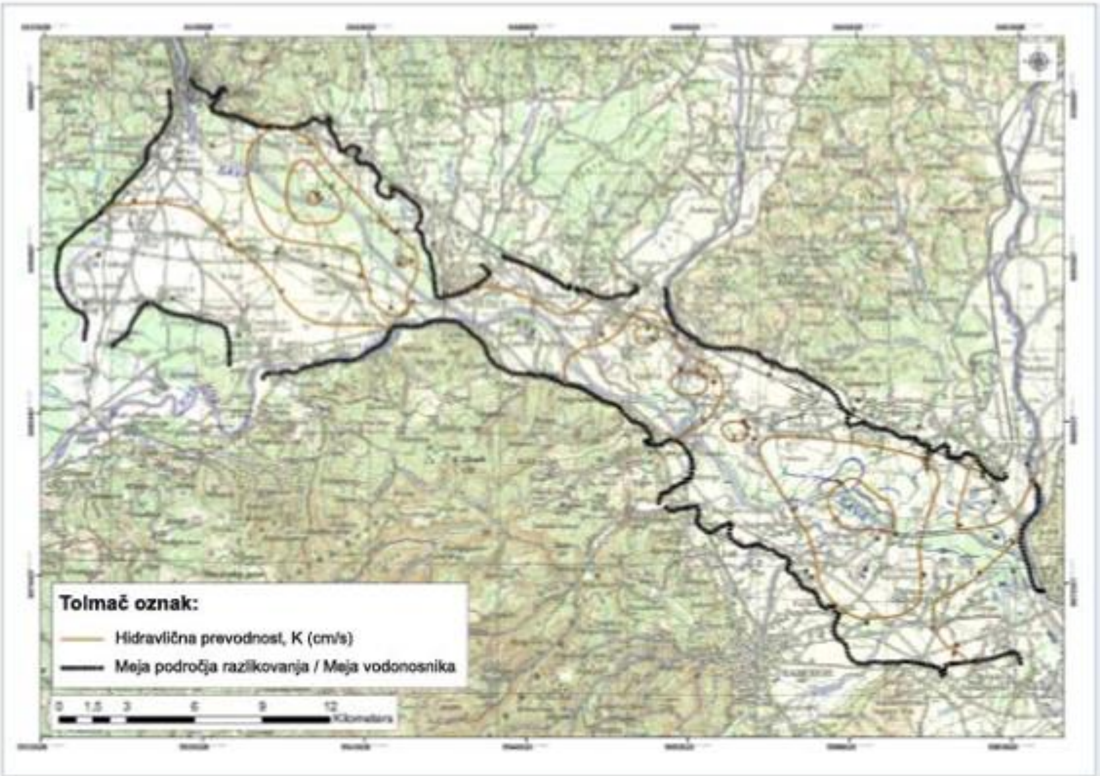


Figure 28: Boundaries of the aquifer from Krško to the end of the Samobor aquifer with hydraulic conductivity values (source: /160/)

Tolmač oznak:	**Map key:**
Hidravlična prevodnost, K (cm/s)	Hydraulic conductivity, K (cm/s)
Meja področja razlikovanja / Meja vodonosnika	Differentiation area / Aquifer boundary

The distribution of the hydraulic conductivity of alluvial deposits along the Sava (Figure 28) shows the highest values (K = 4 cm/s) in the central part of the Krško Polje/Brežiško Polje, as well as in the central part of the Samobor basin. The hydraulic conductivity of the Sava alluvial deposits decreases as the aquifer narrows in the area of Brežice, at Čateško Polje, and at the transition from the Samobor to the Zagreb aquifer /160/.

Groundwater in the alluvial aquifer flows to the south and southeast under the hydrological conditions of low and medium water levels (Figure 29 and Figure 30). The exception occurs at high water levels, when the Sava feeds the alluvial aquifer along its entire length (Figure 31).

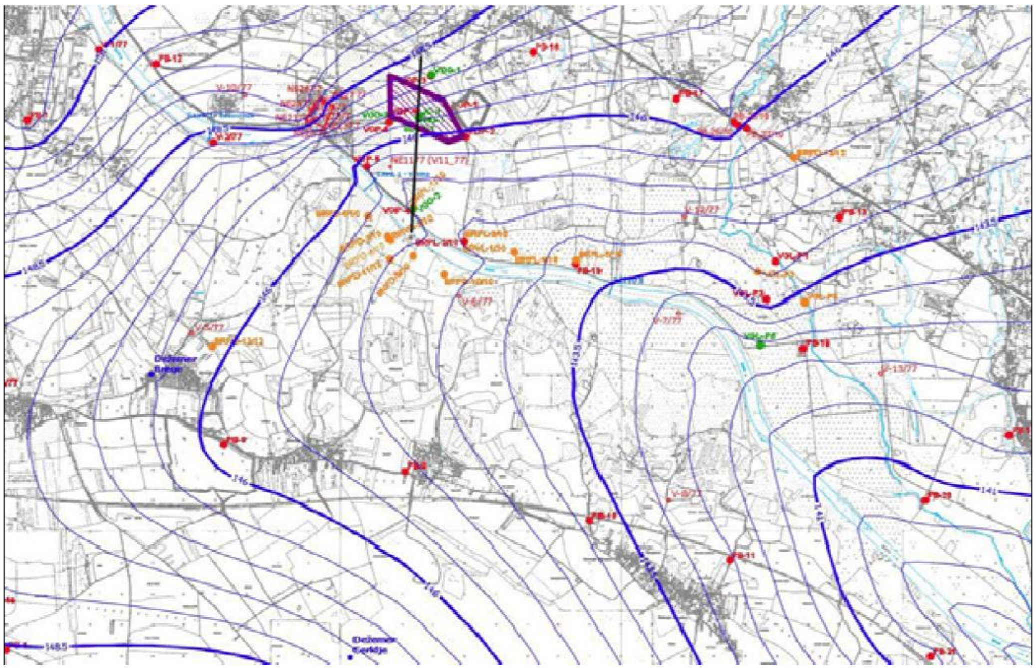


Figure 29: Groundwater contour map for the Quaternary aquifer at low water levels (source: /189/)

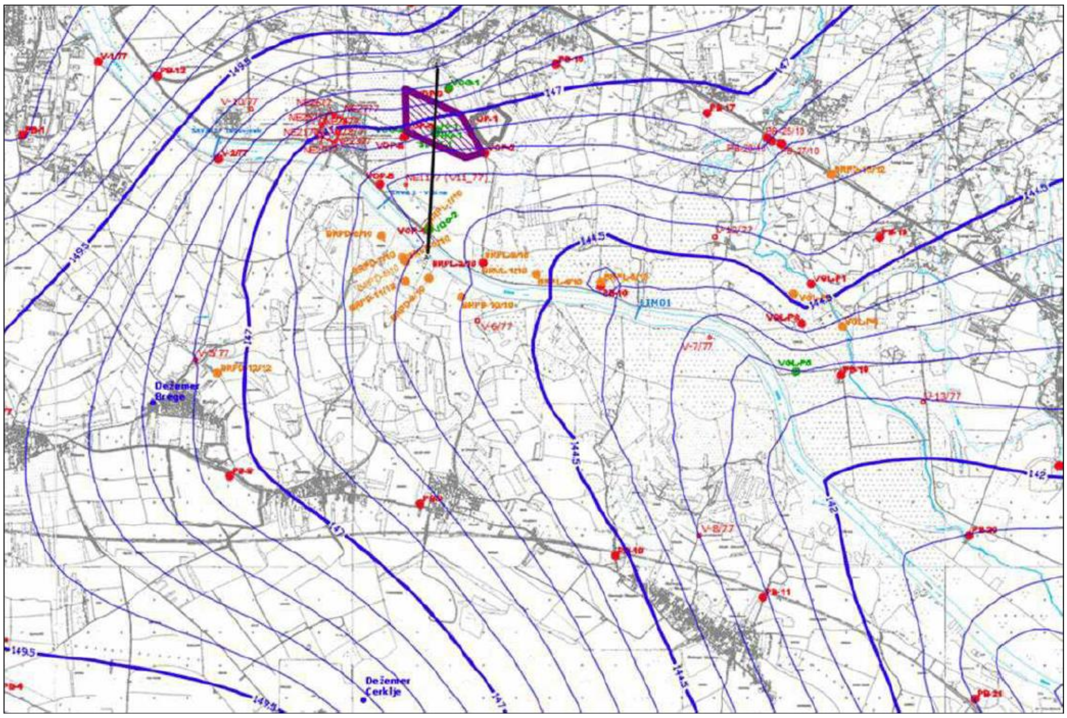


Figure 30: Groundwater contour map for the Quaternary aquifer at medium water levels (source: /189/)

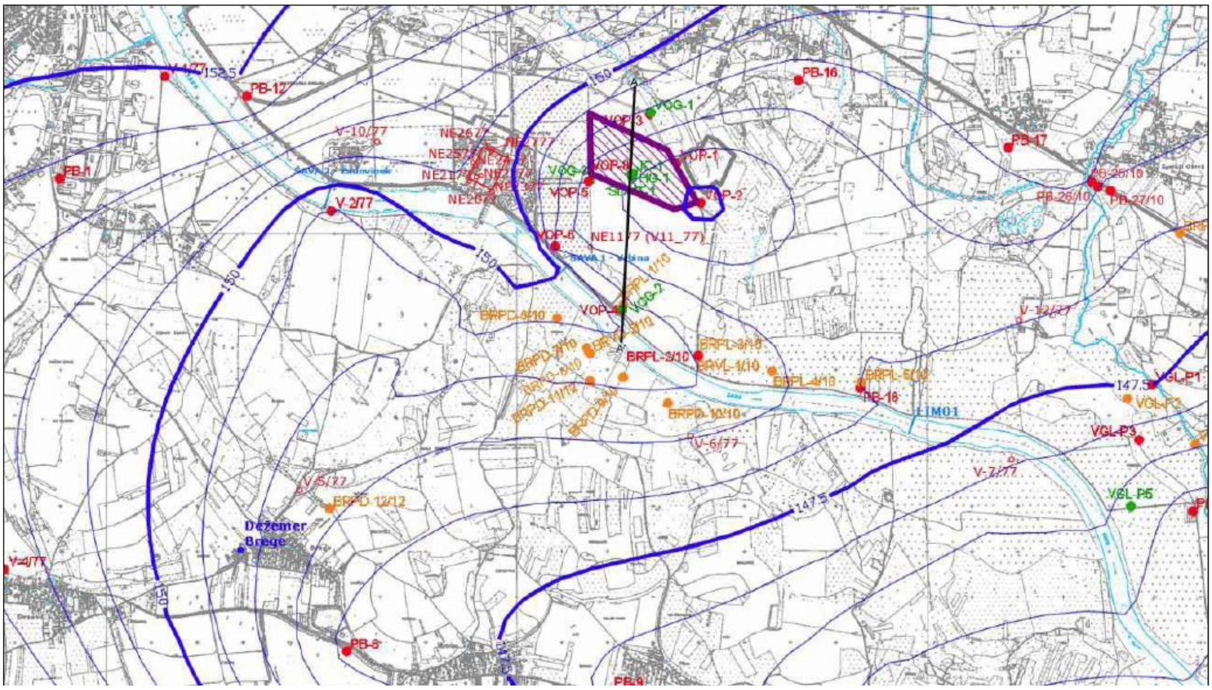


Figure 31: Groundwater contour map for the Quaternary aquifer at high water levels (source: /189/)

Krško nuclear power plant (NEK) was built on the left bank of the Sava in the area of the alluvial aquifer. A dam has been built next to the power plant on the Sava, raising the level of the river to allow gravitational supply of cooling water to NEK. The slowing of the river flow at the dam results in an increase in groundwater levels on the left and right banks upstream from NEK, and a groundwater recharge in all hydrological conditions (low, medium, and high water levels).

NEK was designed on the left bank of the Sava in the form of an "island", built using a sealing curtain measuring 144 m x 192 m, within which NEK and all its installations are located /161/. The top of the curtain is built at an elevation of 154.5 m a.s.l., while the bottom lies at 141.0 m a.s.l., amounting to a total depth of 13 m. NEK is thus almost fully isolated from the highly water permeable Quaternary aquifer. The construction of the Brežice HPP caused the maximum water level of the Sava to rise to an elevation of 153.20 m a.s.l., compared to the maximum water level of 151.21 m a.s.l. recorded prior to the construction of the Brežice HPP.

As part of an inspection of the operation of the sealing curtain, carried out on the interior and exterior sides of the curtain, pairs of piezometric boreholes were drilled in 2009 and a parallel measurement of groundwater levels inside and outside the sealing curtain was performed. A potential difference Δh of 0.3 to 1.3 m was recorded on the two sides of the curtain.

Relative to NEK and the surrounding area enveloped by the sealing curtain, the negative groundwater gradient demonstrates that the groundwater is "bypassing" the protected area of NEK, and flowing without impact towards the Sava, which drains groundwater on its left bank /155/.

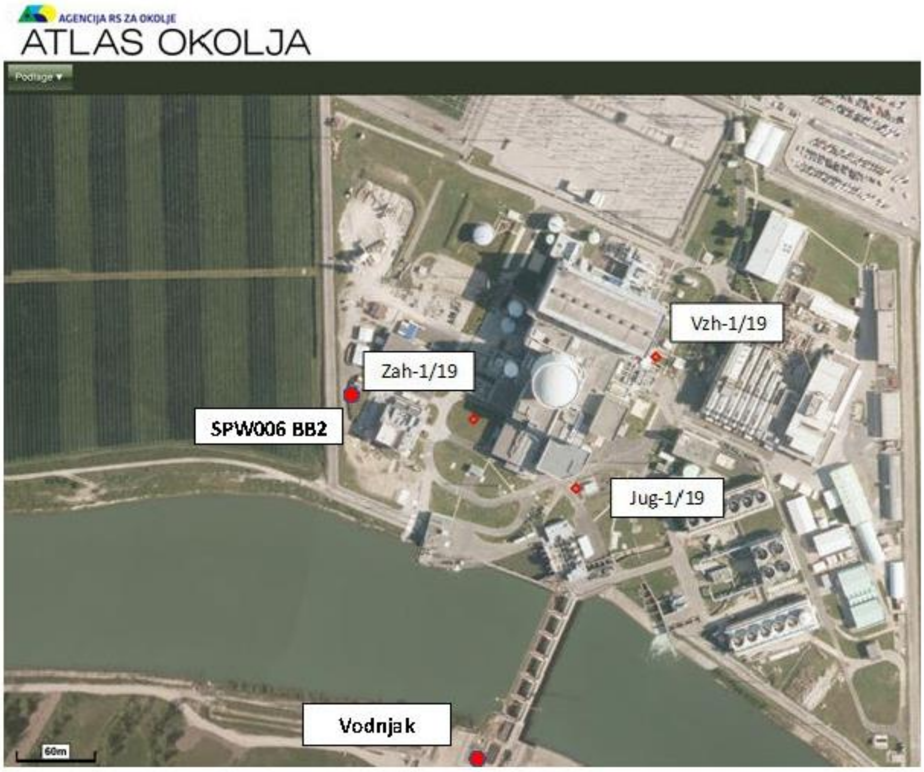


Figure 32: Locations of wells: well on the right bank of the Sava, wells within the sealing curtain area (wells 1/19), well SPWW006 BB2 (source: /163/, /276/)

AGENCIJA RS ZA OKOLJE	SLOVENIAN ENVIRONMENT AGENCY
ATLAS OKOLJA	ENVIRONMENT ATLAS
Zah-1/19	West-1/19
Vzh-1/19	East-1/19
Jug-1/19	South-1/19
Vodnjak	Well

All pairs of piezometers record a difference in the groundwater level; the smallest difference is recorded on the southeastern side of NEK, which may indicate that the resistance to the flow of groundwater is lowest at this part of the sealing curtain. In all cases, a slightly lower groundwater level was recorded within the sealing curtain, although surface and groundwater levels generally rose by around 1 m following the construction of the Brežice HPP. In order to ensure that groundwater levels remain at levels seen before the construction of the Brežice HPP, the Slovenian Water Agency issued a water permit in 2020 for the construction of three wells within the sealing curtain area with a maximum allowable pumping rate of 5.0 l/s at an individual well, or a total of 70,000 m^3/year per well (Figure 32) /163/. The wells have been constructed and pumping tests conducted. The thickness of the Quaternary aquifer at the locations of the wells is around 3.2 m, and the aquifer permeability is 2.3 x 10^{-3} m/s. In this way, the groundwater level within the sealing curtain area is maintained at the previous level.

Another well (depth approx. 13 m) has been in use within the NEK perimeter since 9 September 2021. Water is pumped from the well at a maximum rate of 8.0 l/s (230 m^3/year). The mean value of the permeability coefficient obtained through trial pumping is 1.4*10-2 m/s. In accordance with the water permit /276/, the impact on the water regime is monitored by measuring the current and total quantities of water intake at least once a day. Measurements are also taken of the groundwater level at least once a day. The measurements must clearly show the groundwater level when the well is at rest and when pumping is taking place.

4.1.3.4 Krško Basin (Krška kotlina) groundwater body

There are **two major water areas** in the territory of Slovenia: the **Danube Basin** and the **Adriatic Basin**. The system of drainage from the territory of Slovenia is dominated by the Danube Basin with Slovenia's largest rivers: Sava, Drava and Mura with their tributaries. The Sava, which originates in the Julian Alps and flows across the central part of Slovenia to the border with Croatia, has the largest river basin in Slovenia. At the town of Krško, the Sava flows into the ***VTPodV_1003 Krška kotlina*** **groundwater body**, which covers the entire Krško Polje/Brežiško Polje /164/. Its surface area is 96.76 km^2. It is approximately 9 km wide and 18 km long. According to the water management plan from 2016, VTPodV_1003 Krška kotlina is one of the groundwater bodies assessed as extremely vulnerable /164/.

Three typical aquifers are defined within VTPodV_1003 Krška kotlina. The first is an **intergranular alluvial** aquifer, formed by the sediments of the Sava and Krka and their tributaries. These are extensive, local and moderately to highly productive aquifers. The second aquifer or group of **aquifers formed in Pleistocene and Tertiary sediments** under the alluvial deposits of the Sava. These are intergranular, extensive and local aquifers of low to moderate productivity. The third aquifer or group of aquifers are **thermal aquifers** formed in **carbonate rocks** in the bedrock of Tertiary strata. Aquifers in carbonate rocks are karstic/fissured aquifers. They can be extensive, local and of low to high productivity.

Within the VTPodV_1003 Krška kotlina water body, there is one larger groundwater pumping station, Brege (around 60 l/s), which supplies the town of Krško, as well as 8 smaller local pumping stations. The Drnovo pumping station is currently not operating due to the high levels of nitrates in the water. There are designated water protection areas for all potable water pumping stations. The water protection area of the largest pumping station at Brege extends to the Sava, upstream and downstream from the NEK dam.

The construction of the Brežice HPP reservoir changed the hydrological and hydrogeological conditions in VTPodV_1003 Krška kotlina. Water flow along the Sava towards Brežice has slowed down due to the construction of the dam, which slows down the flow of water to an elevation of 153.20 m – the maximum level of the reservoir with a volume of around 3,120,000.0 m^3. All accompanying construction along the Brežice HPP dam and the upstream part of the reservoir serves the purpose of preserving the previous state of balance between the lake, groundwater, and the biosphere. Embankments have been built along the northeastern and southwestern sides of the lake to limit the uncontrolled expansion of the lake area into the Krško basin. Seepage through the embankments on both sides of the lake is controlled with drainage channels along the embankments, that is, gravitational drainage into the Sava downstream of the dam. The embankment next to NEK, reaching from the dam to the elevation of 154.5 m, has all the characteristics of a flood dyke with no water seepage into the left bank. A groundwater enrichment facility has been built upstream of the NEK dam on the right bank of the Sava, which treats groundwater flowing towards potable water pumping stations on the right bank of the river and the NEK pumping station. In this way, the wider area of NEK is protected from the projected high water levels of the Brežice HPP reservoir, the infiltration of Sava waters into the right bank, where important potable water pumping stations are located, is increased, and a connection to groundwater on both banks is ensured with levels elevated by around 1 m.

4.1.4 Surface waters

The surface water body into which wastewater from NEK is discharged, and which is used by the power plant for technological and cooling purposes, is the Sava Krško–Vrbina water body (Figure 33). Table 26 shows the properties of this water body in accordance with the Rules on the definition and classification of surface water bodies (Official Gazette of RS, Nos. 63/05, 26/06, 32/11, and 8/18).

Table 26: Properties of the Sava Krško–Vrbina water body (source: /93/)

Code	Basin	Surface water	Water body	Type	Classification by type	Criteria used to define the water body				
						Type	Significant hydromorphological change	Interruption	Significant anthropogenic physical change	Significantly different condition
SI1VT913	Sava	Sava	WB Sava Krško–Vrbina	L	11VA	x	x			

L – large catchment area (more than 10 000 km^2), 11 – The Pannonian Plain hydroecoregion, which is part of the Hungarian Lowland ecoregion 11 according to the classification of Illies, A – limestone

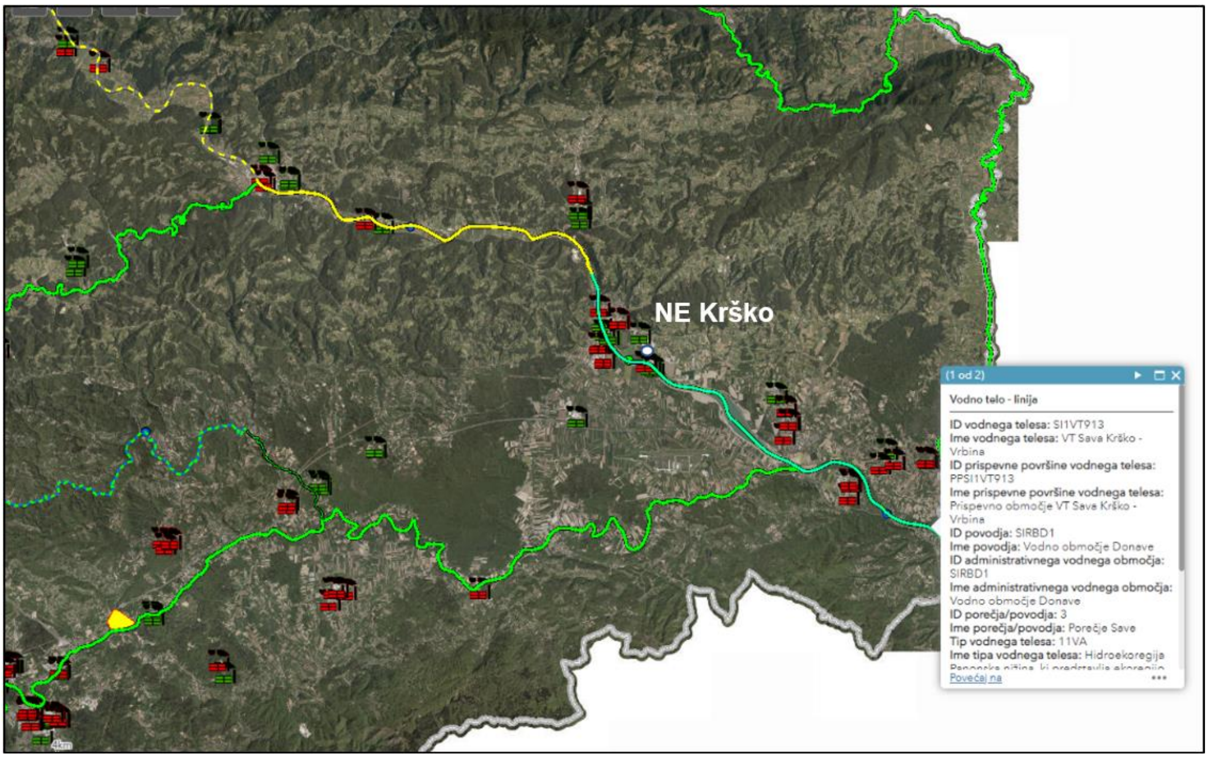


Figure 33: The WB Sava Krško–Vrbina area (source: /61/)

NE Krško	NEK
(1 od 2)	(1 of 2)
Vodno telo – linija	Water body – line
ID vodnega telesa: SI1VT913	ID of the water body: SI1VT913
Ime vodnega telesa: VT Sava Krško – Vrbina	Name of the water body: WB Sava Krško–Vrbina
ID prispevne površine vodnega telesa: PPSI1VT913	ID of the water body catchment area: PPSI1VT913
Ime prispevne površine vodnega telesa: Prispevno območje VT Sava Krško – Vrbina	Name of the water body catchment area: WB Sava Krško–Vrbina catchment area
ID povodja: SIRBD1	ID of the river basin: SIRBD1
Ime povodja: Vodno območje Donave	Name of the river basin: Danube river basin
ID administrativnega vodnega območja: SIRBS1	ID of the administrative river basin district SIRBS1
Ime administrativnega vodnega območja: Vodno območje Donave	Name of the administrative river basin district Danube river basin district
ID porečja/povodja: 3	ID of the river basin: 3
Ime porečja/povodja: Porečje Save	Name of the river basin: Sava river basin
Tip vodnega telesa: 11VA	Water body type: 11VA
Ime tipa vodnega telesa: Hidroekoregija	Name of the water body type: Hydroecoregion

The water quality of the Sava is assessed on the basis of regular monitoring carried out by the Slovenian Environment Agency. According to ARSO data, the chemical status of the Sava at the WB Sava Krško–Vrbina in the 2009–2013 period was assessed as good, with a high degree of reliability. In terms of mercury in organisms, the status was assessed as poor, with a low degree of reliability (this parameter was assessed as poor for all water bodies except WB Krupa).

In the 2009–2015 period, the ecological status of the Sava at the WB Sava Krško–Vrbina was assessed as good, with a high degree of reliability. The same assessment was given to its ecological status with regard to the concentrations of specific pollutants (/166/).

In the River Basin Management Plan for the Danube River Basin District 2016–2021 (RBMP2), the assessment of the status for this water body was in line with the monitoring results referred to above.

The assessment of the state of water bodies for the Danube River Basin Management Plan 2022–2027 (RBMP3) /282/, which is being drafted, is based on the monitoring data from the 2014–2019 period. An overview of the assessment of status in RBMP3 for the Sava Krško–Vrbina water body and the neighbouring Sava Boštanj–Krško and Sava border section water bodies is shown in the tables below (Table 27, Table 28 and Table 29). The assessment of the chemical status includes the state of waters and the status of the biota. The former is assessed as good, the latter as poor (or, together, as poor with a high degree of reliability). With a medium level of reliability, the ecological status is assessed as good. The ecological status with regard to the levels of specific pollutants is assessed as very good. With regard to specific pollutants, the state of the Sava Krško–Vrbina water body was assessed as very good, with a high degree of reliability.

The increased values of mercury and BDE in biota are not linked to NEK operation. The Draft Danube River Basin Management Plan 2022–2027 states as follows:

"Assessments of the chemical status of surface waters for the biota matrix show that, in Slovenia as in all European countries, mercury and brominated diphenyl ethers (BDE) are the substances that cause poor chemical status of surface water bodies because they fail to meet the EQS for biota. The previous water management plan indicated a poor chemical status as a result of the Environmental Quality Standard (EQS) being exceeded for mercury in biota in 98.6% of surface water bodies. Mercury and brominated diphenyl ethers are classed as persistent bioaccumulative toxic contaminants (PBT) and accumulate in organisms. A similar situation is to be found in all European countries that have carried out analyses of these substances in fish.

In Slovenia, monitoring was conducted in biota at 60 surface water bodies, in international profiles, in areas without any human impact, and in polluted areas. The EQS for organisms were exceeded at all measuring points at which analyses of mercury and brominated diphenyl ethers were conducted. In light of this, the poor chemical status for the parameters of mercury and brominated diphenyl ethers was extrapolated to all surface water bodies. A low confidence level is therefore attached to the poor chemical status determined for biota in all surface water bodies in Slovenia in which chemical status was determined by extrapolation."

Estimates indicate that the highest inputs of the contaminants concerned into the Danube RBD are the result of atmospheric depositions in the river basins of the Drava, Srednja Sava, Spodnja Sava and Savinja. Estimates further show that inputs of hydrogen and sulphur from atmospheric deposition fell between 2013 and 2015, with a slight increase observed in 2016. Data was available for 2015 and 2016 for the remaining selected contaminants. As a result, any increase or reduction in the input of contaminants into surface waters cannot be estimated with any degree of reliability.

Taking this into account and comparing the data estimates on the types and strengths of pressures from atmospheric deposition with an assessment of the status of surface water bodies, it is estimated that **atmospheric deposition exerts a significant pressure that causes poor chemical status by exceeding the environmental quality standard for mercury in biota.**

The ecological status of the Krško Vrbina water body is assessed as good and very good for specific elements of quality, as shown in Table 30. As regards hydromorphological status, some elements have been assessed as exerting significant hydromorphological pressures on the water body: hydrological regime in the main flow and inflow, continuity of the main flow and the morphological conditions of the main flow (Table 31).

Table 27: Assessment of the chemical status of surface water bodies for the Management Plan 2022–2027 (RBMP3) *(source: /239/)*

Reference code of surface water body	Name of water body	Surface water	Water region	Period	Chemical status RBMP3 – waters	Level of confidence in assessment of chemical status – waters	Reason for poor chemical status – waters
SI1VT739	WB Sava Boštanj–Krško	SAVA	RBD_1	2014–2019	good	medium	
SI1VT913	WB Sava Krško–Vrbina	SAVA	RBD_1	2014–2019	good	high	
SI1VT930	WB Sava border section	SAVA	RBD_1	2014–2019	good	high	

Continuation of table

Name of water body	Period	Chemical status RBMP3 – biota	Level of confidence in assessment of chemical status – biota	Reason for poor chemical status – biota	Chemical status RBMP3 – waters and biota together	Level of confidence in assessment of chemical status – waters and biota together	Reason for poor chemical status – waters and biota
WB Sava Boštanj–Krško	2014–2019	poor	low	Hg, BDE	poor	low	Hg, BDE
WB Sava Krško–Vrbina	2014–2019	poor	high	Hg, BDE	poor	high	Hg, BDE
WB Sava border section	2014–2019	poor	high	Hg, BDE	poor	high	Hg, BDE

Table 28: Assessment of chemical status of surface water bodies for Management Plan 2022–2027, excluding generally present substances (PBT) (RBMP3) (source: /239/)

Reference code of surface water body	Name of water body	Surface water	Water region	Period	Chemical status for surface water body for RBMP3 – excl. PBT substances	Level of confidence in assessment of chemical status of surface water bodies for RBMP3 – excl. PBT substances
SI1VT739	WB Sava Boštanj–Krško	SAVA	RBD_1	2014–2019	good	high
SI1VT913	WB Sava Krško–Vrbina	SAVA	RBD_1	2014–2019	good	high
SI1VT930	WB Sava border section	SAVA	RBD_1	2014–2019	good	high

Table 29: Assessment of the status of surface water bodies with regard to specific pollutants for the Water Management Plan 2022–2027 (RBMP3) (source: /239/)

Reference code of surface water body	Name of water body	Period	Ecological status with regard to specific pollutants for surface water bodies for RBMP3	Level of confidence in the assessment of ecological status with regard to specific pollutants for surface water bodies for RBMP3
SI1VT739	WB Sava Boštanj–Krško	2014–2019	good	high
SI1VT913	WB Sava Krško–Vrbina	2014–2019	very good	high
SI1VT930	WB Sava border section	2014–2019	very good	medium

Table 30: Estimate of the ecological status of surface water bodies (RBMP3) /239/

Reference code of water body	Name of water body	Nutrient pollution	Pollution with organic substances	Hydromorphological alteration and general degradation	Special contaminants	Ecological status/Ecological potential of surface water body
SI1VT739	WB Sava Boštanj–Krško	good	moderate	moderate	good	moderate
SI1VT913	WB Sava Krško–Vrbina	good	good	good	very good	good
SI1VT930	WB Sava border section	very good	very good	good	very good	good

Key:

Nutrient pollution – assessment of the ecological status of the surface water body in relation to the biological quality elements (phytobenthos and macrophytes for watercourses; phytobenthos, macrophytes and phytoplankton for lakes; phytoplankton and macroalgae for marine waters) and the general physical and chemical elements of quality

Pollution with organic substances – assessment of the ecological status of the surface water body in relation to the biological quality elements of phytobenthos, macrophytes and benthic invertebrates for watercourses, and the general physical and chemical elements of quality

Hydromorphological alteration and general degradation – assessment of the ecological status of the surface water body in relation to the biological quality elements of benthic invertebrates and fish

Special contaminants – assessment of the ecological status of the surface water body in relation to the special contaminants determined in the regulation governing surface waters

Ecological status/Ecological potential of surface water body – overall statement of the ecological status of the surface water body

NR – quality element not relevant for assessing status, or the methodology for the quality element has not yet been developed

Table 31: Significant hydromorphological pressures on surface water bodies (RBMP3) /239/

Reference code of surface water body	Name of surface water body	Significant hydromorphological pressures (SP)					
		SP hydrological regime MF	SP hydrological regime INF	SP continuity of MF	SP continuity of INF	SP morphological conditions of MF	SP morphological conditions of INF
SI1VT739	WB Sava Boštanj–Krško	1	0	1	0	1	1
SI1VT913	WB Sava Krško–Vrbina	1	1	1	0	1	0
SI1VT930	WB Sava border section	0	0	0	0	0	1

Key:

SP – Significant hydromorphological pressure

SP hydrological regime MF – significant hydromorphological pressure on the main flow of the surface water body that could affect the hydrological regime

SP hydrological regime INF – significant hydromorphological pressure on the inflow of the surface water body that could affect the hydrological regime

SP continuity of MF – significant hydromorphological pressure on the main flow of the surface water body that could affect the continuity of flow

SP continuity of INF – significant hydromorphological pressure on the inflow of the surface water body that could affect the continuity of flow

SP morphological conditions of MF – significant hydromorphological pressure on the main flow of the surface water body that could affect the morphological conditions

SP morphological conditions of INF – significant hydromorphological pressure on the inflow of the surface water body that could affect the morphological conditions

1 – significant hydromorphological pressures found in the surface water body

0 – significant hydromorphological pressures not found in the surface water body

Monitoring of the organic load in the waters of the Sava, i.e. the COD and BOD_5 values, has been conducted for NEK for a number of years. Sampling is carried out at three locations every month of the year. The locations are listed in the table below (Table 32).

Table 32: Sava water sampling locations (source: /103/)

Sampling location	Description
Location 1	At NEK, the cooling water intake point
Location 2	In front of NEK, the right bank of the Sava
Location 3	In Brežice, by the road bridge

Fluctuation of the concentrations of the aforementioned indicators in the 2010–2019 period is shown in the figures below (Figure 34 and Figure 35).

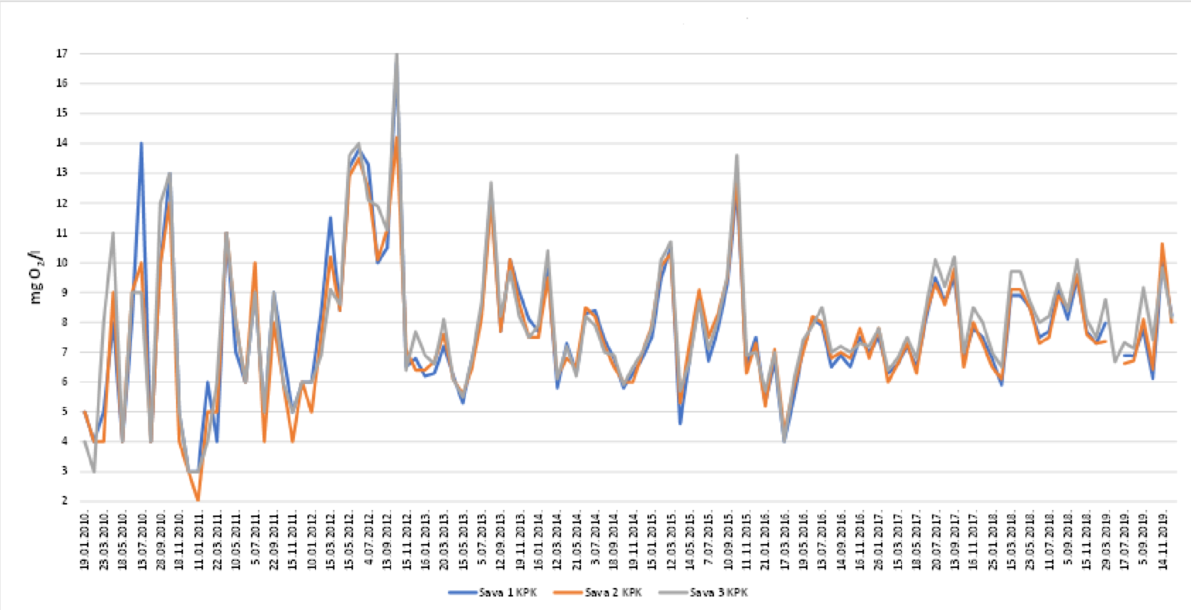


Figure 34: Results of COD monitoring at three sampling locations in the Sava (2010–2019) (source: /103/)

mg O₂/l	mg O₂/l
Sava 1 KPK	Sava 1 COD
Sava 2 KPK	Sava 2 COD
Sava 3 KPK	Sava 3 COD

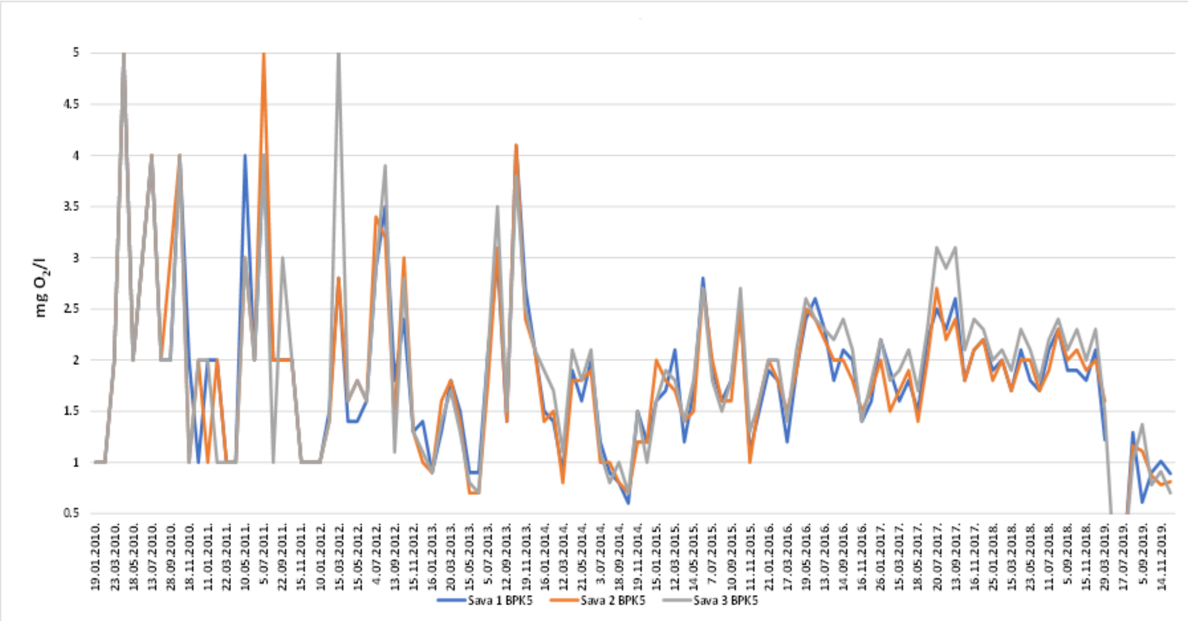


Figure 35: Results of BOD_5 monitoring at three sampling locations in the Sava (2010–2019) (source: /103/)

mg O_2/l	mg O_2/l
Sava 1 BPK5	Sava 1 BOD_5
Sava 2 BPK5	Sava 2 BOD_5
Sava 3 BPK5	Sava 3 BOD_5

4.1.4.1 **Thermal pollution**

The production process of NEK requires cooling water from the Sava, which is collected at two points upstream from the NEK dam:

- up to 1.606 m^3/s of water for the small cooling system (essential service water, ESW) is collected at the small pumping station at the far southeastern part of the NEK complex; and
- up to 25 m^3/s of water for the large cooling system (circulating water, CW) is collected at the pumping station behind the submersible wall upstream of the NEK dam.

Water from the ESW system returns to the Sava upstream from the dam at discharge V1, and water from the CW system through the CW discharge facility at the V7 location. Since the water for the CW system is heated as it passes through the condenser, NEK is obliged to ensure, in compliance with the environmental permit /49/, that:

1. the limit emission value of transmitted heat in the 24-hour average for the removal of wastewater into the Sava via discharges V1 and V7 is equal to 1;
2. the synergetic action of the aforementioned discharges as well as other NEK discharges does not cause the Sava to exceed its natural temperature by more than 3°C at any period of the year;
3. the cooling water recirculation system via the cooling towers is activated in a timely manner so that the Sava does not exceed its natural temperature by more than 3°C;
4. if the combined cooling system is insufficient to fulfil this condition, NEK must reduce the power of the power plant in a timely manner (since the upgrading of the cooling towers, there has been no reduction in plant power);
5. the temperature of water discharged at Discharge V7 does not exceed 43°C.

The amount of water intake from the Sava is stipulated in the Partial Water Permit, issued on 15 October 2009, No. 35536-31/2006-16 /57/, and amended in response to a change in the amount of water intake 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 /50/.

The amendment of the Water Permit of 22 June 2018 sets out the total allowable amount of water intake from the Sava at 29 m^3/s. The permitted annual quantity of intake for technological purposes (Sava and the well on the right bank) is 915,000,000 m^3.

Shown below are three basic modes of operation of the cooling system with regard to the flow rate of the Sava.

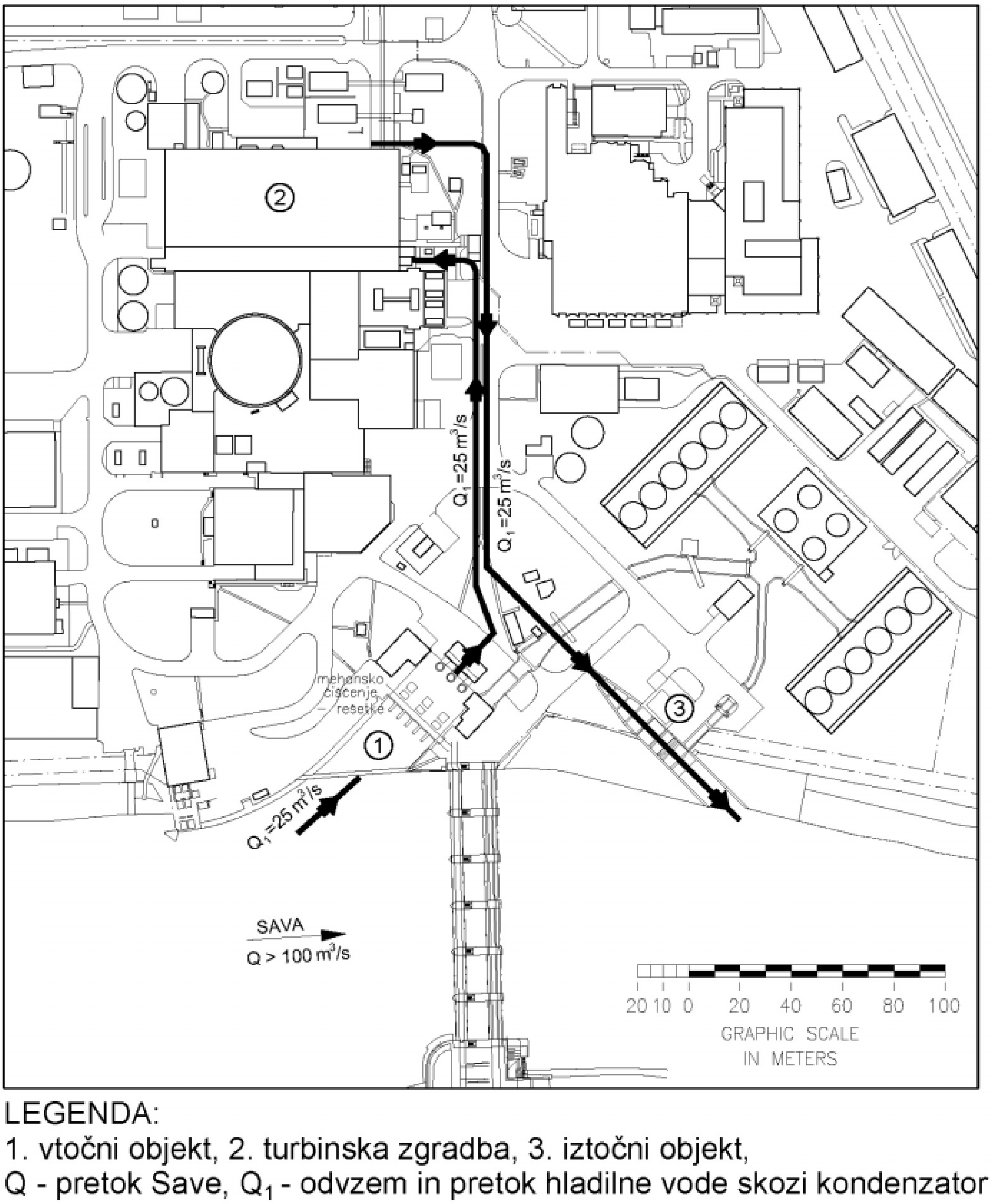
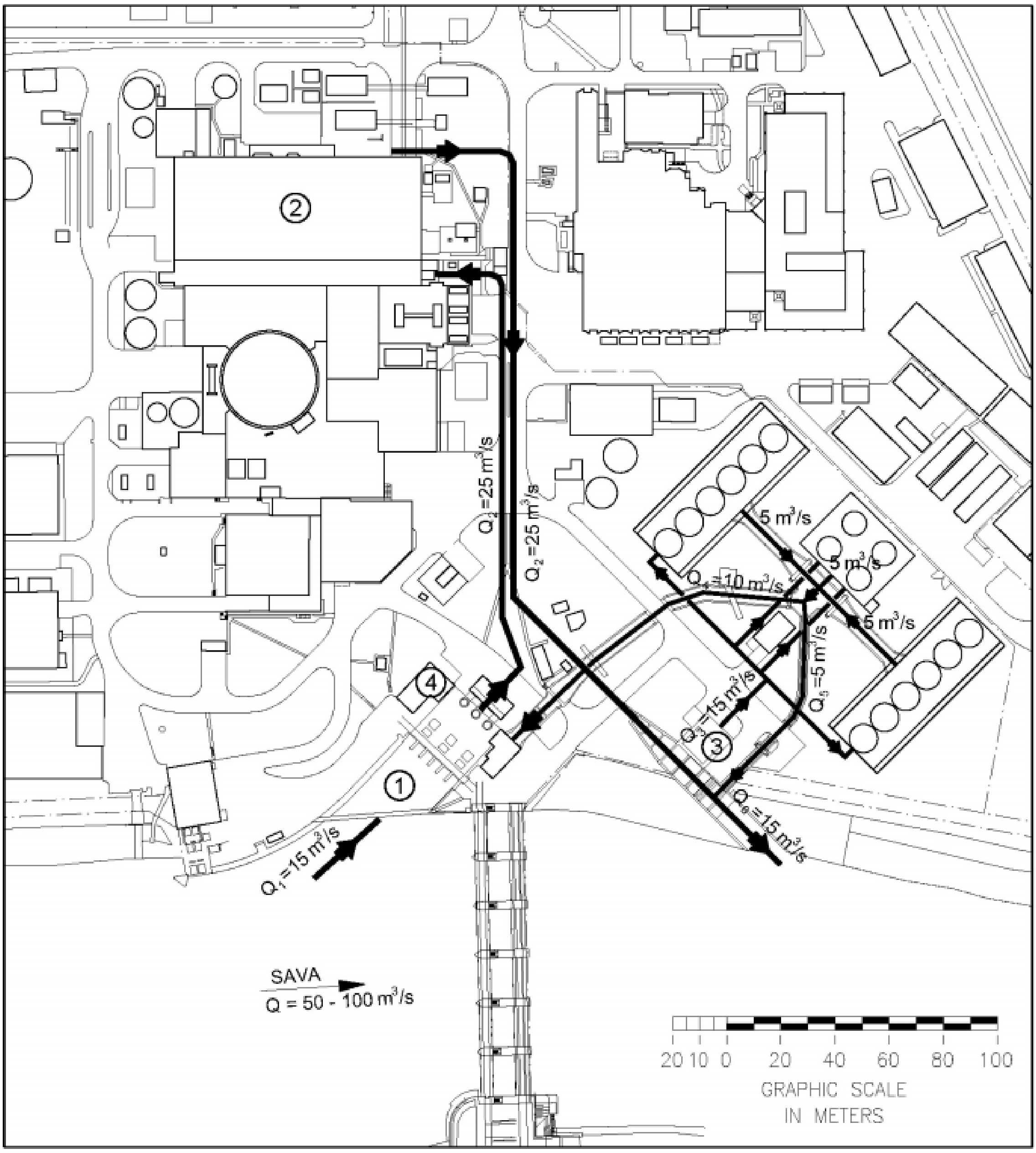


Figure 36: Schematic of the operation of the CW cooling system for the Sava flow rate: Q of the Sava > 100 m^3/s (source: /237/)

mehansko čiščenje – rešetke	mechanical filtering – inlet screen

LEGENDA: 1. vtočni objekt, 2. turbinska zgradba, 3. iztočni objekt,	KEY: 1. intake facility, 2. turbine building, 3. discharge facility,
Q-pretok Save, Q_1-odvzem in pretok hladilne vode skozi kondenzator	Q – flow rate of Sava, Q_1 – intake and flow rate of cooling water through the condenser

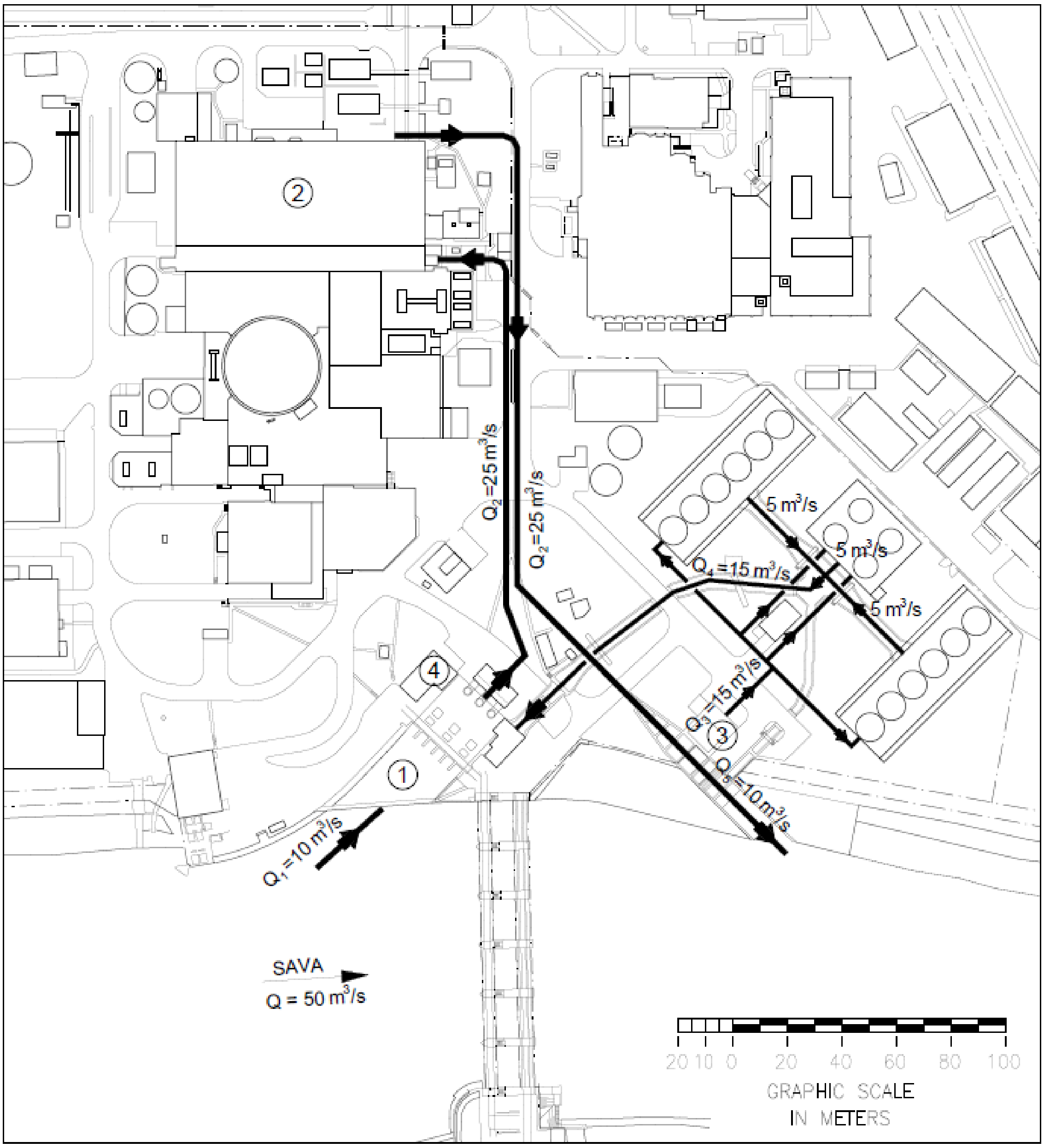


LEGENDA:

1. vtočni objekt, 2. turbinska zgradba, 3. iztočni objekt, 4. mešalni bazen pri vtočnem objektu, Q - pretok Save, Q_1 - odvzem hladilne vode, Q_2 - pretok hladilne vode skozi kondenzator, Q_3 - delež hlajene hladilne vode na celicah, Q_4 - delež recirkulirane hladilne vode, Q_5 - delež izpuščene ohlajene hladilne vode, Q_6 - pretok izpuščene hladilne vode

Figure 37: Schematic of the operation of the CW cooling system for Sava flow rate: 100 m^3/s > Q of the Sava > 60 m^3/s (source: /237/)

LEGENDA: 1. vtočni objekt, 2. turbinska zgradba, 3. iztočni objekt, 4. mešalni bazen pri vtočnem objektu, Q-pretok Save, Q_1-odvzem hladilne vode, Q_2-pretok hladilne vode skozi kondenzator, Q_3-delež hlajene hladilne vode na celicah, Q_4-delež recirkulirane hladne vode, Q_5-delež izpuščene ohlajene hladilne vode, Q_6-pretok izpuščene hladilne vode	KEY: 1. intake facility, 2. turbine building, 3. discharge facility, 4. mixing basin next to the intake facility, Q – flow rate of Sava, Q_1 – intake rate of cooling water, Q_2 – flow rate of cooling water through the condenser, Q_3 – flow rate of cooled cooling water on the cooling cells, Q_4 – flow rate of recirculated cold water, Q_5 – flow rate of discharged cooled cooling water, Q_6 – flow rate of discharged cooling water



LEGENDA:

1. vtočni objekt, 2. turbinska zgradba, 3. iztočni objekt, 4. mešalni bazen pri vtočnem objektu, Q - pretok Save, Q_1 - odvzem hladilne vode, Q_2 - pretok hladilne vode skozi kondenzator, Q_3 - delež hlajene hladilne vode na celicah, Q_4 - delež recirkulirane hladilne vode, Q_5 - pretok izpuščene hladilne vode

Figure 38: Schematic of the operation of the CW cooling system for Sava flow rate: Q of the Sava < 60 m^3/s (source: /237/)

LEGENDA: 1. vtočni objekt, 2. turbinska zgradba, 3. iztočni objekt, 4. mešalni bazen pri vtočnem objektu, Q-pretok Save, Q_1-odvzem hladilne vode, Q_2-pretok hladilne vode skozi kondenzator, Q_3-delež hlajene hladilne vode na celicah, Q_4-delež recirkulirane hladilne vode, Q_5-pretok izpuščene hladilne vode	KEY: 1. intake facility, 2. turbine building, 3. discharge facility, 4. mixing basin next to the intake facility, Q – flow rate of Sava, Q_1 –intake rate of cooling water, Q_2 – flow rate of cooling water through the condenser, Q_3 – flow rate of cooled cooling water on the cooling cells, Q_4 – flow rate of recirculated cold water, Q_5 – flow rate of discharged cooling water

4.1.4.2 Temperatures of the Sava at NEK

As part of the NEK operational monitoring, temperature of the Sava before entering NEK is regularly measured, although results are not statistically processed. Several earlier findings are therefore summarised from the following source: Interactions of energy buildings along and on the Sava from the perspective of the heat load on the Sava – Revision A *(Medsebojni vplivi energetskih objektov ob in na reki Savi z vidika toplotne obremenitve Save – Revizija A)* /147/.

Table 33: Mean monthly temperatures of the Sava in Radeče and at NEK (source: /147/).

Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Avg.
Radeče 1954–63	3.27	3.39	5.89	8.87	11.4	14.2	15.9	16.4	14.1	10.5	7.51	4.58	9.66
Radeče 1964–73	3.02	4.10	5.94	8.69	11.7	14.4	16.6	16.7	14.2	11.0	7.76	4.52	9.87
Radeče 1974–83	4.59	5.35	6.97	9.30	11.5	14.3	16.1	16.8	14.7	11.1	7.63	5.43	10.3
Radeče 1984–93	4.15	4.69	7.24	9.50	12.8	14.7	17.6	18.2	15.2	11.5	7.76	5.60	10.8
NEK 1984–1993	4.3	5.1	7.4	10.1	13.5	15.1	18.8	19.6	16.4	11.6	7.7	5.60	10.9
NEK 1994–2001	5.6	6.6	8.8	11.7	14.1	17.9	19.5	20.6	15.9	12.5	8.8	6.00	11.0

Measurements at Radeče were taken at Radeče water gauging station, which was the main national station for that section of the Lower Sava (Spodnja Sava) from 1909 to 1998. The station was discontinued in 1998 because it was located on the Vrhovo HPP reservoir. The data series can be continued by taking data on the Sava at Hrastnik and on the Savinja at Veliko Širje, where the stations of the national network are currently located. Measurements of the Sava before it enters the NEK complex are carried out at measuring point MM1, as defined in the environmental permit /49/, at the following location: Y = 540280, X = 88332, Z = 150 m a.s.l., on land parcel no. 1246/6, cadastral municipality 1321 – Leskovec, Municipality of Krško.

The Brežice reservoir, which began operating in September 2017, does not significantly affect the operation of NEK in terms of the heat load on the Sava. Studies of the heat load on the Sava, conducted prior to the construction of the reservoir (/147/), and the measurements and analyses after the reservoir was filled (/148/, /149/), established the following:

- average monthly temperatures of water flowing into the HPP chain (into the Vrhovo reservoir) have increased by 1.5 to 2°C in the summer months over recent decades, while temperature peaks in the same period have increased by 3 to 4°C. This means a significantly higher "natural temperature background" for the operation of NEK;
- HPP reservoirs along the lower Sava do not cause additional river warming relative to conditions before the damming;
- in critical summer conditions with low river flow rates and high air temperatures, HPP reservoirs significantly reduce daily variation in river temperature relative to conditions before damming, while also storing cooler water in the lower layers of the reservoirs due to thermal stratification;
- this is reflected in the Brežice HPP reservoir, where accelerated thermal emission from the reservoir into the atmosphere was detected, compared to the previous state;
- in view of these impacts, HPP reservoirs act as measure for mitigating the effects of climate change in terms of the heat load on the Sava, which has a further positive effect on the operation of NEK during periods of reduced river flow and increased water and air temperatures.

The average daily and monthly temperatures of the Sava for 2018, 2019 and 2020 are given below.

Table 34: Average daily and monthly temperatures of the Sava at NEK in 2018 (source: /48/)

Temperature of the Sava at point of entry SW/CW [°C], 2018 – MM1

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.0	6.5	1.7	8.4	14.0	17.1	18.3	22.8	17.3	13.5	10.6	6.4
2	6.6	6.7	1.9	8.6	14.2	17.2	18.2	23.1	17.0	13.7	10.6	6.3
3	6.3	5.9	2.2	8.8	14.2	17.7	18.8	23.3	15.9	13.7	11.1	6.5
4	6.3	4.9	2.6	9.5	14.3	18.0	19.7	23.6	15.6	13.7	11.5	6.9
5	6.3	5.2	3.1	9.7	14.3	18.3	19.8	23.9	15.5	13.4	11.5	7.4
6	6.9	5.7	3.5	9.8	14.0	18.7	19.6	24.4	16.0	13.4	11.6	7.9
7	7.4	5.6	4.5	10.2	14.1	18.9	19.9	24.3	16.3	13.5	11.6	7.9
8	7.8	5.3	5.4	10.3	14.6	18.6	20.0	24.4	16.8	13.7	11.7	7.8
9	7.7	5.2	6.1	10.5	15.0	18.7	20.3	24.4	17.3	14.0	11.6	7.5
10	7.7	5.7	6.5	11.0	15.2	18.6	20.2	24.4	17.6	14.4	11.6	7.6
11	7.6	6.0	6.5	11.1	15.2	18.8	19.9	24.2	18.0	14.6	11.4	7.4
12	7.4	5.8	6.7	11.1	15.2	19.5	19.0	24.1	18.3	14.8	11.5	6.9
13	7.2	5.4	7.1	10.9	15.1	19.6	17.6	24.5	18.5	14.6	11.7	6.5
14	6.9	5.1	7.6	10.2	15.1	19.3	17.9	24.2	18.7	14.6	11.7	6.2
15	6.6	5.1	7.8	10.6	15.1	18.6	18.1	23.8	18.7	14.4	11.5	5.7
16	6.2	5.3	7.9	11.1	13.7	18.2	18.8	23.3	18.8	14.4	10.9	5.3
17	6.2	5.3	7.7	11.4	13.4	18.4	19.2	23.1	18.9	14.3	10.3	5.2
18	6.3	5.1	7.1	11.8	13.9	18.6	19.3	23.1	18.8	14.3	9.8	5.1
19	6.1	5.4	6.4	11.8	14.1	19.0	19.6	23.0	18.9	14.2	9.1	5.1
20	6.0	5.6	5.7	12.2	14.4	19.1	20.0	22.6	18.9	14.1	8.3	5.0
21	6.3	5.2	5.7	12.5	14.9	19.7	20.5	22.6	19.0	13.8	8.0	5.0
22	6.0	4.8	5.9	13.0	15.1	19.8	20.8	22.7	18.8	13.6	7.8	5.1
23	5.9	4.8	6.0	13.3	15.3	19.5	20.7	23.0	18.4	13.7	7.6	5.3
24	5.6	4.6	6.1	13.5	15.5	18.8	20.6	23.2	17.9	13.8	7.9	5.7
25	5.6	4.1	6.5	13.7	15.6	17.6	20.3	22.7	15.4	13.8	8.4	5.9
26	5.7	3.8	6.8	13.7	15.8	17.7	20.3	21.6	15.0	13.3	8.7	6.1
27	6.0	3.4	7.1	13.8	16.6	18.0	20.1	16.9	14.4	13.0	9.0	6.0
28	6.6	2.5	7.7	13.6	17.4	17.7	20.7	15.8	14.1	12.4	8.6	6.0
29	6.5		8.2	13.7	17.8	17.4	21.7	16.2	13.9	12.8	7.8	5.5
30	6.4		8.5	14.0	17.9	17.9	22.0	16.5	13.4	12.2	7.0	5.0
31	6.4		8.3		17.2		22.2	16.8		11.2		4.7
ave.	**6.5**	**5.1**	**6.0**	**11.5**	**15.1**	**18.5**	**19.8**	**22.3**	**17.1**	**13.7**	**10.0**	**6.2**

Table 35: Average daily and monthly temperatures of the Sava at NEK in 2019 (source: /48/)

Temperature of the Sava at point of entry SW/CW [°C], 2019 – MM1

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	4.6	5.0	7.4	10.2	11.2	12.3	22.7	20.4	21.4	16.3	12.0	9.0
2	4.4	5.4	7.8	10.9	11.6	13.2	22.7	21.0	21.6	16.1	11.7	8.3
3	4.4	6.4	8.2	11.4	12.3	14.3	22.3	21.1	21.1	16.2	11.6	8.0
4	4.4	7.0	8.5	11.8	12.9	15.3	21.8	20.9	20.5	15.2	11.1	7.7
5	4.4	6.8	8.6	12.1	12.2	15.9	21.3	19.9	19.5	14.4	11.3	7.1
6	4.5	6.3	9.0	12.1	11.0	16.6	21.1	20.3	18.9	13.7	11.0	6.7
7	4.1	6.0	9.3	11.0	10.3	17.2	20.3	20.5	18.5	13.4	10.7	6.5
8	3.6	5.7	9.5	10.7	10.6	17.7	20.7	20.7	17.9	13.1	10.3	6.7
9	3.5	5.7	9.5	10.6	11.0	18.0	20.9	21.0	16.5	13.3	10.1	6.9
10	3.6	5.9	9.8	10.8	11.5	18.4	19.8	21.9	15.3	13.1	10.1	7.2
11	3.6	6.2	9.8	10.8	11.9	18.7	19.5	22.2	15.3	13.0	9.7	7.3
12	3.7	6.3	9.6	10.2	12.4	18.9	19.3	21.8	15.0	13.0	9.4	6.7
13	3.8	6.1	9.5	9.5	12.1	19.2	19.2	21.8	15.5	13.4	9.6	5.9
14	4.2	6.0	9.4	9.4	10.8	19.1	19.5	21.9	15.6	13.8	9.6	5.9
15	4.3	6.0	8.8	9.7	10.1	19.3	19.8	22.0	16.1	14.0	9.5	6.0
16	4.4	6.2	8.9	10.0	9.7	19.7	20.0	21.8	16.9	14.0	9.7	6.2
17	4.3	6.3	9.1	10.4	10.0	19.8	19.9	21.7	17.6	13.9	10.0	6.9
18	4.5	6.3	9.3	11.3	11.0	19.5	20.4	21.4	17.6	14.1	10.3	8.0
19	4.9	6.4	9.3	11.8	12.1	20.0	20.7	21.1	17.5	14.2	9.8	8.5
20	5.5	6.6	9.6	12.4	12.5	20.1	21.2	21.2	17.5	14.3	9.7	8.7
21	5.5	6.8	9.4	12.9	12.8	20.2	21.8	21.6	17.3	14.6	9.8	9.0
22	4.8	7.0	8.8	13.4	12.6	20.1	21.9	21.5	17.2	14.4	9.9	9.0
23	4.5	6.8	9.0	13.8	12.5	18.7	22.1	21.6	16.4	14.3	9.9	8.5
24	4.4	6.8	9.4	14.1	13.3	17.3	22.4	22.0	15.8	14.6	9.8	8.3
25	4.4	6.9	9.7	13.9	14.5	18.0	22.9	21.3	15.3	14.6	9.8	7.7
26	4.1	6.3	10.0	13.4	15.0	18.6	23.4	20.5	15.4	14.5	9.7	7.3
27	3.9	6.2	10.3	13.4	15.1	20.0	23.8	20.3	15.9	14.3	9.5	7.1
28	4.0	6.9	9.8	13.0	14.7	20.7	23.4	20.3	15.9	14.2	9.5	6.9
29	4.0		9.7	12.3	13.1	21.5	22.8	20.4	15.8	13.8	9.8	6.6
30	4.0		9.8	11.5	11.5	22.0	22.0	20.6	16.1	13.1	9.5	5.8
31	4.6		9.8		11.5		20.5	20.9		12.4		5.2
ave.	**4.3**	**6.3**	**9.2**	**11.6**	**12.1**	**18.3**	**21.3**	**21.1**	**17.2**	**14.1**	**10.1**	**7.3**

Table 36: Average daily and monthly temperatures of the Sava at NEK in 2020 (source: /48/)

Temperature of the Sava at point of entry SW/CW [°C], 2020 – MM1

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	4.9	7.1	7.6	8.8	16.4	15.6	20.3	21.5	18.8	12.6	11.1	6.0
2	5.0	7.1	7.8	9.6	16.0	15.8	20.9	21.7	16.8	12.9	11.3	5.9
3	4.9	7.1	8.3	9.4	15.4	16.5	20.5	21.7	16.3	13.0	11.3	5.6
4	4.9	7.7	8.3	9.1	15.8	16.4	20.3	20.3	15.8	13.6	11.3	5.3
5	4.9	7.7	8.1	9.3	15.6	16.8	20.2	17.8	16.0	13.4	11.5	5.1
6	4.8	7.7	8.0	9.9	15.4	15.5	19.7	17.2	16.5	12.5	11.5	5.2
7	4.8	7.7	8.0	10.4	15.4	13.0	19.8	16.9	16.9	12.0	11.1	6.4
8	4.4	7.2	7.8	11.0	15.7	13.2	19.5	17.4	17.4	12.1	10.9	7.2
9	4.1	6.2	8.2	11.4	16.2	13.6	19.0	18.7	17.7	12.1	10.1	7.1
10	4.1	6.0	8.3	12.0	15.9	12.5	18.7	19.7	17.6	12.1	9.6	6.7
11	4.2	5.9	8.6	12.5	16.0	12.6	19.6	20.1	17.2	12.1	9.3	7.0
12	4.5	6.1	9.0	12.9	16.0	13.5	20.0	20.6	17.6	11.2	9.1	7.2
13	4.7	6.2	9.2	13.4	16.2	14.4	20.1	21.0	17.9	10.8	9.0	7.2
14	4.9	7.2	9.6	13.4	15.5	15.5	19.0	21.2	18.3	10.8	9.1	7.1
15	5.0	7.7	9.8	13.5	14.2	16.0	19.0	20.9	18.5	10.9	9.1	7.0
16	4.9	7.8	9.4	13.8	14.1	16.1	18.9	21.0	18.7	10.6	9.4	6.8
17	4.9	7.7	9.6	14.2	13.5	15.8	18.8	21.1	18.7	10.7	9.5	6.6
18	5.0	7.9	9.7	13.7	13.5	16.0	18.8	20.7	18.7	10.8	9.4	6.6
19	5.3	8.1	9.5	13.3	13.3	16.6	19.2	20.6	18.4	10.9	9.2	6.7
20	5.4	7.8	9.9	13.7	13.5	16.8	19.4	20.7	18.2	10.9	9.0	6.8
21	5.6	7.8	10.7	14.0	13.8	17.4	19.6	20.9	18.1	11.0	8.5	6.8
22	5.5	8.1	10.9	14.5	14.1	17.3	19.6	20.8	18.0	11.1	8.1	7.0
23	5.3	8.4	10.4	14.8	14.8	17.4	20.3	20.8	17.9	11.3	7.6	7.3
24	5.2	8.3	9.9	14.9	15.4	17.5	21.0	21.0	17.6	11.7	7.0	7.7
25	5.0	7.8	9.1	14.7	15.8	18.2	20.5	21.3	17.3	11.9	6.4	8.1
26	4.8	7.5	7.7	14.7	16.3	18.8	19.7	21.5	15.8	11.9	6.4	7.6
27	4.9	7.9	7.2	15.1	16.6	18.5	18.8	21.5	13.2	11.8	6.5	6.8
28	5.0	8.1	7.4	15.5	15.9	18.4	19.3	20.9	12.4	11.7	6.3	6.1
29	5.6	8.0	7.4	15.7	16.0	19.4	20.0	20.8	12.6	11.4	6.1	6.1
30	6.4		7.4	16.1	15.9	19.9	20.8	21.1	12.6	11.1	6.1	6.3
31	6.9		8.1		15.7		21.7	20.6		11.0		6.8
ave.	**5.0**	**7.4**	**8.7**	**12.8**	**15.3**	**16.2**	**19.8**	**20.4**	**16.9**	**11.7**	**9.0**	**6.7**

4.1.5 Pedological characteristics of the area

The site of the activity is a built-up area of long-term energy use (energy infrastructure).

According to the pedological map (1:25,000) /60/, soil in the wider area of the site under consideration is mapped as 70% alluvial soil, carbonate, medium-deep, on sandy gravel alluvium, and 30% alluvial soil, carbonate, deep, on sandy gravel alluvium.

4.1.6 Biological characteristics of the area, ecosystems, flora and fauna, habitats

4.1.6.1 General

The site of the activity is a densely built-up area of long-term energy use (energy infrastructure), fenced and surrounded by numerous road infrastructure, agricultural land, and other industrial buildings in the Vrbina industrial zone. There is no major forest land in the surrounding area, which is mostly built up. There are no protected natural features on the site of the activity itself and its immediate vicinity, and the area does not provide an important habitat for plants and animals, with the exception of the Sava, which flows past the NEK complex and the NEK dam.

Protected areas, Natura 2000 sites, valuable natural features, and important ecological areas in the wider vicinity of the site under consideration are shown below and in the figures in Section 11.2.

4.1.6.2 Protected areas

In accordance with the Rules on the assessment of the acceptability of effects caused by the execution of plans and activities affecting nature in protected areas (Official Gazette of RS, Nos. 130/04, 53/06, 38/10 and 3/11), there are no protected areas in the area of remote impact (2,000 m). The nearest protected area is Kozjanski Park (ID 1413, of national importance), which is approx. 5,060 m northwest. Under Article 20 of the Rules, the area of remote impact established for the specific activity affecting the environment may differ at any time from the area of remote impact of an activity affecting the environment referred to in Annex 2 of those Rules if this is based on findings from the field, detailed data on implementation of the activity and other actual circumstances. In addition to the remote impact within a radius of 2,000 m as defined by the Rules, remote impact is also possible downstream along the Sava, where there are no protected areas. Protected areas are therefore omitted from the discussion below.

4.1.6.3 Natura 2000

Within the 2,000-metre area of remote impact under the Rules on the assessment of the acceptability of effects caused by the execution of plans and activities affecting nature in protected areas (Official Gazette of RS, Nos. 130/04, 53/06, 38/10, 3/11), there is one Natura 2000 area as defined by the Decree on special protection areas (Natura 2000 sites) (Official Gazette of RS, Nos. 49/04, 110/04, 59/07, 43/08, 8/12, 33/13, 35/13 – corrigenda, 39/13 – Constitutional Court decision, 3/14, 21/16, 47/18), i.e. the **Vrbina SAC (SI3000234)**, which is approximately 350 m from the site of the activity. Under Article 20 of the Rules, the area of remote impact established for the specific activity affecting the environment may differ at any time from the area of remote impact of an activity affecting the environment referred to in Annex 2 of those Rules if this is based on findings from the field, detailed data on implementation of the activity and other actual circumstances. In addition to the remote impact within a radius of 2,000 m as defined by the Rules, remote impact is also possible downstream along the Sava. It is assumed that the area of remote impact downstream along the Sava stretches 8 km downstream of the discharges from NEK, where the Sava has been declared a Natura 2000 area (**Lower Sava SAC, SI3000304**). A description of Natura 2000 sites is given in Section 4.4.1.4.

4.1.6.4 Valuable natural features

The nearest valuable natural features, as determined by the Rules on the designation and protection of valuable natural features (Official Gazette of RS, Nos. 111/04, 70/06, 58/09, 93/10, 23/15 and 7/19), are:

- Libna – linden tree next to the church (ID 7860; a valuable botanical natural feature of local importance) – approximately 1,270 m north of the planned activity;
- Stari Grad – gravel pit (ID 7861; aquatic biotope, stopping area for migrating birds and nesting area for endangered bird species, a valuable ecological and zoological natural feature of local importance) – approximately 1,415 m east of the planned activity.

4.1.6.5 Important ecological areas

In the area of the planned activity, there is one important ecological area as defined by the Decree on important ecological areas (Official Gazette of RS, Nos. 48/04, 33/13, 99/13 and 47/18):

- Sava from Radeče to the national border (ID 63700).

4.1.7 Characteristics of the built environment and the presence of special material assets

4.1.7.1 Characteristics of the built environment

The NEK site, which includes the site of the activity, is located in the municipality of Krško, 2.5 km southeast of the town of Krško. The NEK site is demarcated to the south by the Sava riverbed and to the north by the Vrbina industrial zone. The site of the activity is accessible from the R1 Krško–Spodnja Pohanca regional road and then from the local road running in a SE direction from the settlement of Vrbina towards the NEK site.

The fenced perimeter of NEK is surrounded by fruit orchards on its west, north and east sides. The Sava flows past the south side. Although the literature mentions the settlement of Vrbina, which lies approximately 490 m northwest of the activity site, the municipal spatial planning information system PISO /63/ shows it to be an area of central activities in which there is no settlement. The nearest densely populated settlement is Spodnji Stari Grad, which lies approximately 700 m northeast of the activity site.

The town of Krško, which lies to the northwest of the activity site, represents the economic, administrative, educational and cultural centre of the lower Posavje (Sava Valley) area. It was first mentioned in writing in the year AD 895. An 1189 document mentions a castle in a strategically important location at the entrance to the gorge of the Sava. A market town developed below this castle and was granted town rights in 1477. In 1480 the town was surrounded by walls. Leather, shoemaking and tailoring crafts developed in the Middle Ages. Commercial navigation on the Sava later grew in importance and continued to have a significant effect on the town's economy right up until 1862, when river traffic was supplanted by the railway. The development of industry began in 1937 with the opening of a small paper factory in Videm, Krško's present-day industrial zone. This has since grown into a large manufacturer of cellulose, paper and paper products /133/. Other industrial plants followed, with the result that today almost two thirds of the population are employed in industry. Settlements downstream of Krško and Videm have mainly formed on the right bank of the Sava along the main Ljubljana–Zagreb road.

4.1.7.2 Cultural Heritage

The wider site of the activity has always been suitable for settlement, as attested by prehistoric remains (caves Kartuševa and Jermanova jama), Illyrian and Celtic remains (Libna, Dunaj), and the remains of a Roman town and port near the present-day village of Drnovo (Neviodunum).

The NEK complex lies on the Sava plain southeast of the former Videm, where the Sava often changed its course in the past, so the narrower area was less suitable for settlement. Proof of past shifts of the riverbed, which served as a provincial border, is the location of the former boundary stone between Carniola and Styria near Spodnji Stari Grad, situated far from the present-day Sava riverbed. Remains of former riverbeds are still noticeable in the wider area as micro-relief features.

For the purpose of formulating the Detailed plan of national importance for the LILW repository at Vrbina, the Institute for the Protection of Cultural Heritage, Novo Mesto regional unit, prepared a background document on the area around NEK in December 2006, namely the "Archaeological evaluation report on the potential Vrbina location for the LILW repository". 108 test trenches measuring 120 cm x 120 cm were excavated as part of this investigation in the wider area of the planned Vrbina repository, which is located northeast of the NEK. The evaluation used the SAAS methodology (Archaeology on the Motorways of Slovenia, Methods and Procedures, Ljubljana, April 1994). The results of archaeological investigations show that the area was not settled in the past, or that there are no visible signs of human presence in this area in the past.

During the construction of the power plant, excavation and replacement of material was carried out in the entire platform of the power plant, so we expect no archaeological remains to be present within the NEK energy complex.

There are no cultural heritage elements at the site of the activity (the existing NEK complex). Moreover, it is situated outside the area of impact on buildings and cultural heritage sites in the vicinity. The nearest cultural heritage units are more than 470 m away from the site of the activity and lie outside the NEK site. The units are described in the table below, while a graphical representation is given in the following figure and in Section 11.2.

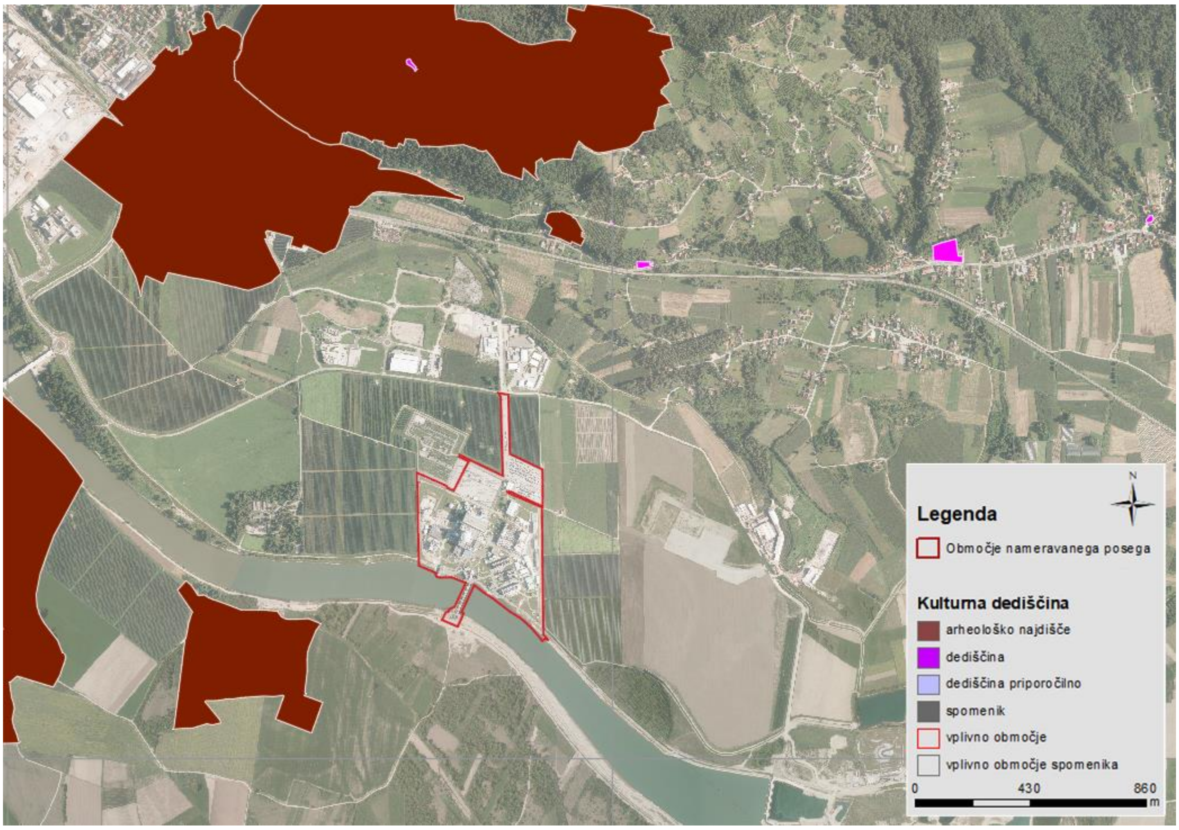


Figure 39: Cultural heritage in the vicinity of the site of the activity (source: /64/)

Legenda	**Key**
Območje nameravanega posega	Site of the planned activity
Kulturna dediščina	**Cultural heritage**
arheološko najdišče	archaeological site
dediščina	heritage
dediščina priporočilno	heritage recommended
spomenik	monument
vplivno območje	impact area
vplivno območje spomenika	monument impact area

Table 37: Immovable cultural heritage buildings and areas in the vicinity of the site of the activity (source: /64/)

ICH unit	Heri-tage No	Type	Scope	Description
Žadovinek – Archaeological site Remen-Tribeže	28988	archaeological heritage	site	The site of the former homestead Globočnik (Globotshnig) and Čečkerjeva pristava (Zhezhker Maierhof), and the potential site of a former outbuilding of the Šrajbarski Turn manor. The site is approx. 450 m away from the site of the activity.
Krško – Archaeological site Stara Vas	16518	archaeological heritage	site	Traces of prehistoric and Roman settlement (finds of pottery) and a mound from the Early Iron Age, investigated in 1890 (among other finds was a tomb of a horseman with a helmet). Written sources also mention tombs from the Late Iron Age and the Roman era. The site is approx. 730 m away from the site of the activity.

ICH unit	Heritage No	Type	Scope	Description
Žadovinek – Archaeological site Petrovce	1327	archaeological heritage	site	Late Bronze Age burial site (26 excavated graves), a possible Iron Age burial site, as attested by a chance discovery of a Celtic tomb, and the site of an outbuilding of the Šrajbarski Turn manor, first mentioned in 1436 (Gornji and Srednji Mairhof). The site is approx. 1,240 m away from the site of the activity.
Spodnja Libna – Prehistoric burial mound site	24419	archaeological heritage	site	Burial mound site: three mounds, one of which was partially explored by M. Hoernes (inhumation graves from the Early Iron Age). Late Iron Age cremation graves (unexplored) were supposedly also discovered here. The site is approx. 610 m away from the site of the activity.
Spodnja Libna – Homestead Spodnja Libna 13	17422	secular architectural heritage	group of buildings	The homestead comprises a ground-floor house with an upper-storey, protruding, accentuated gable resting on three pillars, a wooden garden shed, and several outbuildings to the left and right of the house. The site is approx. 670 m away from the site of the activity.
Libna – Chapel in Spodnja Libna	16233	religious architectural heritage	building	A historic open-plan chapel from the beginning of the 20th century with a crucifix in the interior. The chapel is approx. 740 m away from the site of the activity.
Stari Grad pri Vidmu – Church of St Nicholas	3487	religious architectural heritage	building	The Baroque church was built in 1627 in memory of the plague. It comprises a rectangular nave, a three-sided sanctuary, and a bell tower on the western side. The altar dates to the 19th century. The church is approx. 1,650 m away from the site of the activity.
Libna – Church of St Margaret	3489	religious architectural heritage	building	The church, which comprises a rectangular nave with a flat ceiling, the Chapel of St Anne, a three-sided sanctuary, and a bell tower on the western side, was renovated in the Baroque style in 1765. The high altar is from 1849, while the side altars are Baroque. The church stands atop the Libna hill (354 m a.s.l.) north of the eponymous settlement. The church is approx. 240 m away from the site of the activity (air distance).

The Institute for the Protection of Cultural Heritage of Slovenia (IPCHS), Ljubljana regional office, has issued an Opinion on the data to be contained in the Environmental Impact Assessment Report under the third paragraph of Article 52 of the Environmental Protection Act for the extension of NEK's operational lifetime from 40 to 60 years (preliminary information), No 350-0051/2016-16 of 10 December 2020.

After reviewing the materials on the web server, IPCHS has found that the planned activity does not affect registered cultural heritage units, and therefore has no data that would need to be included in the Environmental Impact Assessment Report. IPCHS further believes that the environmental impact assessment and the acquisition of the environmental consent for reasons of protecting cultural heritage are not required to obtain the extension of NEK's operational lifetime from 40 to 60 years.

4.1.8 Types of land in the area

The site of the activity is located in an area of building land on which mainly industrial buildings classified E – energy infrastructure, and VI – water infrastructure area have been built (intended use of land is presented in Section 1.8.1). The areas to the north, east and south are also built up, while areas to the west and southwest are agricultural land. There is no forest land in the vicinity.

4.1.9 Flood and erosion risk

The wider area of the activity is not at risk from erosion, and since it lies on flat land, it is also outside avalanche risk areas. The map of flood risk is shown in Section 11.2.

The NEK area is located within the Vrbina floodplain, which is the transition point between the eastern edge of the Krško Polje and the western edge of the Brežiško Polje /133/. According to the flood warning map (ARSO /60/), rare and catastrophic floods do not occur in the NEK area, although they may occur north, east, and south of the NEK area boundary. According to the flood map (iKRPN), the entire riverbed of the Sava, which runs parallel to the southern boundary of the NEK area, is classed as an area of high flood risk.

Flood safety

As it is situated on a former floodplain of the Sava, NEK was protected from flooding by embankments along the Sava and Potočnica during the construction. The Sava embankment extends approximately 2 km upstream and 1 km downstream from NEK, while the Potočnica embankment is 750 m long and runs from the mouth of the Potočnica flowing into the Sava to the railway line. During the construction of NEK, the right bank of the Sava was preserved in its natural state, thus ensuring an extreme flood would spill over onto the right-side floodplain along the Sava. At the time of the construction of NEK, the 10,000-year return period flood (Q10,000) peak was estimated at 4,272 m^3/s.

In 2011, flood safety of NEK was re-evaluated, and a new relevant flow of Q10,000 = 4,790 m^3/s was determined as part of the expanded analysis. Based on this analysis, a modification of flood embankments was completed in February 2012 (project NEKPMF-B056/186-2). The crown of the embankment along the Sava was raised up to 1 m at a length of 1,430 m, while the crown of the embankment along the Potočnica was raised up to 1.8 m, and a protective concrete wall was added in the far upstream section.

In March 2018, a second, minor modification of the embankments along the Sava and Potočnica was completed to account for the construction of the Brežice HPP (project NEKPOT-A201/019). The project investors were INFRA, HESS, the Slovenian Infrastructure Agency (DRSI), and the Municipality of Krško. The crown of the embankment along the Sava was minimally corrected at a length of 100 m (up to 10 cm), while flood protection along the Potočnica was raised by an additional 0.5 m by building a parapet wall and raising the height of the existing flood wall.

As a result of the modifications of flood embankments along the Sava and Potočnica in 2011 and 2018, NEK is protected up to a flow of 11,130 m^3/s /3/.

The spent fuel dry storage building is designed to protect against floods with flood embankments. In the event of a probable maximum flood (PMF) following an earthquake above 0.3 g, additional protection is provided by a system of water barriers, i.e. sealing to an elevation of 157.53 m a.s.l. Flood sealing is ensured by the exterior RC walls, and the intrusion of water through the door is prevented by removable flood barriers.

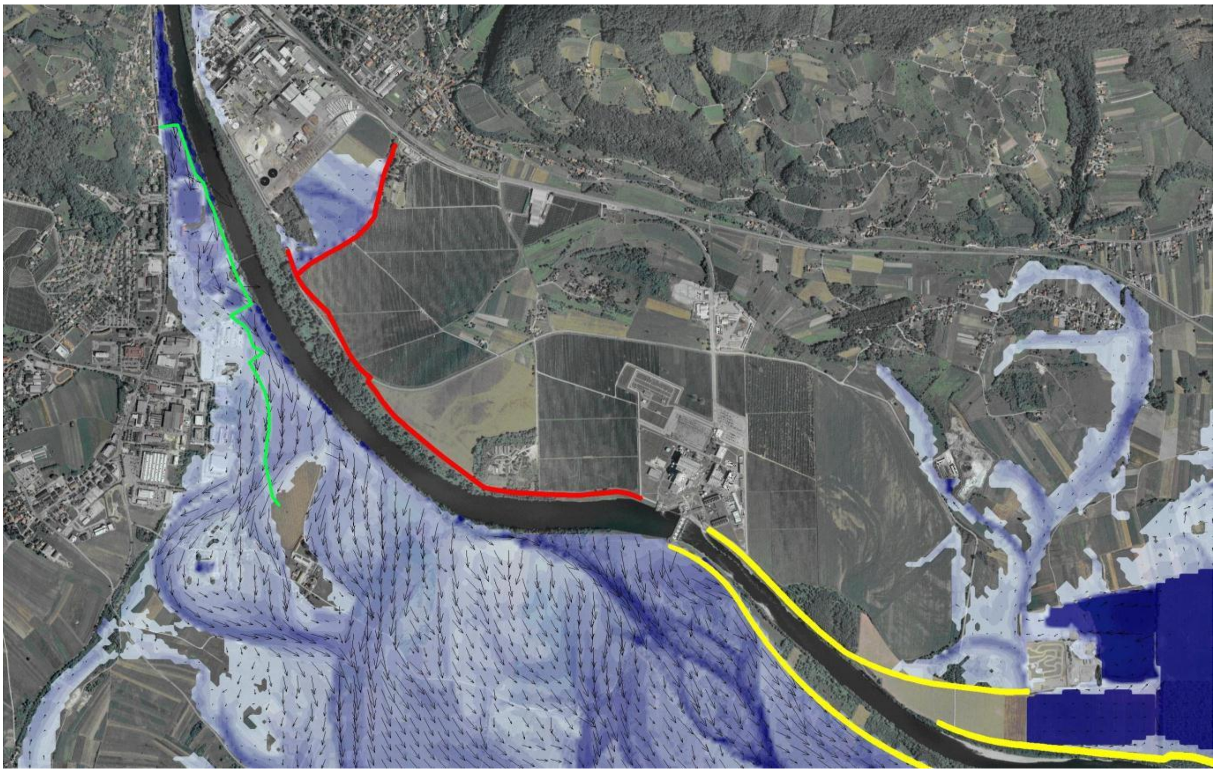


Figure 40: Areas of flooding around NEK and local water velocity vectors at QPMF = 7,081 m^3/s (unsteady flow) for conditions after the construction of the Brežice HPP (source: /151/)

The red line shows NEK embankments along the Sava and Potočnica, the green line shows flood embankments within the Brežice HPP project, and the yellow line shows the Brežice HPP dykes. From: Hydraulic analysis of high water flows in the Sava in the area of NEK under conditions of probable maximum flood (PMF) for conditions following the construction of Brežice HPP (Hidravlična analiza visokih voda reke Save v območju NEK pri največjem verjetnem pretoku (PMF) za stanje po izgradnji HE Brežice) /151/.

Table 38: Highest flows of the Sava recorded at Radeče, which served as a reference water gauging station for NEK until 1994 (source: /3/)

Year	Flow	Year	Flow	Year	Flow	Year	Flow
1990	**2991**	*1909*	1863	*1916*	1466	*1952*	1302
1998	2940	*1991*	1862	*1960*	1458	*1928*	1294
1933	2809	*1987*	1857	*1939*	1458	*1944*	1264
1964	2699	*1969*	1839	*1918*	1458	*1997*	1250
1923	2676	*1985*	1831	*1983*	1450	*1994*	1217
1979	2498	*1949*	1820	*1959*	1420	*1978*	1216
1973	2460	*1962*	1789	*1956*	1420	*1999*	1133
1980	2391	*1940*	1772	*1921*	1420	*1911*	1131
1966	2350	*1915*	1754	*1984*	1416	*1910*	1119
1982	2313	*1993*	1735	*1947*	1412	*1912*	1104
1936	2228	*1967*	1712	*1919*	1400	*1955*	1068
1974	2213	*1968*	1708	*1989*	1391	*1953*	1018
1992	2153	*1948*	1693	*1995*	1390	*1913*	1007
1927	2134	*1963*	1661	*1976*	1380	*1957*	1000
1926	2109	*1931*	1661	*1937*	1380	*1924*	997
1930	2087	*1925*	1576	*1977*	1370	*1971*	973
2000	2080	*1922*	1576	*1970*	1346	*1981*	942
1961	2024	*1951*	1552	*1943*	1341	*1950*	929
1934	1998	*1954*	1536	*1988*	1331	*1941*	849
1965	1957	*1935*	1536	*1932*	1325	*1920*	832
1975	1930	*1917*	1513	*1914*	1321	*1945*	815
1972	1913	*1986*	1492	*1908*	1317	*1942*	805
1996	1865	*1938*	1482	*1958*	1309	*1929*	805
						1946	582

Table 39: Six highest Sava River flows recorded in the Krško HPP profile (source: /246/)

Year	Date	Flow
1933	23.9.	*2940*
1964	25.10.	*2733*
1973	25.9.	*2549*
1979	29.1.	*2630*
1990	1.11.	*3050*
1998	4.11.	*3001*

On the basis of the protection measures described above and the historical flood records, it is concluded that NEK will be adequately protected against floods until 2043, even taking into account the effects of climate change.

4.1.10 Transport links and the burden on roads

NEK is located on the left bank of the Sava in the Krško industrial zone. The power plant is reached by a local road that connects to the regional road R1 Krško–Spodnja Pohanca via the Krško bypass. The plant also has an industrial railway track, which connects it to Krško railway station.

The table below shows the traffic loads on the regional road. The latest available data is for 2018.

Table 40: Average annual daily traffic (AADT) on the regional road in the 2016–2018 period (source:/123/)

Road cat.	Road no.	Section no.	Section	Count point	All vehicles (AADT)		
					2016	2017	2018
R1	220	1334	Krško–Spodnja Pohanca	367 Dolenja vas	5,904	5,810	6,026

Table 41: Average annual daily traffic (AADT) on regional roads in the vicinity of the activity site by type of vehicle in 2018 (source: /123/)

Road cat. and no. Section	All vehicles (AADT)	Motorcycles	Cars	Buses	Lt. trucks <3.5t	Med. trucks 3.5–7t	Hvy. trucks >7t	Trucks w. trailers	Tow trucks
R1 220 1334 Krško–Spodnja Pohanca	**6,026**	44	5,398	43	334	58	61	22	63

The above table shows that medium and heavy trucks account for a relatively small share of the total traffic on regional roads in the area and that cars account for the majority of traffic.

The main railway line from Ljubljana to Zagreb and the state border runs north of NEK. Krško railway station is situated approximately 2,500 m northwest and can be reached via section 220 of the R1.

4.1.11 Seismic safety

Slovenia is a country with a medium seismic hazard. While earthquakes in Slovenia do not reach high orders of magnitude, their effects can be quite serious because of the relatively shallow epicentres. A belt of greater seismic hazard runs across the central part of Slovenia in a contiguous zone from the far northwest to the southeast of the country. Moving away from this belt towards the northeast and southwest, the seismic hazard decreases.

The seismic intensity of the area under consideration reaches grade 8 according to the European Macroseismic Scale (EMS). Seismic accelerations of up to 0.2 g PGA for a 475-year return period earthquake, and 0.45 g PGA for a 10,000-year return period earthquake can be expected in this area. These figures are based on the maps of macroseismic intensities in Slovenia for 475- and 10,000-year return periods /60/.

Detailed geomechanical, hydrological, geophysical, and seismological investigations were carried out at the NEK site in several stages. The first stage was carried out between 1972–1973 and included boring to a depth of 12–13 m and measurements of P and S wave velocities. These investigations were carried out in the wider surroundings of NEK and used to determine its final location.

The second stage took place in the second half of 1973. It covered seismic measurements of P and S wave velocities and microseismic ground noise measurements at the NEK site. These investigations were used to create a geotechnical model and define the seismic loading parameters.

The third stage was carried out in the middle of 1974. It included 30 geomechanical borings between 30 and 90 m in depth, laboratory material tests, and measurements of P and S wave velocities up to a depth of 45 m.

The fourth stage was carried out in 1974. It included 24 new geomechanical borings up to a depth of 100 m, measurements of P and S wave velocities, additional laboratory tests, gamma-gamma measurements of material density, and geoelectrical sounding of the terrain. The second, third and fourth stage of the investigations were carried out at the NEK site and refer to structures of category I.

Further investigations at the site were carried out as part of a seismic probabilistic safety analysis to assess the power plant's vulnerability to seismic events. Geological, seismological, and geophysical investigations were completed between 1994 and 1996. Based on the preliminary results and IAEA recommendations, additional geological, seismological, and geophysical investigations were conducted as part of a revised "Programme for Additional Site Investigations". The studies focused on the NEK area and the surrounding region (radius 25 km) and included:

- update of the seismic event database;
- detailed geological mapping of the Krško basin and adjacent regions in the vicinity of the site at a scale of 1: 5,000;
- geophysical investigations;

- detailed investigations of Quaternary deposits, soils, and geomorphic surfaces that can be used to assess neotectonic deformation;
- acquisition and analysis of geodesic levelling and GPS survey data.

The results of geological, seismological, and geophysical investigations are presented in the first Periodic Safety Review (PSR), which provides an updated seismotectonic model of the Krško basin. This report provides a basis for reassessing and revising the Probabilistic Seismic Hazard Analysis (PSHA, 2002–2004).

After the end of the extensive probabilistic safety analysis for earthquakes /225/, which also involved 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 research. This research focused on individual geological structures (earthquake sources and faults), to better understand the seismic-tectonic structure of the Krško basin and reduce uncertainties in determining the seismic hazard of the location. This research, which has been carried out in the last ten years, has not confirmed the existence of such new faults or geological structures that could, in the event of an earthquake, permanently deform the surface of the location, nor have there been any new findings that could significantly change the existing estimate of seismic hazard at the NEK site /271/ produced between 2002 and 2004 after ten years of previous research.

Power plants are designed for earthquakes with return periods that significantly exceed the return periods of earthquakes applied when ordinary structures are being designed. The earthquake in Petrinja on 29 December 2020, which was also felt in the Krško area, posed no danger to NEK and caused no damage at all.

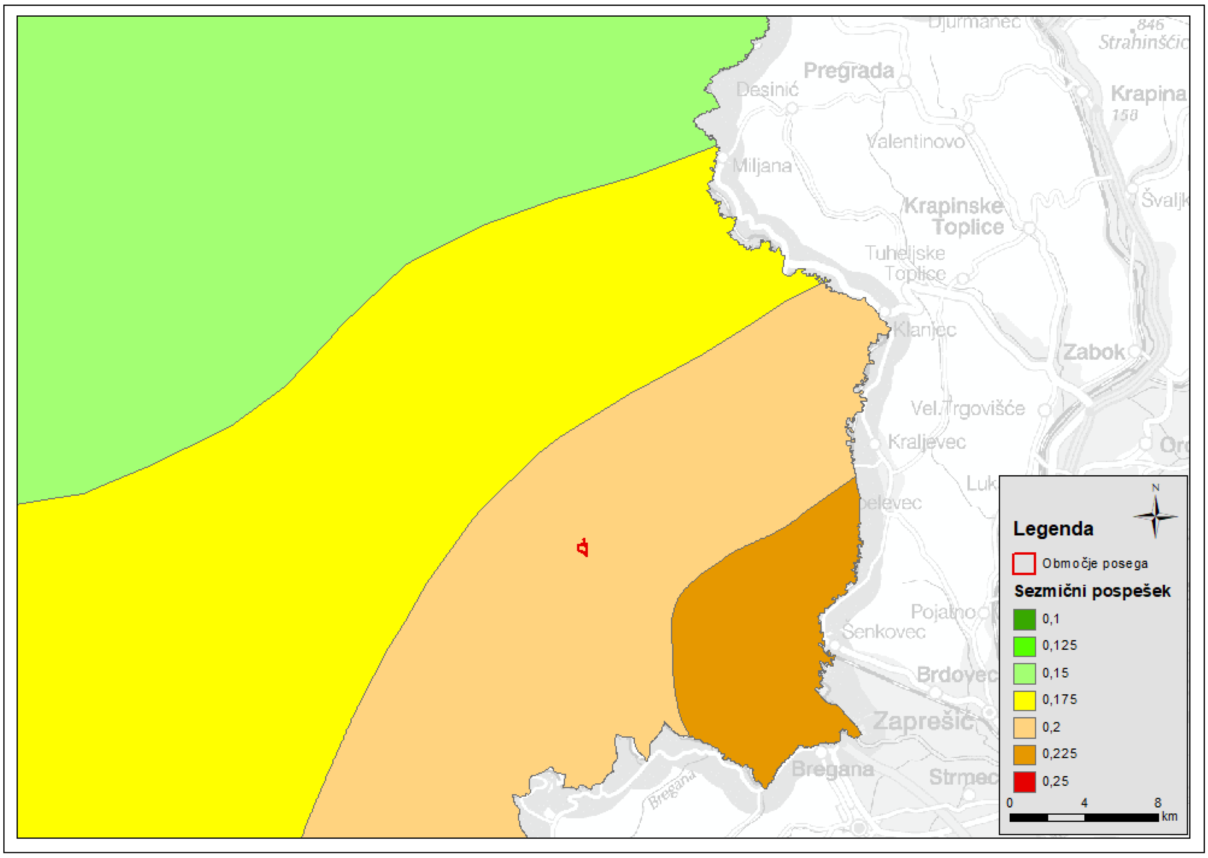


Figure 41: PGA for a 475-year return period (source: /60/)

Legenda	Key
Območje posega	Site of the activity
Seizmični pospešek	**Seismic acceleration**

4.2 AREAS UNDER A SPECIAL LEGAL REGIME

The site is located away from flood risk areas and away from areas protected by nature conservation and cultural heritage protection regulations.

Water protection areas, cultural heritage structures and areas, and areas protected under nature conservation regulations in the vicinity of the site of the activity are shown in figures in Section 11.2.

4.2.1 Protection of drinking water

A small part of the southernmost section of the site of the activity (in the vicinity of the dam) is located in the Drnovo WPA (protection regime II), as per the Decree on the protection of groundwater in the area of protection zones of the Krško pumping station-water supply system (Official Gazette of SRS, No. 12/85).

The Krško area is treated as a single groundwater body (VTPodV_1003 Krška kotlina) and includes the alluvial aquifer on the left and right banks of the Sava from the point where the river flows onto the plain by the town of Krško to the point where it exits it by the town of Brežice. In terms of the geological composition of the Krško Polje/Brežiško Polje, most important water sources are tied to the Quaternary alluvial layers of the Sava. The aquifer ranges in thickness from 12 to 20 m, depending on the morphology of the substrate, which is composed of practically water-impermeable Neogene rock.

A total of nine different sources are used to supply water to the wider area of the town of Krško. Only two pumping stations – Brege and Drnovo – are located within VTPodV_1003 Krška kotlina. Together they supply potable water to the greater part of the wider urban area. The Drnovo source is currently not in use owing to high concentrations of nitrates in the water. In addition to nitrates, pesticides also present a problem. Monitoring of drinking water on Krško Polje has shown that the concentrations of atrazine-desethyl have exceeded the limit values since 2003, with the maximum values achieved in 2005 and 2006, when they were four times higher than the limit value. Excessive concentrations of the pesticides bentazon and S-metolachlor also appeared in the Drnovo water catchment area in 2010. The Drnovo has served as a back-up water source since October 2010. It is used in the event of a major malfunction in the Krško water supply /258/. Investigations show that there is no trend of improvement in the 1003 Krška kotlina water body, while the trend is growing at the Drnovo pumping station /259/, /89/. The source of the Brege has a total capacity of around 60 l/s and has, together with the source of the Drnovo, defined water protection zones extending as far as the right bank of the Sava.

A NEK pumping well has been built in the vicinity of the NEK dam in the Sava, within the area of the Brege and Drnovo water-supply pumping station that falls under protection regime II. This well operates on the basis of a permit issued by ARSO on 15 October 2009 and valid until 31 August 2039 /50/. The maximum quantity of water pumped from the well in order to supply NEK with process water is limited to 16 l/s or 504,576 m^3/year. In 2020 approximately 204,000 m^3 was pumped from the well, which is less than half the permitted quantity. This is similar to the quantities pumped over the last ten years.

The wider area of the town of Brežice is supplied with potable water by a total of 12 pumping stations located outside VTPodV_1003 Krška kotlina. Of these 12 pumping stations, six are low-capacity natural sources (up to 2.2 l/s). These are mainly used to supply smaller settlements in the wider area of the town. The biggest pumping stations are Glogov Brod (around 60 l/s) and Brezina (around 20 l/s), both in settlements north of the town. All potable water pumping stations have a defined water protection area.

4.2.2 Noise protection level

Under the Municipal Spatial Plan the activity site is, in accordance with the Ordinance on the municipal spatial plan (OPN) for the Municipality of Krško (Official Gazette of RS, No. 61/15), located in an area with designated land use E – energy infrastructure, which is classified in the spatial planning document as a **level IV noise protection** area. Also classified as level IV noise protection areas are the direct surroundings of the activity site, consisting of K1 areas (prime agricultural land), IG areas (economic activities), VI areas (water infrastructure) and PC areas (transport surfaces). Designated land use in the wider area of the activity site is shown in the figure in Section 1.8.1.

The nearest residential areas are located north and northeast of the site of the activity (minimum distance 550 m) in the following spatial planning units (SPUs):

- SSG 04 with designated land use SS (residential areas),
- SSG 131 with designated land use A (areas of dispersed settlement),
- SLI 052 with designated land use SS (residential areas).

The above SPUs are categorised as **level III noise protection areas**.

The limit values for noise indicators for level IV and level III noise protection areas shown in the following tables are laid down by the Decree on limit values for environmental noise indicators (Official Gazette of RS, Nos. 43/18, 59/19).

Table 42: Limit values for noise indicators from Tables 1 and 2 of the Decree on limit values for environmental noise indicators – area

Noise protection area	Limit values Table 1		Limit values Table 2	
	L_{night} (dBA)	L_{den} (dBA)	L_{night} (dBA)	L_{den} (dBA)
IV	65	75	80	80
III	50	60	59	69

Table 43: Limit values for noise indicators (installation or plant) from Table 4 of the Decree on limit values for environmental noise indicators

Noise protection area	Limit values			
	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
IV	73	68	63	73
III	58	53	48	58

Key to the above tables:

L_{day} daytime noise indicator (6 am–6 pm)
$L_{evening}$ evening noise indicator (6 pm–10 pm)
L_{night} night-time noise indicator (10 pm–6 am)
L_{den} combined noise indicator (day-evening-night)

Table 44: Limit values for peak noise level L_1 – installation or plant

Noise protection area	Limit values for peak noise level L_1	
	Evening and night (dBA)	Day (dBA)
IV	90	90
III	70	85

4.2.3 Electromagnetic radiation protection level

Under the Municipal Spatial Plan the activity site is, in accordance with the Ordinance on the municipal spatial plan (OPN) for the Municipality of Krško (Official Gazette of RS, No. 61/15), located in an area with designated land use E – energy infrastructure, which is classified in the spatial planning document as a **level II radiation protection** area. Also classified as level II electromagnetic protection areas are the direct surroundings of the site of the activity, consisting of K1 areas (prime agricultural land), IG areas (economic activities), VI areas (water infrastructure) and PC areas (transport surfaces). Designated land use in the wider area of the activity site is shown in the figure in Section 1.8.1.

The nearest residential areas (minimum distance 550 m), located north and northeast of the area of the activity, are classified as **level I electromagnetic radiation protection** areas requiring increased protection against radiation. They are located in the following spatial planning units (SPUs):

- SSG 04 with designated land use SS (residential areas),
- SSG 131 with designated land use A (areas of dispersed settlement),
- SLI 052 with designated land use SS (residential areas).

Limit values of quantities of electromagnetic radiation under the Decree on electromagnetic radiation in the natural and living environment (Official Gazette of RS, Nos. 70/96, 41/04 [ZVO-1]) for low-frequency radiation at 50 Hz are shown in the following table.

Table 45: Limit values of quantities of EMR for low-frequency radiation at 50 Hz

Frequency (Hz)	**Electric field strength – E (V/m)**		**Magnetic flux density – B (µT)**	
	Area I	Area II	Area I	Area II
50	500	10,000	10	100

4.3 SETTLEMENT AND LIVING CONDITIONS IN THE AREA

The NEK site is located in the municipality of Krško, 2.5 km SE of the town of Krško. The area is bounded to the south by the channel of the Sava and to the north by the Vrbina industrial zone. The activity site is accessible from the R1 Krško–Spodnja Pohanca regional road and then from the local road running in a SE direction from the settlement of Vrbina towards the NEK site.

The fenced perimeter of NEK is surrounded by fruit orchards on its west, north and east sides. The Sava flows past the south side. Although the literature mentions the settlement of Vrbina, which lies approximately 490 m northwest of the activity site, the municipal spatial planning information system PISO /63/ shows it to be an area of central activities in which there is no settlement. The nearest densely populated settlement is Spodnji Stari Grad, which lies approximately 700 m northeast of the activity site.

The town of Krško, which lies to the northwest of the activity site, represents the economic, administrative, educational and cultural centre of the lower Posavje (Sava Valley) area. It was first mentioned in writing in the year AD 895. An 1189 document mentions a castle in a strategically important location at the entrance to the gorge of the Sava. A market town developed below this castle and was granted town rights in 1477. In 1480 the town was surrounded by walls. Crafts and trades developed in the Middle Ages. Commercial navigation on the Sava later grew in importance and continued to have a significant effect on the town's economy right up until 1862, when river traffic was supplanted by the railway. The development of industry began in 1937 with the opening of a small paper factory in Videm, Krško's present-day industrial zone. This has since grown into a large manufacturer of cellulose, paper and paper products /133/. Other industrial plants followed, with the result that today almost two thirds of the population are employed in industry. Settlements downstream of Krško and Videm have mainly formed on the right bank of the Sava along the main Ljubljana–Zagreb road.

In the second half of 2019 the municipality had a population of approximately 25,996 (13,358 men and 12,638 women). In terms of number of inhabitants, it was the 11th most populous municipality in Slovenia. There were on average 90 inhabitants per square kilometre of area of the municipality, giving a population density lower than the figure for the country as a whole (102 inhabitants per km^2).

A favourable climate for enterprise can be felt in the municipality, while the development of new business zones, including small-business zones, is a major factor in further development and job creation. The business environment of the Krško municipality represents the largest energy basin in Slovenia, since it is the location of several successful energy companies including NEK, Brežice HPP, GEN Energija and Termoelektrarna Brestanica, and also of the University of Maribor's Faculty of Energy Technology.

Among the larger infrastructure projects undertaken in the last decade is the construction of the Krško bypass, which was connected to the road network in 2019.

Another foundation of the municipality's economic development is the availability of competitively priced land (with utilities connections) in business zones that enjoy a highly strategic position, in that they lie along the main road and rail corridor and thus offer extremely advantageous logistics connections which, in combination with developed support activities, good infrastructure and availability of human resources, represent a competitive advantage that is successfully exploited by a large number of local, national and global businesses. A total of 83 hectares of still unoccupied land is available to developers, while the remaining 82 hectares host business activities that have created more than 700 jobs in the municipality of Krško in recent years.

The diversity of the landscape offers multiple opportunities for breaks and relaxation. There are numerous opportunities for cycling, running, hiking and horse riding. The area also hosts numerous sporting events, notably speedway, horse racing, football, handball, basketball and cycling marathons. Numerous tennis courts and country tracks suitable for cycling offer opportunities for active recreation.

The exposure and relief of the landscape around Krško also make it suitable for the development of agriculture and tourism. Local residents have converted the hills surrounding the Krško Basin into orchards and vineyards, the latter producing "Cviček", the typical local wine.

Figures from the National Institute of Public health (NIJZ) /134/ show that health picture of the municipality of Krško is slightly worse than the national average for the majority of indicators of state of health (see the table below).

Table 46: Certain population health indicators in the municipality of Krško – 2020 (source: /134/)

Indicator	**Municipality**	**Slovenia**	**Unit***
Inhabitants and community			
Level of development of municipality	1.13	1.0	index
Population growth	6.1	6.8	‰
Elderly population (over 80 years old)	5.2	5.3	%
Employment rate	65.7	64.4	%
State of health			
Sick leave	16.9	16.4	days
Asthma in children and adolescents (0–19 years)	0.6	1.0	ASR/1,000
Recipients of medication for diabetes	5.9	5.2	ASR/100
Recipients of medication for high blood pressure	26.1	23.0	ASR/100
Heart attack (35–74 years)	3.3	2.1	ASR/1,000
Stroke (35–84 years)	3.4	2.6	ASR/1,000
New cases of cancer	563	563	ASR/100,000
Mortality			
Mortality by place of permanent residence	965	916	ASR/100,000
Mortality from cardiovascular disease (0–74 years)	83	77	ASR/100,000
Mortality from cancer (all types) (0-74 years)	165	162	ASR/100,000

* ASR: age-standardised rate per 100, 1,000 or 100,000 inhabitants, with respect to the population of Slovenia as at 1 July 2014

- An average of 16.9 calendar days per year of sick leave was taken by the workforce in employment, compared to the national average of 16.4 days.
- The percentage of individuals taking medication for high blood pressure was higher than the national average. The same applied to those taking medication for diabetes.

- The rate of hospital treatments for heart attack was 3.3 per 1,000 inhabitants aged between 35 and 74, compared to a national rate of 2.1.
- Among the elderly population, the rate of hospital treatments for hip fractures was 9.5 per 1,000, compared to a national rate of 6.5.
- The percentage of users of home help services was higher than the national average.
- The suicide mortality rate was 17 per 100,000 population, compared to a national rate of 19.

In order to provide a broader picture, a comparison of the Posavje region (municipalities: Bistrica ob Sotli, Brežice, Kostanjevica na Krki, Krško, Radeče and Sevnica) with the national average is provided below. Figures are taken from the NIJZ publication on health in the region ("Zdravje v regiji 2018") /111/.

The health of the inhabitants of the Posavje region is worse than the national average according to several indicators, particularly as regards health risk factors in terms of prevention and mortality. The healthcare system is also in a slightly worse position and the region stands out in particular for its low number of healthcare personnel and low number of hospital beds per 1,000 inhabitants.

Health indicators for the Posavje region compared to the average for Slovenia show that:

- The percentage of child obesity was typically higher than in Slovenia as a whole.
- The percentage of road accidents in which alcohol was a factor was the highest in the country. The rate of hospital treatments for illnesses directly attributable to alcohol was also among the higher rates in the country.
- The response rate for the SVIT and ZORA cancer screening programmes was typically lower than the national average.
- The percentages of people receiving medication for high blood pressure, diabetes and mental illness were typically higher than the national average.
- The rate of hospital treatments for hip fractures among the elderly population was among the higher rates in the country.
- The percentage of users of home help services was typically higher than the national average.
- The number of hospital treatments due to tick-borne meningoencephalitis was among the lowest in the country.
- General mortality and mortality from cardiovascular disease were typically higher than the national average.

4.4 EXISTING STATE OF THE ENVIRONMENT, ENVIRONMENTAL PRESSURES AND ENVIRONMENTAL QUALITY

4.4.1 Ecosystems, flora and fauna, habitats

Information on flora and fauna (except fish) and habitat types in the area under consideration are based primarily on the findings of a study carried out in 2008 as part of the background documentation for the development of the Brežice and Mokrice hydropower plants. This study was published as Pregled živalskih in rastlinskih vrst, njihovih habitatov ter kartiranje habitatnih tipov s posebnim ozirom na evropsko pomembne vrste, ekološko pomembna območja, posebna varstvena območja, zavarovana območja in naravne vrednote na vplivnem območju predvidenih HE Brežice in HE Mokrice ["Survey of animal and plant species and their habitats and mapping of habitat types with particular regard for species of Europe-wide importance, important ecological areas, special protection areas, protected areas and valuable natural features in the area of influence of the planned Brežice and Mokrice hydropower plants"] (Editors: Govedič, M., A. Lešnik & M. Kotarac). Published by the Centre for Cartography of Fauna and Flora in conjunction with the Lutra Institute for the Conservation of Natural Heritage, the Research Centre of the Slovenian Academy of Sciences and Arts, the National Institute of Biology, VGB Maribor and the Biology Department of the Biotechnical Faculty at the University of Ljubljana. This study is hereinafter referred to as: CKFF, 2008, source /136/.

4.4.1.1 Flora and habitat types

The area of the planned activity comprises the built area inside the NEK complex enclosure, the car park, the access road, the dam on the Sava and the pumping well on the right bank of the river. Located in the immediate surroundings of the NEK complex are areas of intensive orchards (HT 83.22 Shrub and low stem tree orchards). The area on the left bank of the Sava is for the most part under the influence of intensive agriculture (orchards, fields) and the Vrbina industrial zone. Thus, there are no habitat types of greater nature conservation significance within the narrower area of controlled use (650 m) on the left bank of the Sava.

In the wider area of controlled use (1,500 m) to the north and east of the Vrbina industrial zone, we still find some preserved extensive meadows (HT 34.322 Medio-European moderately dry grasslands with dominant species *Bromus erectus*). Such grasslands were once common on carbonate gravel deposits by rivers but today are almost no longer found because they have been converted into fields or intensive meadows. The Decree on habitat types (Official Gazette of RS, Nos. 112/03, 36/09 and 33/13) lists them among habitat types that are in danger of disappearing in the European Union and they have been defined as priority natural habitat types by EU regulations governing the conservation of wild fauna and flora. We can identify them by the presence of *Bromus erectus*, a characteristic component of turf, while other common grass species include *Briza media*, *Brachypodium pinnatum agg.*, *Dactylis glomerata* and *Festuca rupicola*. This habitat type also typically features orchids (*Orchidaceae*).

Riparian woody vegetation (HT 44.132 Eastern European white willow forest with poplars) still survives along the Struga stream. This habitat type is also listed by the Decree on habitat types (Official Gazette of RS, Nos. 112/03, 36/09 and 33/13) among habitat types that are in danger of disappearing in the European Union and they have been defined as priority natural habitat types by EU regulations governing the conservation of wild fauna and flora.

The Sava flows past the NEK complex on its south side. The banks of the river directly adjoining the NEK complex are covered with tall herbaceous species (HT 37.7 Nitrophilous woodland edge fringes and humid riverside tall herbaceous cover), while upstream and downstream we find HT 44.132 Eastern European white willow forest with poplars and HT 44.42 remnants of medio-European oak-ash-elm groves in a narrow belt along the bank. On the right bank of the Sava, the original riparian woody vegetation has, for the most part, been cleared. In this area, which is also a designated Natura 2000 Special Area of Conservation (known as Vrbina SAC), there is a mosaic of various habitat types. Here we find extensive meadows (HT 34.322 Medio-European moderately dry grasslands with dominant species *Bromus erectus* and HT 34.323 Medio-European moderately dry grasslands with *Brachypodium pinnatum agg.*) and moderately cultivated meadows (HT 38.221 Xero-mesophile medio-European lowland hay meadows on relatively dry soils and slopes with dominant species *Arrhenatherum elatius*). In places the area is overgrown with tree and shrub species (HT 31.8121 Medio-European thermophilous basiphilous thickets with wild privet and blackthorn, HT 31.8D Shrubby deciduous forests and areas overgrowing with deciduous tree species). Also present is the black locust (*Robinia pseudoacacia*), a non-native tree species – HT 83.324 Locust tree populations and stands.

As already mentioned, numerous orchid species thrive in medio-European moderately dry grasslands with dominant species *Bromus erectus.* Species recorded in this area include the green-winged orchid (*Orchis morio*), bug orchid (*Orchis coriophora*) and early spider-orchid (*Ophrys sphegodes*). All three species are included as vulnerable species in the Red List of Vascular Plants (Rules on the inclusion of endangered plant and animal species in the Red List, Official Gazette of RS, Nos. 82/02 and 42/10). Also recorded in the wider area is *Pulsatilla nigricans*, which is likewise included in the Red List as a vulnerable species (Bioportal, 2020 /138/). According to data from 2008, a further nine orchid species occur in the wider area, including, from the Red List, *Phleum paniculatum* (rare species), *Agrostemma githago* (vulnerable species), *Ballota nigra* (little-known species), *Fragaria viridis* (vulnerable species), *Muscari botryoides* and *M. comosum* (both vulnerable species) and *Orobanche teucrii* (little-known species). Some orchid species, the perennial bunchgrass *Chrysopogon gryllus*, the sedge *Carex liparocarpos* and the flowering plant *Seseli annuum* have very large populations in the wider area of the Vrbina SAC (CKFF, 2008 /136/).

4.4.1.2 Fauna

Mammals (Mammalia)

Bats (Chiroptera)
The immediate surroundings of the NEK complex also include habitats suitable for bats. Humid forest or forest fringe areas maintaining large numbers of arthropods, particularly insects, are particularly important feeding areas for bats. Insects are the principal source of food for the bats present in the area. Other favourable bat feeding areas are riverbanks with old-growth tree cover such as the banks of the Sava and the surroundings of the Struga stream, as well as the overgrown area on the right bank of the Sava. Many bat species (e.g. Kuhl's pipistrelle, serotine bat) roost in cracks and crevices in buildings. Tree bats (e.g. noctule bats, Daubenton's bat) roost in tree hollows and cracks in older deciduous trees, which in the area in question can be expected to be found in habitat types such as Eastern European white willow forest with poplars and remnants of medio-European oak-ash-elm groves. Many bat species in Slovenia hibernate in caves and other underground spaces. All bats are classified as endangered species (Rules on the inclusion of endangered plant and animal species in the Red List, Official Gazette of RS, Nos. 82/02 and 42/10) and are protected by the Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, Constitutional Court Decision of 13 March 2008, 96/08, 36/09, 102/11, 15/14, 64/16 and 62/19). Within the wider surroundings of the area in question, bats have been observed in St Anne's Church in Leskovec (greater horseshoe bat – *Rhinolophus ferrumequinum*) and the bell tower of St Rupert's Church in Krško (Greater mouse-eared bat – *Myotis myotis*). The calls of the long-eared bat (*Plecotus* sp.) have been recorded in Krško, while calls of Daubenton's bat (*Myotis daubentonii*) are particularly numerous by the Sava. Calls of the common noctule (*Nyctalus noctula*) have been recorded here in the autumn. The common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle *(Pipistrellus pygmaeus*), Kuhl's pipistrelle (*Pipistrellus kuhlii*) and serotine bat (*Eptesicus serotinus*) have been recorded on the banks of the Sava and in settlements in the wider area. Individual specimens of the Mediterranean horseshoe bat (*Rhinolophus euryale*) can be expected on the bank of the Sava in the surroundings of Krško, while Geoffroy's bat (*Myotis emarginatus*) can likewise be expected in the vicinity of bodies of water (CKFF, 2008 /136/). The conservation status of bats in the wider area under consideration is given in the table below.

Table 47: Nature conservation status of bats in the wider area (source: /136/).

Scientific name	Common name	Red List	Decree	FFH
Eptesicus serotinus	serotine bat	O1	1	IV
Myotis daubentonii	Daubenton's bat	O1	1	IV
Myotis emarginatus	Geoffroy's bat	V	1, 2	II, IV
Myotis myotis	greater mouse-eared bat	E	1, 2	II, IV
Nyctalus noctula	common noctule	O1	1	IV
Pipistrellus kuhlii	Kuhl's pipistrelle	O1	1	IV
Pipistrellus pistrellus	common pipistrelle	O1	1, 2	IV
Pipistrellus pygmaeus	soprano pipistrelle	K	1	IV
Plecotus austriacus	grey long-eared bat	V	1, 2	IV
Rhinolophus euryale	Mediterranean horseshoe bat	E	1, 2	II, IV
Rhinolophus ferrumequinum	greater horseshoe bat	E	1, 2	II, IV

Key:
Red List: species is listed in the Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). Ex – extinct; Ex? – presumed extinct; E – endangered; V – vulnerable; R – rare; K – little-known; O/O1 – out of danger/possibility of return to endangered status, I – undefined.
Decree: Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for

which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection.

Otter (Lutra lutra)
The otter is constantly present in the area of the Sava. Its tracks or other signs of its presence have been recorded in riverside and riparian habitats. Gravel pits also constitute an important part of its habitat. Tributaries, particularly their mouth sections, are an extremely important part of the otter's habitat since they provide a sufficient variety of fish species for the otter's diet and also an adequate quantity of food. The area of the NEK complex and its immediate surroundings do not represent a favourable otter habitat, and signs of otter presence have not been observed in the surroundings of NEK (CKFF, 2008 /136/).

European beaver (*Castor fiber*)
The area of the Sava in the immediate vicinity of NEK does not represent a suitable beaver habitat, although the Sava, particularly its lower course, is an important corridor for the recolonisation of past beaver habitats across Slovenia (CKFF, 2008 /136/). Traces of beaver activity have already been observed near Krško, although these probably do not indicate the presence of a family.

Large carnivores
Owing to human settlement and traffic impact, the role of the Krško/Brežice Basin is limited to that of a transitional microhabitat (albeit an important one) for the wolf (*Canis lupus*) and brown bear (*Ursus arctos*). Both species are permanently present in the hills of the Gorjanci/Žumberak range and also occasionally appear in the Krško/Brežice Basin. It is assumed that wolves pass from the Gorjanci through the forest of Krakovski Gozd and the Krško/Brežice Basin to Bohor and Orlica, and then continue on towards the northeast. Individual bears moving towards the north cross the Sava near Sevnica and continue on towards Bohor and Orlica. In order to cross the river, they need a natural riverside area with banks that are at least partly accessible and passable (CKFF, 2008 /136/).

Red deer (*Cervus elaphus*)
The Krško/Brežice Basin represents a passage or functional connection between the Gorjanci in the south and the Posavje Hills and Bohor and Orlica in the north. Today's habitat conditions are favourable for deer, above all because of the state of conservation of riparian vegetation and other habitat types offering ample food and protection (surviving islands of forest of various sizes, field boundaries, etc.). At present, the area between Krško and Brežice is still permeable enough to allow deer to pass between the Gorjanci and Bohor and on towards the Pohorje, which ensures gene flow among population units in its margins. While deer are good swimmers, they prefer to cross running waters in shallows, in places with suitably shaped banks and riverbank vegetation, in which they generally remain for a short while after crossing the watercourse. Owing to relatively natural river flow dynamics, there are still sufficient shallows, banks, isolated rocks and overgrown riverbank areas between Brežice and Obrežje to allow deer to cross and provide them with cover (CKFF, 2008 /136/).

Other mammals
The Krško/Brežice Basin represents a central optimal habitat type for the European hare (*Lepus europaeus*). The wild boar (*Sus scrofa*) is another occasional presence here, crossing from the SE parts of the Gorjanci to agricultural land (fields). Thanks to the presence of stands of forest, other mammals present in the Krško/Brežice Basin include roe deer (*Capreolus capreolus*), badger (*Meles meles*), beech marten (*Martes foina*), European pine marten (*Martes martes*) and fox (*Vulpes vulpes*). Riverside habitats along the Sava are a very important feeding area for the European polecat (*Mustela putorius*) The stoat (*Mustela erminea*) is also likely to be present in fields, meadows and humid habitats, while the least weasel (*Mustela nivalis*) is probably present in open flat plains (CKFF, 2008 /136/). Numerous species of shrew and other small mammals are found across the wider area (Kryštufek, B., 1991 /247/) (table below).

Table 48: List of mammals (excluding bats) in the wider area and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	FFH
Canis lupus	Eurasian wolf	E	1, 2	II, IV*
Capreolus capreolus	roe deer	-	-	-
Castor fiber	Eurasian beaver	Ex/E	1, 2	II, IV
Cervus elaphus	red deer	-	-	-
Crocidura suaveolens	lesser white-toothed shrew	O1	2	-
Crocidura leucodon	bicoloured white-toothed shrew	O1	2	-
Erinaceus concolor	southern white-breasted hedgehog	O1	1	-
Lepus europaeus	European hare	-	-	-
Lutra lutra	otter	V	1, 2	II, IV
Martes martes	European pine marten	-	-	V
Muscardinus avellanarius	hazel dormouse	O1	1, 2	-
Mustela erminea	stoat (ermine)	O1	1, 2	-
Mustela nivalis	least weasel	O1	1, 2	-
Mustela putorius	European polecat	O1		V
Neomys anomalus	Mediterranean water shrew	O1	2	
Sciurus vulgaris	red squirrel	O1	1	
Sorex araneus	common shrew	O1	2	IV
Sorex minutus	Eurasian pygmy shrew	O1	2	IV
Sus scrofa	wild boar	-	-	-
Talpa europaea	European mole	O1	-	-
Ursus arctos	brown bear	E	1, 2	II, IV*

Key:
Red List: species is listed in the Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). Ex – extinct; Ex? – presumed extinct; E – endangered; V – vulnerable; R – rare; K – little-known; O/O1 – out of danger/possibility of return to endangered status, I – undefined.
Decree: Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; **V** – Annex V: animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures, * priority species

Birds (Aves)

The Sava is a habitat for numerous bird species, with the common sandpiper (*Actitis hypoleucos*) and common kingfisher (*Alcedo atthis*) among the species that nest here. The commonest species in the agricultural cultural landscape of the wider area are the Eurasian skylark (*Alauda arvensis*), the house sparrow (*Passer domesticus*) and the Eurasian blackcap (*Sylvia atricapilla*), while the area is also an important feeding ground for the rook (*Corvus frugilegus*) and a nesting area for vulnerable species such as the common nightingale (*Luscinia megarhynchos*), the Eurasian skylark (*Alauda arvensis*), the crested lark (*Galerida cristata*) and the northern lapwing (*Vanellus vanellus*). In areas of alternating dry meadows and shrubland, the commonest species besides the Eurasian blackcap are the great tit (*Parus major*) and the common pheasant (*Phasianus colchicus*), while the barred warbler (*Sylvia nisoria*) and European turtle dove (*Streptopelia turtur*) populations are important from a nature conservation perspective. Of the owls, the long-eared owl (*Asio otus*) and the tawny owl (*Strix aluco*) have been recorded in the wider area (CKFF, 2008 /136/).

A list of birds recorded on the Sava between Krško and Brežice is given in the table below (CKFF, 2008 /136/).

Table 49: List of birds recorded on the Sava and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	Directive
Acrocephalus schoenobaenus	sedge warbler	V	1	
Actitis hypoleucos	common sandpiper	E2	1, 2	
Alcedo atthis	common kingfisher	E2	1, 2	1
Anas platyrhynchos	mallard			2/1, 3/1
Ardea cinerea	grey heron	O1	1	
Buteo buteo	common buzzard	O1	1	
Circus cyaneus	hen harrier		1, 2	1
Falco subbuteo	Eurasian hobby	V1	1	
Haliaeetus albicilla	white-tailed eagle	E1	1, 2	1
Hippolais icterina	icterine warbler	K	1	
Locustella fluviatilis	river warbler	V	1	
Merops apiaster	European bee-eater	E2	1, 2	
Milvus migrans	black kite	E2	1, 2	1
Motacilla cinerea	grey wagtail		1	
Phalacrocorax carbo	great cormorant		1, 2	
Podiceps cristatus	great crested grebe	V1	1	
Remiz pendulinus	Eurasian penduline tit	V	1	
Riparia riparia	sand martin	E2	1, 2	
Sterna hirundo	common tern	E2	1, 2	1

Key:
Red List: species is listed in the Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). Ex – extinct; Ex? – presumed extinct; E – endangered; V – vulnerable; R – rare; K – little-known; O/O1 – out of danger/possibility of return to endangered status, I – undefined.
Decree: species is listed in the Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
Directive: Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (OJ L 103, 25.4.1979, p. 1), **1** – The species mentioned in Annex I shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution. **2/1** – The species referred to in Annex II/1 may be hunted in the geographical sea and land area where this Directive applies; **2/2** – The species referred to in Annex II/2 may be hunted only in the Member States in respect of which they are indicated, **3/1 and 3/2** – species in Annexes **III/1** and **III/2**.

Amphibians (Amphibia)

The site of the activity itself and the areas of intensive orchards in the immediate vicinity of the NEK complex do not represent a suitable habitat for amphibians. Suitable habitats for amphibians are located above all in the surroundings of the Struga stream, oxbows, channels, gravel pits and the mosaic of forest habitats on the left and right banks of the river. In the wider surrounding area we find the European tree frog (*Hyla arborea*), the agile frog (*Rana dalmatina*), the common frog (*Rana temporaria*), the common toad (*Bufo bufo*), the Eurasian water frog (*Pelophylax* sp.), the Italian crested newt (*Triturus carnifex*), the smooth newt (*Lissotriton vulgaris*), the alpine newt (*Ichthyosaura alpestris*) and the European green toad (*Bufotes viridis*) (CKFF, 2008 /136/).

The nature conservation status of amphibians in the area under consideration is shown in the table below.

Table 50: List of amphibians in the wider area and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	FFH
Bufo bufo	common toad	V	1, 2	-
Bufotes viridis	European green toad	V	1, 2	IV
Hyla arborea	European tree frog	V	1, 2	IV
Ichthyosaura alpestris	alpine newt	V	1, 2	-
Lissotriton vulgaris	smooth newt	V	1, 2	-
Pelophylax sp.	Eurasian water frog	V	1, 2	IV, V
Rana dalmatina	agile frog	V	1, 2	IV
Rana temporaria	common frog	V	1	V
Triturus carnifex	Italian crested newt	V	1, 2	II, IV

Key:
Red List: species is listed in the Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). Ex – extinct; Ex? – presumed extinct; E – endangered; V – vulnerable; R – rare; K – little-known; O/O1 – out of danger/possibility of return to endangered status, I – undefined.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; * – priority species; **V** – Annex V: animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures.
Decree: species is listed in the Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.

Reptiles (Reptilia)

Only the common wall lizard (*Podarcis muralis*) can be expected within the anthropogenic habitats of the site of the activity itself. We can expect to find the sand lizard (*Lacerta agilis*) in humid areas near water that are partly overgrown by shrubs or tall herbaceous cover. Large numbers of European green lizards (*Lacerta viridis*) have been recorded in the area of shrubland on the right bank of the Sava opposite NEK. The river itself and the riparian zone are an important habitat for the dice snake (*Natrix tessellata*), while we can also expect the grass snake (*Natrix natrix*) to be present by bodies of water (especially standing water). We can expect the slow worm (*Anguis fragilis*) to be generally distributed across extensively cultivated areas of farmland and shrubland, where we can also expect the rarer Aesculapian snake (*Zamenis longissimus*). Shrubland also provides a habitat for the smooth snake (*Coronella austriaca*). The nature conservation status of reptiles from the area under consideration is shown in the table below.

Table 51: List of reptiles in the wider area and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	FFH
Anguis fragilis	slow worm	O1	1	-

Scientific name	Common name	Red List	Decree	FFH
Coronella austriaca	smooth snake	V	1	IV
Lacerta agilis	sand lizard	E	1, 2	IV
Lacerta viridis	European green lizard	V	1	IV
Natrix natrix	grass snake	O1	1	-
Natrix tessellata	dice snake	V	1	IV
Podarcis muralis	common wall lizard	O1	1	IV
Zamenis longissimus	Aesculapian snake	V	1	IV

Key:
Red List: species is listed in the Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). Ex – extinct; Ex? – presumed extinct; E – endangered; V – vulnerable; R – rare; K – little-known; O/O1 – out of danger/possibility of return to endangered status, I – undefined.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; * – priority species; **V** – Annex V: animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures.
Decree: species is listed in the Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.

Fish (Pisces) and crustaceans (Crustacea)

The Struga stream is not subject to fishery management and is not entered in the fisheries register. The section of the Sava that flows past the NEK area belongs to the Sava 19 fishing district (the Sava from the mouth of the Blanščica to Turški Brod). The fisheries register (RibKat, 2019 /137/) lists 40 species of fish for the Sava 19 fishing district. A list of fish in the Sava 19 fishing district is given in the table below.

Table 52: List of fish in the Sava 19 fishing district and their nature conservation status (source: RibKat, 2019 /137/).

Scientific name	Common name	Red List	Decree	FFH	Conservation period
Abramis brama	freshwater bream	-	-	-	1 May–30 Jun
Alburnoides bipunctatus	spirlin	O1	-	-	-
Alburnus alburnus	common bleak	-	-	-	1 Apr–30 Jun
Aspius aspius	asp	E	2	II	1 May–30 Jun
Barbatula barbatula	stone loach	O1	-	-	-
Barbus balcanicus	Danube barbel	-	2	II, V	1 May–30 Jun
Barbus barbus	common barbel	E	2	V	1 May–30 Jun
Blicca bjoerkna	white bream	-	-	-	1 May–30 Jun
Carassius auratus	goldfish	-	-	-	/
Carassius gibelio	Prussian carp	-	-	-	/
Chondrostoma nasus	common nase	E	2	-	1 Mar–31 May
Cobitis elongata	Balkan loach	E	1, 2	II	-
Cobitis elongatoides	Danubian spined loach	V	1, 2	II	-
Cottus gobio	European bullhead	V	2	II	-
Cyprinus carpio	common carp (farmed form)	-	-	-	/
Esox lucius	northern pike	V	2	-	1 Feb–30 Apr

Scientific name	Common name	Red List	Decree	FFH	Conservation period
Gobio obtusirostris	Danube gudgeon	-	-	-	-
Gymnocephalus cernua	Eurasian ruffle	O1	2	-	-
Hucho hucho	Danube salmon	E	2	II, V	15 Feb–30 Sep
Lepomis gibbosus	pumpkinseed	-	-	-	/
Leuciscus idus	ide	E	2	-	1 Mar–31 May
Perca fluviatilis	common perch	-	-	-	1 Mar–31 May
Phoxinus phoxinus	common minnow	-	-	-	1 Apr–30 Jun
Pseudorasbora parva	stone moroko	-	-	-	/
Rhodeus amarus	European bitterling	E	2	II	-
Romanogobio kesslerii	Kessler's gudgeon	V	1, 2	II	-
Romanogobio uranoscopus	Danubian longbarbel gudgeon	V	2	II	-
Romanogobio vladykovi	Danube whitefin gudgeon	V	1, 2	II	-
Rutilus rutilus	common roach	-	-	-	1 Apr–30 Jun
Rutilus virgo	cactus roach	E	2	II	1 Mar–31 May
Sabanejewia balcanica	Balkan spined loach	E	2	II	-
Salmo trutta fario	river trout	E	-	-	1 Oct–28 Feb
Sander lucioperca	zander	E	-	-	1 Mar–31 May
Scardinius erythrophthalmus	common rudd	-	-	-	1 Apr–30 Jun
Silurus glanus	wels catfish	V	-	-	1 May–30 Jun
Squalius cephalus	common chub	-	-	-	1 May–30 Jun
Telestes souffia	souffia	E	1, 2	II	-
Vimba vimba	vimba bream	E	-	-	1 May–30 Jun
Zingel streber	streber	E	2	II	-

Key:
Red List: species is listed in the Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). Ex – extinct; Ex? – presumed extinct; E – endangered; V – vulnerable; R – rare; K – little-known; O/O1 – out of danger/possibility of return to endangered status, I – undefined.
Decree: species is listed in the Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; * – priority species; **V** – Annex V: animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures.

An ichthyological study of the Brežice HPP reservoir in 2019 confirmed the presence of 27 fish species, of which 24 were native and three were non-native species (stone moroko (*Pseudorasbora parva*), pumpkinseed (*Lepomis gibbosus*) and Prussian carp (*Carassius gibelio*)) /139/.

Invertebrates (Invertebrata)

<u>Molluscs (Mollusca)</u>
Of the mollusc species important from a nature conservation perspective, specimens of the narrow-mouthed whorl snail (*Vertigo angustior*) have been found in the upper course of a tributary of the Struga stream. The big-ear radix (*Radix auricularia*) has been observed at the Stari Grad gravel pit. No other protected or endangered species of mollusc have been observed in the immediate vicinity of NEK. The banks of the Sava also represent a potential habitat for this species. The area of grassland and shrubland

on the right bank of the Sava is also important for molluscs, and the variety of mollusc species here is extremely high (CKFF, 2008 /136/).

Table 53: Molluscs important from a nature conservation perspective in the wider area and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	FFH
Radix auricularia	big-ear radix	R	-	-
Vertigo angustior	narrow-mouthed whorl snail		2	II

Key:
Red List: Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). **Ex** – extinct; **Ex?** – presumed extinct; **E** – endangered; **V** – vulnerable; **R** – rare; **K** – little-known; **O/O1** – out of danger/possibility of return to endangered status, **I** – undefined.
Decree: Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; * – priority species.

Butterflies and moths (Lepidoptera)

Inventories of butterflies have been carried out in the area of dry meadows and shrubland on the right bank of the Sava, although we can also expect the observed species of butterflies in dry meadows and shrubland in the area around the Vrbina industrial zone and the Struga stream. The large copper (*Lycaena dispar*) was recorded in meadows on the right bank of the Sava in 2001, while studies carried out in 2008 recorded 58 species there, including the southern festoon (*Zerynthia polyxena*), Nickerl's fritillary (*Melitaea aurelia*), Assmann's fritillary (*Melitaea britomartis*), the southern small white (*Pieris mannii*), the northern blue (*Plebeius idas*), the mallow skipper (*Carcharodus alceae*), the feathered footman (*Spiris striata*) and the small bagworm moth (*Ptilocephala plumifera*). The area is also important as a favourable habitat for a number of other grassland and shrubland xerothermophilous species of diurnal lepidoptera such as the scarce swallowtail (*Iphiclides podalirius*), the black hairstreak (*Satyrium pruni*), the sloe hairstreak (*S. acaciae*) and the spotted fritillary (*Melitaea didyma*) (CKFF, 2008 /136/). Caterpillars of the eastern eggar (*Eriogaster catax*) were also observed there in 2018 (Bioportal, 2020 /138/).

Table 54: Butterflies and moths important from a nature conservation perspective in the wider area and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	FFH
Carcharodus alceae	mallow skipper	V	-	-
Eriogaster catax	eastern eggar	E	1, 2	II, IV
Lycaena dispar	large copper	V	1, 2	II, IV
Melitaea aurelia	Nickerl's fritillary	V	-	-
Melitaea britomartis	Assmann's fritillary	V	-	-
Pieris mannii	southern small white	V	-	-
Plebeius idas	northern blue	V	-	-
Spiris striata	feathered footman	-	2	-
Zerynthia polyxena	southern festoon	V	1, 2	IV

Key:

Red List: Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). **Ex** – extinct; **Ex?** – presumed extinct; **E** – endangered; **V** – vulnerable; **R** – rare; **K** – little-known; **O/O1** – out of danger/possibility of return to endangered status, **I** – undefined.
Decree: Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; * – priority species.

Dragonflies and damselflies (Odonata)

The exuvia of a green snaketail (*Ophiogomphus cecilia*) has been found in the riparian vegetation of the Sava 800 m below the NEK dam. The green snaketail is a lowland river species and its larvae live on quieter stretches, buried in the sandy bottom (CKFF, 2008). It is protected by the Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16) as a species whose members are protected and whose habitats are safeguarded. It is classified as a vulnerable species on the Red List of dragonflies and damselflies of Slovenia. The Sava is also a habitat of the common clubtail (*Gomphus vulgatissimus*), which also appears as a vulnerable species on the Red List of dragonflies and damselflies of Slovenia. Since there are no waterways apart from the Sava and the Struga stream in the direct vicinity of the site of the activity, the species variety of dragonflies and damselflies in this area is considerably lower than in more distant gravel pits and oxbow lakes. The goblet-marked damselfly (*Erythromma lindenii*) has been observed at the Stari Grad gravel pit, while the eastern willow spreadwing (*Chalcolestes parvidens*), southern emerald damselfly (*Lestes barbarus*), variable damselfly (*Coenagrion pulchellum*) and dainty damselfly (*Coenagrion scitulum*) have been observed at the abandoned gravel pit by the Močnik stream in Vrbina (CKFF, 2008 /136/).

Table 55: Dragonflies and damselflies important from a nature conservation perspective in the wider area and their nature conservation status (source: CKFF, 2008 /136/).

Scientific name	Common name	Red List	Decree	FFH
Chalcolestes parvidens	eastern willow spreadwing	I	-	-
Coenagrion pulchellum	variable damselfly	V	-	-
Coenagrion scitulum	dainty damselfly	V	-	-
Erythromma lindenii	goblet-marked damselfly	V	-	-
Gomphus vulgatissimus	common clubtail	V	-	-
Lestes barbarus	southern emerald damselfly	V	-	-
Ophiogomphus cecilia	green snaketail	V	1, 2	II, IV

Key:
Red List: Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). **Ex** – extinct; **Ex?** – presumed extinct; **E** – endangered; **V** – vulnerable; **R** – rare; **K** – little-known; **O/O1** – out of danger/possibility of return to endangered status, **I** – undefined.
Decree: Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
FFH: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7), last amended by Council Directive 2006/105/EC of 20 November 2006 (OJ L 363, 20.12.2006, p. 368) (Habitats Directive). **I** – Annex I: natural habitat types of Community interest whose conservation requires the designation of special areas of conservation; **II** – Annex II: animal and plant species of Community interest whose conservation requires the designation of special areas of conservation; **IV** – Annex IV: animal and plant species of Community interest in need of strict protection; * – priority species.

Beetles (Coleoptera)

The surviving natural arboreal vegetation along the Struga stream represents a habitat for the European stag beetle (*Lucanus cervus*), where medium-large densities of this beetle were identified during a study in 2008 (CKFF, 2008 /136/). A potential habitat for this species is also represented by the arboreal vegetation along the Sava. Individual older trees along the Struga and Sava represent a potential habitat for the hermit beetle (*Osmoderma eremita*) and the marbled rose chafer (*Liocola lugubris*). Gravel beds in the Sava are a potential habitat for the carabid beetles *Bembidion friebi* and *Lionychus quadrillum* (CKFF, 2008 /136/). Specimens of the weaver beetle (*Lamia textor*), a rare non-flying species that lives predominantly in stands of softwood deciduous trees, were found in overgrown meadows 1.1 km southeast of the NEK dam in 2018 (Bioportal, 2020 /138/).

Table 56: Beetles important from a nature conservation perspective in the wider area and their nature conservation status (source: CKFF, 2008 /136/; Bioportal, 2020 /138/).

Scientific name	Common name	Red List	Decree	FFH
Bembidion friebi	-	V	1, 2	-
Lucanus cervus	European stag beetle	E	1, 2	II
Lamia textor	weaver beetle	E	-	-
Liocola lugubris	marbled rose chafer	E	-	-
Lionychus quadrillum	-	-	2	-
Osmoderma eremita	hermit beetle	E	-	II, IV

Key:
Red List: Rules on the inclusion of endangered plant and animal species in the Red List (Official Gazette of RS, No. 82/02). **Ex** – extinct; **Ex?** – presumed extinct; **E** – endangered; **V** – vulnerable; **R** – rare; **K** – little-known; **O/O1** – out of danger/possibility of return to endangered status, **I** – undefined.
Decree: Decree on protected wild animal species (Official Gazette of RS, Nos. 46/04, 109/04, 84/05, 115/07, 32/08 – Constitutional Court Decision, 96/08, 36/09, 102/11, 15/14 and 64/16). **1** – Annex 1 (section A): animal species for which a protection regime has been defined for the protection of animals and populations; **2** – Annex 2 (section A): animal species for which habitat conservation measures and guidelines for maintaining their habitats in a favourable state have been defined; **2*** – Annex 2 (section A): priority animal species for the conservation of which the European Union has particular responsibility in view of the proportion of their natural range which falls within the territory of the European Union.
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4.4.1.3 Important ecological areas (IEA) and valuable natural features (VNF)

In the area of the planned activity, there is one important ecological area as defined by the Decree on important ecological areas (Official Gazette of RS, Nos. 48/04, 33/13, 99/13 and 47/18):

- Sava from Radeče to national border (ID 63700).

IEA of the Sava from Radeče to the national border (ID 63700)

This is the stretch of the Sava that crosses the flat Krško/Brežice Polje from Krško to the mouth of the Sotla, where the river creates an extensive flood plain. It is an area with a great diversity of habitats in a relatively small space. Surviving gravel beds, sections of eroded walls, occasionally flooded channels, oxbow lakes, water meadows and fragments of lowland floodplain forest provide a habitat for numerous protected and endangered species. Among the fish are the asp, the streber, the Danubian longbarbel gudgeon and the Balkan loach. Nine species of amphibians are present and there is also a varied avian fauna. Fragments of softwood floodplain forest connected to the remains of poplar plantations and zones of riparian vegetation along the Močnik and Struga streams are a habitat for saproxylic beetles (scarlet flat bark beetle, hermit beetle and European stag beetle) and the narrow-mouthed whorl snail. The surviving fragments of once extensive dry grassland on the right bank in the Vrbina area are important orchid sites /62/.

Valuable natural features
The nearest valuable natural features, as determined by the Rules on the designation and protection of valuable natural features (Official Gazette of RS, Nos. 111/04, 70/06, 58/09, 93/10, 23/15), are:

- Libna – linden tree by church (ID 7860) Linden tree by St Margaret's Church in Libna, east of Krško. A valuable botanical natural feature of local importance situated approximately 1,270 m north of the planned activity.
- Stari Grad – gravel pit (ID 7861) Aquatic biotope, stopover site for migrating birds and nesting area for endangered bird species SE of Krško. A valuable ecological and zoological natural feature of local importance situated approximately 1,415 m east of the planned activity.

4.4.1.4 Protected areas

Within the 2,000-metre area of remote impact under the Rules on the assessment of the acceptability of effects caused by the execution of plans and activities affecting nature in protected areas (Official Gazette of RS, Nos. 130/04, 53/06, 38/10, 3/11), there is one Natura 2000 area as defined by the Decree on special protection areas (Natura 2000 sites) (Official Gazette of RS, Nos. 49/04, 110/04, 59/07, 43/08, 8/12, 33/13, 35/13 – corrigenda, 39/13 – Constitutional Court decision, 3/14, 21/16, 47/18), i.e. the **Vrbina SAC (SI3000234)**, which is approximately 350 m from the site of the activity. Under Article 20 of the Rules, the area of remote impact established for the specific activity affecting the environment may differ at any time from the area of remote impact of an activity affecting the environment referred to in Annex 2 of those Rules if this is based on findings from the field, detailed data on implementation of the activity and other actual circumstances. In addition to the remote impact within a radius of 2,000 m as defined by the Rules, remote impact is also possible downstream along the Sava. It is assumed that the area of remote impact downstream along the Sava stretches 8 km downstream of the discharges from NEK, where the Sava has been declared a Natura 2000 area (**Lower Sava SAC, SI3000304**)**.**

Vrbina SAC (SI3000234)
Three smaller areas of calcareous dry grasslands with orchid sites are defined on the right bank of the Sava on the flood plain between Krško and Brežice, while on the left bank, in Vrbina, there are fragments of softwood floodplain forest connected to the remains of poplar plantations and zones of riparian vegetation along the Močnik and Struga streams, which are a habitat for saproxylic beetles (scarlet flat bark beetle, hermit beetle and European stag beetle) and the narrow-mouthed whorl snail /62/.

Qualifying species:

- scarlet flat bark beetle – *Cucujus cinnaberinus* (1086)

The scarlet flat bark beetle is a small beetle measuring between 11 and 15 mm with an elongated, parallel, flattened body. The head, prothorax and elytra are bright red, while the legs and antennae are black. The head is wrinkled and the prothorax and elytra are ribbed. The species prefers to live under the rotting damp bark of deciduous trees (oak, poplar, maple and beech) or conifers (spruce, fir and pine). In both developmental phases it feeds predatorily, while the larvae also partly feed on wood detritus. The larvae are frequently found together with larvae of woodboring beetles, on which they also feed. Development lasts two years or more. The species is threatened by the forestry management method in which old and dying trees are removed /62/.

- European stag beetle – *Lucanus cervus* (1083)

It is among the largest beetle species in Europe. Sexual dimorphism is very pronounced in this species. The male is usually bigger and grows to between 25 and 75 mm. The female is usually smaller and grows to between 30 and 50 mm. This large size range is the consequence of differences in the quality of food available to the larvae. The body is elongated, broad and partly flattened. The females have small jaws, while male's jaws are transformed into an antler-like formation, which is the origin of the name 'stag beetle'. The head, prothorax and legs are black or dark brown, while the colour of the elytra varies from dark brown to chestnut red. Development is tied to various species of deciduous trees, among which oaks predominate. Female stag beetles lay their eggs on or next to tree stumps or old or fallen trees. The larvae feed on dead or rotting tree roots and pupate in soil (at a depth of 15–20 cm). The full process of development takes place very slowly and can last up to five years. Adult beetles, which only live a few weeks, are mostly active at dusk and feed on a variety of plant secretions. In our assessment, the species is not yet endangered in Slovenia, although it has been placed on the Red List because of the excessive zeal of collectors (particularly for very large specimens of male stag beetles). An unsuitable forestry management intervention from the point of view of the species is cutting trees too low (just above the ground) /62/.

- hermit beetle – *Osmoderma eremita* (1084)

The hermit beetle is a relatively large (20–35 mm) species of chafer, dark brown to purple in colour and difficult to confuse with other chafers. Larvae develop in deep tree hollows, for the most part in deciduous trees (oak, willow, fruit trees, lime tree, ash), where there is a larger quantity of decaying wood on which the larvae can feed. Development takes two to three or even four years, depending on the nutritional quality of the decaying wood on which they feed. Adult males only live a few days (10–20), while females can live up to a month or two. They feed on plant material and drink sweet tree sap. They are not very mobile and for the most part stay close to their place of development (hence the name "hermit"). For this reason, the proximity or density of tree hollows is important for their survival. As a result of human activity, this density is greatest in anthropogenic environments such as old tree avenues, riparian willow communities or tall orchards. One threat factor is therefore the abandoning of certain customs – e.g. the removal of large, old willow trees from riverbanks, changes in the method of agriculture and the disappearance of tall orchards /62/.

- narrow-mouthed whorl snail – *Vertigo angustior* (1014)

The shell of this tiny snail is 1.8 mm high and 0.9 mm wide, sinistral, with five whorls, a finely ribbed surface, red-brown in colour and glossy. The species is found in tall herbs in marshy meadows and valley groves, in sedges and among mosses in bogs, and in the leaf litter of waterside shrubs and bushes. It frequently lives on the boundaries of different habitats, for example the boundary between reed beds and marsh or in the transitional zone between grassland and salt marsh. It can also live in completely dry environment such as dry forests. It is sensitive to rapid changes in humidity in its habitat, to changes in grazing conditions (it tolerates grazing to a certain extent) and to physical disturbances. In areas liable to flooding, it is important that higher sections of bogs and reed beds are preserved, since these represent flood refuges /62/.

<u>Qualifying habitat types:</u>

- 6210[12] Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*)

This habitat type consists of meadows or pastures on limestone, dolomite or, more rarely, flysch, or on sand and old gravel beds. Growing sites are dry, light and warm. The substrate is neutral or slightly basic, with few nutrients. They do not tolerate fertilisation, except on very arid soil, where they also do well with moderate fertilisation. They grow on the slopes of hills (except north-facing slopes) where the soil is shallow and the ground is bare in places. They do not tolerate high levels of moisture or stagnation of water. They need extensive pasture or mowing 1–2 times a year, first after the majority of meadow plants have finished flowering, without fertilisation, with hay drying in the meadow, and are not damaged by pasture at the end of the season (August–October). In Slovenia, this habitat type appears in scattered form on suitable surfaces (unfertilised, particularly calcareous soils, sunny slopes). Threats include fertilisation of meadows, hay baling, conversion of meadows into fields, overgrowing with woody species and, in places, hill walking and infrastructure developments /62/.

- 6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)

Lowland hay meadows thrive on moderately fertilised, damp to moderately dry soils. They are mown 2–3 times a year. In the traditional cultural landscape, they usually appear as part of a mosaic that also includes dry and damp meadows. They are found across Slovenia but are rare in the Slovenian part of the Istrian peninsula and on the Karst plateau. They are not present in high mountain areas. Three forms of this habitat type are present in Slovenia: damp, dry and mesophilic. The last of these is, for the time being, least at risk, while dry grassland is most at risk from overgrowing, and damp grassland from drying out and intensification of meadows (conversion into fields, oversowing with grass mixtures, baling, overfertilisation, over-frequent mowing) /62/.

[12] important orchid sites

Lower Sava SAC (SI3000304) – approximately 8 km from the site of the activity.
The Sava from the mouth of the Krka to the national border represents a connecting habitat for Danube roach populations from the Sotla and Krka rivers /62/. Following the decision of a biogeographical seminar held in Ljubljana in June 2014 to ensure the connectivity of the Danube roach population between the Krka and the Sotla, the section of the Sava between the mouth of the Krka and the national border with Croatia was defined as a new area for the species *Rutilus pigus*. The Danube roach that live in Slovenia actually belong to the species *Rutilus virgo* (common name: cactus roach), once defined as the subspecies *Rutilus pigus virgo*. Today this is defined as a species in its own right that inhabits the Danube basin, unlike *Rutilus pigus*, which naturally inhabits the northern part of the Adriatic basin. Lake populations of *Rutilus pigus* inhabit deep open lakes in Italy, while river populations inhabit tributaries of the Po. The distributions of the two species do not overlap and *Rutilus pigus* does not live in Slovenia. The species *Rutilus pigus* is, however, defined as a qualifying species for all Natura 2000 areas in Slovenia on the reference list of Natura 2000 species, since this name derives from the Habitats Directive and, in the case of Slovenia, covers the species *Rutilus virgo* (interpretation of the Institute of the Republic of Slovenia for Nature Conservation (ZRSVN)).

Qualifying species:

- Danube roach – *Rutilus pigus* (1114)

The Danube roach is 60 cm long with a laterally flattened body that is silver in colour, passing to grey-green on the back. The mouth is inferior. It lives in moderately rapid flowing medium to large watercourses. At spawning time it also finds its way into smaller watercourses with submerged aquatic plants and/or a gravel bed. Even at this time it prefers faster flowing waters. It spawns from April to May in tributaries and backwaters and usually deposits roe on plants or the stream bed. Males develop large white breeding tubercles on the back and head during spawning. The Danube roach feeds on aquatic plants and aquatic invertebrates. In Slovenia it is found in all watercourses of the Danube basin. The largest populations are in the basin of the Ljubljanica, the lower course of the Sava, the Mirna, the Krka and the Kolpa. It is an endemite of the Danube basin. In terms of ecological characteristics, the Danube roach is classified as a rheophilic, potamic, lithophilic or litho-phytophilic and invertivore fish /141/, /142/ that according to some sources migrates for short distances /140/ and according to other sources more than 150 km /143/.

4.4.2 Soil quality and characteristics

The activity site is located in a predominantly built area with a long history of use by the energy industry, in which for the most point no natural surface soil horizons are any longer present. The soil is urban soil which differs from non-urban (agricultural, forest, etc.) soils in structure and use. In most cases we detect an absence of natural horizons or layers, the material is mixed up, and we frequently find remains of construction or other materials. Since soils in urban environments frequently develop in materials of non-autochthonous origin, e.g. material transported from elsewhere, they are frequently very heterogeneous and are usually more compacted than agricultural soils as a result of the use of heavy machinery in construction, and so on.

Soil analyses were carried out in **2020** and, on the basis of these, a soil status report was drawn up for the site of the planned construction of a dry storage facility for spent fuel /16/.

On the basis of excavation and soil description, the analysis provider classified the soil as follows: Fluvisol, typical (deep, eutric, mollic, medium deep humus) on carbonate gravel.

Concluding assessment
The soil in parcel No. 1197/44, cadastral district 1321 Leskovec, where Nuklearna elektrarna Krško d.o.o. (NEK) intends to build an SFDS facility with an area of 3,312 m^2, was examined in accordance with the Rules on soil status monitoring (Official Gazette of RS, Nos. 66/17 and 4/18), including a detailed description and pollution testing.

Following evaluation of hazardous substance content pursuant to the Decree on limit values, alert thresholds and critical immission values of dangerous substances in soil (Official Gazette of RS, Nos. 68/96 and 41/04 – ZVO-1), the analysis provider finds that the values of the relevant parameters do not exceed limit immission values, which means a level of soil pollution that does not represent a deterioration of the quality of groundwater and soil. In the case of the values obtained, the effects or impact on human health or the environment are still within acceptable limits.

The soil analysis report is annexed to the report as a stand-alone annex.

Other soil analyses in the area

Soil pollution analyses carried out in 1991 in the context of national monitoring (ROTS) in the wider surroundings of the site under consideration, specifically at sampling point 13657 Spodnji Stari Grad (field), located near Krško approximately 800 m to the east (GKX = 541000, GKY = 88000), included analysis of inorganic hazardous substances below the limit value laid down in the Decree on limit values, alert thresholds and critical immission values of dangerous substances in soil (Official Gazette of RS, Nos. 68/96 and 41/04 – ZVO-1). In the case of organic hazardous substances, atrazine and simazine were above the limit value but still below the alert value. The values of desethyl-atrazine and alachlor were also elevated. The values of other organic hazardous substances were below the limit of detection (LOD) /60/.

Soil pollution examinations and pedological studies were carried out in the area of the planned site of the Vrbina LILW repository (around 350 m from the site of the activity) in the municipality of Krško in 2006 as a basis for evaluation of the production potential of agricultural land, in accordance with Ministry of Agriculture, Forestry and Food (MKGP) guidelines, in the process of the preparation of a strategic environmental impact assessment /85/.

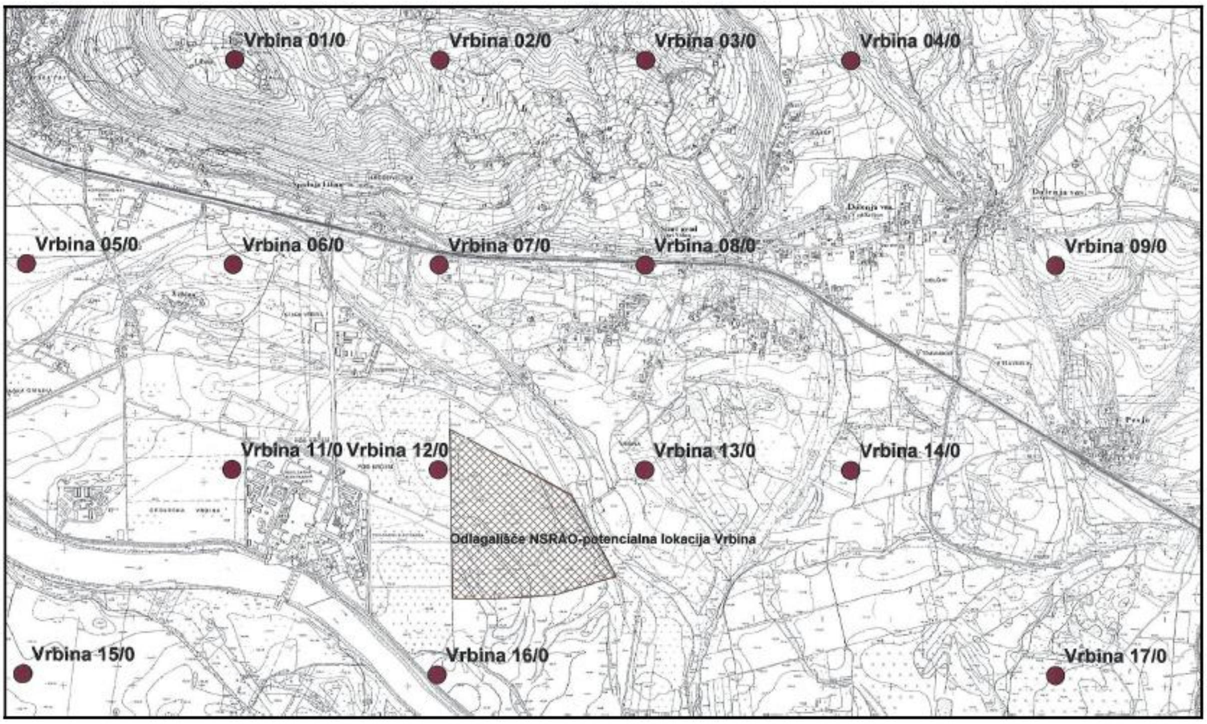


Figure 42: Overview of sampling locations for soil pollution examinations in the wider area (source: /85/)

Odlagališče NSRAO – potencialna lokacija Vrbina	LILW repository – Vrbina potential location

The results of the examinations showed that immission limit values (mg/kg) for the chemical elements from the examination programme are not exceeded. The only two exceptions are the measured lead and mercury levels at the location Vrbina 16/0, Žadovinek area. However, when measurement uncertainty is taken into account, this exceedance is considered insignificant. Mercury levels at the locations Vrbina 1/0, Vrbina 11/0 and Vrbina 12/0 are also assessed as "elevated", but the immission limit value is not exceeded. At the location Vrbina 16/0, Žadovinek area, the immission alert values (for lead and mercury) are not exceeded.

Measured values for manganese are within the framework of expected natural values for sedimentary carbonate geological substrates. The measured thallium and vanadium levels do not exceed the target values defined by the Holland List. The exception is vanadium at the locations Vrbina 2/0 and Vrbina 3/0. However, taking measurement uncertainty into account, the exceedance is considered insignificant. In this case, the indicative values are not exceeded.

The measured selenium content is in all cases below the lower limit of quantification for the testing method used, while the target value defined by the Holland List was not exceeded. The presence of organochlorine compounds from the DDT, "drins", HCH and PCB group was not detected in the examined soils. The presence of other organochlorine compounds for which limit values are not defined by Slovenian regulations was not detected either. For all organochlorine compounds the measured content is at the limit of detection for the testing methods used.

Mineral oil levels exceeding the immission limit value were not detected in the soils examined.

The measured phenolic substance levels at the sampling sites Vrbina 3/0, Vrbina 6/0, Vrbina 7/0 and Vrbina 13/0 exceed the immission limit value. Bearing in mind that phenolic substances at concentration levels around the limit of quantification of 0.1 mg/kg can also be of natural origin, and taking measurement uncertainty into account, the exceedance is considered insignificant. In all the cases mentioned, the immission alert value was not exceeded.

The measured total polycyclic aromatic hydrocarbons (PAH) content did not exceed the immission limit value.

4.4.3 Quality and quantity of groundwater and its use

In the context of national groundwater monitoring, the quality of groundwater in the Krška kotlina water body (VTPodV 1003) is monitored at several monitoring points, whose number has changed over time. The chemical status of the water body since 2009 is presented in the table below. In 2019 and 2020, the Drnovo measuring point on the Krška kotlina water body was non-compliant as a result of nitrates and the pesticide desethyl-atrazine. Drnovo has been a non-compliant measuring point over the years as well. In certain years, the Brege measuring point was also non-compliant as a result of desethyl-atrazine /89/.

Table 57: Chemical status of VTPodV 1003 Krška kotlina 2009–2020 (source: ARSO /89/)

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Chemical status	poor	good	good	good	good	good	good	good	good	good
No. of measuring points	*8*	*8*	*11*	*11*	*11*	*11*	*11*	*14*	*14*	*14*
No. of non-compliant measuring points	*2*	*1*	*1*	*1*	*1*	*1*	*2*	*1*	*1*	*2*

Year	**2019**	**2020**
Chemical status	good	good
No. of measuring points	*14*	*13*
No. of non-compliant measuring points	*1*	*1*

Groundwater quality in the narrower area under consideration is not monitored as part of national monitoring. The two closest measuring points on Krško Polje, respectively to the west and the southeast of the site in question, are Vrbina NE-1077 (P62060) – approximately 0.5 km west and Stari Grad NE 1177 (P62120) – approximately 0.8 km southeast.

Table 58: Compliance of the closest measuring points on Krško Polje 2006–2020 (source: ARSO /89/)

Measuring point	**Distance**	**Year**	**Compliance**
Vrbina NE-1077 (P62060)	0.5 km W	2006–2020	compliant
Stari Grad NE 1177 (P62120)	0.8 km SE	2006–2020	compliant

At the site of the activity, water may be taken from one well to a maximum quantity of 16 litres per second (water permit no. 35536-31/2006-16 of 15 September 2009) /50/, from three wells to a quantity of 5 litres per second at each well (annual total of 70,000 m^3, water permit no. 35530-100/2020-4 of 14 November 2020) /163/ and from one well to a quantity of 8 litres per second (annual total of 230 m^3, water permit no. 35530-48/2020-3 of 9 September 2021) /276/ (Figure 32). Within the area surrounding the site in question, groundwater is pumped and used for the irrigation of agricultural land, for process purposes, for obtaining heat and for other purposes.

An assessment of the status of water body 1003 (Krška kotlina) based on the Danube River Basin Management Plan 2022–2027 /282/is given in Table 59, Table 60 and Table 61 below. The chemical status and quantitative status are assessed as good.

Table 59: Assessment of the chemical status of groundwater bodies for 2014–2019 /282/

Reference code of water body	Name of water body	Period	Chemical status	Confidence level	Reason for poor chemical status
1003	Krška kotlina	2014–2019	Good	Medium	

Table 60: Trend in nitrate levels in water bodies with poor chemical status and more heavily polluted groundwater bodies for 1998–2019 /282/

Reference code of water body	Name of water body	Period	Nitrate trend	Atrazine trend
1003	Krška kotlina	1998–2019	No trend	

Table 61: Overall assessment of the quantitative status of groundwater bodies /282/

Groundwater body (reference code and name)	Test 1	Test 2	Test 3	Test 4	Confidence level	Assessment of status
1003 Krška kotlina	+				High level	GOOD

A document entitled "Upgrading of the hydrogeological interpretation of monitoring data in the wider area of the LILW repository site at Vrbina in the Municipality of Krško, IRGO Inštitut, March 2016" was produced for the siting requirements of the LILW repository /86/, with updates in 2018 and 2019 /257/.

The figure below shows the locations of the measuring points for measurements of groundwater parameters in the area in question.

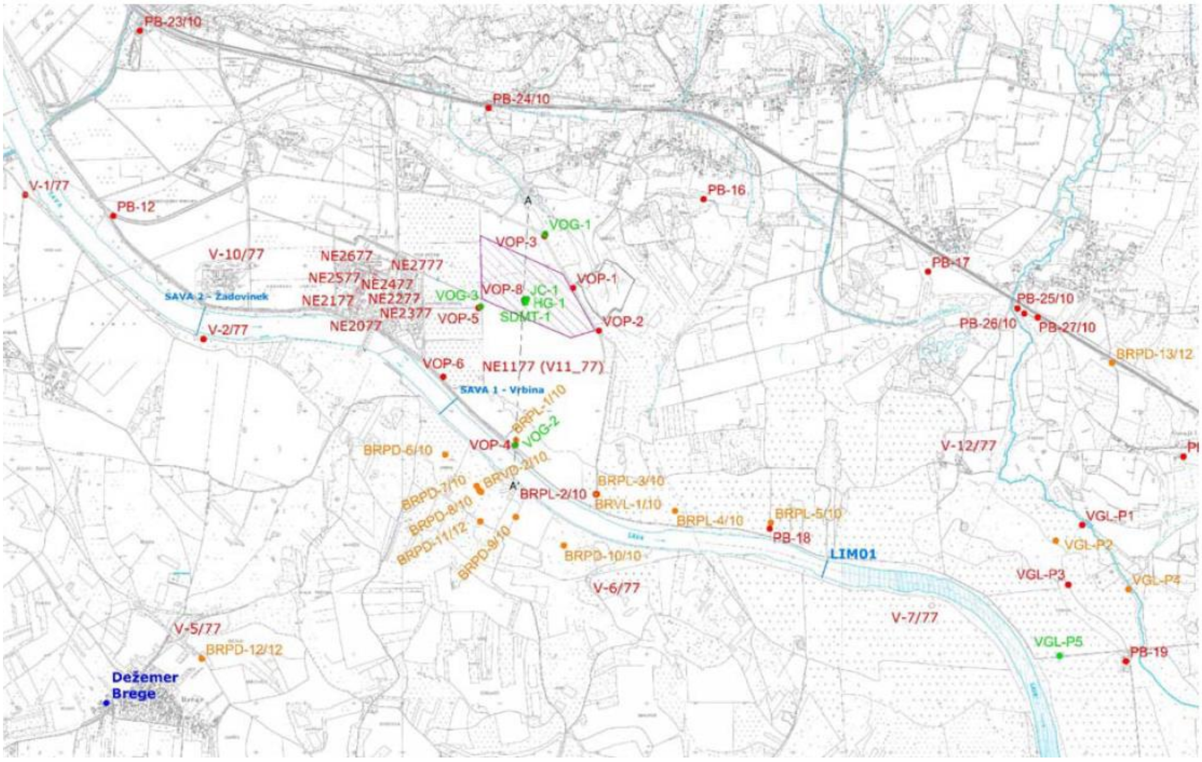


Figure 43: Overview of locations of piezometers (source: /86/)

The range of groundwater levels in the core area in question is limited downwards by the Sava as the drainage base of the area. The highest values of groundwater levels are linked to piezometer PB-12, which lies furthest upstream of the NEK dam. As well as this piezometer, some piezometers of the NE series in the area of NEK and piezometer V-10/77 are located upstream. The NEK dam has a major impact on groundwater flow in the Quaternary aquifer. This impact is further increased by the presence of a sealing curtain down to the Miocene substratum in the area of NEK.

In general terms, we can use the data from monitoring to confirm the identified hydrogeological conditions, i.e. that groundwater levels fall along the course of the river and from the edge of the aquifer towards the river. Oscillation amplitudes are highest by the river (VOP-4 and the BRPL/D series piezometers) and reduce towards the interior of the aquifer, which is consistent with the damped oscillation of the pressure wave induced by the Sava. Water level oscillation is likewise damped in the depthwise direction, i.e. into the Miocene layers, where oscillation amplitudes are even lower (from 0.95 m in VOG-1 to 2.83 m in VOG-2). Data from the BRPL and BRPD series piezometers shows that groundwater in the upper part of the Plio-Quaternary aquifer responds extremely well to induced pressure waves from the river, since the statistical data is highly comparable to data from the Sava at the Sava-1 measurement site /86/.

The results of the research show that the direction of the groundwater flow during low groundwater levels (the predominant state) is towards the south and during high water levels is towards the east and southeast /257/.

Seasonal temperature fluctuation is evident, depending on the atmospheric temperature and, consequently, the temperature of infiltrated surface water (river water and precipitation). Groundwater temperature ranges in individual piezometers in the Miocene layers are relatively small, since the impact of temperature fluctuations of the atmosphere and surface water decrease with depth. Of the deep piezometers, only VOG-2, located by the Sava, shows a greater range. The piezometers in the Quaternary aquifer show wider ranges of values, with the biggest range pertaining to piezometer VOP-

4. Bigger ranges in temperature measurements are also characteristic of piezometers NE0277, NE0377 and V-1/77. All these piezometers are located in the immediate vicinity of the Sava /86/. While the temperature of the groundwater has not changed significantly in the piezometers on the right bank of the Sava since the Brežice HPP reservoir was filled, the piezometers on the left bank of the Sava have recorded temperature fluctuations of greater amplitude, particularly piezometers VOP-4, VOP-6 and PB-20, all of which are in the vicinity of the Sava /257/.

The piezometers in the Quaternary aquifer in the area of NEK typically show a small temperature fluctuation, while the piezometers located within the sealing curtain below the facility (NE2077, NE2277, NE2477 and NE2677) show higher values. The highest temperatures were measured in piezometer NE2677, where they deviate to the greatest extent from the others. This piezometer is located within the NEK sealing curtain. The piezometers in the Plio-Quaternary aquifer (BRPD and BRPL series) show small temperature fluctuations, with only piezometer BRPD-6/10 showing a slightly greater range. The lowest temperatures were measured in piezometer NE0277, which is located near the river. Low values were also measured in piezometers NE0377, V-12, V-1/77 and PB-18. Considerable fluctuation between values also occurs, which means that transfer between surface water and groundwater is relatively rapid and undamped.

Continuous measurements of electrical conductivity are carried out in the following piezometers within the core area: VOG-3, VOP-1, VOP-2, VOP-3, VOP-4, VOP-5, VOP-6, VOP-8, HG-1, JC-1, SDMT-1, NE2077, NE2177, NE2277, NE2377, NE2477, NE2577, NE2677 and NE2777.

On the basis of the presented measurements and measurements of electrical conductivity of groundwater in the Plio-Quaternary aquifer in the Vrbina area by the Sava, which were carried out during pumping tests, it was found that the electrical conductivity of the Quaternary aquifer amounts to approximately 800 µS/cm, while the values for the Plio-Quaternary aquifer were lower: between 420 and 480 µS/cm. We can thus state that electrical conductivity in the Quaternary layers is higher than in the Plio-Quaternary layers, since in the latter predominantly silicate boulders are present, while in the Quaternary sediments we also find carbonate boulders, which are more easily dissolved and thus contribute to an increased total mass of dissolved solids and increased electrical conductivity. The lowest electrical conductivity is in Miocene silts, which are predominantly composed of silicate minerals. Nevertheless it is probably also necessary to seek the causes for such high values in the Quaternary aquifer in anthropogenic impacts (agriculture, urbanisation, etc.).

The results of radiological measurements of groundwater from the Quaternary aquifer show the expected radiological picture of gamma emitters and Sr-90/Sr-89, which is typical of the groundwater from the Krško-Brežice area. Only concentrations of K-40 are slightly higher – a consequence of the ubiquity of potassium in the topsoil. The concentration of Ra-226 does not differ significantly from the national average in Slovenia. The concentration of Cs-137 in the samples was below the limit of detection. The results of measurements of the concentration of Sr-90/Sr-89 showed that these values are comparable to the values from measurements in samples from borehole E1 NEK and in groundwater in Croatia, while the concentration of Sr-90/Sr-89 in the water supply network and at pumping stations is 2–3 times lower. The results of the measurements show a radiological picture that is typical for water pipes and pumping stations in the Krško-Brežice area, for all gamma emitters. Only the specific activity of Ra-226 is slightly increased. The values for tritium are in line with expectations. They are also acceptable for drinking water /86/.

4.4.4 Quality and quantities of surface waters and their use

The chemical and ecological status of Sava in the section under consideration is affected by the presence of contaminants throughout the catchment area of the Sava, which in this case also means a considerable part of Slovenia, including the most polluted areas such as the Ljubljana and Celje Basins, and industrial areas such as Jesenice, Zagorje, Trbovlje and Hrastnik. Pollution of the watercourse is also significantly impacted by agriculture (use of animal and artificial fertilisers and plant protection products on arable land).

The assessment of the chemical status of water bodies between 2014 and 2019 shows that the chemical status of the Sava Krško–Vrbina water body is good for the water matrix, poor for the biota matrix, and poor for the water and biota matrices together. The 'poor' assessments are due to parameters that are not related to NEK emissions (mercury and diphenyls (BDE), see Section 4.1.4), and are the result of general pollution.

According to information from the Slovenian Environment Agency on concessions granted and water permits issued /61/, water from the section of the Sava flowing through Krško is used for process purposes and for irrigation.

The developer uses water from the Sava for process purposes on the basis of partial water permit no. 35536-31/2006–16 of 15 October 2009, Decision no. 35536-26/2011-9 of 23 May 2013 and the Decision governing the change in water permit no. 35530-7/2018-2 of 22 June 2018 /50/; Water rights for the direct use of water for process purposes for the customer, NEK, by which the developer was granted water rights for the direct use of water for process purposes (Sava and the well on the right bank) at a maximum rate of 29,000 l/s (i.e. a maximum quantity of 915,000,000 m^3/year), valid until 31 August 2039.

According to information from the Slovenian Environment Agency /94/, scenarios of future changes in hydrological conditions for the moderately optimistic climate scenario RCP4.5, which assumes significant mitigation action regarding emissions of greenhouse gases for the 2021–2050 period (in comparison to the reference period of 1981–2010), show the following picture:

- mean annual flow rates will increase slightly in the northern half of the country, while indications point to a reduction in flows in the southern half of the country;
- the 90th percentile (Q90) low mean daily flow rates indicator points to an increase in low flow rates in the northern half of the country and a reduction in the southern half of the country;
- maximum annual flow rates point to a reduction in the eastern half of the country and an increase in the western half of the country, with the biggest increase in the northwest;
- maximum annual flow rates point to a reduction in the eastern half of the country and an increase in the western half of the country, with the biggest increase in the northwest.

4.4.4.1 Emissions of substances and heat from NEK in 2020

The situation regarding emissions of substances and heat into water is taken from the Report on operational monitoring of wastewater for NEK, drawn up for 2020 by the National Laboratory of Health, Environment and Food (NLZOH), Novo Mesto /237/.

Exceedances with regard to annual quantities of pollutants and/or the emission share of transmitted heat in cases of discharge into a watercourse (for the whole plant) are identified pursuant to the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14, 98/15). The waste heat emission ratio (WHER) is calculated in accordance with the equation:

$$WHER = \frac{\Delta\mathrm{T\ of\ Sava\ [°C]}}{3\ [°C]}$$

The ΔT for the large cooling system CW is calculated using the following equation:

$$\Delta\mathrm{T} = \frac{(T_{outlet} - T_{inlet}) \cdot Q_{cond} + (T_{cool} - Tinlet) \cdot Q\_cool}{Q\_total}$$

The variables in the equation are:

T_outlet – temperature of the outlet water from the condenser as measured at point M2
T_inlet – temperature of the Sava at the point of entry to the NEK complex as measured at point M1
Q_cond – flow rate through the condenser at point M2

T_cool – temperature of the cooled water from the cooling towers as measured at point M3
Q_cool – flow rate of cooling water at point M3

The value of the Q_total variable depends on the method of operation of Brežice HPP and the NEK dam:

- If the Brežice HPP is in operation and the NEK dam is not functioning, the Q_total is equal to the flow rate through Krško HPP, which is the sum of the flow rates through generators 1, 2 and 3, the flow rates below the segmented sluice gates and the flow rates through flaps 1–5.
- If the Brežice HPP is not in operation and the NEK dam is functioning (this method of operation was only in place for a limited period during the Brežice HPP outages in 2018, 2019 and 2020), the Q_total is calculated using the equation under which all quantities are measured at NEK:

$$Q\_total = Q\_cond + Q\_cool + Q\_dam$$

The significance of all the variables and the locations of their measurements or calculations can be seen in the schematic of NEK operation in the figure below:

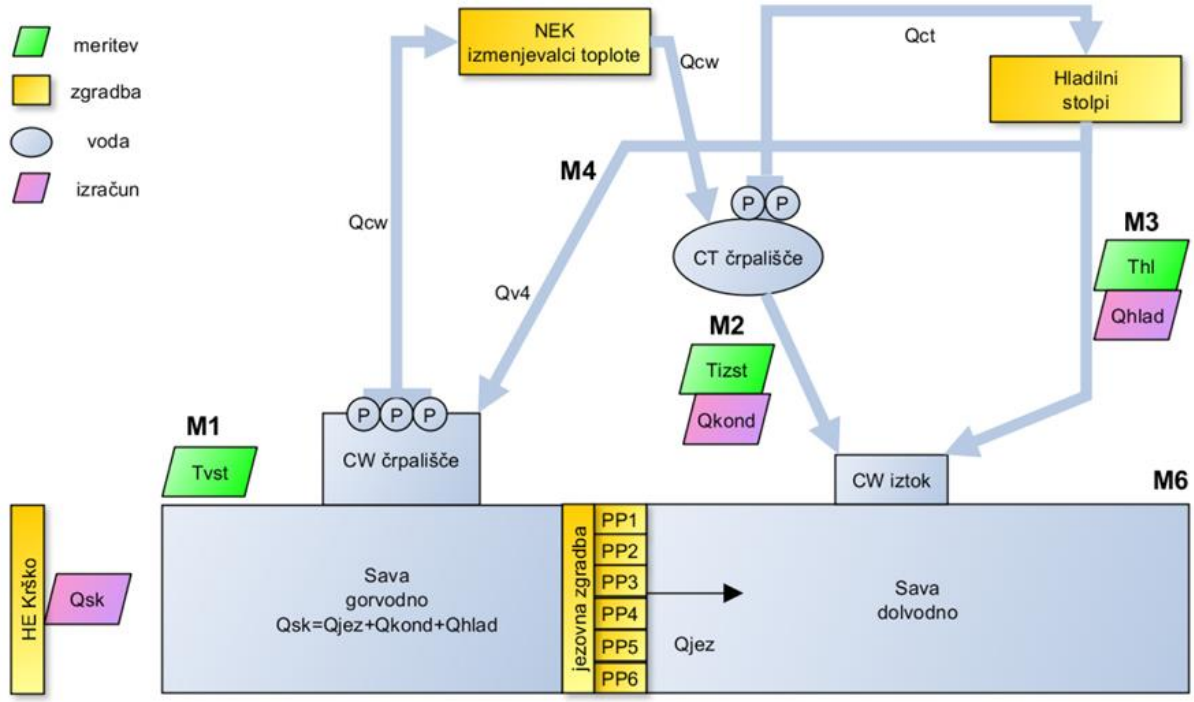


Figure 44: Schematic of NEK operation and measurements for controlling thermal pollution of the Sava (source: /48/)

meritev	measurement
zgradba	building
voda	water
izračun	calculation
NEK izmenjevalci toplote	NEK heat exchangers
Qcw	Q_cw
Qct	Q_ct
Hladilni stolpi	Cooling towers
M4	M4
CT črpališče	CT pumping station
M3	M3
Thl	T_cool
Qhlad	Q_cool

Qv4	Q_v4
M2	M2
Tizst	T_outlet
Qkond	Q_cond
M1	M1
Tvst	T_inlet
CW črpališče	CW pumping station
CW iztok	CW discharge
M6	M6
HE Krško	Krško hydroelectric power plant
Qsk	Q_total
Sava gorvodno Qsk=Qjez+Qkond+Qhlad	Sava upstream Q_total = Q_dam + Q_cond + Q_cool
jezovna zgradba	dam building
PP1	PP1
PP2	PP2
PP3	PP3
PP4	PP4
PP5	PP5
PP6	PP6
Qjez	Q_dam
Sava dolvodno	Sava downstream

The locations of measurements of water temperatures from the equation and the schematic of operation are:

- T_inlet: Y = 540280 X = 88332 (point M1 in the schematic or MM1 from the environmental permit)
- T_outlet: Y = 540400 X = 88162 (point M2 in the schematic or MM3 from the environmental permit)
- T_cool: Y = 540435 X = 88154 (point M3 in the schematic or MM4 from the environmental permit)

The warming of water (ΔT) in the small SW cooling system is calculated as the difference in the measurement at the inflow point:

- TE 2800 (inflow into the ESW catchment): Y = 540222 X = 88200

and the discharge point at location V1 (from the environmental permit):

- TE 2836A (eastern discharge or route A of ESW): Y = 540252 X = 88202
- TE 2836B (western discharge or route B of ESW): Y = 540250 X = 88202

The measurement at the discharge depends on which of the ESW routes of the system are in operation at the time.

In accordance with Article 11 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant is treated as a whole entity.

The WHER for the entire installation is calculated as the total WHER for the large CW cooling system and the small SW cooling system. The proportion of WHER from the small SW cooling system is not visible from the results as it is calculated to three decimal places, while the total value is shown only to one decimal place.

When Sava flow rates are low, NEK occasionally returns some of the cooling water from the condensers that would otherwise be discharged into the Sava to the CW pumping station (recirculation), which is why there are deviations in the WHER calculation or high values are shown. These can be further increased because of the values being rounded to one decimal place. In the data presented, such situations arose on 29 December 2020, 19 February 2020, 25 September 2020, 21, 22 and 23 September 2020, and 4 November 2020. In all cases, the main reason for the high WHER values is the inclusion of T_outlet and Q_cond in the WHER calculation even though this water is not actually released into the Sava but returned to the CW pumping station (recirculated). It is mainly cooled water from the cooling towers that is released into the Sava.

As a whole entity, the plant does not place excessive pressure on the environment through the discharge of industrial wastewater because annual quantities of adsorbable organic halides (AOX) are not exceeded and because the plant as a whole does not exceed thermal emission limits.

Table 62: Emission share of transmitted heat – NEK for 2020 (source: NLZOH /237/)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0.5	0.9	0.8	1.0	0.8	1.0	1.0	1.0	0.3	0.5	0.5	1.0
2	0.5	1.0	0.3	1.0	1.0	1.0	1.0	1.0	0.4	0.5	0.5	1.0
3	0.6	1.0	0.2	1.0	1.0	1.0	0.6	0.7	0.6	0.5	0.6	1.0
4	0.6	1.0	0.2	1.0	1.0	0.9	0.7	0.3	0.6	0.2	0.7	1.0
5	0.6	1.0	0.2	1.0	1.0	0.5	0.9	0.3	0.9	0.2	0.7	0.8
6	0.6	0.9	0.3	1.0	1.0	0.2	1.0	0.5	0.9	0.2	0.7	0.3
7	0.7	1.0	0.3	1.0	1.0	0.3	0.4	0.6	0.7	0.2	0.7	0.1
8	0.7	0.9	0.4	1.0	1.0	0.4	0.4	0.7	0.8	0.2	0.9	0.2
9	0.7	1.0	0.4	1.0	1.0	0.2	0.8	0.9	1.0	0.3	0.7	0.1
10	0.7	1.0	0.5	0.9	1.0	0.2	0.9	0.9	0.9	0.3	0.8	0.2
11	0.8	1.0	0.5	1.0	1.0	0.2	0.9	0.9	1.0	0.3	0.8	0.2
12	0.8	1.0	0.7	0.9	0.7	0.3	0.6	0.9	1.0	0.1	0.8	0.3
13	0.7	1.0	0.6	0.9	0.6	0.4	0.6	1.0	1.0	0.2	0.9	0.3
14	0.8	1.0	0.6	0.9	0.6	0.4	0.8	0.9	1.0	0.2	1.0	0.3
15	0.9	1.0	0.7	1.0	0.6	0.5	1.0	0.9	1.0	0.2	1.0	0.4
16	1.0	1.0	0.7	1.0	0.5	0.5	1.0	0.8	1.0	0.2	0.7	0.4
17	0.9	1.0	0.7	1.0	0.4	0.7	0.9	1.0	1.0	0.2	0.2	0.5
18	0.9	1.0	0.8	1.0	0.5	0.6	0.8	0.9	1.0	0.2	0.4	0.5
19	1.0	1.0	0.8	1.0	0.6	0.8	1.0	1.0	1.0	0.3	0.4	0.6
20	0.9	0.9	0.8	1.0	0.5	0.6	1.0	1.0	1.0	0.3	0.5	0.6
21	0.9	1.0	1.0	1.0	0.7	0.7	1.0	1.0	1.0	0.3	0.7	0.6
22	1.0	1.0	0.7	1.0	0.8	0.7	1.0	1.0	0.9	0.4	0.7	0.6
23	1.0	1.0	0.8	1.0	1.0	0.8	1.0	1.0	0.9	0.4	0.7	0.6
24	1.0	1.0	0.8	1.0	0.8	0.9	0.6	1.0	0.9	0.4	0.8	0.6
25	1.0	1.0	1.0	1.0	0.6	0.9	0.5	1.0	0.7	0.4	0.7	0.3
26	1.0	1.0	0.9	1.0	0.8	0.6	0.7	1.0	0.2	0.4	0.9	0.2
27	1.0	0.7	1.0	0.9	1.0	0.7	1.0	1.0	0.3	0.4	0.9	0.3
28	1.0	0.9	0.9	0.8	1.0	0.9	0.9	1.0	0.3	0.3	0.9	0.3
29	0.8	1.0	1.0	0.8	1.0	1.0	1.0	1.0	0.2	0.3	1.0	0.1
30	0.8		1.0	0.7	1.0	1.0	0.5	0.9	0.3	0.4	1.0	0.0
31	0.9		1.0		1.0		0.8	0.5		0.5		0.1
NEK outages in 2020: There were no outages in 2020.												

The temperature of the Sava did not exceed the natural temperature by more than 3°C on any operating day as a result of the discharge of wastewater from cooling systems and other sources.

Table 63: ΔT of the Sava (°C) in 2020 (source: NLZOH /237/)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	1.36	2.84	2.34	2.88	2.54	3.00	2.99	2.97	0.98	1.37	1.63	2.86
2	1.46	2.97	0.76	2.92	2.85	3.00	2.93	2.98	1.35	1.61	1.51	2.91
3	1.78	2.98	0.49	2.95	3.00	3.00	1.78	2.22	1.76	1.56	1.70	2.90
4	1.73	2.96	0.53	2.97	2.99	2.82	2.21	0.85	1.93	0.68	2.11	2.91
5	1.75	2.91	0.73	2.98	3.00	1.59	2.85	0.88	2.56	0.67	2.10	2.45
6	1.87	2.78	0.88	2.90	2.98	0.60	2.89	1.59	2.70	0.58	2.01	0.78
7	2.01	2.91	1.00	2.98	3.00	0.87	1.27	1.82	2.12	0.68	2.03	0.29
8	2.06	2.79	1.06	2.96	3.00	1.15	1.35	2.19	2.25	0.68	2.57	0.46
9	2.17	2.92	1.34	2.91	2.98	0.59	2.32	2.62	2.88	0.88	2.06	0.43
10	2.18	2.97	1.36	2.82	2.96	0.51	2.70	2.63	2.78	0.97	2.48	0.56
11	2.46	2.99	1.49	2.89	3.00	0.70	2.73	2.71	2.97	1.01	2.55	0.64
12	2.30	2.92	2.07	2.82	2.23	0.91	1.80	2.82	2.98	0.25	2.52	0.78
13	2.23	3.00	1.81	2.77	1.78	1.14	1.72	2.93	2.97	0.51	2.60	0.93
14	2.30	3.00	1.85	2.56	1.75	1.19	2.46	2.82	2.91	0.66	2.94	1.00
15	2.73	2.99	2.09	2.91	1.82	1.49	2.99	2.67	2.94	0.65	2.90	1.32
16	2.90	2.96	2.18	3.00	1.48	1.57	2.98	2.52	2.96	0.46	2.16	1.27
17	2.79	3.00	2.24	3.00	1.24	2.15	2.60	2.87	2.97	0.62	0.62	1.51
18	2.66	2.97	2.51	3.00	1.63	1.92	2.48	2.79	2.91	0.70	1.14	1.43
19	2.93	2.87	2.26	3.00	1.73	2.40	2.94	2.92	3.00	0.85	1.23	1.68
20	2.82	2.83	2.46	2.96	1.62	1.92	2.95	3.00	2.88	0.93	1.62	1.93
21	2.77	2.96	2.89	2.94	2.13	2.11	2.98	2.91	2.93	1.04	2.09	1.71
22	2.93	3.00	2.24	2.92	2.25	2.18	2.98	2.98	2.69	1.17	2.01	1.82

23	2.97	2.99	2.34	2.98	2.92	2.36	3.00	2.96	2.65	1.21	2.09	1.85
24	2.98	3.00	2.53	2.90	2.32	2.60	1.94	2.96	2.85	1.21	2.43	1.81
25	2.95	3.00	2.93	2.99	1.78	2.70	1.53	2.94	2.25	1.05	2.22	0.78
26	2.99	2.85	2.68	2.90	2.31	1.75	2.22	2.97	0.58	1.18	2.70	0.57
27	2.97	2.01	2.89	2.62	2.97	2.08	2.94	2.96	0.76	1.09	2.64	0.79
28	2.98	2.82	2.83	2.42	2.96	2.83	2.81	3.00	0.79	0.84	2.80	0.92
29	2.54	2.93	2.90	2.28	2.95	2.95	2.93	2.97	0.74	0.97	2.96	0.35
30	2.47		2.88	2.13	2.98	2.96	1.38	2.66	0.96	1.31	2.91	0.00
31	2.69		2.98		2.95		2.36	1.61		1.51		0.44
Average	**2.44**	**2.90**	**1.98**	**2.84**	**2.45**	**1.90**	**2.45**	**2.57**	**2.27**	**0.93**	**2.18**	**1.29**

Discharge V9 – Effluents from treatment plant

The results of the monitoring of wastewater emissions at measuring point MM6 (V-9) in 2020 are given in the table below (Table 64).

Table 64: Results of the monitoring of wastewater emissions at measuring point MM6 (V-9) in 2020 (source:/237/)

Parameter	ELV	21 April 2020	9 October 2020
COD	150 mg/l	40	58
BOD_5	30 mg/l	2.0	7.8

Evaluation under Article 10 (exceedance of limit values)
Under Article 10 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant did not exceed the limit values laid down in the following environmental permits at this discharge in 2020: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3 /49/.

Evaluation under Article 11 (identifying excessive environmental impact)
Under Article 11 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant did not place an excessive burden on the environment at this discharge in 2020.

Discharges V2, V3, V4, V5 and V6

Measurements were not planned for municipal or cooling water (except for the cooling water discharged into waters, where temperature measurements are compulsory) /237/.

Evaluation under Article 10 (exceedance of limit values) – not envisaged for cooling water.

Evaluation under Article 11 (identifying excessive environmental impact) – not envisaged for cooling water.

Discharge V7-11 – Outlet from the water preparation tank

The results of the monitoring of wastewater emissions at measuring point MM5 (V7-11) in 2020 are given in the table below (Table 65).

Table 65: Results of the monitoring of wastewater emissions at measuring point MM5 (V7-11) in 2020 (source: /237/)

Parameter	ELV	10 March 2020	21 March 2020	8 December 2020
Temperature	30°C	15.2	23.5	15.8
pH	6.5–9.0	8.7	7.3	7.7
Suspended substances	0.3 ml/l	LOD	LOD	0.1
Insoluble substances	80 mg/l	2	2	2
Toxicity to water fleas	3	2	1	1
Free chlorine	0.2 mg/l	0.05	0.05	0.05

COD	90 mg/l	17	10	9
BOD_5	25 mg/l	5.6	5.0	7.5
AOX	1 mg/l	LOD	LOD	0.03

LOD or underlined – between the limit of detection and the limit of determination LOD – below the limit of detection

Evaluation under Article 10 (exceedance of limit values)
Under Article 10 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant did not exceed the limit values laid down in the following environmental permits at this discharge in 2020: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3.

Evaluation under Article 11 (identifying excessive environmental impact)
Under Article 11 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant did not place an excessive burden on the environment at this discharge in 2020. The annual quantity of hazardous AOX substances specified in the environmental permit was not exceeded. The maximum permitted annual quantity of AOX substances is 3,810.3 kg/year and the quantity emitted is 0.04 kg.

Discharge V7-10 NEK – Cooling towers

The results of the monitoring of wastewater emissions at measuring point MM4 (V7-10) in 2020 are given in the table on the next page (Table 66).

Table 66: Results of the monitoring of wastewater emissions at measuring point MM4 (V7-10) in 2020 (source: /237/)

Parameter	ELV (May–September)	ELV (October–April)	17 February 2020	20 April 2020	8 May 2020	14 September 2020	7 December 2020
Temperature	43°C	30°C	18.1	18.0	16.4	19.4	19.7
pH	6.5–9.0	6.5–9.0	8.4	8.3	8.6	8.2	8.6
Suspended substances	0.5 ml/l	0.5 ml/l	LOD	LOD	LOD	LOD	0.1
Insoluble substances	80 mg/l	80 mg/l	2.0	7.9	5.0	3.2	190
Toxicity to water fleas	3	3	1	1	1	1	1
COD	120 mg/l	120 mg/l					
BOD_5	25 mg/l	25 mg/l	2.0	2.4	LOD	2.0	2.0
AOX	(a)	(a)					
Free chlorine	0.3 mg/l	-	0.05	0.05	0.05	0.05	0.05
Sava flow rate – 24-hour average	m^3/s	m^3/s	75	79	74	81	965

LOD or underlined – between the limit of detection and the limit of determination LOD – below the limit of detection COD in the text

AOX and bromine are analysed four times a year during the application of the biocides sodium hypochlorite and sodium bromide.

(a) No AOX compounds may be present in wastewater except those contained in raw water. In the case of shock dosing, the ELV is 0.15 mg/l

Evaluation under Article 10 (exceedance of limit values)
Under Article 10 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant exceeded the limit values laid down in the following environmental permits at this discharge in

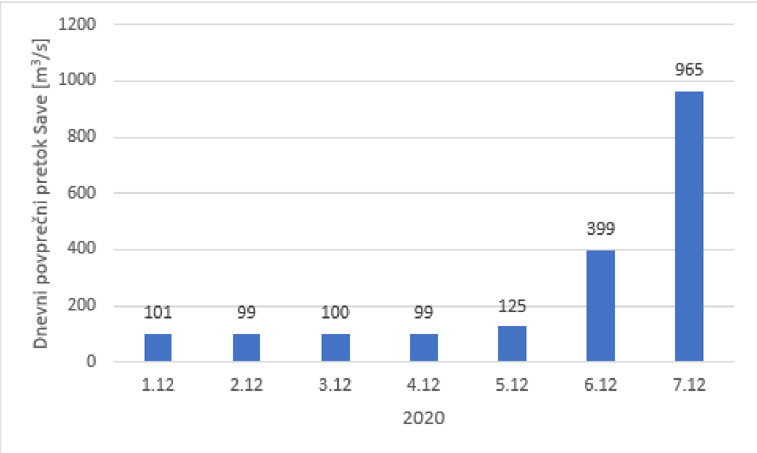
2020: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3, i.e. once in the insoluble substances parameter.

The measured COD values are:

- 6 mg/l O_2
- 9 mg/l O_2
- 7 mg/l O_2
- 8 mg/l O_2
- 20 mg/l O_2

<u>Evaluation under Article 11 (identifying excessive environmental impact)</u>
Under Article 11 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant placed an excessive burden on the environment at this discharge in 2020 because one measurement of the insoluble substances parameter exceeded the limit value by more than 50%.

The measurement results at this measuring point in the 2015–2020 period show that there was exceedance in 2016 as well. A check was made to establish whether work had been carried out on the system (on 7 December 2020) that could have led to the value for the concentration of suspended substances being exceeded. It was found that no work had taken place. Similar exceedances for insoluble substances occasionally take place when wastewater is being monitored. The reason for this is the rapid increase in the Sava flow rate during sampling, which lasts 24 hours and occurs monthly. This event increases the turbidity of the Sava. The increase in insoluble substances is expected and is something over which NEK has no influence. Figure 45 shows the Sava flow rates at the time of exceedance and six days prior to this for 17 November and 7 December 2020. It shows that the Sava flow rate increased on the days the measurements were performed and on the days before those measurements.



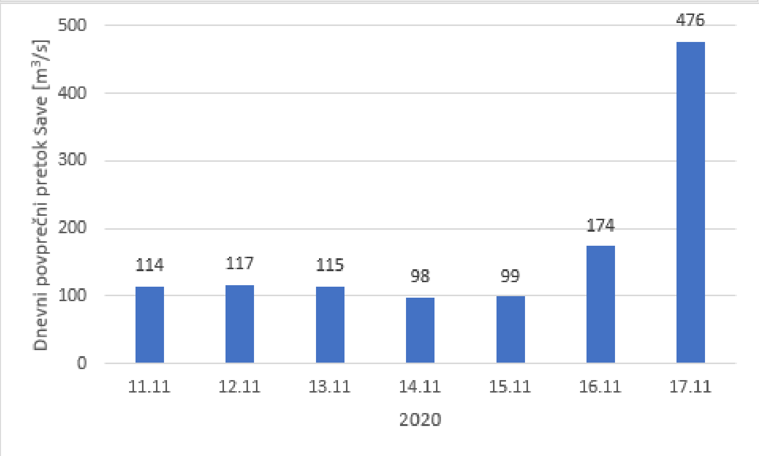


Figure 45: The flow rates six days before and at the time the insoluble substances and solid particles were sampled at measuring points: 1) reserve service water (V1-1) MM1, 2) cooling water (V7-7) MM3 and water from the CW cooling towers (V7-10) MM4, days on which there were exceedances because of impurities in the Sava

Dnevni povprečni pretok Save [m^3/s]	Average daily flow rate of the Sava [m^3/s]

Discharge V1-1 – Discharge of reserve service water

The results of the monitoring of wastewater emissions at measuring point V1-1 (MM1) in 2020 are given in the table below (Table 67).

Table 67: Results of the monitoring of wastewater emissions at measuring point V1-1 (MM1) in 2020 (source: /237/)

Calendar months													
Parameter	ELV	1	2	3	4	5	6	7	8	9	10	11	12
Temperature	30°C	9.2	10.6	10.9	16.4	17.8	15.1	17.7	23.5	21.0	14.3	11.0	11.0
ΔT max (ºC)	10ºC	2.9	2.7	2.8	2.6	2.6	2.6	2.5	3.1	2.6	2.6	2.9	2.8
pH	6.5–9.0	8.3	8.4	8.2	8.6	8.5	8.1	8.2	8.1	8.1	8.3	7.6	7.6
Suspended substances	0.5 ml/l	LOD	LOD	LOD	LOD	LOD	LOD	LOD	LOD	LOD	<u>0.1</u>	<u>0.1</u>	***1.1***
Insoluble substances	80 mg/l	<u>2</u>	3.6	3.3	11	4.5	9.9	4.0	4.9	4.1	20	***96***	***290***
Toxicity to water fleas	3	1	1	1	1	1	1	1	1	1	1		1
COD	120 mg/l												
BOD_5	25 mg/l	3.8	LOD	<u>2.0</u>	2.8	LOD	<u>2.0</u>	<u>2.0</u>	2.2	LOD	LOD	<u>2.0</u>	3.1
Sava flow rate – 24-hour average	m^3/s	130.3	94.2	<u>199.5</u>	87.0	126.1	<u>209.1</u>	<u>135.2</u>	122.6	164.4	379.1	<u>165.5</u>	338.1

LOD or underlined – between the limit of detection and the limit of determination LOD – below the limit of detection, bold, red and italics – above the limit of detection COD in the text

<u>Evaluation under Article 10 (exceedance of limit values)</u>
Under Article 10 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant exceeded the limit values laid down in the following environmental permits at this discharge in 2020: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3, i.e. twice in the insoluble substances parameter and once in the suspended substances parameter.

COD values measured:

- <5 mg/l O_2
- 7 mg/l O_2
- 6 mg/l O_2
- 11 mg/l O_2
- 9 mg/l O_2
- 7 mg/l O_2
- 9 mg/l O_2
- 9 mg/l O_2
- 6 mg/l O_2
- 10 mg/l O_2
- 16 mg/l O_2
- 111 mg/l O_2

<u>Temperature increase</u>

The temperature increase of the small cooling system SW – MM1 for 2020 is shown below in Table 69.

The temperature increase limit value for the small flow-through cooling system (10°C) as laid down in the following environmental permits was not exceeded: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3. The highest increase amounted to 3.1°C.

Evaluation under Article 11 (identifying excessive environmental impact)

Under Article 11 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant placed an excessive burden on the environment at this discharge in 2020 because one measurement of the insoluble substances parameter exceeded the limit value by more than 50% and one measurement of the suspended substances parameter exceeded the limit value by more than 50%. The plant did not place an excessive burden on the environment at this discharge in 2019. When the 2015–2020 measurements were reviewed, it was found that the exceedances for insoluble and suspended substances had occurred because of increased parameters in the Sava.

Emission share of transmitted heat

The emission share of transmitted heat (small cooling system SW) for 2020 is shown below in Table 68.

Emission share of transmitted heat at this source; In none of the daily averages of 366 operating days in 2020 did the discharge of reserve service water (small cooling system – SW) exceed the limit value (1) laid down in environmental permit nos.: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3.

Table 68: Emission share of transmitted heat – small cooling system SW for 2020 (source: NLZOH /237/)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0.003	0.006	0.004	0.005	0.004	0.007	0.005	0.005	0.002	0.002	0.003	0.006
2	0.003	0.006	0.001	0.005	0.005	0.007	0.005	0.005	0.002	0.003	0.003	0.006
3	0.003	0.006	0.001	0.006	0.006	0.007	0.003	0.003	0.003	0.002	0.003	0.006
4	0.003	0.006	0.001	0.006	0.005	0.006	0.004	0.002	0.003	0.001	0.004	0.006
5	0.003	0.006	0.001	0.007	0.006	0.003	0.005	0.002	0.005	0.001	0.004	0.004
6	0.003	0.005	0.002	0.007	0.007	0.001	0.005	0.003	0.005	0.001	0.003	0.001
7	0.004	0.006	0.002	0.006	0.007	0.002	0.002	0.004	0.004	0.001	0.004	0.001
8	0.004	0.006	0.002	0.006	0.007	0.002	0.002	0.004	0.004	0.001	0.004	0.001
9	0.004	0.006	0.002	0.007	0.007	0.001	0.004	0.004	0.005	0.002	0.004	0.001
10	0.004	0.006	0.003	0.007	0.007	0.001	0.005	0.004	0.005	0.002	0.004	0.001
11	0.005	0.007	0.003	0.006	0.007	0.001	0.005	0.005	0.005	0.001	0.005	0.001
12	0.004	0.007	0.004	0.006	0.005	0.002	0.003	0.005	0.006	0.001	0.005	0.001
13	0.004	0.006	0.003	0.006	0.003	0.002	0.003	0.005	0.006	0.001	0.005	0.002
14	0.004	0.006	0.003	0.006	0.003	0.002	0.004	0.005	0.007	0.001	0.005	0.002
15	0.005	0.006	0.004	0.005	0.003	0.002	0.005	0.005	0.007	0.001	0.005	0.002
16	0.006	0.006	0.004	0.005	0.003	0.003	0.005	0.004	0.007	0.001	0.003	0.002
17	0.006	0.008	0.004	0.006	0.002	0.004	0.004	0.005	0.007	0.001	0.001	0.003
18	0.005	0.007	0.005	0.007	0.003	0.003	0.004	0.005	0.007	0.001	0.002	0.003
19	0.006	0.007	0.004	0.007	0.003	0.004	0.005	0.005	0.007	0.002	0.002	0.003
20	0.006	0.007	0.004	0.007	0.003	0.003	0.005	0.005	0.009	0.002	0.003	0.003
21	0.006	0.005	0.006	0.006	0.004	0.004	0.005	0.005	0.009	0.002	0.004	0.003
22	0.006	0.007	0.004	0.006	0.003	0.004	0.005	0.006	0.007	0.002	0.004	0.003
23	0.006	0.007	0.004	0.006	0.005	0.004	0.005	0.006	0.007	0.002	0.004	0.003
24	0.006	0.007	0.005	0.006	0.004	0.005	0.003	0.007	0.006	0.002	0.004	0.003
25	0.006	0.007	0.006	0.007	0.003	0.005	0.003	0.006	0.003	0.002	0.004	0.001
26	0.006	0.006	0.005	0.009	0.004	0.002	0.004	0.006	0.001	0.002	0.005	0.001
27	0.006	0.004	0.006	0.008	0.005	0.004	0.005	0.007	0.001	0.002	0.005	0.001
28	0.006	0.005	0.005	0.007	0.005	0.005	0.005	0.007	0.001	0.002	0.005	0.002
29	0.005	0.006	0.006	0.007	0.005	0.005	0.005	0.009	0.001	0.002	0.005	0.001
30	0.005		0.006	0.003	0.005	0.005	0.002	0.007	0.002	0.002	0.006	0.001
31	0.004		0.006		0.007		0.004	0.003		0.003		0.001
NEK outages in 2020: There were no outages in 2020.												

Table 69: Temperature increase small cooling system SW – MM1 for 2020 (source: NLZOH /237/)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	2.8	2.7	2.5	2.5	2.4	2.5	2.4	2.4	2.4	2.5	2.4	2.6
2	2.7	2.6	2.5	2.5	2.4	2.4	2.5	2.3	2.4	2.5	2.4	2.6
3	2.7	2.6	2.5	2.6	2.4	2.5	2.4	2.4	2.4	2.5	2.4	2.8
4	2.7	2.6	2.5	2.6	2.3	2.4	2.4	2.5	2.4	2.4	2.5	2.6
5	2.7	2.6	2.5	2.5	2.4	2.4	2.4	2.7	2.4	2.5	2.4	2.6

6	2.7	2.6	2.5	2.5	2.4	2.6	2.4	2.6	2.3	2.5	1.8	2.6
7	2.7	2.6	2.5	2.5	2.3	2.4	2.2	3.1	2.3	2.4	2.5	2.5
8	2.8	2.7	2.5	2.5	2.3	2.5	2.4	2.4	2.3	2.4	2.5	2.5
9	2.8	2.7	2.5	2.5	2.3	2.5	2.2	2.2	2.3	2.5	2.5	2.5
10	2.9	2.6	2.5	2.6	2.4	2.5	2.5	2.2	2.3	2.5	2.5	2.4
11	2.8	2.6	2.5	2.5	2.3	2.5	2.4	2.3	2.3	2.5	2.5	1.7
12	2.8	2.6	2.5	2.5	2.4	2.4	2.4	2.2	2.5	2.6	2.6	2.5
13	2.8	2.6	2.5	2.5	2.3	2.5	2.4	2.2	2.4	2.5	2.6	2.5
14	2.8	2.5	2.4	2.5	2.6	2.4	2.5	2.2	2.4	2.6	2.5	2.5
15	2.8	2.6	2.5	2.5	2.5	2.4	2.5	2.2	2.5	2.5	2.5	2.7
16	2.8	2.6	2.5	2.5	2.5	2.4	2.5	2.2	2.5	2.2	2.5	2.7
17	2.8	2.6	2.6	2.5	2.5	2.5	2.1	2.2	2.4	2.4	2.4	2.8
18	2.7	2.6	2.5	2.6	2.5	2.4	2.4	2.2	2.5	2.4	2.5	2.7
19	2.7	2.6	2.5	2.5	2.5	2.4	2.4	2.2	2.5	2.4	2.5	2.6
20	2.7	2.6	2.5	2.5	2.4	2.4	2.4	2.2	2.4	2.4	2.5	2.6
21	2.8	1.9	2.5	2.5	2.4	2.5	2.4	2.2	2.6	2.4	2.5	2.6
22	2.7	2.5	2.5	2.5	1.8	2.5	2.4	2.3	2.5	2.3	2.6	2.6
23	2.7	2.5	2.5	2.4	2.4	2.4	2.3	2.2	2.5	2.3	2.6	2.6
24	2.7	2.5	2.6	2.5	2.4	2.4	2.5	2.2	2.5	2.3	2.6	2.6
25	2.7	2.6	2.6	2.5	2.4	2.4	2.4	2.2	2.5	2.3	2.7	2.6
26	2.7	2.6	2.6	2.5	2.4	1.6	2.5	2.2	2.6	2.5	2.8	2.6
27	2.7	2.5	2.8	2.5	2.4	2.5	2.5	2.3	2.4	2.4	2.9	2.6
28	2.7	2.5	2.6	2.5	2.5	2.4	2.4	2.3	2.5	2.4	2.6	2.5
29	2.7	2.5	2.6	2.5	2.4	2.4	2.4	2.5	2.5	2.4	2.4	2.5
30	2.6		2.6	1.6	2.4	2.3	2.4	2.4	2.5	2.4	2.6	2.7
31	2.0		2.6		2.4		2.3	2.3		2.4		2.5
NEK outages in 2020: There were no outages in 2020.												

Discharge V7-7 – Discharge of cooling water

The results of the monitoring of wastewater emissions at measuring point MM3 (V7-7) in 2020 are given in the table below (Table 70).

Table 70: Results of the monitoring of wastewater emissions at measuring point MM3 (V7-7) in 2020 (source: /237/)

		Calendar months											
Parameter	ELV	1	2	3	4	5	6	7	8	9	10	11	12
Temperature	43°C	18.2	22.2	19.7	26.6	27.4	25.1	24.1	32.8	30.6	23.7	21.1	21.1
pH	6.5–9.0	8.4	8.2	7.9	8.8	8.8	8.1	8.2	8.3	8.0	8.2	7.8	8.1
Suspended substances	0.5 ml/l	LOD	LOD	LOD	LOD	LOD	LOD	LOD	LOD	LOD	0.1	0.1	***1.4***
Insoluble substances	80 mg/l	2	2.5	4.6	6.1	2	7.4	4.0	6.2	3.0	38	47	***340***
Toxicity to water fleas	3	1	1	1	1	1	1	1	1	1	1	1	1
COD	120 mg/l												
BOD_5	25 mg/l	LOD	2.0	2.0	2.0	LOD	2.0	2.0	2.0	2.0	LOD	2.0	2.2
AOX	(a)												
Free chlorine	0.3 mg/l	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sava flow rate – 24-hour average	m^3/s	130.3	94.2	199.5	87.0	126.1	209.1	135.2	122.6	164.4	379.1	165.5	338.1

LOD or underlined – between the limit of detection and the limit of determination LOD – below the limit of detection, bold, red and italics – above the limit of detection COD in the text

AOX and bromine are analysed four times a year during the application of the biocides sodium hypochlorite and sodium bromide.

(a) No AOX compounds may be present in wastewater except those contained in raw water. In the case of shock dosing, the ELV is 0.15 mg/l

Evaluation under Article 10 (exceedance of limit values)

Under Article 10 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant exceeded the limit values laid down in the following environmental permits at this discharge in 2020: 35441-103/2006-24; 35402-10/2010-4; 35441-103/2006-33; 35444-11/2013-3, i.e. once in the insoluble substances parameter and once in the suspended substances parameter.

The measured COD values are:

- <5 mg/l O_2
- 6 mg/l O_2
- 7 mg/l O_2
- 7 mg/l O_2
- 7 mg/l O_2
- 7 mg/l O_2
- 8 mg/l O_2
- 7 mg/l O_2
- 7 mg/l O_2
- 9 mg/l O_2
- 18 mg/l O_2
- 36 mg/l O_2

Evaluation under Article 11 (identifying excessive environmental impact)

Under Article 11 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), the plant placed an excessive burden on the environment at this discharge in 2020 because one measurement of the insoluble substances parameter exceeded the limit value by more than 50% and one measurement of the suspended substances parameter exceeded the limit value by more than 50%. A review of the measurement data 2015–2020 showed one exceedance in 2016. As previously explained, the exceedances were not the result of NEK emissions or activities.

The plant did not place an excessive burden on the environment at this discharge in 2019.

Table 71: Emission share of transmitted heat – large cooling system CW for 2020 (source: NLZOH /237/)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0.4	1.0	0.7	1.0	0.8	1.0	1.0	1.0	0.3	0.4	0.5	1.0
2	0.5	1.0	0.2	1.0	0.9	1.0	1.0	1.0	0.4	0.5	0.5	1.0
3	0.5	1.0	0.1	1.0	1.0	1.0	0.5	0.7	0.6	0.5	0.5	1.0
4	0.5	1.0	0.2	1.0	1.0	0.9	0.7	0.3	0.6	0.2	0.7	1.0
5	0.5	1.0	0.2	0.8	1.0	0.5	0.9	0.3	0.8	0.2	0.7	0.8
6	0.6	0.9	0.3	0.7	0.9	0.2	1.0	0.5	0.9	0.2	0.6	0.2
7	0.6	1.0	0.3	1.0	0.9	0.3	0.3	0.6	0.7	0.2	0.6	0.1
8	0.6	0.9	0.3	1.0	0.9	0.3	0.4	0.7	0.7	0.2	0.8	0.1
9	0.6	1.0	0.4	1.0	0.9	0.2	0.8	0.9	1.0	0.3	0.6	0.1
10	0.7	1.0	0.4	0.9	0.9	0.2	0.9	0.9	0.9	0.3	0.8	0.2
11	0.8	1.0	0.5	0.9	0.9	0.2	0.9	0.9	1.0	0.2	0.8	0.2
12	0.7	0.7	0.6	0.8	0.6	0.3	0.6	0.9	1.0	0.1	0.8	0.3
13	0.7	1.0	0.6	0.9	0.6	0.4	0.6	1.0	1.0	0.2	0.8	0.3
14	0.7	1.0	0.6	0.7	0.6	0.4	0.8	0.9	0.9	0.2	1.0	0.3
15	0.9	1.0	0.7	1.0	0.6	0.5	1.0	0.9	0.9	0.2	1.0	0.4
16	1.0	1.0	0.7	1.0	0.5	0.5	1.0	0.8	0.9	0.1	0.6	0.4
17	0.9	0.7	0.7	1.0	0.4	0.6	0.9	1.0	0.9	0.2	0.2	0.4
18	0.9	0.7	0.8	0.9	0.5	0.6	0.8	0.9	0.9	0.2	0.4	0.4
19	1.0	0.6	0.7	1.0	0.5	0.8	1.0	1.0	1.0	0.3	0.4	0.5
20	0.9	0.7	0.8	0.9	0.5	0.6	1.0	1.0	0.8	0.3	0.5	0.6
21	0.9	0.9	1.0	0.8	0.6	0.7	1.0	0.9	0.8	0.3	0.7	0.5
22	1.0	0.9	0.7	0.8	0.7	0.7	1.0	0.9	0.7	0.4	0.6	0.6
23	1.0	0.9	0.8	0.8	1.0	0.8	1.0	0.9	0.6	0.4	0.7	0.6
24	1.0	0.9	0.8	0.8	0.7	0.9	0.6	0.9	0.9	0.4	0.8	0.6
25	1.0	0.9	1.0	0.8	0.6	0.9	0.5	0.9	0.5	0.3	0.7	0.2
26	1.0	0.9	0.9	0.7	0.7	0.5	0.7	0.9	0.2	0.4	0.9	0.2
27	1.0	0.7	1.0	0.6	1.0	0.7	1.0	0.9	0.2	0.3	0.9	0.3
28	1.0	0.9	0.9	0.6	1.0	0.9	0.9	0.9	0.3	0.3	0.9	0.3
29	0.8	1.0	1.0	0.6	1.0	1.0	1.0	1.0	0.2	0.3	1.0	0.2
30	0.8		1.0	0.7	1.0	1.0	0.4	0.9	0.3	0.4	1.0	0.0
31	0.9		1.0		0.9		0.8	0.5		0.5		0.1
NEK outages in 2020: There were no outages in 2020.												

Table 72: Annual wastewater discharges between 2015 and 2020

Wastewater discharge, 1,000 m^3/year	V1-1	V2, V3, V4, V5, V6	V7-7	V7-10	V7-11	V9
2015	21,766	105	609,465	20,299	4	10
2016	22,249	120	598,714	27,726	4	10
2017	22,007	159	603,397	54,586	4	10
2018	21,394	146	655,863	30,060	4	10
2019	21,203	140	654,246	26,496	4	10
2020	20,835	170	725,562	22,225	4	10

The data on the quantities of wastewater discharged are taken from the annual reports on the operational monitoring of wastewater at NEK.

Other sources of discharge of wastewater into the Sava Krško–Vrbina water body

The sources of wastewater emissions in the wider NEK area are shown in the figure below and the annual quantities of wastewater from these sources in 2019 are shown in Table 73.

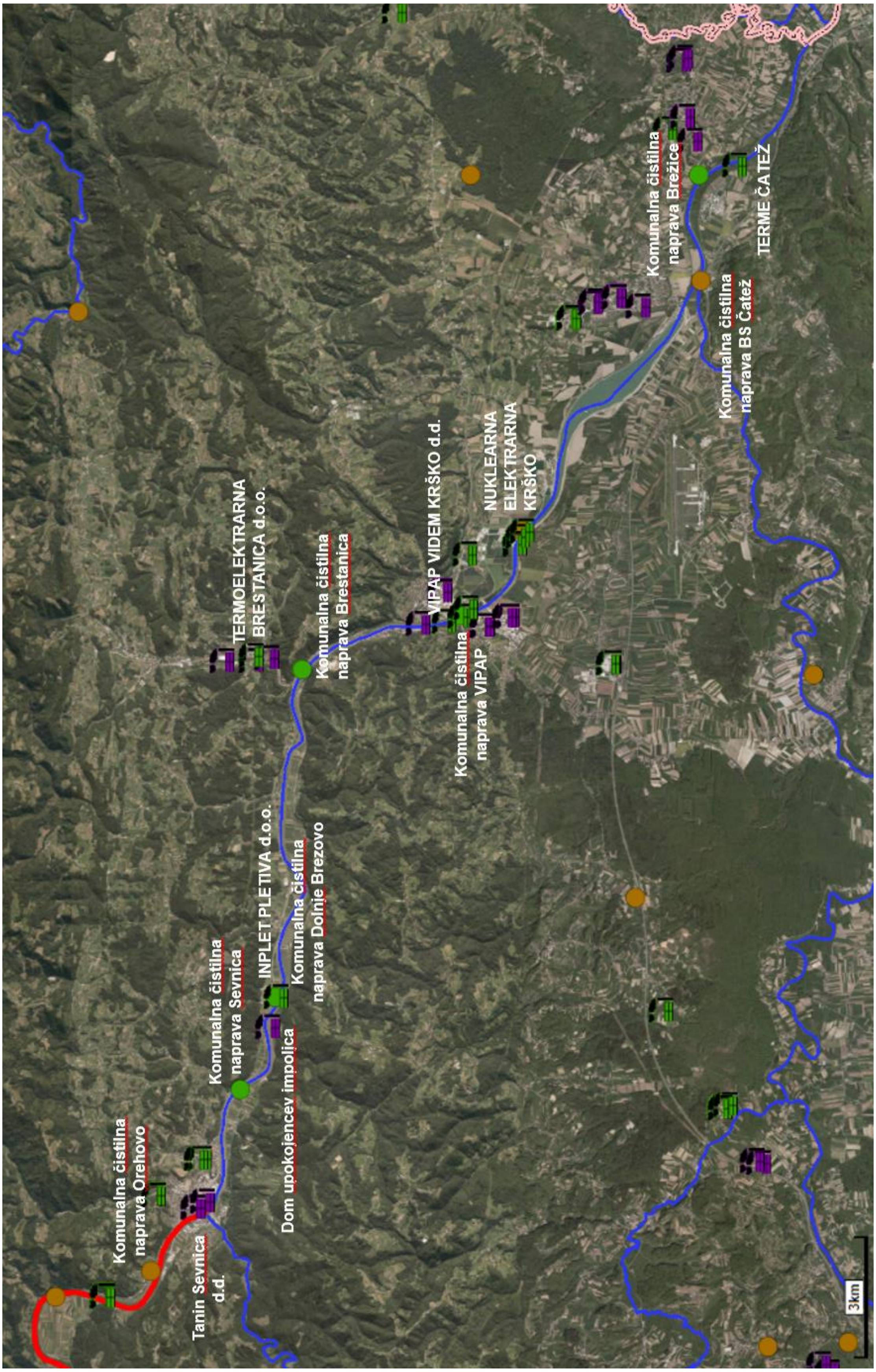


Figure 46: Discharges into the Sava in the wider NEK area (source: /60/

Komunalna čistilna naprava Orehovo	Orehovo municipal treatment plant
Tanin Sevnica d.d.	Tanin Sevnica d.d.
Komunalna čistilna naprava Sevnica	Sevnica municipal treatment plant
INPLET PLETIVA d.o.o.	INPLET PLETIVA d.o.o.
Dom upokojencev Impoljca	Impoljca retirement home
Komunalna čistilna naprava Dolnje Brezovo	Dolnje Brezovo municipal treatment plant
TERMOELEKTRARNA BRESTANICA d.o.o.	TERMOELEKTRARNA BRESTANICA d.o.o.
VIPAP VIDEM KRŠKO d.d.	VIPAP VIDEM KRŠKO d.d.
Komunalna čistilna naprava Brestanica	Brestanica municipal treatment plant
Komunalna čistilna naprava VIPAP	VIPAP municipal treatment plant
NUKLEARNA ELEKTRARNA KRŠKO	KRŠKO NUCLEAR POWER PLANT
Komunalna čistilna naprava Brežice	Brežice municipal treatment plant
Komunalna čistilna naprava BS Čatež	BS Čatež municipal treatment plant
TERME ČATEŽ	TERME ČATEŽ

Table 73: Annual quantities of wastewater discharged into the Sava from the wider NEK area in 2019 (source: /60/)

Discharges of wastewater into the Sava	Quantities of wastewater discharged, m^3/year
Orehovo municipal treatment plant, secondary treatment stage	3,194 27 PE
Tanin Sevnica d.d.	Cooling water for the vacuum pumps and condensate cooler: 44,000 (discharge into the Sevnična stream)
Sevnica municipal treatment plant, secondary treatment stage	970,800 6,339 PE
Impoljca retirement home, laundry	25,979
INPLET PLETIVA d.o.o.	125,163
Dolnje Brezovo municipal treatment plant, tertiary treatment stage	158,119 1,880 PE
Brestanica municipal treatment plant, secondary treatment stage	520,800 2,142 PE
TERMOELEKTRARNA BRESTANICA d.o.o.	40 (discharge into the Brestanica stream)
VIPAP VIDEM KRŠKO d.d. (manufacturer of paper and cardboard)	V1 – Channel KIIT (MMV1): 782,414 V2 – Channel KVT – treatment plant (MMV2): 3,856,425
VIPAP municipal treatment plant, tertiary treatment stage	5,010,585 (180,084 PE)
BS Čatež municipal treatment plant, secondary treatment stage	2,946 69 PE
Brežice municipal treatment plant, tertiary treatment stage (discharge: sink)	1,456,389 17,562 PE
TERME ČATEŽ	V2 – Pool wastewater OV – V1-2 outlet (wastewater from internal pools): 461,900 V1 – Pool wastewater – V1-1 outlet (wastewater from external pools): 479,100 Wastewater from municipal treatment plant: 198,000

4.4.5 Air quality

4.4.5.1 Ambient air quality

In accordance with the Decree on ambient air quality (Official Gazette of RS, Nos. 9/11, 8/15, 66/18), and for the purpose of assessing air quality, Slovenia is divided into two areas and two agglomerations, which vary in terms of the presence of heavy metals and other contaminants. For the purpose of assessing ambient air quality with reference to SO_2, NO_2, NO_x, CO, O_3, C_6H_6, PM_{10}, $PM_{2.5}$ and BaP, Slovenia is divided into the inland zone (SIC) and coastal zone (SIP). For heavy metals, the Upper Meža Valley is excluded from the territory of Slovenia because of its specific features and is dealt with separately. The other parts of Slovenia are located in the SITK (heavy metals) zone.

Under the Decree on ambient air quality (Official Gazette of RS, Nos. 9/11, 8/15, 66/18), the Municipality of Krško is classified as part of:

- the inland zone (SIC) in respect of sulphur dioxide, nitrogen dioxide, nitrogen oxides, PM_{10} and $PM_{2.5}$, benzene, carbon monoxide and benzo(a)pyrene;
- the heavy metals (SITK) zone in respect of lead, arsenic, cadmium and nickel.

An individual zone, sub-zone or agglomeration is classified as having Level I or Level II air pollution as follows:

- Level I air pollution is where the pollution level exceeds the limit or target value, or there is a risk that the pollution level will exceed the alert threshold;
- Level II air pollution is where the pollution level does not exceed the limit or target value.

The Order classifying zones, agglomerations and sub-zones with regard to ambient air pollution (Official Gazette of RS, Nos. 38/17, 3/20, 152/20) sets the air pollution levels for the SIC and SITK zones and the classification according to the lower and upper assessment thresholds, as shown in the tables below.

Table 74: Air pollution levels in the SIC sub-zone and SITK zone relative to the limit values

Designation	SO_2	NO_2	NO_x	PM_{10}	$PM_{2.5}$	Lead	CO	Benzene
SIC	II	II	II	/	II	/	II	II
SIC other than SIC_CE, SIC_MS, SIC_ZS	/	/	/	II	/	/	/	/
SITK	/	/	/	/	/	II	/	/

Key: II = below the limit value, / = n/a

Table 75: Air pollution levels in the SIC sub-zone and SITK zone relative to the target values

Designation	Ozone	Arsenic	Cadmium	Nickel	Benzo(a)pyrene
SIC	I	/	/	/	II
SIC other than SIC_CE, SIC_MS, SIC_ZS	/	/	/	/	/
SITK	/	II	II	II	/

Key: I = above the limit value, II = below the limit value, / = n/a

Table 76: Ambient air pollution levels in the SIC zone relative to the upper and lower assessment thresholds

Designation	SO_2	NO_2	NO_x	PM_{10}	$PM_{2.5}$	Lead	CO	Benzene	Arsenic	Cadmium	Nickel	Benzo (a) pyrene
SIC	1	2	2	3	3	/	1	1	/	/	/	3
SITK	/	/	/	/	/	1	/	/	1	2	1	/

Key:

1 = below the lower assessment threshold, 2 = between the lower and upper assessment threshold, 3 = above the upper assessment threshold, / = n/a

4.4.5.2 Existing emissions from industrial sources

The tables below show data from the official records of the Slovenian Environment Agency on the annual quantities of substances discharged into the atmosphere and on the assessment of diffuse emissions in 2019 from the developer and other installations in the immediate vicinity (within a radius of approximately 2,000 m from the location under consideration) that are liable for the monitoring of emissions into the atmosphere from stationary sources of pollution. /55/

Table 77: Annual quantities of substances discharged into the air from emissions from installations, and an estimate of diffuse emissions in 2019 (entities liable for emission monitoring in the immediate vicinity) (source: ARSO /55/)

Liable entity	Contaminant	Emissions of substances from discharges (kg)	Estimate of diffuse emissions (kg)
AVTOLINE KRŠKO trgovina in servis d.o.o.	total dust	5.86	0
CGP d.d. – Asfaltna baza Drnovo	TOTAL carcinogens Risk Category III	134.40	0
	nitrogen oxides (NO and NO_2), expressed as NO_2	138.43	0
	total dust	307.20	0
	carbon monoxide (CO)	2,044.51	0
DS SMITH SLOVENIJA D.O.O.	total dust	11.10	0
FARME IHAN – KPM d.o.o. – Krško	ammonia (NH_3)		7,778
	methane (CH_4)		11,162
KEMOKOVINA KRŠKO D.O.O.	total dust	15.35	5
	organic compounds, expressed as total organic carbons (TOC)	99.67	0
Kostak d.d.	methane (CH_4)		104,500
	carbon dioxide (CO_2)		396,800
Kostak d.d. Spodnji Stari Grad	total dust	82.99	10
	ammonia (NH_3)	823.54	99
	methane (CH_4)	5,602.40	673
	organic compounds, expressed as total organic carbons (TOC)	8,736.00	1,048
Krka d.d. Krško plant	polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF)	0.00006451	0
	methyl chloride (CH2Cl)	19.35	0
	total dust	20.97	0
	carbon monoxide (CO)	322.56	0
	organic compounds, expressed as total organic carbons (TOC)	491.90	444
	nitrogen oxides (NO and NO_2), expressed as NO_2	1,056.38	0
METALNA SENOVO, D.O.O.	total dust	125.40	50
RESISTEC UPR. d.o.o. & Co.k.d.	total dust	12.96	0
	organic compounds, expressed as total organic carbons (TOC)	1,163.36	0
Šumi bonboni d.o.o., Krško business unit	total dust	43.58	0
BRESTANICA THERMAL POWER PLANT	sulphur oxides (SO_2 and SO_3) expressed as SO_2	177.00	0
	total dust	376.26	0
	carbon monoxide (CO)	509.05	0
	nitrogen oxides (NO and NO_2), expressed as NO_2	12,281.85	0
	smoke number		0
VIPAP VIDEM KRŠKO, Proizvodnja papirja in vlaknin d.d.	polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF)	0.00000189	0
	SUM of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	2.17	0

Liable entity	Contaminant	Emissions of substances from discharges (kg)	Estimate of diffuse emissions (kg)
	TOTAL carcinogens Risk Category I	4.10	0
	TOTAL inorganic particulate matter Category III	6.07	0
	TOTAL inorganic particulate matter Category II	21.08	0
	TOTAL inorganic particulate matter Categories I and II	21.87	0
	TOTAL inorganic particulate matter Categories I, II and III	27.94	0
	inorganic chlorine compounds, unless they appear in Risk Category I, expressed as HCl	120.00	0
	organic compounds, expressed as total organic carbons (TOC)	563.08	0
	total dust	14,545.70	138
	sulphur oxides (SO_2 and SO_3) expressed as SO_2	62,774.00	0
	carbon monoxide (CO)	75,677.00	0
	nitrogen oxides (NO and NO_2), expressed as NO_2	261,213.00	0
	fluorine and its compounds, expressed as HF		0
	thallium and its compounds, expressed as Tl		0
	TOTAL Cd, Tl		0
	mercury and its compounds, expressed as Hg		0
Willy Stadler d.o.o.	total dust	15.68	0
	organic compounds, expressed as total organic carbons (TOC)		6,213

Table 78: Total emissions of substances from industrial sources in the Municipality of Krško, kg/year notified to ARSO for 2019

	SO_2	NOx	CO	TOC	NH_3	TSP (total dust)
Emissions from discharge	62,951.0	274,689.7	78,553.1	11,054.0	823.5	15,563.0
Estimated diffuse emissions	0	0	0	7,705.0	7,877.0	203.0
Total	62,951.0	274,689.7	78,553.1	18,759.0	8,700.5	15,766.0

4.4.5.3 Existing emissions from traffic

Traffic on public roads also constitutes a source of emission of substances into the air. NEK is located on the left bank of the Sava in the Krško industrial zone. The local road leads to NEK along the Krško ring road, and connects the Krško–Spodnja Pohanca R1 regional road. NEK also has an industrial railway track that connects it to Krško railway station. The main railway line from Ljubljana to Zagreb and the state border proceeds north of NEK. Krško railway station is situated approximately 2,500 m northwest and can be reached from Section 220 of the R1.

Information on the traffic density of the regional road near NEK is presented in the tables below (Table 79 and Table 80), containing the average annual daily traffic (AADT) for 2015–2018 and the AADT in 2018 by type of vehicle for the road section under observation.

Table 79: Average annual daily traffic (AADT) on regional roads 2015–2018 (source:/123/)

Road category	Road no	Section no	Traffic section	Count point location	All vehicles (AADT)			
					2015	2016	2017	2018
R1	220	1334	Krško–Spodnja Pohanca	367 Dolenja vas	5,859	5,904	5,810	6,026

Table 80: Average annual daily traffic (AADT) on regional roads in the vicinity of the activity site by

type of vehicle in 2018 (source:/123/)

Road category and number, road section	All vehicles (AADT)	Motorcycles	Private cars	Buses	Light goods vehicles <3.5 t	Medium goods vehicles 3.5–7 t	Heavy goods vehicles >7 t	Goods vehicle with trailer	Towing vehicles
R1 220 1334 Krško–Spodnja Pohanca	6,026	44	5,398	43	334	58	61	25	63

Table 81 shows that medium and heavy goods vehicles account for a relatively small percentage of total traffic on the regional roads near NEK, and that the majority of traffic comprises private cars, for which an estimate of air pollution emissions is produced.

The total annual emissions from private car traffic on the R1 220 1334 Krško–Brežice road section, calculated as the average value and using emission factors, figures on the total number of private cars in 2018, figures on traffic density and a regional road length of 12,715 m, are shown in Table 81. The emission factors are based on the COPERT 5 model for notified national private vehicle emissions in 2018 and on an assumption regarding vehicle structure /190/. Estimates of the emissions from private car traffic include emissions from fuel combustion, from the evaporation of petrol from petrol-driven vehicles, from tyre and brake wear, and from road wear.

Table 81: Emissions of SO_2, NOx, CO, PM_{10}, $PM_{2.5}$ and NMVOC from road traffic, private cars in 2018, kg/year

Source	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	NMVOC
Private car traffic on R1 220 1334 Krško–Brežice	24.09	11,177.04	15,391.55	1,858.82	1,031.29	2,643.91
Emission factors kg/vehicle	0.0045	2.0706	2.8515	0.3444	0.1911	0.4898

4.4.5.4 Emissions from the generation of electricity and heat in Slovenia

In 2018 two thermal power plants were in operation, in Šoštanj (TEŠ) and Ljubljana (TE-TOL). TE-TOL used exclusively imported coal with a high net calorific value and low sulphur content for the generation of electricity and heat, while TEŠ uses lignite from a domestic coal mine situated adjacent to the power plant itself. In addition to these thermal power stations, there is also the smaller Brestanica power station (TEB), which uses natural gas and operates mainly as an auxiliary power station whenever more electricity is needed or another power station is being refitted.

Total emissions of SO_2, NOx, CO, PM_{10} and $PM_{2.5}$ in 2018 from the electricity and heat generation sector /190/ is shown in Table 82.

Table 82: Emissions of the pollutants SO_2, NOx, CO, PM_{10}, $PM_{2.5}$ and NMVOC from the electricity and heat generation sector in 2019, kt/year

Source	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	NMVOC
Generation of electricity and heat	1.59	3.52	1.32	0.32	0.28	0.15

We can conclude from the substance emissions observed that the electricity and heat generation sector was a key source of SO_2, NOx, PM_{10} and $PM_{2.5}$ emissions in Slovenia in 2019.

4.4.5.5 National emissions

Total national emissions of SO_2, NOx, CO, PM_{10}, $PM_{2.5}$ and NMVOC in 2019 are shown in Table 83, along with the share taken by the activity, i.e. emissions calculated during the operation of NEK and emissions during the construction of the spent fuel dry storage.

Table 83: National emissions of SO_2, NOx, CO, PM_{10}, $PM_{2.5}$ and NMVOC, kt/year, and the contribution of all observed sources to total national emissions in 2019

Source	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	NMVOC
National emissions	4.3	29.2	96.6	13.1	10.6	31.20
Contribution of the electricity and heat generation sector to national emissions	36.9%	12.0%	1.4%	2.4%	2.6%	0.5%
Contribution of private car traffic on R1 220 1334 Krško–Brežice	0.0005%	0.04%	0.02%	0.014%	0.010%	0.008%
Contribution of total industrial emissions to national emissions	1.7%	1.0%	0.1%	-	-	0.1%
Contribution of activity to national emissions	0.009%	0.002%	0.0001%	0.0002%	0.0001%	0.00002%

4.4.5.6 Existing emissions from NEK – non-radioactive material

Emissions of substances that affect air quality are very small and are the consequence of the burning of fossil fuels at the site of the activity.

Emissions of SO_2, NOx, CO, PM_{10}, $PM_{2.5}$ and NMVOC come from the following sources:

- Diesel generators for EMR power supply (DG1 and DG2 3,500 kW and DG3 4,000 kW). They are activated only when the power plant is without its own supply and when external supply cannot be guaranteed. Tests of the operational readiness of a diesel generator are made every 18 months during outage. An average of 72.8 t of diesel fuel was used every year between 2014 and 2019.
- The auxiliary boilerhouse (two boilers with a total power of 16,321 kW, each with its own stack approximately 40 m in height), which operates during outage and occasionally provides auxiliary steam during start-up of the power plant for maintaining the warm state of the turbines and other systems. An average of 125.6 t of diesel fuel was used every year between 2014 and 2019.
- Internal freight transport at the plant. NEK has around ten vehicles for internal transport. Their emissions are almost negligible.
- Private car transport in the car park. There are vehicle emissions on the short section of access road and while vehicles are being parked (main access road and car park, both to the north). As these emissions are tiny (ten times lower than the emissions from stationary sources, i.e. the diesel generators and auxiliary boilerhouse), they are not enumerated.

Under the Decree on the emission of substances into the atmosphere from medium-sized combustion plants, gas turbines and stationary engines (Official Gazette of RS, Nos. 17/18, 59/18), the DG1, DG2 and DG3 diesel engines and the boilerhouse are not bound by the emission limit values or by the requirement to measure emissions; this is because they operate for less than 300 hours a year and serve as a back-up source of power. The boiler has operated for 778 hours over the last five years (an average of 155.6 hours a year).

Table 84shows the average values of annual emissions, with account taken of emission factors and data on fuels from /190/.

Table 84: Emissions of SO_2, NO_x, PM_{10}, $PM_{2.5}$ and NMVOC from NEK, kg/year

Source	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	NMVOC
Diesel generators	145.6	198.2	49.4	9.8	2.4	2.4
Auxiliary boilerhouse	251.1	341.7	85.2	16.8	4.2	4.2

Source	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	NMVOC
Total	396.7	539.9	134.6	26.6	6.6	6.6

4.4.6 Ionising radiation (radioactive radiation)

The effects of ionising radiation on all environmental factors are set out below. The monitoring results are taken from the "Monitoring of radioactivity in the vicinity of NEK, Report for 2020" document /87/.

4.4.6.1 Existing emissions of substances into the atmosphere from NEK – radioactive material

We have taken the figures for existing emissions of radioactive material into the atmosphere from the annual report on radioactive emissions from NEK compiled by NEK for 2020 /88/ and from the "Monitoring of radioactivity in the vicinity of NEK, Report for 2020" document /87/.

Emissions are sampled at NEK's main ventilation channel, where samples are taken for the measurement of iodine, tritium (H-3), carbon (C-14) and aerosols (aerosol filters in the RM-24 monitor), and measurements of noble gases are conducted.

The dose resulting from the total annual activity of discharged noble gases for 2020 amounts to approximately 0.076% of the annual limit, which is similar to 2019. If we also examine 2018, 2017 and other years, emitted noble gases account for less than 0.1% of the annual limit.

Isotopes of radioactive iodine were not measured or detected, which is one of indicators showing that the integrity of the nuclear fuel is adequate.

Radioactive isotopes of cobalt and caesium that appear in the form of dust particles in the atmosphere are given as values at the detection limit.

The table and figures below provide more detailed information.

Table 85: Data on radioactivity in atmospheric discharges for 2020

Radioactive material	annual limit	Activity discharged	Percentage of limit
fission and activation gases (total)	dose < 50µSv	0.945 TBq	7.6 E-02
Iodines (I-131 and others)	18.5 GBq (I-131 equivalent)	0	0
dust particles (cobalt, caesium, etc.)	18.5 GBq	1.39 kBq	7.5 E-06
tritium (H-3)	-	3.45 TBq	-
carbon (C-14)	-	19.8 GBq	-

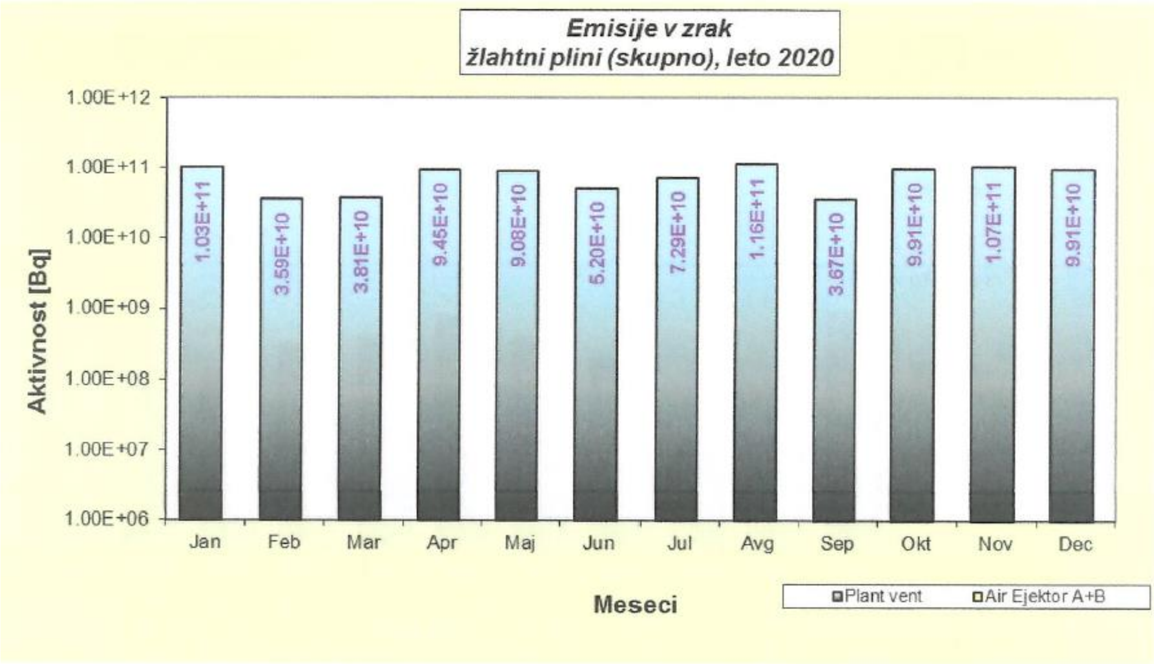


Figure 47: Monthly activity of noble gases in atmospheric discharges in 2020[13] (source: /88/)

Emisije v zrak ***žlahtni plini (skupno), leto 2020***	***Emissions into the atmosphere*** ***noble gases (total), 2020***
Aktivnost [Bq]	**Activity [Bq]**
Jan	Jan
Feb	Feb
Mar	Mar
Apr	Apr
Maj	May
Jun	Jun
Jul	Jul
Avg	Aug
Sep	Sep
Okt	Oct
Nov	Nov
Dec	Dec
Meseci	**Months**
Plant vent	Plant vent
Air ejektor A+B	Air ejector A+B

[13] Plant vent – main ventilation channel, Air ejector – ventilation of the secondary side condenser.

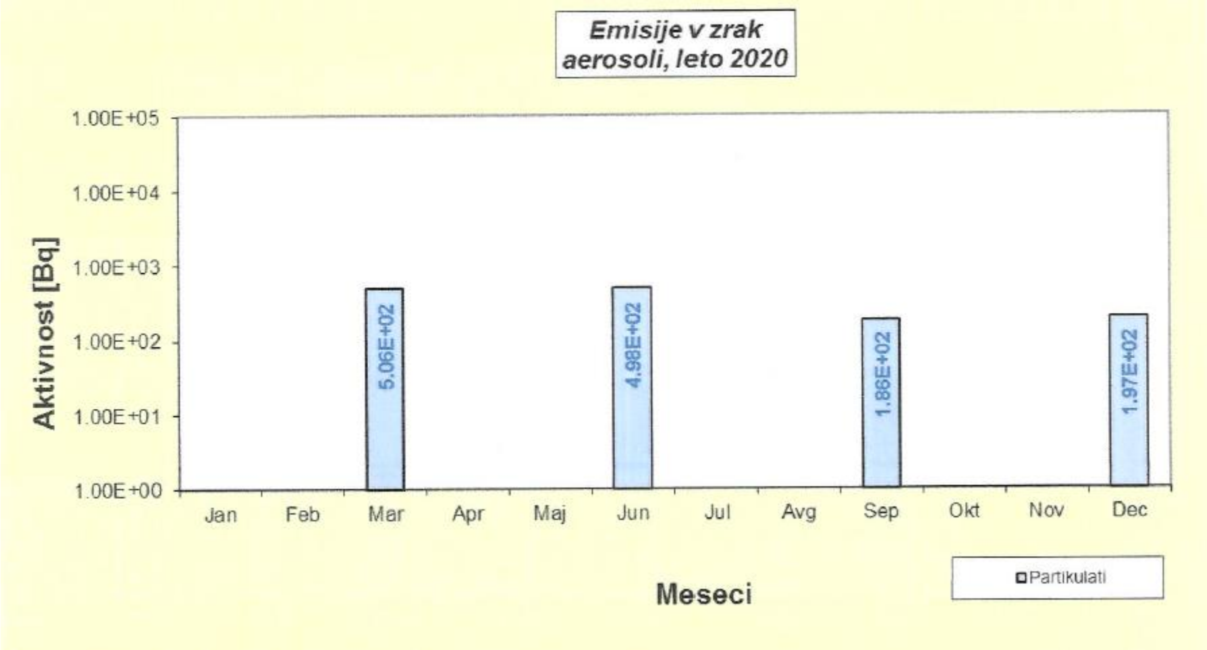


Figure 48: Monthly activity of particulates (aerosols) in atmospheric discharges in 2020 (source: /88/)

Emisije v zrak aerosoli, leto 2020	***Emissions into the atmosphere aerosols, 2020***
Aktivnost [Bq]	**Activity [Bq]**
Jan	Jan
Feb	Feb
Mar	Mar
Apr	Apr
Maj	May
Jun	Jun
Jul	Jul
Avg	Aug
Sep	Sep
Okt	Oct
Nov	Nov
Dec	Dec
Meseci	**Months**
Partikulati	Particulates

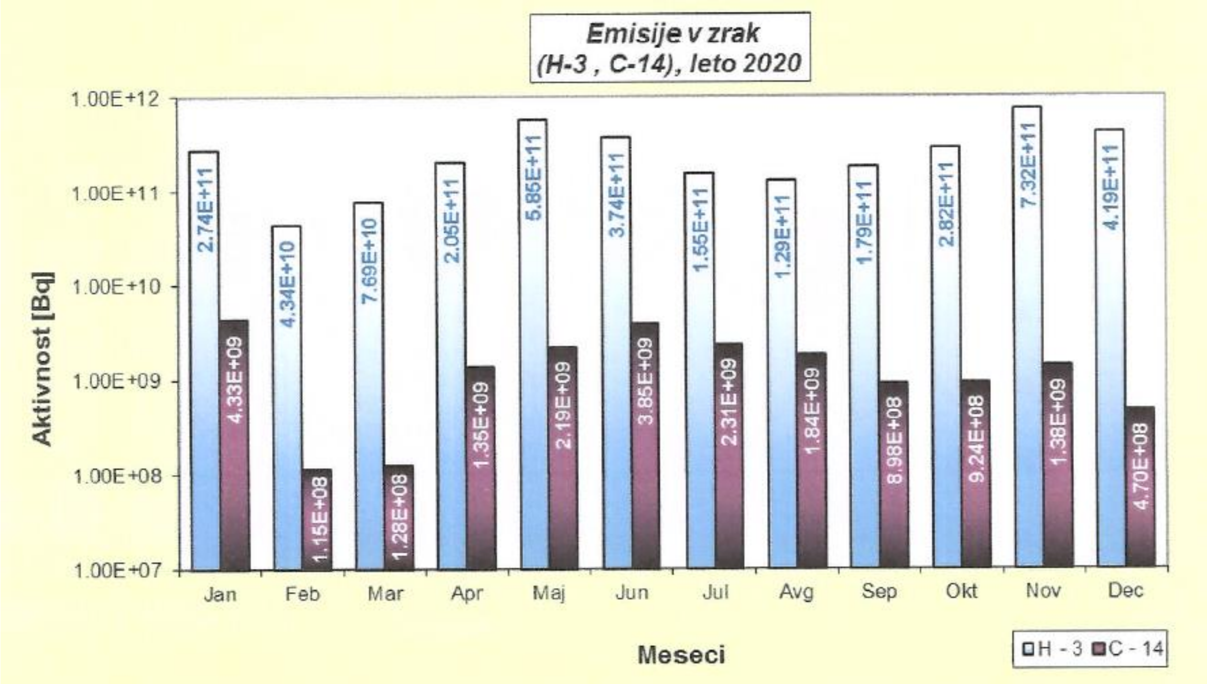


Figure 49: Monthly activity of C-14 and H-3 in atmospheric discharges in 2020 (source: /88/)

Emisije v zrak (H-3, C-14), leto 2020	***Emissions into the atmosphere (H-3, C-14), 2020***
Aktivnost [Bq]	**Activity [Bq]**
Jan	Jan
Feb	Feb
Mar	Mar
Apr	Apr
Maj	May
Jun	Jun
Jul	Jul
Avg	Aug
Sep	Sep
Okt	Oct
Nov	Nov
Dec	Dec
Meseci	**Months**
H-3	H-3
C-14	C-14

The annual activity of C-14 in atmospheric discharges from NEK is several times higher in years in which there is outage compared to years in which there is no outage. In 2019, an outage year, the annual activity of C-14 in atmospheric discharges was 74.7 GBq. This compares with 19.8 GBq in 2020, a year in which there was no outage. Although it appears at first glance that this is a large difference, it makes only a minor contribution to the dose and an almost insignificant contribution to the dose loading of reference members of the population.

All technical rules for the operation of the power plant have been adhered to so that the current concentration of radioactive isotopes in the atmosphere or the dose rate at a distance of 500 m from the reactor did not exceed the prescribed values.

Gaseous emissions

In 2020 the activity of noble gases in gaseous effluents was comparable to that of the previous year, as was the total activity of I-131 equivalent. Both figures confirm that the integrity of the nuclear fuel is adequate. Atmospheric discharges from the secondary side ejector does not contain noble gases in measurable quantities, which means that the steam generators do not pass from the primary to the secondary side.

The annual discharged activity of dust particles/aerosols was extremely low, with activity totalling 1.39 kBq or approximately 8 millionths of one per cent of the annual limit, which cannot be measured in practical terms. This activity was solely comprised of radionuclide Sr-90, which was detected at the IJS in the filters of the main NEK exhaust.

The total annual atmospheric discharges of H-3 and C-14 were comparable with the values of recent years. The measured activity was in line with expectations.

No alpha emitter activity was detected in gaseous emissions (or rather, was below the detection limit of 0.001 Bq/m^3 for the main ventilation channel).

The figures below give a comparison with individual years.

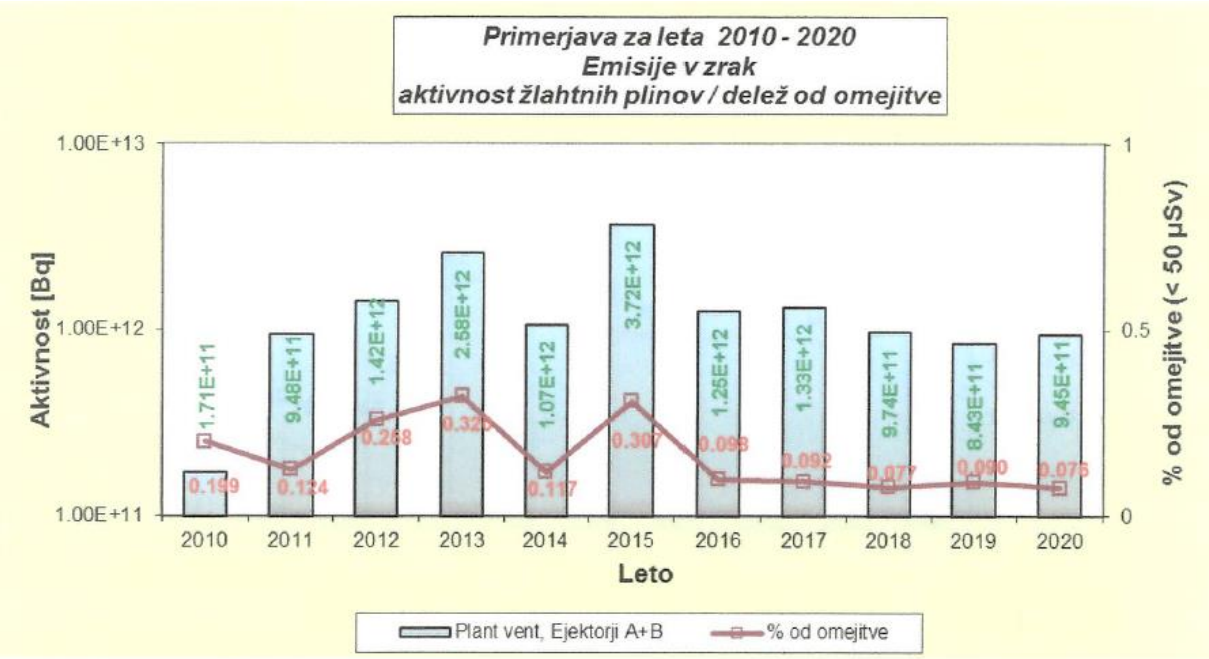


Figure 50: Annual comparison of the activity of noble gases in atmospheric discharges (source: /88/)

Primerjava za leta 2010-2020 Emisije v zrak aktivnost žlahtnih plinov / delež od omejitve	Comparison for 2010–2020 Emissions into the atmosphere activity of noble gases/% of limit
Aktivnost [Bq]	**Activity [Bq]**
% od omejitve (< 50 µSv)	**% of limit (< 50 µSv)**
Leto	**Year**
Plant vent, Ejektorji A+B	Plant vent, Ejectors A+B
% od omejitve	% of limit

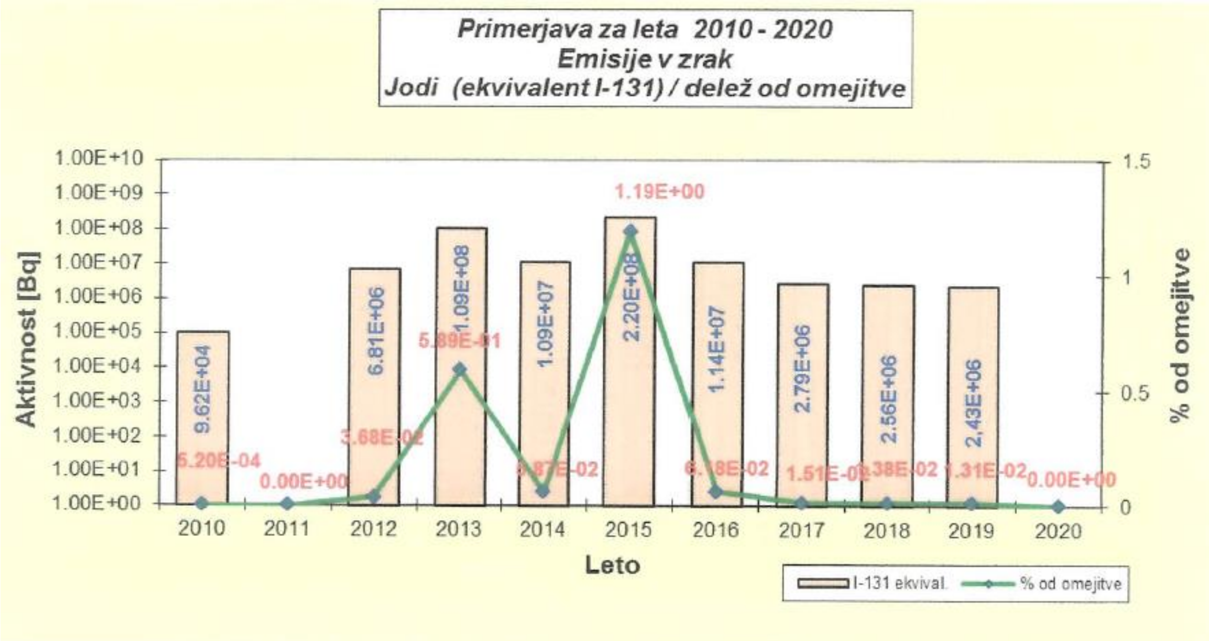


Figure 51: Annual comparison of I-131 activity in atmospheric discharges (source: /88/)

Primerjava za leta 2010-2020 Emisije v zrak Jodi (ekvivalent I-131) / delež od omejitve	***Comparison for 2010–2020 Emissions into the atmosphere Iodines (I-131 equivalent)/% of limit***
Aktivnost [Bq]	**Activity [Bq]**
% od omejitve	**% of limit**
Leto	**Year**
I-131 ekvival.	I-131 equivalent
% od omejitve	% of limit

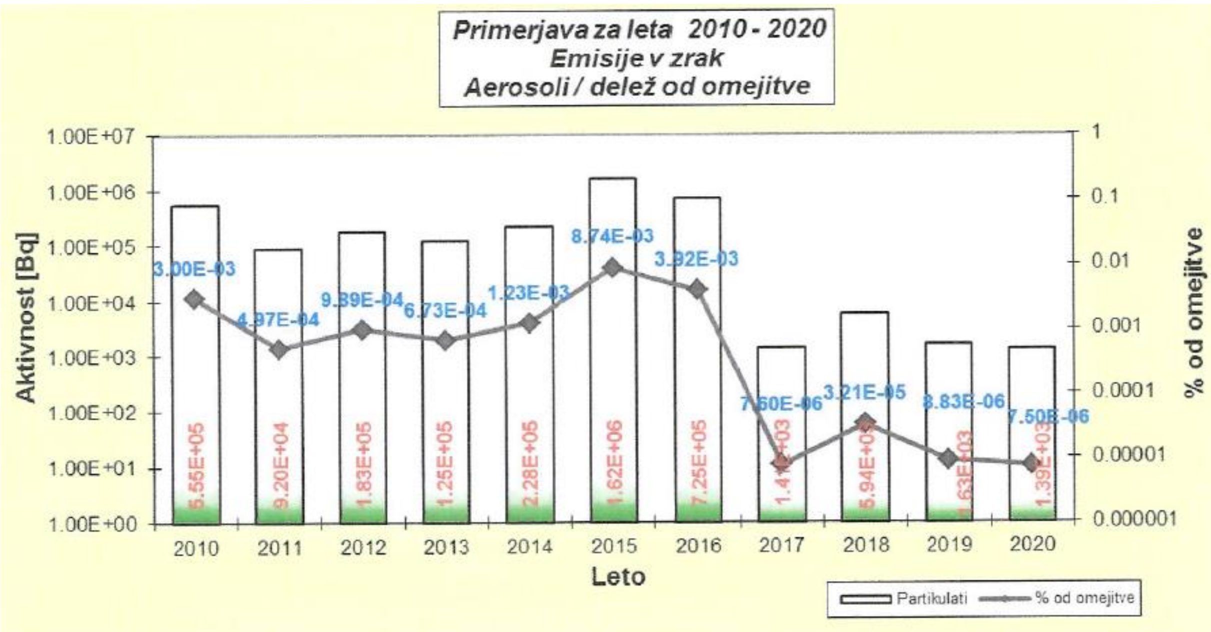


Figure 52: Annual comparison of activity of particulates (aerosols) in atmospheric discharges (source: /88/)

Primerjava za leta 2010-2020 Emisije v zrak Aerosoli / delež od omejitve	***Comparison for 2010–2020 Emissions into the atmosphere Aerosols/% of limit***

Aktivnost [Bq]	**Activity [Bq]**
% od omejitve	**% of limit**
Leto	**Year**
Partikulati	Particulates
% od omejitve	% of limit

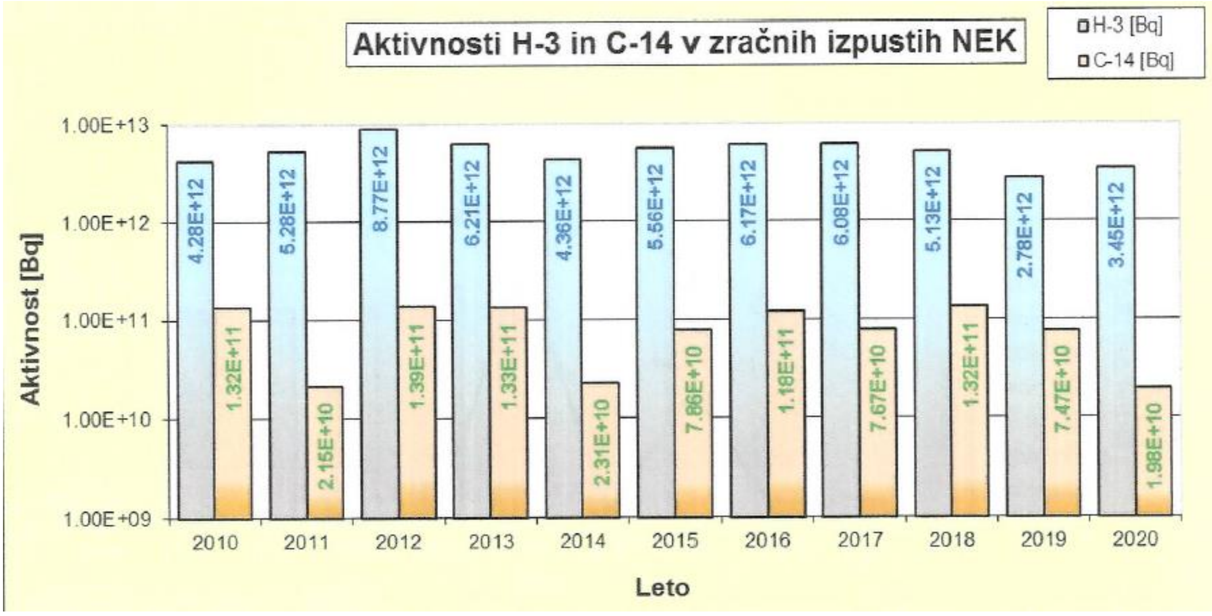


Figure 53: Annual comparison of C-14 and H-3 in atmospheric discharges (source: /88/)

Aktivnosti H-3 in C-14 v zračnih izpustih NEK	**Activity of H-3 and C-14 in atmospheric discharges from NEK**
H-3 [Bq]	H-3 [Bq]
C-14 [Bq]	C-14 [Bq]
Aktivnost [Bq]	**Activity [Bq]**
Leto	**Year**

Emissions of radioactive material into the atmosphere are also monitored by means of measurements taken in the vicinity of NEK, which monitor the spread of atmospheric radioactive discharges into the surrounding area.

The monitoring results for 2020 below are taken from the "Monitoring of radioactivity in the vicinity of NEK, Report for 2020" document /87/. Radioactivity in the atmosphere is monitored at the following locations:

a) the sampling of aerosols is carried out by continuously pumping air through aerosol filters that are replaced every 15 days; pumps are installed at eight locations surrounding NEK (Spodnji Stari Grad, Krško – Stara Vas, Leskovec, Brege, Vihre, Gornji Lenart, Spodnja Libna and the Dobova reference location) and at the control location in Ljubljana (monitoring of radioactivity in the living environment in Slovenia);
b) the sampling of iodine I-131 is carried out using special pumps and filters at the same locations as the sampling of aerosols (except in Dobova);
c) only in Dobova is sampling for the specific measurement of Sr-90/Sr-89 carried out using a special pump;
d) emission measurements are conducted on the main NEK vent, where samples are taken for the measurement of iodine, tritium (H-3), carbon (C-14) and aerosols, and measurements of noble gases are conducted;
e) collection of samples of atmospheric carbon C-14 in CO_2 took place continuously at two locations on the NEK perimeter. Control measurements took place in Zagreb, Croatia.

Measurements of filters for aerosols and special filters for I-131 are conducted using high-resolution gamma spectrometry, while specific measurements of Sr-90/Sr-89 are performed using a beta scintillation counter. Radiochemical analysis of Sr-89/Sr-90 is conducted on the same samples as the high-resolution gamma spectrometry. The measurement of the specific activity of C-14 in atmospheric CO_2 takes place using a liquid scintillation counter, generating benzene from CO_2.

Results in 2020

Tritium H-3 and C-14 are the two isotopes with the highest levels in total atmospheric discharges from NEK (4.5 TBq, with H-3 at 3.5 TBq and C-14 at 0.02 TBq). Their presence in the environment is assessed by using a model of the spread of airborne material on the basis of measurements carried out at the source. C-14 is also measured at two locations within the NEK perimeter.

During operation, discharges of Co-60, Te-125, Te-127m, Cs-137 and Sr-90 were detected at the NEK outlet in 2020. However, these radionuclides, with the exception of the last two, were not detected at any of the seven measurement points in the vicinity of NEK or in Ljubljana. At the sampling stations, the calculated activity concentrations of Cs-137 and Sr-90 are at least three orders of magnitude lower than the measured values. Cs-137 and Sr-90 in the environment are mostly the result of general contamination.

The average monthly concentrations of Cs-137 activity at locations in the vicinity of NEK in 2020 were lower than the long-term averages and lower than elsewhere in Slovenia. We presume that the presence of Cs-137 in the atmosphere is the result of the use of solid fuels (firewood, briquettes and pellets) and less the result of the re-suspension of dust particles from the ground.

Strontium Sr-90 measurements in the environment are only carried out in Dobova (and even there only on quarterly composite samples). The average activity concentration in 2020 was 0.07 $\mu Bq/m^3$. However, all measurements were below the detection limit. The multi-annual average of activity concentration for Sr-90 is less than 0.7 $\mu Bq/m^3$. The Sr-89 radionuclide was not detected in atmospheric discharges from NEK in 2020.

The I-131 radionuclide was not detected in 2020 in any of the seven measurement points in the vicinity of NEK at which combined pumps had been set up (aerosol filters, charcoal filters). Even the high-performance aerosol pumps at the locations in Dobova (radioactivity monitoring in the vicinity of NEK) and Ljubljana (national radioactivity monitoring) did not show the presence of airborne I-131.

Measurements of naturally occurring radionuclides in aerosols in samples from the vicinity of NEK indicate the presence of radionuclides, which were also obtained as part of monitoring measurements at other locations around Slovenia. It should be noted that the average concentrations of Be-7 and Pb-210 activity in 2020 match well at all measurement points in the vicinity of NEK and in Ljubljana. The average activity concentration of Be-7 in 2020 in the vicinity of NEK was 3.4 mBq/m^3, while that of Pb-210 was 0.6 mBq/m^3. The average concentrations in Ljubljana were 4.6 mBq/m^3 and 0.8 mBq/m^3, respectively. In terms of other naturally occurring radionuclides (isotopes of the uranium and thorium decay chains and K-40), the differences between individual measurement points in the vicinity of NEK were somewhat higher, but still within the limits of measurement uncertainty and expected deviations, which was the result of a greater re-suspension on cultivated agricultural land.

4.4.6.2 Existing liquid emissions – radioactive material

The figures below (Figure 54, Figure 55, Figure 56) illustrate annual liquid emissions of H-3 and C-14 (Annual report on emissions from NEK for 2020), while Table 86 presents the annual averages /88/.

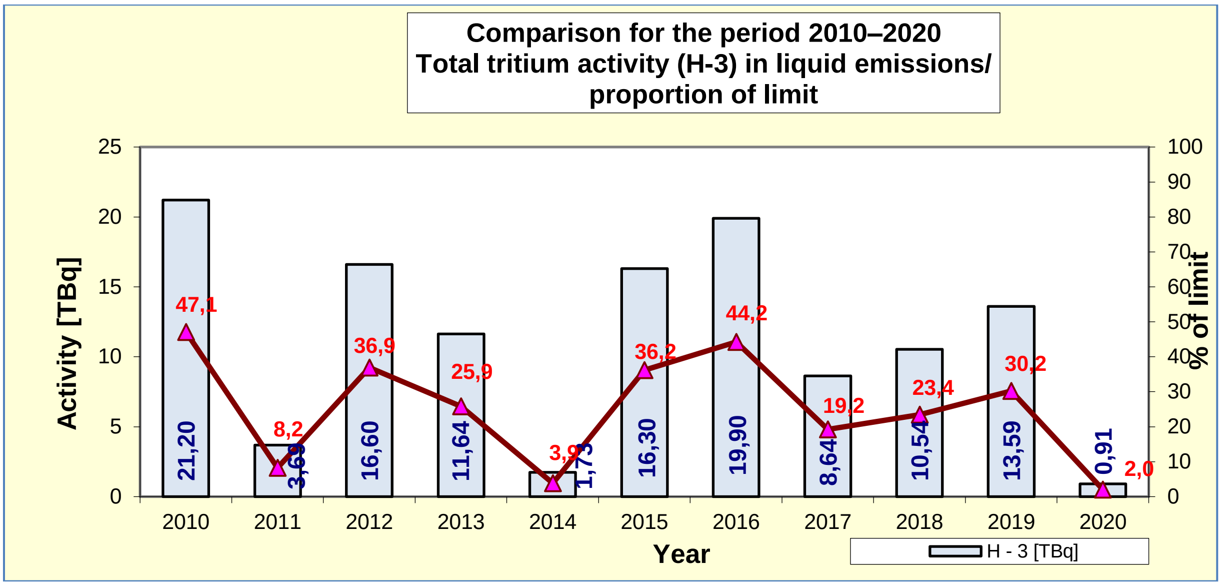


Figure 54: Total H-3 activity in liquid emissions (source: /88/)

Figure 55: C-14 activity in liquid emissions (source: /88/)

Aktivnosti C-14 v tekočinskih efluentih	C-14 activity in liquid effluents
C-14 [Bq]	C-14 [Bq]
Aktivnost [Bq]	**Activity [Bq]**
Leto	**Year**

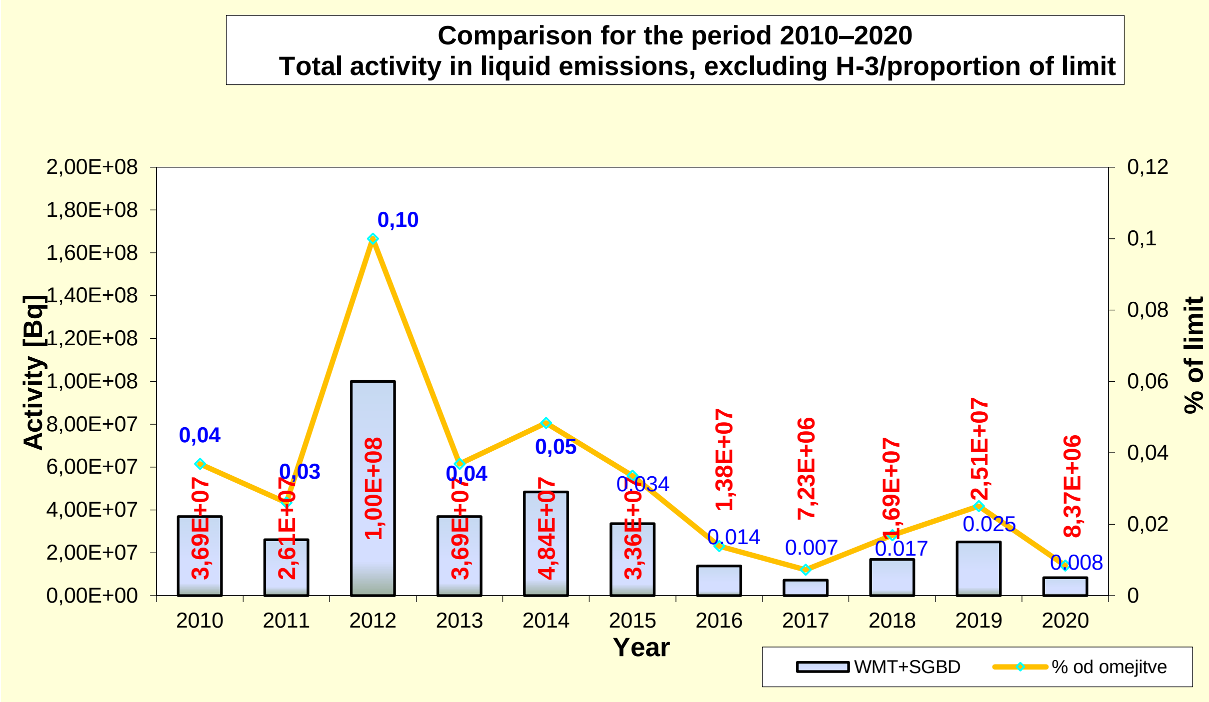


Figure 56: Total activity in liquid emissions, excluding H-3 (source: /88/)

WMT+SGBD	WMT + SGBD
% od omejitve	% of limit

Table 86: Average annual liquid radioactive emissions in the period 2010–2020 for H-3 and for the period 2013–2019 for C-14

	Average annual value	Proportion of annual limit
Total H-3 activity	11.3 TBq	0.25
Total C-14 activity	1.7 GBq	n.a.
Total activity, excluding H-3	33 MBq	0.033

4.4.6.3 Measurements of radioactivity in the water supply network and at pumping stations

As part of the monitoring of radioactivity in the surrounding area, NEK also measures radioactivity in the water supply network and at pumping stations. The monitoring results are taken from the "Monitoring of radioactivity in the vicinity of NEK, Report for 2020" document /87/. Sampling took place as follows:

- individual annual water samples taken from the water supply system in Ljubljana (reference location);
- individual quarterly water samples taken from the water supply systems in Krško and Brežice;
- monthly compiled samples taken from the pumping stations in Brege, Rore, Brežice and the Spodnji Stari Grad and Brežice water supply systems;
- the sampling of groundwater in the immediate vicinity of the power plant (quarterly one-time samples from borehole E1 inside the NEK perimeter and monthly one-time samples from borehole VOP-4, Vrbina) and at two locations in Croatia (the Medsave and Šibice boreholes);
- monthly samples from boreholes VOP-1/06, V-7/77 and V-12/77.

The sample measurements include the determination of the activity concentration of gamma emitters through high resolution gamma spectrometry, the determination of the activity concentration of tritium

(H-3) by liquid scintillation counting, and the determination of the activity concentration of Sr-90/Sr-89 by radiochemical separation and counting using a proportional counter. Radiochemical analysis of Sr-89/Sr-90 is conducted on the same samples as high-resolution gamma spectrometry.

Results for 2020

Regarding artificial radionuclides, Sr-90 (strontium) and Cs-137 (caesium) were detected or measured in drinking water and groundwater in 2020. The latter was for the most part detected but not measured because values were below the limit of quantification. As in previous years, I-131 was not detected in any sample of water from the water supply system or of groundwater in 2020. H-3, which can be either of natural or artificial origin, was measured.

Concentrations of tritium activity in drinking water in the surroundings of NEK are of the same order of magnitude as seen elsewhere in Slovenia. The tritium values at the Brege pumping station or in Spodnji Stari Grad, which is connected to the Krško water supply system, are the highest in Slovenia and are undoubtedly a result of the impact of NEK. However, even the highest values are still less than 2% of the limit values set out in the EU Drinking Water Directive (100 Bq/l).

Table 87shows the mean values of H-3 concentrations at the pumping stations and water supply systems in the vicinity of NEK between 2017 and 2020. Here we observe three categories with regard to H-3 activity concentrations: the Brege pumping station and the Spodnji Stari Grad water supply system, the Brežice water supply system and Glogov Brod pumping station, and the Rore pumping station. The mean values for the Rore pumping station and the Brežice pumping station and water supply system have not changed significantly in this period because they involve boreholes that are not directly exposed to atmospheric tritium. In the case of the Rore pumping station, H-3 concentration corresponds to the natural concentration in surface waters, while the case of Brežice involves water in which most of the tritium has almost completely decomposed (because the water has penetrated to the depth of the borehole for more than 20 years).

Table 87: Mean values of H-3 concentrations at the pumping stations and water supply systems in the vicinity of NEK 2017–2020

	2020 (Bq/m^3)	**2019 (Bq/m^3)**	**2018 (Bq/m^3)**	**2017 (Bq/m^3)**
BREGE PUMPING STATION	1,473 ± 48	1,319 ± 46	2,043 ± 67	1,846 ± 64
RORE PUMPING STATION	554 ± 18	620 ± 24	600± 20	580 ± 22
SPODNJI STARI GRAD WATER SUPPLY SYSTEM	1,058 ± 35	1,177 ± 41	2,010 ± 61	1,746 ± 59
BREŽICE WATER SUPPLY SYSTEM	99 ± 8	77 ± 41	83 ± 8	125 ± 11
BREŽICE PUMPING STATION	114 ± 27	81 ± 18	250 ± 52	125 ± 21

The table above shows the reduction in the mean value in samples from the Brege pumping station and the Spodnji Stari Grad water supply system. In 2020, this water supply system, or that of Krško, pumped water from the two pumping stations (Brege and Rore) in approximately equal shares. The annual average H-3 activity concentrations in precipitation are slightly higher for Brege and Krško than they are for Dobova or Ljubljana, which could also have an impact on the groundwater at this location.

The direct influence of liquid effluents can be detected in the monitoring boreholes in the vicinity of the Sava. In 2020 the liquid effluents were among the lowest of the last 20 years in terms of activity. The correlations between these boreholes close to the Sava and the discharges were probably not observed or were not as pronounced as in the previous two years, when the changed values at certain boreholes were linked to the changed hydrological regime on the Krško Polje/Brežiško Polje resulting from the filling of the Brežice HPP reservoir. With regard to the differences in the activity concentrations in the boreholes, 2020 was a quiet year, as the highest measured concentrations were practically of the same order of magnitude as the activity concentrations in the Sava river. Tritium activity concentrations in VOP-4 and the Medsave borehole were not correlated with each other and with discharges from NEK in 2020. In borehole V-7/77, which generally follows discharges from NEK, albeit with a greater delay than boreholes VOP-4 and Medsave, we observed only a relaxation and a fall in activity in 2020, following the larger discharges that took place in 2019 and evened out in the first half of 2020.

4.4.6.4 Measurements of radioactivity in the Sava

As part of the monitoring of radioactivity in the surrounding area, NEK also measures radioactivity in the Sava. The monitoring results are taken from the following reports: Monitoring of radioactivity in the vicinity of NEK, Report for 2019 /71/ and the Report for 2020 /87/. Sampling in the Sava took place as follows:

- continuous sampling at four locations (Krško – 3.2 km upstream, above the Brežice HPP dam – 7.2 km downstream, Brežice – 8.2 km downstream and Jesenice na Dolenjskem – 17.5 km downstream) for long-lived radionuclides and one-time samples of unfiltered water in Krško, on the left and right banks of the reservoir, in the replacement habitat, above the Brežice HPP dam, in Brežice, in Jesenice na Dolenjskem and in Podsused near Zagreb (Croatia, around 30 km downstream from NEK) for short-lived radionuclides;
- one-time quarterly samples are taken from the Sava in Krško and Brežice;
- sampling of sediments at ten locations (upstream of Krško, below the NEK dam, Pesje, on the left and right banks of the Brežice HPP reservoir, above the Brežice HPP dam, Brežice, Jesenice na Dolenjskem, downstream of Podsused (Croatia));
- samples of fish: Krško, reservoir, Brežice, Jesenice na Dolenjskem, Podsused (Croatia) and Otok (Croatia).

The sample measurements include the determination of the activity concentration of gamma emitters through high resolution gamma spectrometry, the determination of the activity concentration of tritium (H-3) by liquid scintillation counting, and the determination of the activity concentration of Sr-90/Sr-89 by radiochemical separation and counting using a proportional counter. Radiochemical analysis of Sr-89/Sr-90 is conducted on the same samples as the high resolution gamma spectrometry.

Results for 2019

Tritium (H-3) is regularly present in liquid effluents from NEK. The highest monthly liquid discharge of H-3 in 2019 was in August (5.6 TBq), which is comparable to the highest monthly discharges in 2016 and 2017. The total annual discharge of 13.6 TBq is comparable to the long-term average (the long-term average from 2002 to 2018 is 12.6 TBq), taking data scatter into account (dispersion is 6 TBq).

The results of monthly measurements from the sampling sites Brežice HPP and Brežice show good correlation and indicate slightly higher activity concentrations of H-3 above the dam. The correlation coefficient is 1. Correlation is also good between monthly discharges and monthly measured values at both sampling sites (the correlation coefficient is 0.7). Similarly good correlation was recorded in 2018: the correlation coefficient between measured values at both locations was 0.9, while the correlation coefficient between monthly discharges and measured values was also 0.9.

The highest value of monthly activity concentrations of H-3 in front of the Brežice HPP dam was (21.5 ± 0.8) kBq/m^3 in September. The activity concentration of H-3 in Brežice in this period was (18.6 ± 0.7) kBq/m^3. By way of comparison, the activity concentration of H-3 in Krško (upstream of NEK) was (0.88 Bq/m^3 ± 0.08) kBq/m^3. The highest measured activity concentration in Brežice is 21 times higher than at the reference sampling location in Krško in September, while the highest measured activity concentration of H-3 at Brežice HPP in September is 25 times higher than at the reference sampling location in Krško.

The average of monthly H-3 activity concentrations was 0.61 kBq/m^3 in Krško and 3.5 kBq/m^3 above the Brežice HPP dam. The average of monthly activity concentrations in Brežice was 3.2 kBq/m^3, which is comparable to the average monthly H-3 activity concentrations above the Brežice HPP dam, and lower than the long-term average of 4.1 kBq/m^3 in the last 16 years.

Measured concentrations below the dam (Brežice) are comparable to measurements in Jesenice na Dolenjskem (yearly average 3.2 kBq/m^3), which is different to the period before the reservoir was filled.

Before this, concentrations of tritium activity in Jesenice na Dolenjskem were usually lower as a result of the additional dilution of the Sava by the Krka and the Sotla (below 1 kBq/m^3) by a factor of 1.8, while in 2018 and 2019 the quotient is 1.1. The long-term average of monthly H-3 activity concentrations in Jesenice na Dolenjskem is 2.4 kBq/m^3.

Increased tritium activity concentration was detected in individual samples of unfiltered water in September and October at all locations above Brežice HPP. The highest monthly concentrations of individual samples were 1.7 kBq/m^3 (September) and 4.9 kBq/m^3 (October) on the left bank and 12 kBq/m^3 (September) and 2.2 kBq/m^3 (October) on the right bank of the reservoir. We detected the highest value on the right bank of the Brežice HPP reservoir, which correlates with findings from past years that the principal flow of the river favours the right bank below the reservoir.

The total annual C-14 activity discharge into the Sava was 0.09 GBq in 2019, which is more than in the past year. Discharges are one order of magnitude lower than the long-term average (1.9 GBq) from 2013. It should be emphasised that a scheduled maintenance outage took place at NEK in October. Higher discharges were therefore expected and, with them, a potential measurable environmental impact.

C-14 is a radionuclide that is present in the environment and is also produced in nuclear reactions. C-14 was measured in the water of the Sava and in fish in 2019. Individual quarterly samples were taken at the locations on the left and right banks of the Brežice HPP reservoir. The average quarterly C-14 activity concentration on the right and left banks of the reservoir were 89 pMC (10.1 Bq/m^3 of water) and 87 pMC (9.6 Bq/m^3), respectively. Measurements were taken of two samples of fish (bleak and carp) from the Brežice HPP reservoir. The measured relative specific activities of C-14 measured in the fish were up to 98 pMC (221 Bq/kg of carbon). All measured activities are lower than current atmospheric C-14 activities (103 pMC).

I-131 is used in medicine to treat thyroid conditions. It enters the environment through secretions from patients undergoing therapy of this type, and is consequently detected in rivers. In 2019, I-131 was present on a regular basis at all monitoring locations on the Sava, both upstream of the power plant and downstream in Brežice and Jesenice na Dolenjskem. The average I-131 activity concentration in individual samples ranged between 3.1 Bq/m^3 and 5.7 Bq/m^3. It was highest at the Brežice HPP sampling location. The highest individual value of 20 Bq/m^3 was measured on the right bank of the Brežice HPP reservoir in October. Only one liquid discharge of I-131 (195 kBq) was made from NEK in October. If we compare the results of measurements taken as part of operational monitoring of radioactivity in the vicinity of NEK with the results of measurements taken within the context of the monitoring of radioactivity in the living environment in Slovenia, the average activity concentrations of I-131 in the Sava at Brežice were similar to those measured in the Sava at Ljubljana (2.3 Bq/m^3), and are also comparable to the long-term average of 4.6 Bq/m^3 in Brežice.

In 2019 iodine was only detected in ground sediment in a single sample at the Brežice HPP (left bank, 1.3 Bq/kg).

No I-131 was detected in fish samples as part of the reference sampling (in Krško above the dam), nor in samples from the monitoring sampling locations below the NEK dam. This situation is the same as in previous years.

The annual liquid discharge of Cs-137 from the NEK into the Sava was 2.2 MBq, which is similar to the figure in past years.

The average of monthly activity concentrations in river water was 0.17 Bq/m^3 at the reference location in Krško, 0.28 Bq/m^3 in Brežice and 0.26 Bq/m^3 at Brežice HPP. The results of measurements of caesium in the water of the Sava were below the limit of detection at the majority of sampling locations. While in the past Cs-137 usually appeared in slightly higher concentrations in filter residue, as well as in dry residue from water, we are now reporting measurement results that are below the limit of detection.

The Cs-137 content in the Sava is attributed to global contamination, since the calculated increment in the activity concentration of Cs-137 in Brežice, taking into account annual liquid effluents, the average Sava flow rate and the dilution ratio on the left bank in Brežice, was 0.5 mBq/m^3. This contribution cannot be distinguished from the non-homogeneously distributed global contamination.

The measured activity concentration of Cs-137 in rivers throughout Slovenia varies by the location of sampling, with the highest (2.2 ± 0.2 Bq/m^3) being in the Drava. Cs-137 was not detected in the Soča or the Krka in 2019. The same applies to one sample from the Sava at Laze (Ljubljana), the Kolpa, and the Sava at Brežice. In another sample from the Sava at Laze (Ljubljana) and the Kolpa, it was below the limit of quantification. Average Cs-137 activity concentration in 2019 ranged from 0.02 Bq/m^3 in the Kolpa to 1.3 Bq/m^3 in the Drava. Average Cs-137 concentration in rivers was lower in 2019 than the average between 2008 and 2018 for each individual river (with the exception of the Drava).

The average specific activity of radioactive caesium in riverside sediments was 7.2 Bq/kg in Krško below the bridge, 7.0 Bq/kg below the NEK dam, 9.5 Bq/kg on the left bank of the Brežice HPP reservoir (Pesje), 4.0 Bq/kg in Brežice, 4.5 Bq/kg in Jesenice na Dolenjskem and 0.9 Bq/kg in Podsused. The specific activity of caesium in sediments shows the highest average of monthly activity concentrations on the left bank of the Brežice HPP (Pesje). It is evident from the results of measurements that specific Cs-137 activity has been increasing in recent years at the majority of locations, both at the reference location and in the reservoir. It has been established that the specific activity of caesium in sediment at all locations fell systematically until 2011. This has been linked to radionuclide decay (from global contamination) and simultaneously to leaching from ground sediment. Between 2011 and 2018, specific Cs-137 activity in ground sediment increased in Krško and Brežice. This may be attributed to interventions in the environment related to the construction of hydropower plants on the lower Sava in this period.

Average specific activities of Cs-137 in fish in four locations (Krško, in front of the Brežice HPP dam, Brežice and Jesenice na Dolenjskem) range from 0.03 Bq/kg to 0.05 Bq/kg and are below the limit of quantification in 11 out of 16 cases. The maximum value at the reference location in Krško (upstream of NEK) was 0.03 Bq/kg, compared to 0.05 Bq/kg in the Brežice HPP reservoir and 0.05 Bq/kg in Brežice, while in Jesenice na Dolenjskem the highest specific activity of Cs-137 in fish was less than 0.045 Bq/kg. Allowing for measurement uncertainty, specific Cs-137 activities in fish are the same at all sampling locations upstream and downstream of NEK.

Similarly to Cs-137, strontium Sr-90 is present in the environment as a result of global contamination, i.e. bomb tests in the 1960s and nuclear accidents, particularly the Chernobyl accident in 1986. Of course, it is also produced by nuclear reactions and is monitored in the areas around nuclear facilities. Radioactive strontium (Sr-90) is regularly measured in liquid effluents from NEK. Activity discharge into the Sava in 2019 was 0.08 MBq, which, allowing for measurement uncertainty, is the same as in previous years.

The activity concentration of Sr-90 in water is 1.0 Bq/m^3 at the Krško reference location, 1.7 Bq/m^3 in front of the Brežice HPP dam, 2.0 Bq/m^3 in Brežice and 2.0 Bq/m^3 in Jesenice na Dolenjskem. Activity concentrations of Sr-90 in individual water samples were the same as those shown by continuous sampling of filtered water, allowing for measurement uncertainty. The quarterly averages are from 1.3 Bq/m^3 to 2.4 Bq/m^3 in all locations. The maximum individual measured value was on the right bank above the Brežice HPP dam (5.8 Bq/m^3).

The average strontium activity concentrations in other rivers throughout Slovenia are similar to or higher than the values measured in the Sava in the vicinity of NEK. The average concentration measured in the Sava at the Laze pri Ljubljani location was 2.2 Bq/m^3, in the Mura 2.3 Bq/m^3 and in the Drava 1.5 Bq/m^3.

The specific activities of strontium in riverside sediments are typically lower than caesium specific activities. Average activities were typically below the lower limit of detection (0.7 Bq/kg) in Krško, 0.3 Bq/kg on the left bank of the Brežice HPP reservoir, 0.5 Bq/kg on the right bank of the Brežice HPP reservoir and 0.3 Bq/kg in Brežice and 0.4 Bq/kg in Jesenice na Dolenjskem. The average specific activity of Sr-90 in ground sediments in Podsused near Zagreb (Croatia) was 0.03 Bq/kg.

Strontium was also detected in all fish samples. The average specific activities of Sr-90 in fish were 0.07 Bq/kg in Krško and Jesenice na Dolenjskem and 0.09 Bq/kg in Brežice to 0.17 Bq/kg in front of the Brežice HPP dam. Taking data scatter into account, specific activities for all locations are equal or similar to those in past years.

Other fission and activation products (Co-58, Co-60, Ag-110m, Cs-134) normally appear regularly in liquid effluents from NEK. Their total activity in 2019 was at least six orders of magnitude lower than for tritium. None of the listed radionuclides has been detected in the environment in the last few years. Most recently, Co-60 was detected in 2003 and 2006 in water and in sediments.

The naturally occurring radionuclides of the uranium (U-238, Ra-226 and Pb-210) and thorium (Ra-228 and Th-228) decay series have been detected on a regular basis in all water samples. In unfiltered water, activity concentrations of U-238 (up to 19 Bq/m^3), Ra-226 (up to 32 Bq/m^3), Pb-210 (up to 58 Bq/m^3), Ra-228 (up to 11 Bq/m^3) and Th-228 (up to 8.7 Bq/m^3) were detected at all sampling locations. The cosmogenic radionuclide Be-7 was also measured regularly, and showed activity concentrations of between 4.6 Bq/m^3 and 420 Bq/m^3. The values were similar to those measured in other Slovenian rivers. Activity concentrations of K-40 range from 35 Bq/m^3 to 200 Bq/m^3. Significant fluctuations linked primarily to river pollution and, to a lesser extent, to the geological structure of soil are particularly characteristic of K-40. Specific activities of U-238 (up to 52 Bq/kg), of Ra-226 (up to 34 Bq/kg), of Ra-228 (up to 39 Bq/kg) and of Th-228 (up to 33 Bq/kg) were detected in sediments at all sampling locations. Specific activities of K-40 ranged from 17 Bq/kg (Jesenice na Dolenjskem) to 470 Bq/kg (Krško). Be-7 with an average of 51 Bq/kg to 62 Bq/kg was detected in sediment at all locations. Specific Pb-210 activities are typically higher and ranged from 24 Bq/kg to 93 Bq/kg.

Results for 2020

Tritium is regularly present in liquid effluents from NEK. An overview of the average monthly activity concentrations of H-3 in the Sava at the continuous sampling stations (filtered water) upstream and downstream of the NEK dam in 2020 is given in Figure 57.

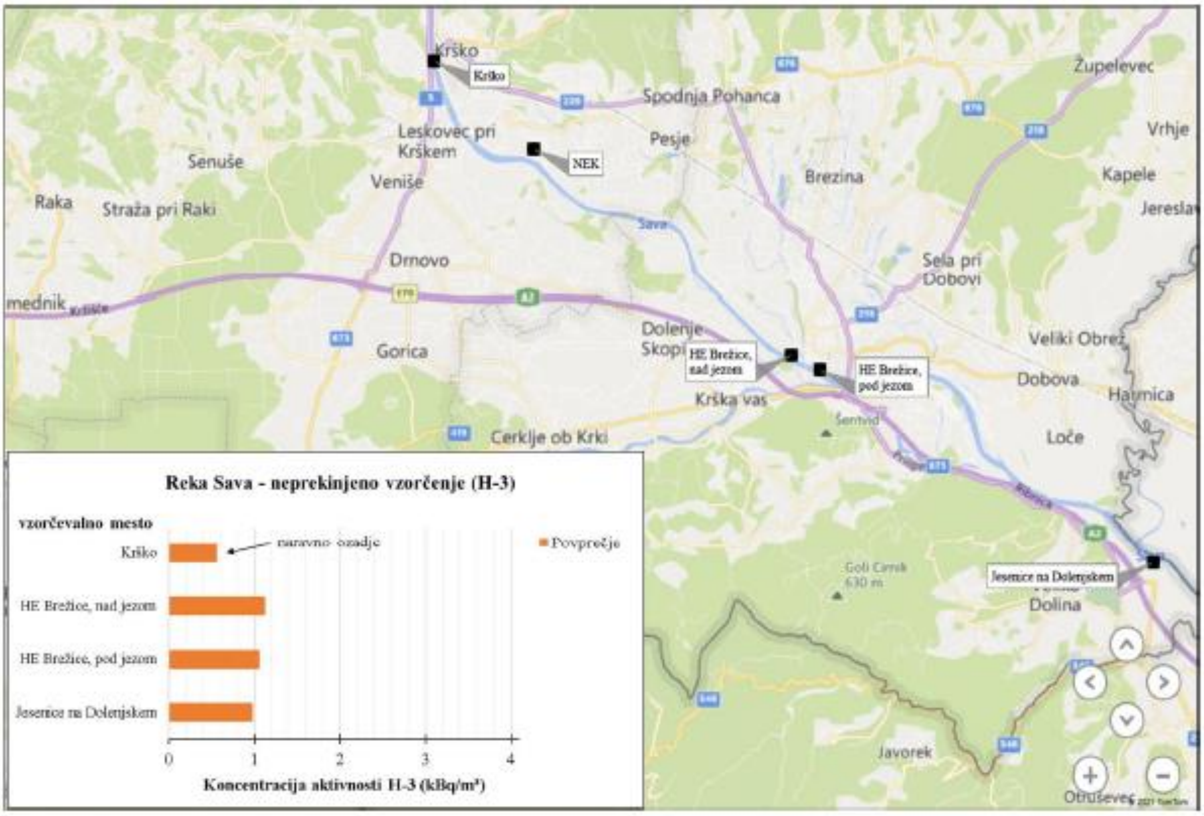


Figure 57: Overview of the average monthly activity concentrations of H-3 in the Sava at the continuous sampling stations upstream and downstream of the NEK dam in 2020[14] (source: /87/)

Reka Sava – neprekinjeno vzorčenje (H-3)	Sava river – continuous sampling (H-3)
vzorčevalno mesto	sampling point
HE Brežice, nad jezom	Brežice HPP, above the dam
HE Brežice, pod jezom	Brežice HPP, below the dam
naravno ozadje	natural background
Povprečje	Average
Koncentracija aktivnosti H-3 (kBq/m^3)	Activity concentration of H-3 (kBq/m^3)

After the Brežice HPP was constructed and installed, the course of the Sava changed and the timing of the H-3 concentrations at the sampling points in the HPP reservoir (left bank, right bank, in front of the HPP dam) no longer coincided with the timing of H-3 discharges from NEK. The situation was same in 2020. We have noticed that H-3 concentrations in the Sava as sampled on the left and right banks at the widest part of the reservoir are, with due regard to measurement uncertainty, comparable with each other. We can assume that the flow is slower but more pronounced along the right-hand side of the reservoir up to the reservoir's widest part, and then follows the principal flow of up to the Brežice HPP dam. This can also be concluded from bathymetric measurements of the depth of the river carried out above the Brežice HPP dam [25]. Figure 58 below shows the activity concentrations of H-3 at locations upstream and downstream of the NEK dam, where the individual samples (unfiltered water) were taken in 2020. As there were no outages in 2020, concentrations were lower than in years in which outages took place (see document footnote).

While it is not yet completely clear what effect the construction of Brežice HPP has on the spread of H-3 in the Sava, changes have certainly occurred. Figure 59 below shows the time progression of the increase in the activity concentration of H-3 in Brežice and at Brežice HPP, and provides a comparison with the calculated increase (model-based calculation).

[14] The long-term average (since 2002) of monthly H-3 activity concentrations in Brežice is 4.0 kBq/m^3. The average over several months (since 2017) of monthly H-3 activity concentrations at the sampling station in front of the Brežice HPP dam is 2.9 kBq/m^3. The concentrations of tritium activity in Jesenice na Dolenjskem are lower as a result of the additional dilution of the Sava by the Krka and the Sotla. The long-term average of monthly H-3 activity concentrations in Jesenice na Dolenjskem is 2.4 kBq/m^3.

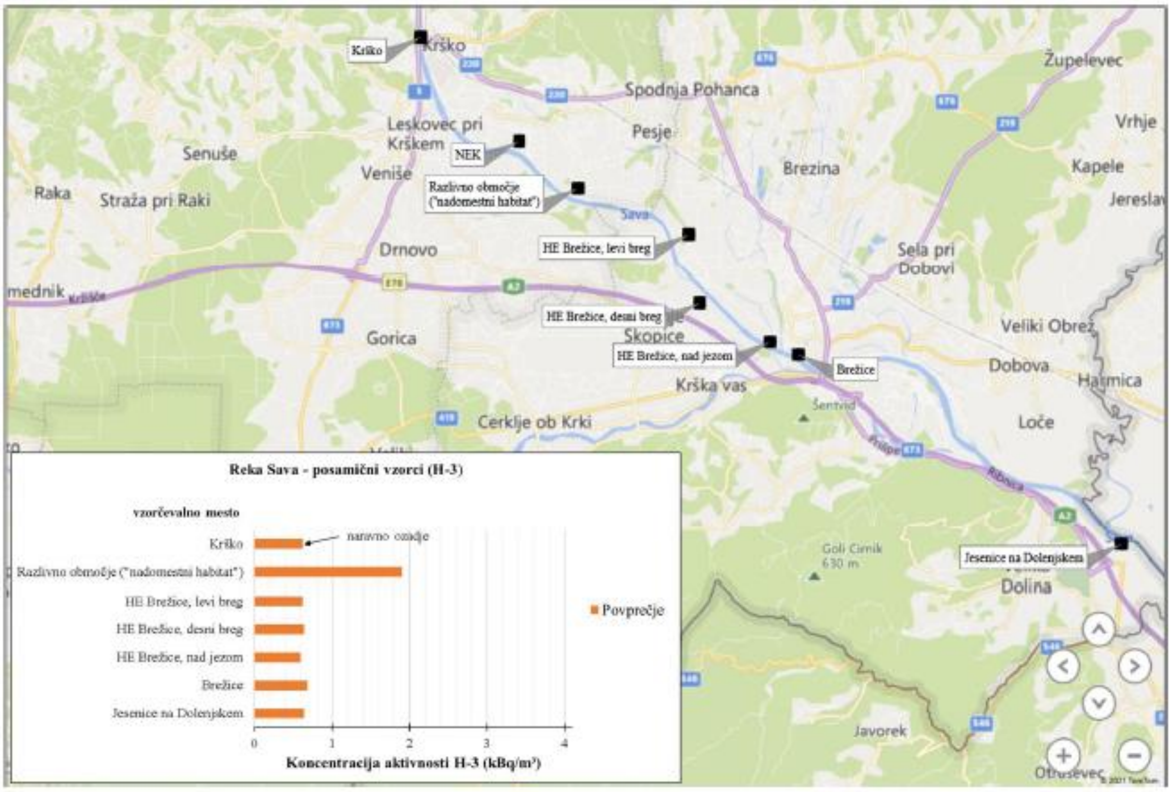


Figure 58: Overview of the average monthly activity concentrations of H-3 in the Sava at locations upstream and downstream of the NEK dam in which individual samples (monthly or quarterly) were taken in 2020 (source: /87/)

Reka Sava – posamični vzorci (H-3)	Sava river – individual samples (H-3)
vzorčevalno mesto	sampling point
Razlivno območje (»nadomestni habitat«)	Run-off area ("replacement habitat")
HE Brežice, levi breg	Brežice HPP, left bank
HE Brežice, desni breg	Brežice HPP, right bank
HE Brežice, nad jezom	Brežice HPP, above the dam
naravno ozadje	natural background
Povprečje	Average
Koncentracija aktivnosti H-3 (kBq/m^3)	H-3 activity concentration (kBq/m^3)

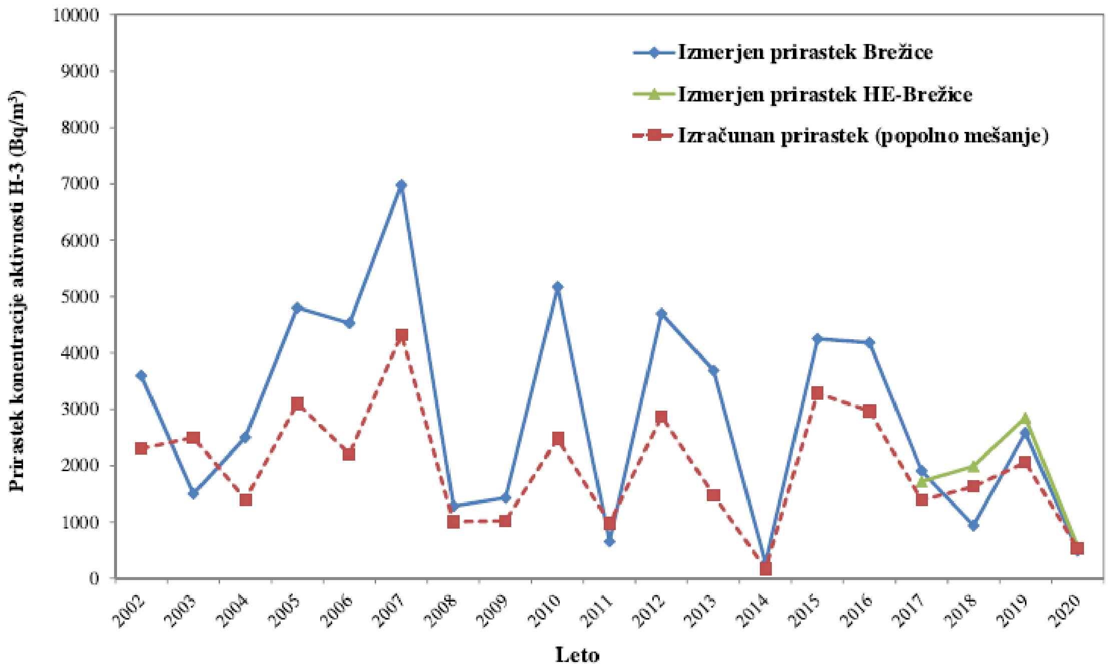


Figure 59: Comparison between annual average increases in H-3 concentrations in the Sava at and behind the Brežice HPP dam, and the calculated concentration of H-3 under the existing model of the spread of radionuclides in the Sava (one-dimensional model) obtained from annual liquid effluents and the Sava flow rate, under the assumption of complete mixing (source: /87/)

Prirastek koncentracije aktivnosti H-3 (Bq/m^3)	Increase in activity concentration of H-3 (Bq/m^3)
Izmerjen prirastek Brežice	Measured increase Brežice
Izmerjen prirastek HE Brežice	Measured increase Brežice HPP
Izračunan prirastek (popolno mešanje)	Calculated increase (complete mixing)
Leto	Year

The total annual C-14 activity discharge into the Sava was 0.3 GBq in 2020, which is one order of magnitude lower than the long-term average (1.9 GBq) since 2013. C-14 was also measured in the water of the Sava and in fish. Individual quarterly samples were taken at the locations on the left and right banks of the Brežice HPP reservoir. All measured specific activities are lower than current atmospheric activities (103 pMC or 226 Bq/kg C). The specific activities of C-14 in the Sava and in fish were, within the boundaries of uncertainty, the same in 2019 and 2020.

I-131 is regularly present at all monitoring locations on the Sava, both upstream of the power plant and downstream in Brežice and Jesenice na Dolenjskem. The average activity concentration of I-131 in samples of filtered water (continuous collection) ranged from 0.53 Bq/m^3 in front of the Brežice HPP dam to 1.8 Bq/m^3 in Jesenice na Dolenjskem. The highest single value of 6.5 Bq/m^3 was yielded by the June sample in Brežice (taken below the Brežice HPP dam). The highest activity concentration for I-131 was 8.3 Bq/m^3, detected in the first quarter in a single sample of unfiltered water from Brežice. The average quarterly activity concentrations ranged from 1.5 Bq/m^3 on the right bank of the reservoir to 4.0 Bq/m^3 in Brežice. The highest activity concentration was detected in the first quarter of 2020 at all sampling points. We can attribute the presence of I-131 in the Sava
to discharges from hospitals into the rivers that flow into the Sava upstream from the NEK dam (Ljubljanica, Savinja). I-131 was not detected in liquid effluents from NEK in that year. The monitoring of radioactivity in the living environment in Slovenia in 2020 shows that the average concentrations in the Sava at Brežice were similar to those measured in the Sava at Ljubljana (3.4 Bq/m^3) and were also comparable to the long-term average of 5.1 Bq/m^3 in Brežice.

Iodine was not detected in ground sediment in 2020. I-131 was not detected in fish samples from reference sampling (in Krško, above the dam), nor in samples from the monitoring sampling locations below the NEK dam, as in previous years.

The annual liquid discharge of Cs-137 from the NEK into the Sava was 0.9 MBq, which was less than in previous years (long-term average of 15.1 MBq). Cs-137 levels in the Sava is attributed to global contamination, since the calculated increment in the activity concentration of Cs-137 in Brežice, taking into account the annual liquid effluents, the average flow rate of the Sava and the dilution ratio on the left bank in Brežice, was 2 E-4 Bq/m^3. This contribution cannot be distinguished from the non-homogeneously distributed global contamination.

The average monthly activity concentrations of Cs-137 in river water (filtered) was 0.17 Bq/m^3 at the reference location in Krško and 0.41 Bq/m^3 at Brežice HPP. At Brežice it was below the limit of detection. The average concentrations of Cs-137 in individual samples of unfiltered water ranged from 0.33 Bq/m^3 in Krško to 0.52 Bq/m^3 on the left bank of the reservoir and 0.55 Bq/m^3 on the right bank of the reservoir. Cs-137 concentrations were below the limit of detection in front of the Brežice HPP dam, in Brežice and in Jesenice na Dolenjskem. Cs-137 concentrations in filter residues ranged from 0.12 Bq/m^3 to 0.43 Bq/m^3 in Brežice and to 1.0 Bq/m^3 in Jesenice na Dolenjskem. Cs-137 concentrations were below the limit of detection in all filter residues in Krško and in front of the Brežice HPP dam.

The measured activity concentration of Cs-137 in rivers throughout Slovenia varies by sampling location, with the highest (9.6 ± 0.8) Bq/m^3 being recorded in the Mura. Average Cs-137 activity concentration in 2020 ranged from 0.002 Bq/m^3 in the Kolpa to 5 Bq/m^3 in the Mura.

Radioactive strontium (Sr-90) is regularly measured in liquid effluents from NEK. In 2020, 0.04 MBq was discharged into the Sava, which is lower than previous years. Sr-90 levels in the Sava is attributed to global contamination, since the calculated increment in the activity concentration of Sr-90 in Brežice, taking into account the annual liquid discharges, the average flow rate of the Sava and the dilution ratio on the left bank in Brežice, was 1 E-5 Bq/m^3. This contribution cannot be distinguished from the non-homogeneously distributed global contamination.

Most of the strontium is dissolved in water, as its concentration in water is at least ten times higher than it is in filter residues. Generally speaking, strontium concentrations in water are ten times higher than they are for caesium. The average concentration of Sr-90 in filtered water was 1.7 Bq/m^3 at the Krško reference location, 1.8 Bq/m^3 in front of the Brežice HPP dam, 1.6 Bq/m^3 in Brežice and 2.1 Bq/m^3 in Jesenice na Dolenjskem. If the data is scattered, the values are comparable with each other. Similarly, data scattering also shows that the concentrations of Sr-90 in filtered water are comparable with the long-term concentrations at these locations. Sr-90 concentrations in individual unfiltered water samples were the same as those produced by the continuous sampling of filtered water (with allowances made for measurement uncertainty). The quarterly averages range between 1.5 Bq/m^3 and 2.5 Bq/m^3 at all locations. The maximum individual measured value was on the right bank above the Brežice HPP dam (3.0 Bq/m^3).

The average strontium concentrations in other rivers throughout Slovenia are similar to or higher than the values measured in the Sava in the vicinity of NEK. The average concentration measured in the Sava at the Laze pri Ljubljani location was 2.3 Bq/m^3, in the Mura 0.3 Bq/m^3 and in the Drava 1.6 Bq/m^3.

We attribute the presence of Cs-137 and Sr-90 in sediments to global contamination, as liquid effluents from NEK contribute a specific activity of 5 E-4 Bq/kg for Cs-137 and 2 E-5 Bq/kg for Sr-90 in riverside sediments in Brežice. The contributions are negligible in comparison with the average specific activities of 5.2 Bq/kg for Cs-137 and 0.56 Bq/kg for Sr-90 in riverside sediments in Brežice in 2020.

We attribute the measured specific activities of the Cs-137 and Sr-90 radionuclides in fish to global contamination, as the contributions of radionuclides from liquid effluents from NEK are between four and five orders of magnitude lower than the measured specific activities of both radionuclides in fish.

Other fission and activation products (Co-58, Co-60, Mn-54, Ag-110m, Cs-134, Sb-125) appear regularly in liquid effluents from NEK. The total activity of these radionuclides in 2020 was at least six orders of magnitude lower than for tritium. Tritium is an isotope with very low radiotoxicity; for example, if it is ingested or inhaled, it provides a dose that is 100 times lower than Cs-137 with the same activity. Cs-134 was last measured in liquid effluents in 2016. None of the listed radionuclides has been detected in the environment in the last few years. Co-60 was last detected in 2003 and 2006 in water and sediment, and Cs-134 was last detected in sediment in 2002.

The naturally occurring radionuclides of the uranium (U-238, Ra-226 and Pb-210) and thorium (Ra-228 and Th-228) decay series have been detected on a regular basis in all water samples. In unfiltered water at all sampling locations, activity concentrations were up to 8 Bq/m^3 for U-238, up to 6 Bq/m^3 for Ra-226, up to 39 Bq/m^3 for Pb-210 and up to 3 Bq/m^3 for Ra-228. The values were similar to those measured in other Slovenian rivers. Specific activities of U-238 (up to 53 Bq/kg), of Ra-226 (up to 55 Bq/kg), of Ra-228 (up to 62 Bq/kg) and of Th-228 (up to 3 Bq/kg) were detected in sediments at all sampling locations. The average specific activities of K-40 ranged from 220 Bq/kg (Jesenice na Dolenjskem) to 560 Bq/kg (Krško, below the NEK dam). Be-7 was detected in sediment at all locations, with values ranging from 9.3 Bq/kg to 110 Bq/kg. The specific activities of Pb-210 ranged from 32 Bq/kg to 90 Bq/kg.

4.4.6.5 Precipitation and dry depositions

Radioactivity in precipitation and dry sediment is monitored at the following locations:

- monthly composite samples from precipitation collection tanks in Brege and Krško, at the reference location in Dobova and in Ljubljana (control location, as part of the monitoring of radioactivity in the living environment in Slovenia);
- monthly replacement of petroleum jelly collection tanks of dry deposition at eight locations in the narrow and wider surrounding area of NEK and in Ljubljana (reference location).

Measurements using high-resolution gamma spectrometry were performed on samples of precipitation. The concentration of tritium (H-3) activity was ascertained using liquid scintillation spectrometry and the activity concentration of Sr-90/Sr-89 using radiochemical analysis. Radiochemical analysis of Sr-89/Sr-90 is conducted on the same samples as the high-resolution gamma spectrometry. Measurements using high resolution gamma spectrometry were carried out on petroleum jelly samples.

Results for 2020

In 2020 the annual quantity of precipitation was 1,263 mm in Ljubljana, 1,055 mm in Krško, 914 mm in Brege and at least 879 mm in Dobova. If the data is scattered, the quantities of precipitation by location are comparable with those of previous years. The spread of annual precipitation quantities is ±60 mm. The variation in precipitation levels is more pronounced when broken down by month. In January, there was very little precipitation, for which reason we were unable to obtain a representative sample. Markedly dry months occur practically every year and are not necessarily always the same months.

The concentration of tritium activity in precipitation varies significantly. Only activity concentrations above 2 kBq/m^3 could be attributed to discharges from NEK. Tritium activity concentration in precipitation was higher than 2 kBq/m^3 on four occasions in 2020: three times in Brege in the autumn and once in Krško in the spring. The average monthly concentrations of H-3 in precipitation are shown in Figure 60 below.

The impact of NEK on concentrations of tritium activity in precipitation in the immediate vicinity of the power plant is noticeable if we look at the annual averages, which are higher every year in Brege and Krško (Stara Vas) than they are in Dobova and Ljubljana. In the autumn (September to November), the activity concentrations of tritium in Brege were higher than the average value. This matches the atmospheric discharges, which were at their highest levels at that time of the year. There is a moderate correlation between atmospheric discharges and the measured activity concentrations of H-3, with the correlation coefficient being 0.58 in Krško, 0.63 in Brege and 0.24 in Dobova (weak correlation). We can therefore establish, for nearby locations, that the impact from H-3 discharges from NEK into the environment is moderate, and weak in the case of Dobova. The correlation coefficient is negative for Ljubljana (reference location).

The timing of the activity concentrations of H-3 in Dobova is similar to that seen at the reference location in Ljubljana. The monthly values are 40% higher than in Ljubljana. The activity concentrations of tritium roughly follow the natural annual fluctuation of tritium levels in the atmosphere in the northern hemisphere, where levels are generally higher in the summer than the winter.

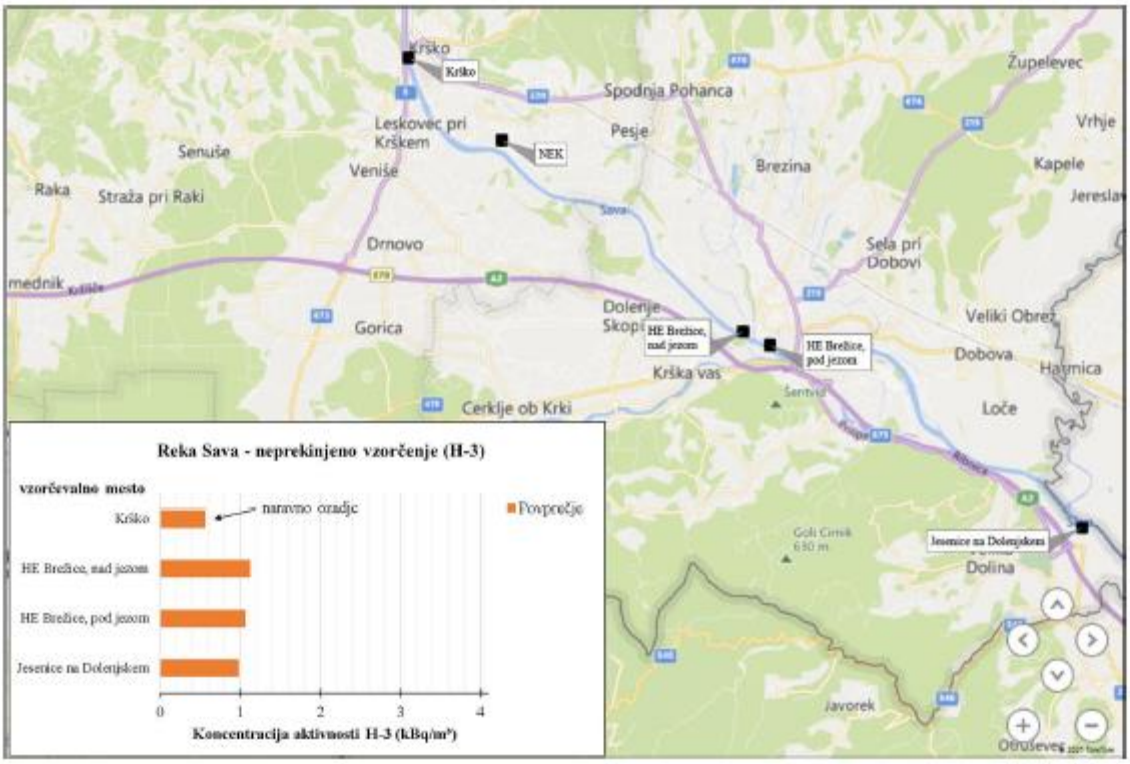


Figure 60: Average monthly activity concentrations of H-3 in precipitation in the vicinity of NEK and in Ljubljana (source: /87/)

Reka Sava – neprekinjeno vzorčenje (H-3)	Sava river – continuous sampling (H-3)
vzorčevalno mesto	sampling point
HE Brežice, nad jezom	Brežice HPP, above the dam
HE Brežice, pod jezom	Brežice HPP, below the dam
naravno ozadje	natural background
Povprečje	Average
Koncentracija aktivnosti H-3 (kBq/m^3)	Activity concentration of H-3 (kBq/m^3)

The highest monthly precipitation depositions of H-3 were measured in Brege (up to 0.35 Bq/m^2 in October). The values and time lines for Ljubljana and Dobova are comparable in terms of value scatter, with the peaks coinciding with the months of higher precipitation. The timelines for Krško and Brege are qualitatively similar, but differ slightly in comparison with Ljubljana and Dobova. The highest values come in the months with the most precipitation.

The highest Cs-137 activity concentration in precipitation for locations in the vicinity of NEK was measured in the April sample in Brege, i.e. (15 ± 1) Bq/m^3, while the highest Cs-137 activity concentration in precipitation in Ljubljana was recorded in January ((16 ± 20) Bq/m^3). As regards the activity concentration of Cs-137, the marked deviation from the average in Brege can be attributed to resuspension in the soil, while the size of the collected sample remains small in Ljubljana, which contributes to the high degree of uncertainty of the measurement result. Many of the measurement results have a high degree of uncertainty, meaning that the values are below the limit of quantification. Similarly, Cs-137 was not detected in more than half the months of the year (7–8 months).

The highest measured values of precipitation deposition for Cs-137 were: for Ljubljana, 0.22 Bq/m^2 in January; for Brege, 0.66 Bq/m^2 in April; for Krško, 0.041 Bq/m^2 in June; in Dobova, 0.1 Bq/m^2 in March.

All cases involved low or lower quantities of precipitation, except in Krško, when moderate quantities of precipitation fell.
In these cases, we attribute the increase to the resuspension of particulates in the soil. In the winter months, the burning of solid fuels is an additional factor.

At all locations, deposition is comparable with the values of the pre-Chernobyl period (1982–1985).

4.4.6.6 External radiation exposure

External radiation

- the external radiation dose (gamma radiation and ionising component of cosmic radiation) is measured using 57 TL-dosimeters in the vicinity of NEK (positioned in a circle around NEK at distances of up to 10 km) and nine TL-dosimeters on the NEK perimeter. The dosimeters are read at half-yearly intervals, and the reference dosimeter for all measurements of the external radiation dose is located in Ljubljana. A further ten TL-dosimeters have been installed in Croatia;
- measurements are also taken using TL-dosimeters installed at 50 locations around the country;
- a total of 14 MFM-203 continuous radiation monitoring devices have been installed in the vicinity of NEK; they function as part of the early warning system, and include 13 monitoring devices from the NEK network and one device operated by the Slovenian Nuclear Safety Administration. An additional 60 continuous monitoring devices have been incorporated into the early warning system in Slovenia.

All TL-dosimeters in Slovenia are read on the IJS MR 200 (C) system, while the dosimeters in Croatia are read on the system used by the Ruđer Bošković Institute in Zagreb. Data from the continuous monitoring devices is collected and provided by the URSJV.

Soil

- soil samples are collected at three locations of uncultivated land downstream from NEK in flood zones (Amerika – 3.5 km from NEK, Gmajnice – 2.5 km from NEK and Kusova Vrbina-Trnje – 8.5 km from NEK). The sampling takes place twice a year, separately at depths of up to 30 cm.

Gamma emitter measurements are performed using high-resolution gamma spectrometry, while the specific activity of Sr-90/Sr-89 is determined by means of radiochemical analysis. Radiochemical analysis of Sr-89/Sr-90 is conducted on the same samples as high-resolution gamma spectrometry.

2020 results – external radiation

The external radiation to which the population in the vicinity of NEK is exposed includes cosmic radiation, radiation from naturally occurring radionuclides (particularly radon decay products) in the atmosphere, radiation from the radioactive cloud produced by the discharge into the environment of radioactive material from NEK, external radiation from the deposits left after the cloud has passed, and external radiation from naturally occurring and artificial radionuclides in the soil. As environmental TLDs do not measure the dose from the neutron component of cosmic radiation, the authors of the report /87/ have calculated it using the EXPACS programme. This programme enables a calculation to be produced of the dose deriving from individual components of cosmic radiation, including the neutron component for any longitude and latitude. The TLD network therefore measures the total gamma radiation dose from naturally occurring radionuclides in the environment, the ionising components of cosmic radiation, and the contribution made by global Cs-137 contamination.

Figure 61 below shows the average annual environmental dose equivalent H*(10) in the vicinity of NEK, at the NEK perimeter and in Slovenia as a whole from the time measurements began to 2020. For 2020 we also present a comparison between the average environmental dose equivalents H*(10) measured in the vicinity of NEK and at the reference location in Ljubljana, the average equivalents measured in Croatia as part of the programme for the monitoring of radioactivity in the vicinity of NEK, and the average equivalents measured as part of radioactivity measurements in the living environment in Slovenia. When the data is scattered, the measured annual environmental dose equivalents do not deviate from the multi-year average at individual locations. The lowest annual H*(10) is at the NEK perimeter, where the ground is gravelly and the soil layer has been removed. External radiation from the ground is further weakened by the asphalt surfaces and the structures within the NEK perimeter.

Measurements in Slovenia show that the average annual environmental dose equivalent in the vicinity of NEK is systematically lower than in the living environment in Slovenia. We attribute this to the diversity of the Slovenian landscape, the orography, the composition of the soil, the thickness of snow cover, and the uneven deposition of Cs-137 following the Chernobyl nuclear reactor disaster, which has an impact on the external radiation dose. There is also a certain degree of landscape diversity in the areas close to NEK, while local specificities in the siting of dosimeters in the environment (meadow, field, forest, asphalt surfaces, proximity of buildings, ground temperature, etc.) contribute to the fluctuation in the effective doses measured using TLDs in nearby locations.

A significant decline in the annual dose equivalent is characteristic in all instances of measurements of external radiation in Slovenia, particularly in the first few years after the Chernobyl accident (1986). This trend is also continuing in 2020. The reason for this lies in the decay of deposited short-lived gamma emitters, which in the initial period contributed most to external radiation, and the penetration of Cs-137 into the soil. The annual environmental dose equivalent from global Cs-137 contamination at locations in the vicinity of NEK, estimated under the assumption of the realistic depth distribution of Cs-137, are in the range of between 0.003 mSv and 0.033 mSv. This is comparable with the values at those locations where the soil is sampled as part of the monitoring of radioactivity in Slovenia. There the estimated annual doses H*(10) range between 0.015 mSv and 0.052 mSv.

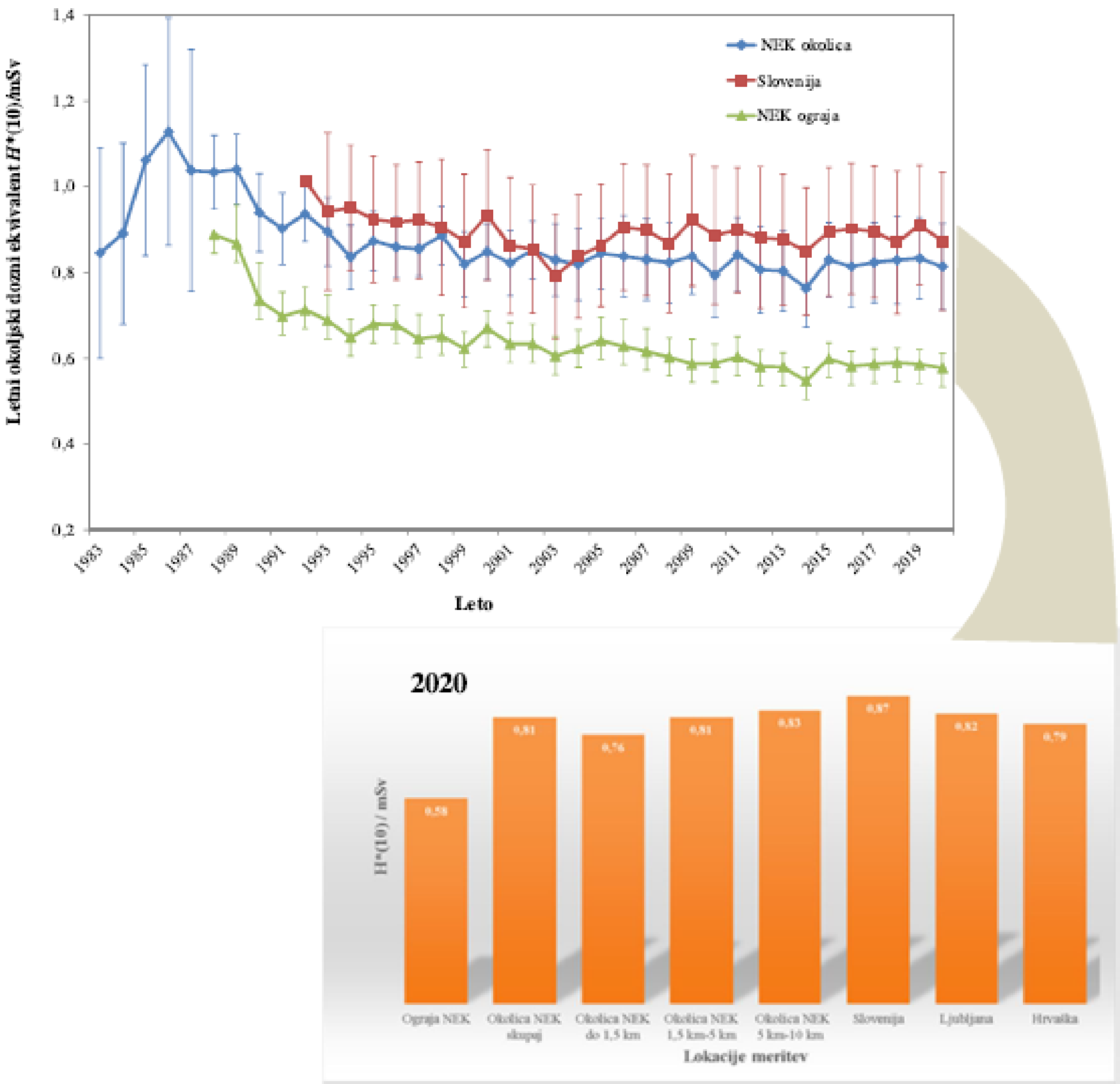


Figure 61: Average annual environmental dose equivalent H(10) in the vicinity of NEK, at the NEK perimeter and in Slovenia from the start of measurements to 2020[15] (source: /87/)*

Letni okoljski dozni ekvivalent H*(10)/mSv	Annual environmental dose equivalent H*(10)/mSv
NEK okolica	Vicinity of NEK
Slovenija	Slovenia
NEK ograja	NEK perimeter
Leto	Year
H*(10)/mSv	H*(10)/mSv
Ograja NEK	NEK perimeter
Okolica NEK skupaj	Total for vicinity of NEK
Okolica NEK do 1,5 km	NEK surroundings up to 1.5 km
Okolica NEK 1,5 km-5 km	NEK surroundings 1.5–5 km
Okolica NEK 5 km-10 km	NEK surroundings 5–10 km
Slovenija	Slovenia
Ljubljana	Ljubljana
Hrvaška	Croatia
Lokacije meritev	Measurement locations

2020 results – soil

Soil sampling is carried out on flood zones, where deposition from the air and flooding are pathways for discharges from NEK.

In 2020, the specific activity of Cs-137 in the soil ranged from 2.5 Bq/kg at a depth of 5–10 cm at the Amerika location to 63 Bq/kg at a depth of 5–10 cm at Gmajnice. The measurement results indicate that there was quite a significant scattering of specific activity of Cs-137 at micro-locations in individual years. We can attribute the fluctuation in values to the non-homogeneity of the fresh deposition following the Chernobyl accident, and the redistribution of the deposition at the micro-location. Redistribution is the consequence of hydrogeological processes that affect the penetration of Cs-137 into the soil. This finding can be further supported by the established shift of the centre of gravity of the deposition into depth at the Kusova Vrbina location. The two pronounced rises in the depth of the centre of gravity are definitely a result of floods that caused an additional deposit of fresh fine sand. This is also the reason why the penetration of Cs-137 into the soil appears to be quicker than at the other two locations. If data since 1992 is taken into account, the starting depth of the centre of gravity of the deposition at the Kusova Vrbina location is correspondingly higher. We also find that only a ten-year moving average evens out the local non-homogeneity of the deposition and the impact of hydrogeological processes in the upper layers. Figure 62 and Figure 63 below show the depositions of Cs-137 and Sr-90 by depth for locations close to NEK. Depositions in the rest of Slovenia are provided for comparison. We can see that depositions in the vicinity of NEK are lower than they are in the rest of Slovenia.

[15] For 2020 a comparison is presented between the average environmental dose equivalents H*(10) measured in the vicinity of NEK and at the reference location in Ljubljana, the average equivalents measured in Croatia as part of the programme for the monitoring of radioactivity in the vicinity of NEK, and the average equivalents measured as part of radioactivity measurements in the living environment in Slovenia.

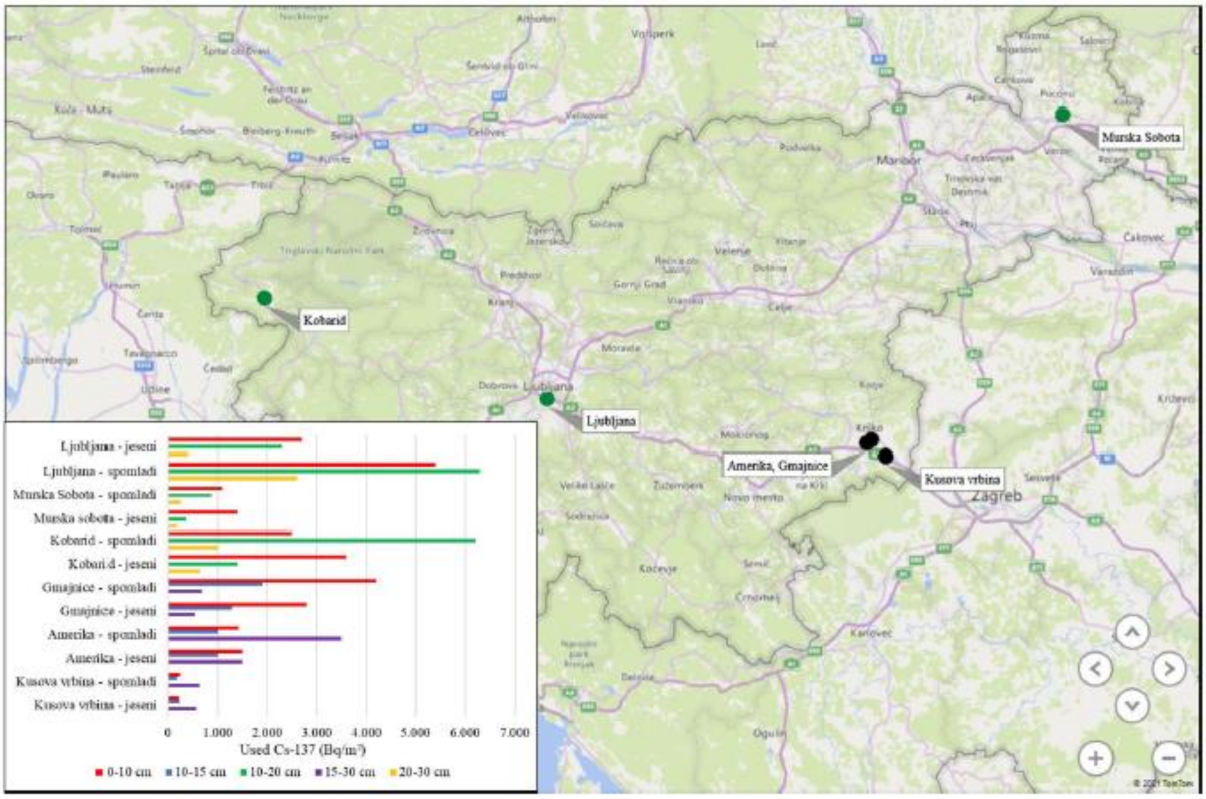


Figure 62: Cs-137 depositions in Slovenia (source: /87/)

Ljubljana – jeseni	Ljubljana – autumn
Ljubljana – spomladi	Ljubljana – spring
Murska Sobota – spomladi	Murska Sobota – spring
Murska Sobota – jeseni	Murska Sobota – autumn
Kobarid – spomladi	Kobarid – spring
Kobarid – jeseni	Kobarid – autumn
Gmajnice – spomladi	Gmajnice – spring
Gmajnice – jeseni	Gmajnice – autumn
Amerika – spomladi	Amerika – spring
Amerika – jeseni	Amerika – autumn
Kosova vrbina – spomladi	Kosova Vrbina – spring
Kosova vrbina – jeseni	Kosova Vrbina – autumn
Used Cs-137 (Bq/m^3)	Cs-137 deposition (Bq/m^3)

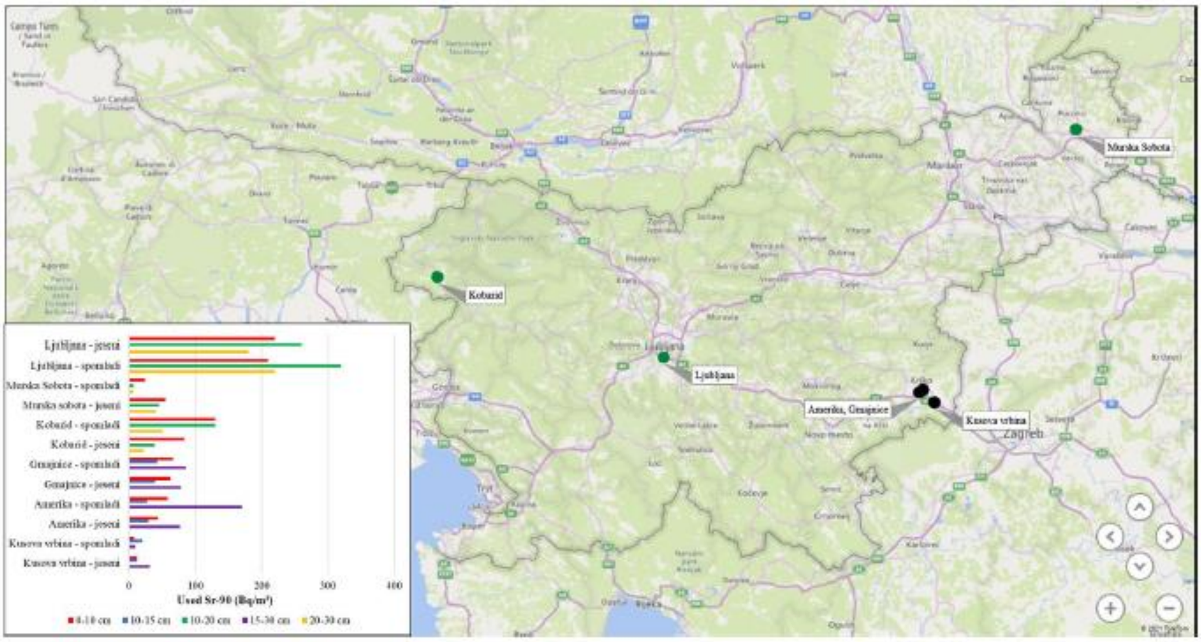


Figure 63: Sr-90 depositions in Slovenia (source: /87/)

Ljubljana – jeseni	Ljubljana – autumn
Ljubljana – spomladi	Ljubljana – spring
Murska Sobota – spomladi	Murska Sobota – spring
Murska Sobota – jeseni	Murska Sobota – autumn
Kobarid – spomladi	Kobarid – spring
Kobarid – jeseni	Kobarid – autumn
Gmajnice – spomladi	Gmajnice – spring
Gmajnice – jeseni	Gmajnice – autumn
Amerika – spomladi	Amerika – spring
Amerika – jeseni	Amerika – autumn
Kosova vrbina – spomladi	Kosova Vrbina – spring
Kosova vrbina – jeseni	Kosova Vrbina – autumn
Used Sr-90 (Bq/m^3)	Sr-90 deposition (Bq/m^3)

4.4.6.7 Food

- The sampling locations for food in 2020, marked on the map enclosed at the end of the report, were: an orchard adjacent to NEK (fruit), Pesje (milk, vegetables), Brege (meat, milk, vegetables), Vihre (vegetables), Vrbina (eggs, fruit), Spodnji Stari Grad (meat, eggs, vegetables), Žadovinek (vegetables, cereals), Trnje (vegetables), Leskovec (meat, fruit) and Dolenje Skopice (milk, vegetables). Thirty-two types of food were sampled in the vicinity of NEK in 2020.
- Vegetables, cereals and fruit were sampled between June and October, and meat and eggs in January, March and July. Milk was sampled on a monthly basis.
- Measurements of C-14 levels in plant samples were taken in July and September 2020 in the vicinity of NEK (outer circle) and at the control point in Dobova. The specific activity of C-14 was measured in corn and wheat.

The specific activity of gamma emitters was measured using high-resolution gamma spectrometry, while the specific activity of Sr-90/Sr-89 was measured by means of radiochemical analysis. Radiochemical analysis of Sr-89/Sr-90 is conducted on the same samples as high-resolution gamma spectrometry.

Results 2020

We did not detect any radionuclides in food, either in atmospheric or liquid effluents from NEK. The exceptions were C-14, Cs-137 and Sr-90, which were primarily of cosmogenic origin or the result of global contamination. C-14 enters plants during the process of photosynthesis, and mainly enters animals and human beings via the consumption of plant-based food. The specific activity of C-14 was measured in corn and wheat in the vicinity of NEK in July and September 2020. There are no statistically significant differences between the average levels of C-14 in food and plants measured in July and September at the same locations. The highest specific activity of C-14 ((242 ± 3) Bq per kg of carbon) was measured in corn in July at Location M (Žadovinek).

The calculated specific activities of radionuclides that have entered the environment through atmospheric discharges from NEK are at least five orders of magnitude lower than the specific activities measured in food. This means that the presence of Cs-137 and Sr-90 in food can be attributed to global contamination. The specific activities of radionuclides in food in the vicinity of NEK and around Slovenia vary greatly, which is the result of the uneven distribution of global contamination, orography, soil composition and other geographical features. Within the boundaries of uncertainty for averages by nutrient group, the specific activities of Cs-137 and Sr-90 are comparable for the groups sampled in the vicinity of NEK and in the rest of Slovenia.

K-40 is the most prominent naturally occurring radionuclide in food. It enters food through various pathways from the soil, artificial fertilisers and the atmosphere. Radionuclides from the U-238 and Th-232 decay series are also present. In 2020, the specific activity of K-40 in food cultivated on the Krško Polje/Brežiško Polje ranged from 27 Bq/kg for cucumbers to 399 Bq/kg for beans. Elsewhere in Slovenia, specific activity ranged from 32 Bq/kg in pears to 176 Bq/kg in milk. Leafy and fruiting vegetables comprise the group with a greater specific activity of K-40 in the vicinity of NEK, while milk and fruit are among the foodstuffs with lower activity.

4.4.7 Estimate of the effects of ionising radiation

The estimate of the effect of ionising radiation on the existing situation is taken from the "Monitoring of radioactivity in the vicinity of NEK, Report for 2020" document /87/.

4.4.7.1 <u>Liquid effluents in 2020</u>

When NEK is in operation, environmental concentrations of discharged radionuclide activity (with the exception of H-3) are significantly below the limits of detection, or else it is difficult to separate any contribution made by these radionuclides from the background (C-14, Cs-137). We therefore evaluate their impact on human beings and the environment indirectly from data on discharges into the atmosphere and liquid effluents. Public exposure is assessed using models that describe the spread of radionuclides via various pathways in the environment.

The construction of the Brežice hydroelectric power plant and creation of the reservoir led to changes in the methods and pathways of public exposure. The current estimate of the effects of discharged radionuclides, as set out below, is based on old assumptions and does not take into account all the hydraulic parameters and the configuration of the Sava channel, such as mixing at the dam, the uncertainty of flows, and the swelling of the Sava downstream into the groundwater (before the construction of the Brežice HPP reservoir).

The model calculation, which is based on liquid effluents and data on the annual flow of the Sava, and takes into account the characteristics of the reference group (i.e. fishermen who fish in the reservoir up to 350 m downstream from the NEK dam, spend considerable amounts of time on the bank and consume fish from the river), has shown that the effective dose for an adult from discharges into the Sava was 0.006 µSv per year (time spent on the bank and the consumption of fish) in Brežice in 2020. The calculated annual effective dose for an adult 350 m from the NEK dam is 0.014 µSv. If the average habits of the reference person were taken into account, the effective dose received would be several times lower. H-3 accounts for the biggest single share of the total effective dose (44%), with the predominant pathway being the consumption of fish. Spending time on the bank accounts for most of the total dose load from discharges of Co-60 and Co-58. H-3 would contribute the most to the dose load from the consumption of Sava water (100%), which is an unlikely pathway into the human body.

The highest estimated annual effective dose in the vicinity of NEK in 2020 resulting from the drinking of water from the water supply system was

calculated, on the Krško/Brežice Polje, for the Brege pumping station (4.5 µSv for an adult reference person, 6.4 µSv
for children and 26.9 µSv for infants). Practically all the load derives from naturally occurring radionuclides. Artificial radionuclides contribute a maximum of 1.2% to the load, primarily as a result of global contamination rather than NEK operations. This percentage is even smaller for children and infants. In comparison with the other two pumping stations and with the Ljubljana water supply system, the impact of naturally occurring radionuclides is highest for Brege. There is a direct link at this pumping station between the surface and the groundwater in the case of the use of chemical agents in agriculture, as the measurements contained in the "Report on the quality of drinking water in the public water supply system, and on the discharge and treatment of wastewater in the municipalities of Krško and Kostanjevica na Krki in 2019" also show /280/. The higher concentration of naturally occurring radionuclides (potassium K-40) in water, which is around three times higher for Brege than for Rore, is also evidence of this.

The estimated annual effective doses from artificial radionuclides in drinking water in the Brežice and Krško water supply system are far below the authorised dose limit (50 µSv), while the activity concentrations are below the derived activity concentration limits calculated by taking into account the fact that the value of the effective dose limit is 100 µSv per year.

4.4.7.2 Atmospheric discharges 2020

Effective dose from emissions monitoring
When calculating doses, several conservative assumptions were made with regard to weather conditions (least favourable annual dilution factor per wind direction), level of discharge (ground discharge) and the permanent presence of an imaginary person at a distance of 500 m. The purpose of this calculation is to make a comparison with the administrative dose limit in the immediate vicinity of the power plant, not to ascertain the actual irradiation of the population, which is (understandably) significantly lower.

Given that the emission of the more typical fission products is negligible, the contributions of H-3 and C-14 (as C_xH_y) were more significant in relative terms, accounting for 93% of the total dose.

The contribution made by discharged noble gases was 7% of the total dose, while other radionuclides were less important.

The dose is calculated for radiation from the cloud of noble gases and for internal irradiation resulting from the inhalation of other radionuclides.

The effective dose is calculated by using the Lagrange model of annual dispersion for ground discharge, and amounts to 0.45 µSv at a distance of 500 m from the reactor shaft. The contributions of individual isotopes to the dose received from atmospheric emissions are shown in Figure 64.

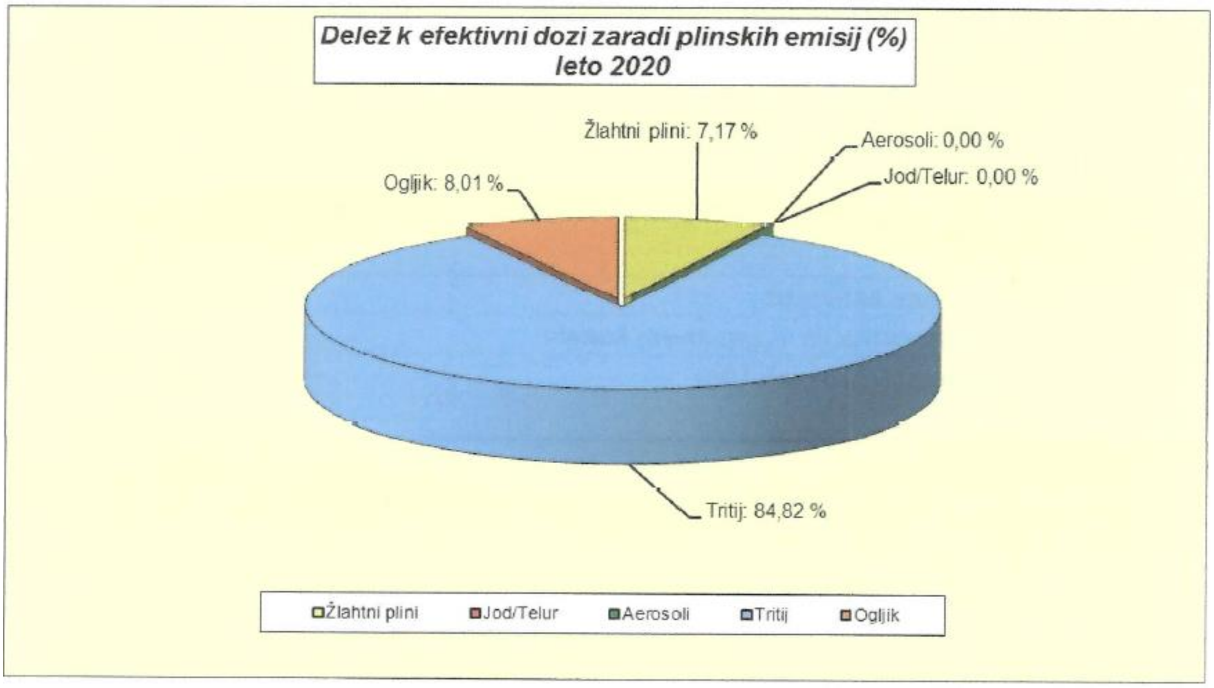


Figure 64: Calculated contribution of individual elements within gaseous emissions to the dose at a distance of 500 m from the reactor (source: /88/)

Delež k efektivni dozi zaradi plinskih emisij (%) Leto 2020	***Contribution of gaseous emissions to effective dose (%) 2020***
Žlahtni plini: 7,17 %	Noble gases: 7.17%
Aerosoli: 0,00 %	Aerosols: 0%
Jod/Telur: 0,00 %	Iodine/Tellurium: 0%
Tritij: 84,82 %	Tritium: 84.82%
Ogljik: 8,01 %	Carbon: 8.01%
Žlahtni plini	Noble gases
Jod/Telur	Iodine/Tellurium
Aerosoli	Aerosols
Tritij	Tritium
Ogljik	Carbon

Effective dose from emissions monitoring

The following groups of radionuclides are considered when the impact of atmospheric discharges is being evaluated:

- noble gases that are exclusively significant with regard to external exposure during cloud passage;
- pure beta emitters, such as H-3 and C-14, that are biologically significant only in the case of entry into the organism via inhalation (H-3, C-14) and ingestion (C-14);
- beta/gamma emitters in aerosols (isotopes of Co, Cs, Sr, etc.) via pathways: inhalation, external radiation from deposition, ingestion of radionuclides deposited on plants;
- isotopes of iodine in various physical and chemical forms, significant in the case of inhalation during cloud passage and as a result of intake into the body with milk.

The two tables below provide an evaluation of atmospheric emissions using a model calculation of the dilution coefficients in the atmosphere for 2020 and for individual groups of radionuclides by most important pathway for adult inhabitants of Spodnji Stari Grad, which is the nearest settlement to the exclusion zone (Table 88), and at the NEK perimeter. The estimates also apply in approximate terms at a distance of 500 m from the reactor shaft (Table 89). There is a limit applying to additional public exposure at the edge of the exclusion zone (500 m from the reactor shaft). Furthermore, the total annual effective dose of the contributions from all pathways may not exceed 50 µSv per individual. It is evident from the tables that contributions to the annual effective dose for an adult inhabitant are 0.0079 µSv at the NEK perimeter and 0.0066 µSv in Spodnji Stari Grad.

The dilution factors for external radiation from cloud and inhalation have been assessed using the Lagrange model since 2007. This model includes the characteristics of the terrain in the vicinity of NEK and a larger set of meteorological variables. The model uses all the measured data in the EIS ecological information system managed by NEK. For emissions, this is the flow of gases from the main NEK exhaust. The model also requires the speed of the discharged gases and the cross-section of the exhaust stack. After consulting NEK, a temperature of 25°C was determined as the temperature of the flue gases. The contribution made by radiation from deposition was, until 2010, further estimated using the Gaussian model, with consideration given to ground discharge. The atmospheric immersion estimate in 2020 is comparable to that of previous years in terms of data scatter.

Table 88: Public exposure to radiation (adults) in Spodnji Stari Grad resulting from atmospheric discharges from NEK in 2020 (source:/87/)

Method of exposure	**Pathway**	**Most significant radionuclides**	**Annual dose (mSv)**
external radiation	inversion (cloud) radiation from deposition	noble gases (Ar-41, isotopes of Xe) aerosols (isotopes of I and Co, Cs-137)	3.6 E–7 7.2 E–16
inhalation	cloud	H-3, C-14, I-131, I-132, I-133	6.3 E–6
ingestion	plant-based food	C-14	0[16]

Table 89: Public exposure to radiation (adults) at the NEK perimeter resulting from atmospheric discharges from NEK in 2020 (source:/87/)

Method of exposure	**Pathway**	**Most significant radionuclides**	**Annual dose (mSv)**
external radiation	inversion (cloud) radiation from deposition	noble gases (Ar-41, isotopes of Xe) aerosols (isotopes of I and Co, Cs-137)	5.6 E–7 4.7 E–15
inhalation	cloud	H-3, C-14, I-131, I-132, I-133	7.3 E–6
ingestion	plant-based food	C-14	5.0 E–5

C-14 measurements were conducted on samples of wheat and corn at Institut Jožef Stefan in 2020. The measurement results show the expected slight increase in the specific activity of C-14 in samples at a distance of up to 1 km from the reactor shaft relative to the samples taken at the reference point in Dobova. The estimated annual effective dose from the ingestion of C-14 is therefore 5 E-5 mSv higher in the vicinity of NEK (up to 1 km from the plant) than at the control point in Dobova. When calculating the C-14 dose received in the vicinity of NEK, we made the conservative assumption that local residents consumed food from the immediate vicinity of the plant (close to the edge of the exclusion zone) two months a year and food from elsewhere (Dobova) for the other ten months. It follows that, in the case of the calculation of the C-14 dose as well, we take into account the fact that residents consume food produced in the Krško-Brežice area (from the NEK perimeter to Dobova).

The difference between the calculation of the C-14 dose and the dose received from the entry of other radionuclides into food lies in the fact that a weighted average of the specific activity of C-14 is taken into account with respect to the sampling location. This is not possible for other radionuclides because of the different sampling methods involved. The C-14 dose relates to food and not to a specific type of food, as the specific activity of C-14 (in Bq per kg of carbon) does not differ according to type of food. The ratio between the C-14 and C-12 isotopes is constant in all organisms and reflects the ratio between the two isotopes in the atmosphere. In the case of artificial C-14 discharges, the ratio between the C-

[16] The result is lower than the measurement uncertainty.

14 and C-12 isotopes may change in the atmosphere as well as in organisms, as C-14 isotopes replace C-12 isotopes in organic molecules.

4.4.7.3 Natural radiation 2020

Measurements of external radiation in the vicinity of NEK in 2020 confirmed previous findings, i.e. that it is a typical natural environment such as is also found elsewhere in Slovenia and around the world. The annual dose equivalent H*(10) of gamma radiation and the ionising component of cosmic radiation in the vicinity of NEK was, on average, 0.90 mSv outdoors. This is higher than the estimated annual effective dose for indoor premises of 0.83 mSv (1998).
To this it is necessary to add the contribution of H*(10) neutron cosmic radiation, which is 0.07 mSv per year for the NEK area. The total effective dose of natural external radiation H*(10) in 2020 in the vicinity of NEK was therefore 0.97 mSv per year. The relevant annual effective dose (taking into account the conversion factors from the Radiation Protection 106 publication) is 0.81 mSv per year, which is lower than the global average of 0.87 mSv per year.

As the specific activity of naturally occurring radionuclides in food is comparable with average values around the world, we therefore take the conclusions from UNSCEAR for the effective dose from food intake.[17]

Individual contributions to the natural radiation dose are shown in Table C of the original document. The total annual effective dose is estimated at 2.39 mSv, which is comparable with previous years in terms of value scatter, as well as with the global average of 2.4 mSv per year.

Table 90: Effective dose E from natural sources of radiation in the vicinity of NEK in 2020 (source:/87/)

Source	Annual effective dose E (mSv)
gamma radiation and directly ionising cosmic radiation cosmic neutrons[18]	0.76 0.06
ingestion (K, U, Th) ([55], effective dose)	0.27
inhalation (short-lived progeny of Rn-222, effective dose)[19]	1.3
total	**2.39**

4.4.7.4 Naturally occurring radionuclides in 2020

The measured activity of naturally occurring radionuclides (uranium and thorium chain, K-40, Be-7) does not differ markedly from the values measured at other locations in Slovenia or the values set out in the literature. This applies to the Sava, groundwater, water supply system and sediment, as well as to air and food. It is also the case that the values are comparable with those of previous years.

4.4.7.5 Chernobyl contamination, nuclear test explosions and the Fukushima accident (2020)

In 2020, as in previous years, the anthropogenic radionuclides Cs-137 and Sr-90, which originate from the Chernobyl disaster and from nuclear test explosions, are still measurable in the soil. There was no detectable impact in 2020 from the radionuclides discharged into the atmosphere after the accident at the Fukushima nuclear plant in Japan in 2011.

[17] UNITED NATIONS, Sources and effects of Ionizing Radiation, Report to the General Assembly with Scientific Annexes, United Nations Scientific Committee on the Effects of Atomic Radiation, (UNSCEAR), YN, New York, 2000
[18] Estimate of the effective dose of external radiation from environmental dose equivalent of dose H*(10), taking into account conversion factor E/H*(10) = 0.84 for 600 keV photons (Radiation Protection 106, EC, 1999). The conversion factors in the range of 100 keV to 6 MeV are in the range of 0.84 to 0.89.
[19] The typical contribution of short-lived radon progeny to the effective dose was estimated in the report for 2000 (IJS-DP-8340, #3 on p. 7).

The contribution of Cs-137 to external radiation was estimated at less than 0.017 mSv per year, which is 2.5% of the average annual external dose from natural radiation in the vicinity of NEK. The estimate is comparable with the estimates of previous years.

The predicted effective dose resulting from the inhalation of radionuclides that are the consequence of general contamination (Cs-137 and Sr-90) is estimated at 2.7 E–7 mSv per year for an adult individual.

Traces of Cs-137 and Sr-90 from nuclear tests and the Chernobyl disaster were measured in individual types of food. In 2020 the effective dose as a result of eating such food was estimated to be 3 E–4 mSv per year for Cs-137 and 1.3 E–3 mSv per year for Sr-90, which is a total of around 0.8% of the annual effective dose from naturally occurring radionuclides (excluding K-40) in food. The estimated dose is comparable to the figure from previous years.

The greatest contribution to the annual effective dose comes from C-14 that arrives in the food chain via natural pathways and as a result of the above-ground nuclear tests that took place in the 1960s.

4.4.7.6 Comparison with previous years (2020)

Table 91 shows the individual contributions to the annual effective dose from NEK emissions between 2016 and 2020 as they apply to an adult at the NEK perimeter. The estimates also approximately apply at a distance of 500 m from the reactor shaft. The exception is the dose from external irradiation, which is measured by TLDs. During the construction of NEK, the top layer of earth was removed and gravel strewn on the surface. As a result, the average annual environmental dose equivalent in the vicinity of NEK is 40% higher than that recorded at the NEK perimeter. Consequently, we give the average environmental dose equivalent for the area surrounding NEK.

Table 91: Summary of annual exposures of the population in the vicinity of NEK 2016–2020 (source:/87/)

		Annual effective dose E (mSv)				
Source	**Pathway**	**2020**	**2019**	**2018**	**2017**	**2016**
natural radiation	gamma and ionising cosmic radiation	0.76**	0.64**	0.70**	0.69**	0.68**
	cosmic neutrons	0.06	0.08	0.09	0.08	0.1
	ingestion (K, U, Th)	0.27	0.27	0.27	0.27	0.27
	inhalation (short-lived progeny of Rn-222)	1.30	1.30	1.30	1.30	1.30
	Total natural radiation	2.39	2.29	2.36	2.34	2.35
NEK direct radiation along the NEK perimeter	direct radiation from NEK facilities	indeterminable	indeterminable	indeterminable	indeterminable	indeterminable
NEK atmospheric discharges* (at the NEK perimeter)****	external radiation from cloud	5.6 E–7	1.2 E–6	9.4 E–7	7.1 E–7	6.9 E–7
	external radiation from deposition (isotopes of I and Co, Cs-137)	4.7 E–15	2.7 E–12	2.1 E–12	1.2 E–12	5.8 E–12

		Annual effective dose E (mSv)				
Source	**Pathway**	**2020**	**2019**	**2018**	**2017**	**2016**
	inhalation from cloud (H-3, C-14)	7.3 E–6	1.6 E–5	3.0 E–5	2.4 E–5	1.3 E–5
	ingestion (C-14)	5.0 E–5	8.0 E–5	8.0 E–5	1.0 E–4	1.0 E–4
NEK liquid effluents (Sava)	reference group (350 m below NEK dam)	1.4 E–5	1.2 E–5	8.0 E–6	8.0 E–6	2.7 E–4
	adult, Brežice	6.3 E–6	5.4 E–6	4.0 E–6	4.0 E–6	1.3 E–4
Chernobyl contamination nuclear tests	external radiation**	< 1.7 E–2***	<1.3 E–2***	<2.3 E–2***	<3.3 E–2***	<4.0 E–2***
	ingestion of plant and animal food (excluding C-14)	1.6 E–3	1.0 E–3	1.5 E–3	1.4 E–3	Total ingestion: 1.4 E–3
	ingestion of plant-based food (C-14)	1.5 E–2	1.5 E–2	1.5 E–2	1.5 E–2	
	ingestion of fish	8.9 E–5	1.4 E–4	7.5 E–4	1.1 E–3	

* The totals for NEK contributions are not stated, since contributions are not all additive in that they do not relate to the same groups of the population.
** Estimate of the effective dose of external radiation from environmental dose equivalent of dose H*(10), taking into account conversion factor E/H*(10) = 0.84 for 600 keV photons (Radiation Protection 106, EC, 1999).
*** This estimate does not take into account the fact that the population spends about 20% of its time outdoors and that the indoor radiation shield factor is 0.1. This is a conservative estimate.
**** The estimate also approximately applies at a distance of 500 m from the reactor shaft.

When we add the values for atmospheric and liquid effluents, we find that the impact of the monitored discharges from NEK on the population is significantly below the authorised dose limit. One should emphasise at this point that different population groups are involved, and that the total value is therefore only a rough estimate of the annual effective dose.

Figure 65 contains an estimate of the annual effective doses for individual reference groups resulting from NEK emissions. The annual authorised limit (0.05 mSv) is also marked.

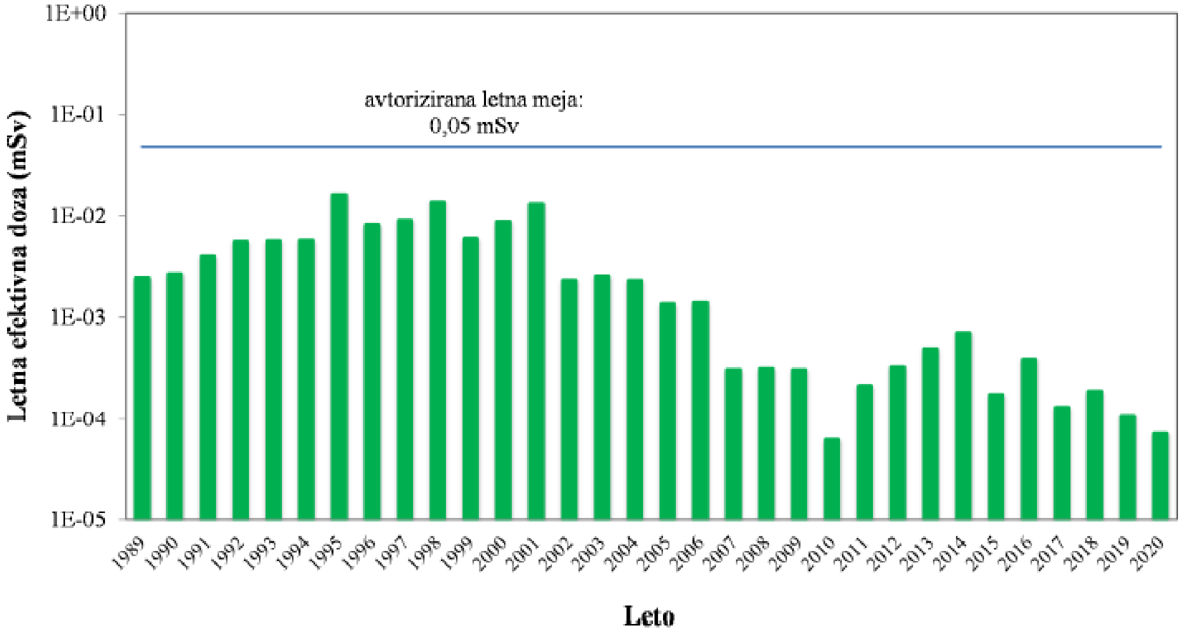


Figure 65: Estimated annual effective doses for individual reference groups resulting from NEK emissions (source:/87/)

avtorizirana letna meja: 0,05 mSv	authorised annual limit: 0.05 mSv
Letna efektivna doza (mSv)	Annual effective dose (mSv)
Leto	Year

The total value fell between 2005 and 2011, while since 2012 the annual effective dose per inhabitant at the NEK perimeter (the estimates also apply approximately to a distance of 500 m from the reactor shaft) has been slightly higher as a result of the impact of C-14 on the food chain during the growing period and the changed assumptions within the dose calculation. However, it still remains two orders of magnitude below the authorised dose limit. We observed an increase in the annual effective dose in 2013 and 2014. However, this could be attributed exclusively to the contribution of C-14 to liquid effluents, something that we had not taken into account in previous years.

In 2020, the total gives the second lowest value of the last 31 years (the lowest was in 2010). We can attribute these low values to the small controlled discharges from NEK (high-quality fuel) and the fact that no regular outage took place in 2020. When comparing the contributions in individual years, one should also take into account the fact that, since 2007, calculations of external radiation from cloud and inhalation have used the Lagrange model, which can give a lower exposure value, and that the values of the contribution to the dose made by the ingestion of C-14 (from atmospheric discharges) were, up until 2006, estimated on the basis of discharges and data from similar power plants.

We can therefore also state that the radiation effects of NEK are several orders of magnitude lower than global contamination and the effects of the use of radionuclides in medicine. Moreover, the estimated value of the radiation effects (annual effective doses) of NEK on the population at the NEK perimeter (and approximately 500 m from the reactor shaft) is approximately 0.003% of the typical, unavoidable natural background.

Measurements were taken in the vicinity of NEK of other radionuclides that form a major part of global contamination (C-14, Sr-90, Cs-137), are used in medicine (I-131) or are of cosmogenic origin (H-3, C-14). The contributions to the annual effective dose are collected, by medium for all artificial radionuclides received by the population (adults) from the closest settlements or reference locations, in Table 91, with a comparison with previous years also provided. In 2020 the largest contribution from external radiation came from the presence of Cs-137 in the soil (global contamination). The second largest contribution came from C-14 in food. We can also state that the total contributions are falling year by year, with reduced estimates of Cs-137 radiation in the soil making the biggest contribution to this fall.

The producers of the report /87/ **find** that all methods of public exposure were **negligible** in comparison with natural radiation, dose limits and authorised dose limits.

4.4.7.7 Conclusions – 2020

A summary of public exposure in the area around NEK for 2020 is given in Table 91, which shows the contributions of natural radiation, the impacts of NEK at the perimeter, and the residual impacts of Chernobyl contamination and nuclear test explosions:

- in 2020 all the radioactive effects of NEK at the NEK perimeter (the estimate is approximately valid also at a distance of 500 m from the middle of the reactor) and 350 m downstream from the NEK dam were estimated to be less than
  7.14 E–5 mSv per year for the nearby population;
- the estimated value of the radiation effects from NEK along the NEK perimeter is approximately 0.003% of the typical
  unavoidable natural background. The estimate also approximately applies at a distance of 500 m from the reactor shaft;
- the estimated value is small in comparison with the authorised dose limit for the population in the vicinity of NEK (the effective dose of 50 µSv annually at a distance of 500 m and more for contributions via all pathways);
- the sum total of all radiation effect contributions was the second lowest of the last 31 years. We can attribute these low values to the small controlled discharges from NEK (high-quality fuel) and the fact that no regular outage took place in 2020. Credit for the low impact of the nuclear power plant should also go to NEK employees, who are careful to control and limit discharges;
- the consumption of food (86.9%), leading to the intake of C-14, makes the biggest contribution to the total effective dose;
- the effective dose from inhalation accounts for 10.2% of the total effective dose. With regard to radionuclides, the biggest
  contribution comes from H-3;
- the effective dose from external radiation accounts for 2.9% of the total effective dose. With regard to radionuclides, the biggest contribution comes from Co-60;
- the sum total of effective dose contributions calculated from the measurements of samples from the environment is falling year by year, with reduced Cs-137 radiation in the soil making the biggest contribution to this fall. This is a remnant of the atmospheric and precipitation depositions following the Chernobyl nuclear reactor disaster in 1986.

4.4.8 Odour pollution

The report does not address the issue of odour (see the explanation in Section 1.7.4).

4.4.9 Waste contamination

According to findings made following a field inspection, the narrower and wider area of the site is not contaminated by waste. Manufacturing and municipal waste is given to the relevant collectors/processors of specific types of waste on a regular basis, and to the public municipal waste service provider.

4.4.10 Radioactive waste pollution

4.4.10.1 General

With the start of trial operation at NEK in 1981, significant quantities of radioactive waste began to be produced on a continuous basis in Slovenia. It is generated in gaseous, liquid and solid form. In accordance with the authorised limits set by the administrative authority, some of the liquid and gaseous radioactive waste is discharged into the environment as it is produced or at periodic intervals. The remaining radioactive waste has to be processed as required into solid form during the radioactive waste management process, and then stored and deposited in the radioactive waste repository.

The Rules on radioactive waste and spent fuel management (Official Gazette of RS, No. 125/21) address the sorting of radioactive waste in solid form. In accordance with the level and type of radioactivity, radioactive waste in solid form is classified into the following categories:

- transitional radioactive waste;
- very low-level radioactive waste;
- low- and intermediate-level radioactive waste (LILW):
- high-level waste (HLW) and
- radioactive waste containing naturally occurring radionuclides.

With RAW, the lifetime of the radionuclides that the waste contains is particularly important (in addition to its activity), since this lifetime determines how long the waste will remain radioactive, thereby also determining its management and the conditions for its disposal. In accordance with this, some of the RAW at NEK is transitional radioactive waste. After several years of storage, the specific activity of the radionuclides it contains falls to a level at which the waste may be cleared in accordance with the regulation governing radiation practices. Some of the RAW comprises very low-level radioactive waste for which the decision on clearance is made by the URSJV. LILW accounts for the largest share. High-level radioactive waste will only be produced during the NEK decommissioning phase. There is no radioactive waste containing naturally occurring radionuclides at NEK.

4.4.10.2 Existing RAW inventory

The annual quantity of stored operating LILW, which was approximately 100 m^3 during the initial period of NEK operation, has been continuously reduced on account of active measures to reduce the quantities of LILW generated and appropriate procedures to process LILW and condition it for storage, so that it currently amounts to less than 35 m^3, which is also NEK's long-term operational target.20 Operating waste is stored in the storage facility, which was originally designed to take 5,000 drums or five years of LILW production. The capacity was subsequently increased to 11,200 drums or 3,000 tube type containers (TTCs), which is a form of LILW packaging. At the end of 2019, the volume of LILW at the storage facility was 2,274 m^3. As the radioactive waste storage facility was 95% full by 2012, NEK began to plan the construction of a waste manipulation building (WMB) in 2013. The new facility relieves the problems associated with delays in the construction of the LILW repository. Construction work was completed on the facility in 2018. The new structure has enabled measuring equipment and the supercompactor to be withdrawn from the handling area of the storage facility, which has freed up reserve storage capacity at the facility (5%) for emergency events. According to NEK, this reorganisation of the storage facility will ensure that there is enough space for the storage of radioactive waste until 2022. If NEK is to operate normally after 2022, activities to construct the LILW repository must be stepped up and the facility made ready to receive LILW in 2023[21]. Construction of the LILW repository is an independent project and entirely separate from the project of NEK operational lifetime extension. A dedicated environmental impact report was prepared for the project, and environmental protection consent for it was received in 2021.

The quantities of operating LILW at the NEK storage facility are shown in the following chart (Figure 66).

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[20] Resolution on the National Programme for Radioactive Waste and Spent Fuel Management (ReNPRRO16–25), point 3.1.1.3.

[21] Krško nuclear power plant, Annual report on NEK operation for 2020, February 2021

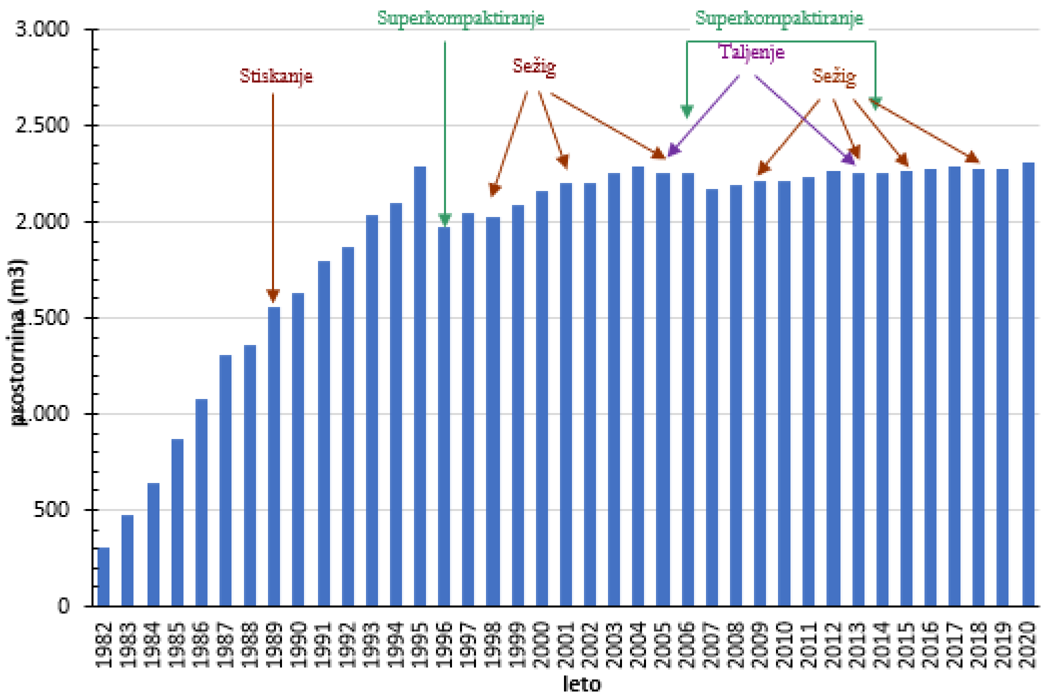

Figure 66: Quantities of LILW at the LILW storage facility at NEK (as at the end of 2020) /227/

Superkompaktiranje	Supercompacting
Stiskanje	Compacting
Sežig	Incineration
Taljenje	Melting
prostornina (m^3)	volume (m^3)
leto	year

A decontamination building was constructed at NEK in 1999. It holds the two old steam generators that were replaced in 2000, as well as other contaminated equipment. The total volume of the contaminated equipment in the decontamination building is approximately 1,000 m^3. The (old) reactor pressure vessel head was stored in the decontamination building following its replacement in 2012. With the storage of the reactor pressure vessel head, the available storage capacity of the decontamination building was temporarily considerably reduced. Clearance is planned for most of the stored contaminated equipment prior to the start of decommissioning. This equipment could therefore be given for processing, or deposited as non-radioactive waste.

4.4.10.3 Predicted quantities of LILW /195/

If NEK operation is extended to 2043, 3,005 m^3 (storage volume) or 6,025 t of operating LILW will be generated by the plant. If NEK operates until 2023, the respective figures will be 547 m^3 or 884 t lower, i.e. 2,458 m^3 or 5,141 t.

In addition to operating LILW, LILW resulting from decommissioning will be produced after NEK ceases operation.[22] A portion of this LILW will be produced during the decommissioning process after operation comes to an end. There will be 2,860 t or 2,842 m^3 (storage volume) of such waste regardless of whether NEK continues to operate until 2023 or 2043. Some of the LILW from decommissioning will be produced during the decommissioning of the spent fuel dry storage (2103–2106). There will be 392 t

[22] The decommissioning of the facility is not part of this assessment and will be subject to other administrative procedures relating to construction, nuclear safety and environmental protection.

or 407 m^3 of such waste. [23] Small quantities of HLW will also be produced in the decommissioning process.

4.4.10.4 Pre-conditioning of waste for Vrbina LILW

LILW packages will be taken by the competent organisations in Slovenia (ARAO) and Croatia (FOND). The division itself will take place in the waste manipulation building (WMB). Existing tools and equipment will be used for the process. In order to reduce the radiological pressures on those carrying out the activity, additional protection will be employed in the form of mobile protective walls, remote handling, etc. The WMB was designed precisely for the purpose of conditioning LILW before it is sent for processing (incineration, melting), activities that NEK is already carrying out, and for the final handover and packaging in special canisters for final takeover by ARAO and FOND.

Existing packages will be directly placed in the planned N2d, RCC or ISO IP2 transport canisters at the WMB. The building has been designed in such a way as to ensure radiological protection of the surrounding area and the environment, as well as provide adequate working conditions in the building itself (thickness of walls, closed ventilation filter system, implementation of a closed floor drainage system, etc.). Prior to the insertion of the packages into the canisters, the formal transfer of the ownership of the LILW from NEK to the receiving organisations (ARAO and FOND) will take place. The covering of the N2d and RCC canisters with filling mortar using mobile equipment is also planned. After the completion of the drying process and the hardening of the filling mortar, the canisters will be loaded onto lorries and taken from the NEK site, whereby all requirements for the transport of radioactive material will be observed. ARAO and FOND will be responsible for organising the transport.

That portion of the LILW that cannot be placed directly into RCC or N2d canisters and that will have to be further processed will be placed in ISO IP2 transport canisters and taken from NEK to the competent receiving organisations. After the external contractor has processed and conditioned the LILW abroad, the waste will be returned for long-term storage in Croatia or Slovenia.

4.4.10.5 RAW handling methods

Measures for reducing the production of RAW

Production of RAW in the smallest possible quantities is a legal obligation (Article 121 of the ZVISJV-1), which is also reflected in the power plant's internal documents. The power plant management system handbook (MD-1 Internal guidelines and objectives – five-year development plan) gives guidelines on reducing the quantity of RAW by means of consistent monitoring and the elimination of coolant leaks, the decontamination and re-use of tools and materials, the prevention of contamination, the consistent separation of contaminated from clean materials, and the use of volume-reducing technologies. The option of clearance is used.[24] /229/

Processing of gaseous waste material

The system of processing gaseous waste material comprises two equal parallel closed circuits with compressor and catalytic incinerators for hydrogen, and six compressed fission gas decay and containment tanks. The system removes gases from the reactor coolant that have accumulated there as a result of damage to the fuel rod cladding. Most of the gas comes from the volume control tank (VCT) and smaller amounts from the boron recycling evaporator, the reactor coolant drainage collecting tank, the boron recycling tank and the analysis systems. Hydrogen is led into the VCT, which separates the fission gases from the reactor coolant in the gaseous phase. In the nitrogen circuit, this contaminated hydrogen is led to the catalytic incinerator, where oxygen is added and incineration performed so that the hydrogen is burned into steam in the catalyser. After the water is removed, the

[23] Third Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Programme, Version 1.3, September 2019, ARAO – Agency for Radwaste Management, Ljubljana, Fund for Financing the Decommissioning of the Krško NPP, Zagreb (PO3), Table 4-17.
[24] Radioactive Waste Management Programme, TD-0C, Rev. 8, point 8.

remaining gases circulate (with the help of a compressor) through one of six gas decay and containment tanks. Figure 67 contains a simplified flowchart of the process /3/.

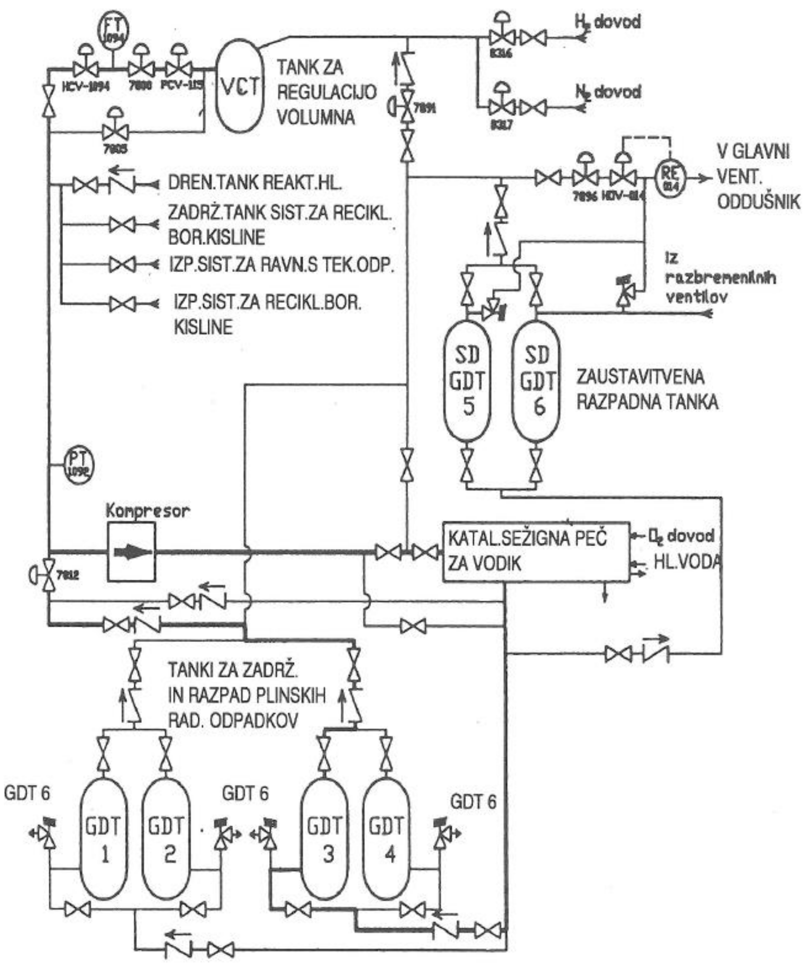

Figure 67: Schematic presentation of the gaseous RAW management system /4/

TANK ZA REGULACIJO VOLUMNA	VOLUME CONTROL TANK
H_2 DOVOD	H_2 SUPPLY
N_2 DOVOD	N_2 SUPPLY
DREN. TANK REAKT. HL.	REACTOR COOLANT DRAINAGE COLLECTING TANK
ZADRŽ. TANK SIST. ZA RECIKL. BOR. KISLINE	TANK FOR RECYCLING OF BORONIC ACID
IZP. SIST. ZA RAVN. S TEK. ODP.	EVAPORATOR FOR HANDLING OF LIQUID WASTE
IZP. SIST. ZA RECIKL. BOR. KISLINE	EVAPORATOR FOR RECYCLING OF BORONIC ACID
V GLAVNI VENT. ODUŠNIK	TO THE MAIN VENTILATION STACK
Iz razbremenilnih ventilov	From relief valves
ZAUSTAVITVENA RAZPADNA TANKA	SHUTDOWN DECAY TANK
Kompresor	Compressor
KATAL. SEŽIGNA PEČ ZA VODIK	CATALYTIC HYDROGEN INCINERATOR
O_2 dovod	O_2 supply
HL. VODA	COOLING WATER
TANKI ZA ZADRŽ. IN RAZPAD PLINSKIH RAD. ODPADKOV	GASEOUS RADIOACTIVE WASTE CONTAINMENT AND DECAY TANKS

The containment capacities of the system make it possible for gases not to be discharged into the atmosphere on a daily basis. Via the ventilation system, gases are filtered with the help of highly effective charcoal particulate filters. Discharges are timed to coincide with favourable atmospheric conditions. Gaseous emissions are monitored by means of a system of radiological monitors featuring the automatic prevention of discharge in the event of the alert values being exceeded.[25]

Discharges of gaseous RAW take place after analyses have been performed and with recording and reporting measures in place.

Processing of liquid waste material

The liquid RAW management system (Figure 68) is designed for the reception, separation, processing, recycling and discharge of liquid RAW. At NEK, liquid RAW is processed by means of evaporation, ion exchange, filtration and drying (in-drum drying system, IDDS). Liquid RAW is placed into two groups according to how it was generated and its chemical properties: the first comprises RAW that can be reused because it has a reactor level of chemical purity (it is processed through Channel A of the liquid RAW management system), while the second comprises liquid RAW that does not reach a reactor level of chemical purity (it is processed through Channel B of the liquid RAW management system). The system is also designed for the management of spent ion exchangers.

Channel A processes wastewater produced by means of closed drainage and leakage from reactor cooling system equipment. It is collected in the waste holding tank (WHT). The main component of this water, in addition to radionuclides, is boronic acid. This wastewater is processed through a waste evaporator system (EVWD). If the results of the analysis of samples of WHT content show that this wastewater does not require processing through evaporation, and even if the WHT is overfilled, the liquid waste is pumped into the floor drain tank (FDT). In the EVWD, concentration of up to 12% of the boronic acid solution, up to 20% of solid material or up to a radioactivity concentration of 1.5 TBq/m^3 (up to the value achieved first) is carried out. The waste concentrate is processed in the in-drum drying system (IDDS). If the waste evaporator (EVWD) is not in operation, the wastewater from the WHT is processed by the boron recycle system evaporator (EVRE). The distillate is pumped into the waste evaporator condensate tank (WCT). Water from the WCT may then be reprocessed with the EVWD or the waste evaporator condensate demineraliser (DMWC). It may also be pumped into WMT #2.

Channel B processes liquid RAW that is generated by the open drainage and discharge of primary system components and the decontamination of equipment, work surfaces and protective equipment, and is collected in the FDT and laundry and hot shower tank (LHST). As the wastewater from the LHST usually does not need to be decontaminated, it is pumped through the strainer and filter into WMT #1 and from there into the discharge channel. Liquids that flow into the FDT are decontaminated as required by the waste monitor tank demineraliser (DMMT) or by evaporation. After decontamination, the wastewater undergoes controlled pumping into WMT#2 and from there into the discharge channel. Pumping is monitored by the RM 018 process monitor.[26]

[25] SOP-3.2.211, Waste Gas System (GH), Supplement 7.6, Figure 2.
[26] RAW Management at NEK, Technical Report, ESD-TR-03/97, Rev. 3, NEK, 2008.

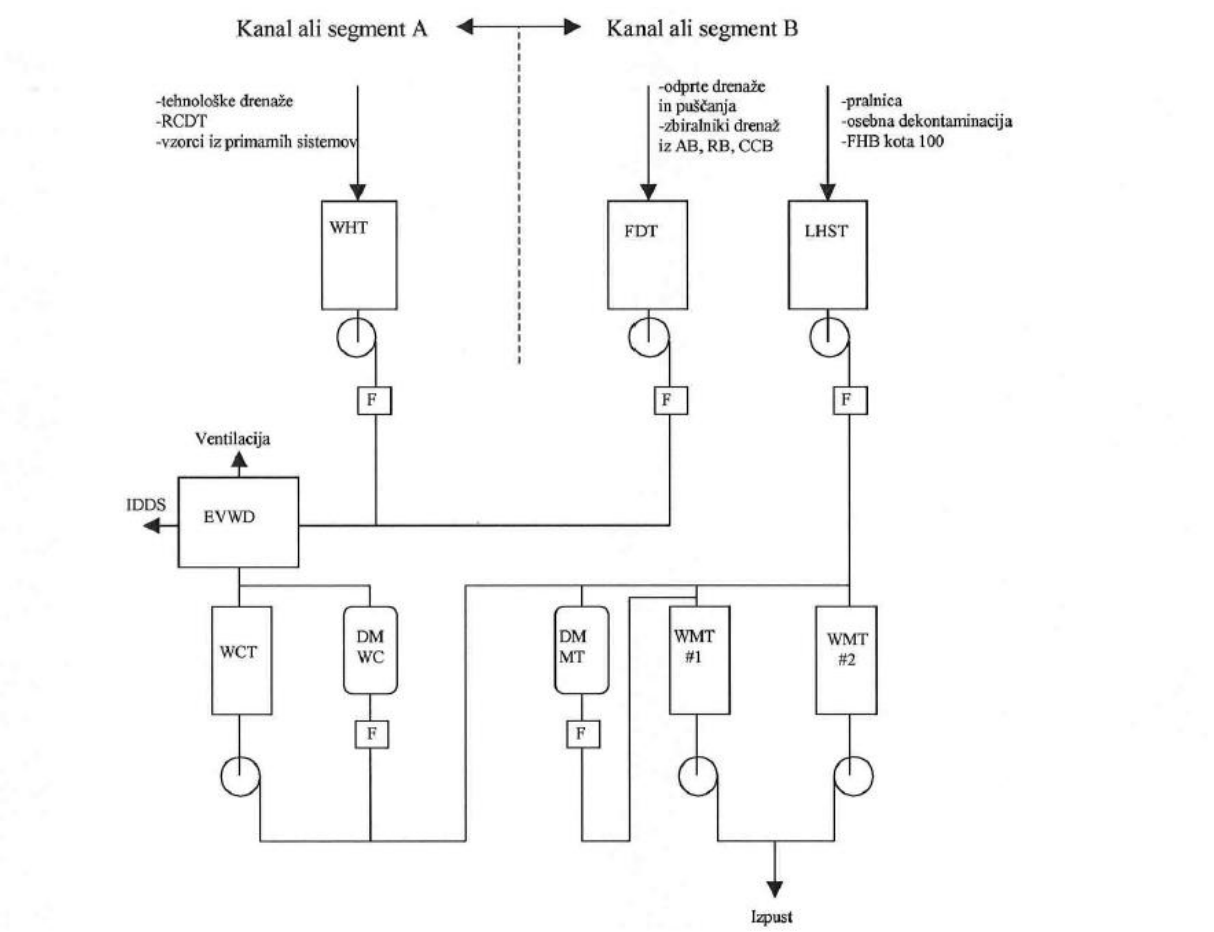

Figure 68: Schematic presentation of the liquid RAW management system /228/

Kanal ali segment A	Channel or Segment A
Kanal ali segment B	Channel or Segment B
- tehnološke drenaže - RCDT - vzorci iz primarnih sistemov	- technological drainage - RCDT - samples from primary systems
- odprte drenaže in puščanja - zbiralniki drenaž iz AB, RB, CCB	- open drainage and discharge - collectors of drainage from AB, RB, CCB
- pralnica - osebna dekontaminacija - FHB kota 100	- laundry – personal decontamination – FHB elevation 100
WHT	WHT
FDT	FDT
LHST	LHST
EVWD	EVWD
Ventilacija	Ventilation
IDDS	IDDS
WCT	WCT
DM WC	DMWC
DM MT	DMMT
WMT #1	WMT #1
WMT #2	WMT #2
Izpust	Discharge

Solid RAW processing systems

Solid RAW comprises solidified or encapsulated liquid RAW, contaminated filters and contaminated solid waste materials (plastics, cloths, paper, personal protective equipment, tools, machinery and electrical devices, construction waste). The most common form of solid RAW processing is RAW volume reduction. The methods used to reduce volume depend on the type of RAW, and are outlined in Table 10).

For waste material that comes from a radiologically controlled area and has a contamination value or specific activity below the reference values, radiological monitoring is discontinued and the waste is classified as ordinary waste.

Conditioning of LILW

The basic packaging for the conditioning of LILW comprises drums of differing designs made from ordinary and stainless steel plate. D1 is a basic drum made from ordinary steel plate. Drums D3, D4 and D5 are variations of Drum D1 with different interior shields or inserts. Drum D3 has a concrete shield and is used to store spent cartridge filters. Drum D4 has a steel basket in its interior, with the space between the basket and the drum filled with vermiculite cement. It has been used for storing spent ion exchanger resins. Drum D5 has a steel insert in its interior, with the space between the insert and the drum filled in with vermiculite cement. It has been used for storing evaporator concentrates and sludge. Drum D2 is used to store incineration residues, while Drum D6 has been used as a canister for storing smaller drums and supercompacted drums. Drum H3 has been used for storing dried spent resins from steam generator blowdown. Drums H1 and H2 are made of stainless steel plate. Drum H1 is used for storing dried spent resins from steam generator blowdown and dried evaporator concentrates and sludge. Drum H2 has a steel shield in its interior and is used to store dried spent resins from the primary circuit. Tube-type containers T1 and T2 are made from ordinary steel plate and are used to store drums in the temporary storage facility at the NEK site. An overview of the drum and TTC types is contained in Table 92.

Table 92: Types of drum and TTC for storing operating LILW at NEK /231/

Designation	Dimensions D x H (mm)	Net volume (l)	Weight of empty drum (kg)	Design weight (kg)	Material
D1	570 x 825	208	23	300	ordinary steel plate
D2	460 x 700	113	33	300	stainless steel plate
D3	605 x 872	320	400	500	ordinary steel plate
D4	570 x 825	65	190	300	ordinary steel plate
D5	570 x 825	110	180	300	ordinary steel plate
D6	660 x 946	320	37	500	ordinary steel plate
H1	563 x 816	200	65	800	stainless steel plate
H2	506 x 779	150	450	800	stainless steel plate
H3	563 x 818	204	60	800	ordinary steel plate
T1	640 x 2,695	864	117	3,000	ordinary steel plate
T2	640 x 2,698	869	135	3,000	ordinary steel plate

LILW processing

The following types of operating waste are defined in the process of characterising LILW at NEK in accordance with the method of generation and the properties of the waste:

- evaporator concentrates and sludge (EB);
- spent ion exchanger resins (SR, BR);
- spent cartridge filters (F);

- compressible waste (CW);
- non-compressible waste (NCW) and
- miscellaneous solid waste (SW).

Evaporator concentrates and sludge are produced during the processing of process liquids and liquids from drainage tanks. Processing that uses evaporation generates water and evaporator concentrates and sludge. Under the original technology used, the evaporator concentrates and sludge generated in this way were solidified by means of encapsulation in a vermiculite cement matrix in a drum. This technology has been abandoned and replaced by an in-drum drying system, with the evaporator concentrates and sludge being dried in drums. The final waste is dry matter with a residual moisture content of up to 5%.

The ion exchange process is also used in the processing of process liquids in the primary and secondary parts of the power plant. After a long period of use, ion exchangers become ineffective. As these liquids contain radioactive material, they are not regenerated, but merely need to be replaced, thereby becoming radioactive waste. Owing to the difference in activity and dose speed, spent ion exchanger resins from the primary and secondary circuits are collected and processed separately. Under the original technology used, spent resins were placed in drums and solidified using vermiculite cement. This technology has been abandoned and replaced by a drying system in which the spent resins are dried in a dryer, thereby reducing their volume. The dry matter from the dryer then falls into the drum. The final waste is dry matter (without free water) with a residual moisture content of up to 30%.

Cartridge filters are used for the removal of solid particles from process liquids and gaseous effluents. When they become unusable, they need to be replaced, thereby becoming radioactive waste. Cartridge filters are partly solidified with cement and partly packed into drums. Spent HEPA cartridge filters from ventilation systems are classed as non-compactable waste.

Different contaminated or activated material is separated into compactable and non-compactable waste in a radiologically controlled area of the power plant. Compactable waste is further compacted prior to storage by means of a hydraulic press or supercompactor.

Waste has been packed into different types of drum according to type, period of production and processing technology used. Some of the waste has been further processed by means of supercompacting and some has been sent for incineration and melting. Supercompacted drums have then been inserted into larger drums or TTCs. Drums with incineration residues have been inserted into larger drums and set in concrete. The table below shows the types of operating waste according to type of packaging.

Table 93: Types of operating LILW and its packing and processing /231/

Type	Type of drum	Description and method of processing and conditioning
EB	D5	evaporator concentrate
	H1	dried evaporator concentrate
	H1	dried sludge
	D5/T1	supercompacted EBD5 packages placed in Canister T1
	D5/T2	supercompacted EBD5 packages placed in Canister T2
	D5/D6	supercompacted EBD5 packages placed in Drum D6
	D5/T1	EBD5 packages placed in Canister T1
	H1/T2	DCH1 packages placed in Canister T2
	H1/T2	DSH1 packages placed in Canister T2
SR, BR	D4	spent resins
	H2	dried spent resins from the primary circuit
	H1	dried spent resins from steam generator blowdown

Type	Type of drum	Description and method of processing and conditioning
	D4/T1	SRD4 drums placed in Canister T1
	H2/T2	PRH2 drums placed in Canister T2
	H1/T2	BRH1 drums placed in Canister T2
F	D3	spent cartridge filters in the drum with a concrete shield and set in concrete
	D3	spent cartridge filters in the drum with a concrete shield
	H2	spent cartridge filters in the drum with a steel shield
	D3/T1	CFD3 drums placed in Canister T1
CW	D1	compacted waste
	D6	supercompacted CWD1 drums placed in Drum D6
	D1/T1	supercompacted CWD1 drums placed in Canister T1
	D1/T2	supercompacted CWD1 drums placed in Canister T2
	D2/D1	ash in Drum D2; Drum D2 placed in Drum D1 and set in concrete
NCW	D1	solid non-compressible waste
	D1/D6	supercompacted OD1 drums placed in Drum D6
	D1/T1	supercompacted OD1 drums placed in Canister T1
	D1/T2	supercompacted OD1 drums placed in Canister T2
	D1/T1	OD1 drums placed in Canister T1
	D1	compacted spent HEPA cartridge filters
	D2/D1	incineration residues in Drum D2; Drum D2 placed in Drum D1 and set in concrete
SW	H1	corundum powder
	D1	charcoal cartridge filters
	D1/T1	supercompacted ACD1 drums placed in Canister T1
	D1/T2	supercompacted ACD1 drums placed in Canister T2

4.4.10.6 LILW disposal

Relations between Slovenia and Croatia concerning the disposal of RAW from NEK are regulated by the BHRNEK treaty.[27] In accordance with Point 3, Article 10 of the BHRNEK treaty, the disposal of LILW will be managed as set out in the programme for the disposal of RAW and spent fuel (hereinafter: SF). Point 6, Article 10 of the BHRNEK treaty goes on to stipulate that the location of NEK may be used to store RAW only temporarily until the end of its lifetime, and point 7 sets out that if the parties fail to agree on a joint solution for radioactive waste and spent fuel disposal by the end of the regular lifetime, they undertake to complete the acceptance of RAW, with each side taking half, within two years of that deadline.

Coordinated performance of BHRNEK provisions in Slovenia and Croatia is ensured by an intergovernmental commission (BHRNEK, Article 18). The commission is the successor of the Inter-Republic Coordination of Slovenia and Croatia for RAW, established in 1989. In its 11th meeting on 21 November 2017, the Intergovernmental Commission established a coordination committee to monitor the implementation of the third revision of the Programme for the Disposal of RAW and SF from NEK and the NEK Decommissioning Programme. The Commission is also responsible for preparing a joint proposal for the construction of an LILW repository. In its 13th meeting on 30 September 2019, the Intergovernmental Commission adopted a resolution taking into account the findings of the Coordination Committee, declaring that a joint solution for LILW disposal was not feasible.

[27] Act Ratifying the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations regarding Investment in and the Exploitation and Decommissioning of the Krško Nuclear Power Plant (Official Gazette of RS [International Treaties], 5/2003; signed 19 December 2001, KK; effective as of 11 March 2003, Official Gazette of RS [International Treaties], 8/2003–35/2003).

The Programme for the Disposal of RAW from NEK was, along with the Programme for the Decommissioning of NEK, first drafted in 2004, with its second revised version being drafted in 2011. However, this second version was not addressed or approved by the Intergovernmental Commission monitoring BHRNEK implementation and performing other responsibilities under the treaty. In 2017 the third revision of the Programme for the Decommissioning of NEK and the Programme for the Disposal of RAW and SF from NEK (PO3) began to be drafted after the terms of reference were approved.[23] Both programmes were ratified at the 14th meeting of the Intergovernmental Commission on 14 July 2020.

Under the PO3, the parties will separately provide for LILW disposal: the Slovenian half of LILW from NEK will be disposed of at the Vrbina LILW repository, which is not far from NEK, and the Croatian half will be disposed of in a repository whose location has yet to be specified. Until such disposal starts in 2050, LILW will be stored at the Centre for Radioactive Waste Management in Čerkezovac. The provisions do not apply to the disposal of LILW generated while the spent fuel dry storage for SF at NEK is being decommissioned. This LILW will be disposed of at the deep geological repository for SF, which is a joint project of Slovenia and Croatia. The owners' decision on joint management of SF was adopted along with the decision on LTE.[28]

4.4.11 Spent fuel (SF)

4.4.11.1 General observations on SF

The fuel used at NEK is Westinghouse standard fuel 16 x 16 STD with variations and improvements (V5, V+, mV+). In the fourth fuel cycle, 40 KWU 16 x 16 fuel elements were also used. General information on the fuel is given in *Table 94*.[29]

Table 94: General information on spent fuel /3/

Characteristics	Value
type of fuel element	Westinghouse 16x16 STD, V5, V+, mV+; KWU 16 x 16
maximum enrichment	5% U-235
average burn-up of the element (maximum permitted)	60 GWD/MTU
number of fuel rods in the element	235
no of other locations in the fuel element	21
length of fuel element	4,058.03 mm
length of fuel element with control assembly	4,231.64 mm
width of fuel element	197.18 mm
weight of fuel element	595 kg
weight of fuel element with control assembly	658 kg

All spent fuel at NEK is currently stored in the spent fuel pool, where 1,694 cells are available in storage racks. The storage capacity was increased for the first time in 1983, from 180 to 828 cells, when all the storage racks were replaced. Current capacity was achieved in 2003 with the removal of three old racks and the installation of nine new ones.

[28] Joint minutes of the 10th meeting of the Intergovernmental Commission for the monitoring of the implementation of the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations regarding Investment in and the Exploitation and Decommissioning of the Krško Nuclear Power Plant (MDU), NEK, 20 July 2015; Ad.2.
[29] USAR NEK Ch. 4

Spent fuel (SF) is the term used for fuel elements that have reached their limit of use in technical and economic terms and are permanently removed from the reactor core. In relation to the division of radioactive waste in terms of its specific activity, it would be regarded as high-level radioactive waste (HLW). However, because a decision has been made to store it temporarily until the end of the power plant's operational lifetime, we refer to it as 'spent fuel elements'. SF is a secondary raw material from which uranium and plutonium can be obtained, through processing, to be used as raw material for new fuel.

Under the adopted strategy, it is stored in a separate building at NEK, i.e. in the spent fuel pool.

Spent fuel elements are highly radioactive and release considerable amounts of heat. They are therefore stored in racks surrounded by water. Boronic acid is added to the water. The thick layer of water is simultaneously a radiation shield and a means of removing heat. Figure 69 shows the insertion of a spent fuel element in a rack in the pool.[30]

Figure 69: Insertion of a spent fuel element in a rack in the spent fuel pool /233/

The residual heat released by SF is removed from the spent fuel pool with the help of cooling water and heat exchangers via the SF, CC and ESW system into the Sava.

4.4.11.2 Existing SF inventory

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. The total number of all SF elements in the pool and the number of elements inserted in the pool during an outage, up to and including the outage in 2020, are shown in Figure 70.[21]

[30] Krško nuclear power plant – Spent fuel (nek.si)

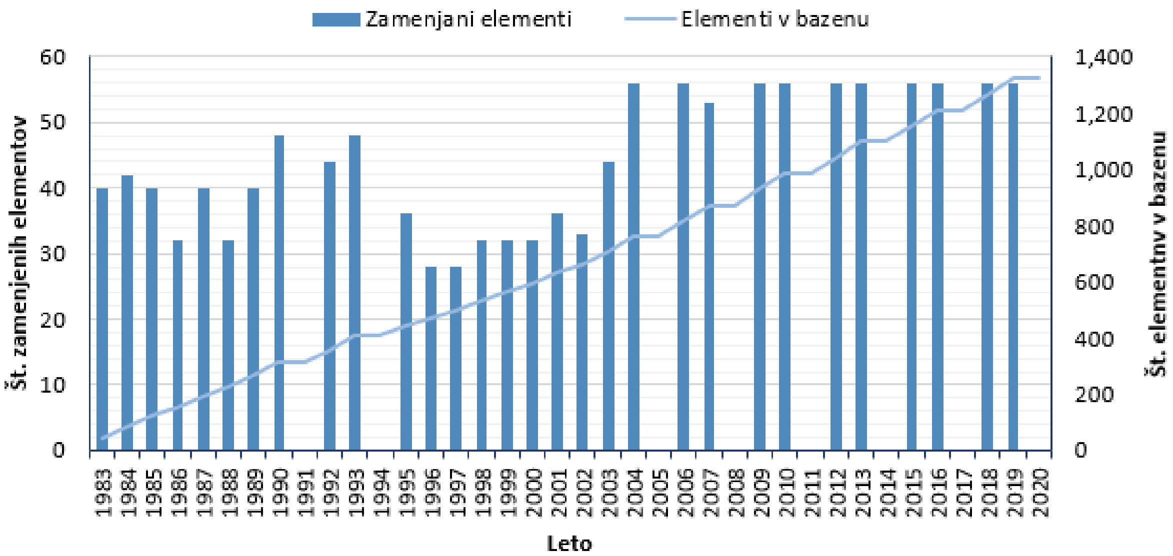

Figure 70: Number of SF elements in the pool and number of stored SF elements during outages /227/

Zamenjani elementi	Replaced elements
Elementi v bazenu	Elements in the pool
Št. zamenjanih elementov	No of replaced elements
Št. elementov v bazenu	No of elements in the pool
Leto	Year

4.4.11.3 Anticipated quantities of SF

If NEK operates until the end of 2023, 1,553 elements of spent fuel will be produced. If NEK operates until the end of 2043, 2,281 spent fuel elements will be produced. If NEK operates until 2023, SF will remain at the NEK site for the foreseeable future.

4.4.11.4 SF handling methods

After a five-year cooling period in the pool, all spent fuel will be transferred from the pool to the SF dry storage. Four transfer campaigns will take place: the first will be performed immediately after the construction of the spent fuel dry storage, the second in 2028, the third in 2038 and the fourth in 2048.

Table 95: Campaigns for the transfer of SF from the pool to dry cask storage /226/

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

For the requirements of dry cask storage, all fuel will be inserted and sealed in multi-purpose canisters (MPCs) that provide a containment barrier and subcriticality while the SF is being stored, moved and transported, and MPCs with SF in storage modules of the HI-STORM type in the dry cask storage building. These storage modules provide an adequate radiological shield. In addition to providing a radiation shield, HI-STORM storage modules cool the MPC during storage, and protect it against projectiles, natural impacts and accidents. For the requirements of natural ventilation, there are eight axisymmetrically arranged vents in the lower part of the cylindrical shield. Air passes through the lid. Figure 71 shows HI-STORM storage modules installed in the spent fuel dry storage. All other residual heat from SF stored in the spent fuel dry storage will be directly released into the atmosphere or the surrounding area without additional energy consumption. Thermal power will fall over time. There will be no emissions of substances into the atmosphere from the spent fuel dry storage. There will be no discharges of liquids from the technological section of the facility.

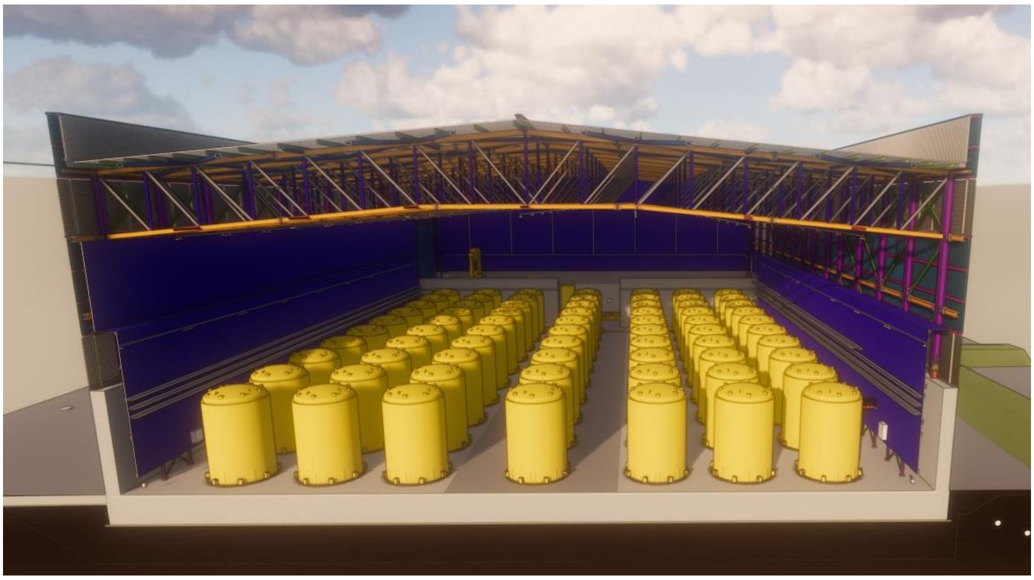

Figure 71: Storage modules containing SF in a spent fuel dry storage (source: /226/)

NEK is examining the option, and will continue to do so, of processing SF into new fuel. After the decommissioning of NEK is complete, management of the spent fuel dry storage will be assumed by the Agency for Radwaste Management, which will also be in charge of disposing of SF from NEK (ReNPRRO, point 4.5).

The decision to extend the operational lifetime was made at the same time as the owners' decision on the joint provision of SF disposal. There are plans to build a joint deep geological repository in the territory of Slovenia or Croatia. Use of the Swedish KBS-3V disposal concept is planned /244//245/. The timetable for the disposal of SF for the baseline and sensitivity case scenarios is given in Table 96 (PR3). Both scenarios assume that NEK will continue operating until 2043. The first (baseline) scenario envisages that the repository will commence operation in 2093, while the sensitivity scenario assumes that it will start operating in 2065. Under both scenarios, 2,281 fuel elements would be deposited in 571 canisters over the ten years of operation of the repository.

Table 96: Timetable for the construction of the SF repository (source: /226/)

Activity	Baseline scenario (year)	Sensitivity case scenario (year)
activation of procedure	2053	2025
start of location selection process	2055	2027
definition of location	2069	2041
start of construction of underground test facility	2079	2051
start of research in the test facility	2083	2055
confirmation of location	2086	2058
start of construction of repository	2087	2059
start of trial operation	2092	2064
start of regular operation	2093	2065
removal of last SF from dry storage	2103	2075
start of decommissioning	2104	2076

Activity	Baseline scenario (year)	Sensitivity case scenario (year)
start of closure	2108	2080
end of closure	2110	2082

4.4.12 Noise pollution

We have taken the presentation of the existing noise pollution at the site of the activity and the surrounding area from the results of the most recent operational monitoring of noise, performed in 2020 by ZVD d.o.o, Center za fizikalne meritve, Laboratorij za fizikalne meritve or the Report on Noise in the Environment No. LOM-20200588-KR/P /52/.

External sources are mainly responsible for environmental noise. At the measurement points, impacts from the following were observed during the measurement period:
- internal transport operations, handling, delivery vehicles;
- sound signals (chiefly from the internal communication system – 'paging', enclosed area of NEK);
- transformers and turbine generator operation (in the turbine building);
- external generators.

Sources of noise at NEK are not continuous, with the intensity of their operation varying according to need. The cooling towers were not in operation during the measurement period on 22 December 2020. The cooling towers are designed to cool process water prior to its discharge into the Sava. They are used mainly in the event of adverse weather conditions (high environmental temperature) and a low Sava flow rate. According to the client's representative, they operate for approximately 100 days, which is chiefly dependent on weather conditions.

The noise sources operate according to two regimes:
- operating regime: continuous operation, 24 hours a day, 18-month fuel cycles;
- outage, one-month cycles between fuel cycles, during which time the fuel is replaced. The environment is most heavily polluted with noise during start-up of the power plant (short releases of steam during a period of two hours).

During the measurement period, the plant was in the operating regime (with the exception of the cooling towers, all the sources referred to were in operation). The operating conditions were provided by the client, who states that the operating mode corresponded to the operating conditions, which reflect normal conditions.

NEK's production and non-production sources are located in the Vrbina industrial zone east of Krško. There are no noise-sensitive residential buildings in the immediate vicinity of NEK. The nearest residential buildings are located in the settlements of Žadovinek, Spodnji Stari Grad, Vrbina and Krško:

- residential building: Spodnji Stari Grad 2: approx. 550 m east of the site of the activity;
- residential building: Spodnja Libna 8: approx. 560 m north of the site of the activity;
- residential building: Žadovinek 20A: approx. 1,500 m southwest of the site of the activity;
- residential building: Brege 3A: approx. 2,000 m southwest of the site of the activity;
- residential building: Mrtvice 13, 21, 27, 37: approx. 2,500 m south of the site of the activity.

There are other companies in the vicinity of NEK that are also subject to noise restrictions, although these are in a considerably milder form than is the case with residential and other noise-sensitive buildings. There are therefore also restrictions within the industrial zone on the boundaries between individual companies or on the parcel boundaries of NEK.

The following companies are located in the vicinity of NEK: GEN Energija d.o.o., Saramati Adem d.o.o., SeCOM, Kostak d.d. (waste management centre) and the Betonarna Kostak cement works.

In addition to the noise sources from the liable entity and the surrounding plants, the area in question is also polluted by noise from road traffic around the Vrbina industrial zone and the Novo Mesto–Zagreb motorway.

Noise at the assessment points was measured using noise measurements at six measurement points. The measurements were performed on 22 December 2020 during daytime, evening and night time hours. The data from the measurement points is shown below:

Figure 72: Locations of measurement points during operational noise monitoring in 2020 (source: /52/)

Table 97: Data on measurement points during operational noise monitoring in 2020 (source: ZVD /52/)

Measurement point	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Measurement point 1 Southeastern section (Mrtvice) at a distance of around 580 m from NEK GKY: 540583 GKX: 87559	40.7	40.7	33.5	42.9
Measurement point 2 Southern parcel boundary at a distance of around 270 m from NEK GKY: 540236 GKX: 87803	38.1	38.1	35.7	42.8
Measurement point 3 Western section (Žadovinek) at a distance of around 1,350 m from NEK GKY: 538797 GKX: 88409	40.5	40.5	39.1	45.9
Measurement point 4	39.6	39.6	36.4	43.8

Measurement point	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Southeastern side in the direction of the settlement of Spodnji Stari Grad at a distance of around 440 m from NEK GKY: 541023 GKX: 88749				
Measurement point 5 Northern section, in front of the nearest commercial building of Saramati Adem d.o.o., at a distance of around 130 m from NEK GKY: 540133 GKX: 88941	47.5	47.5	40.9	50
Measurement point 6 Western section, in the direction of buildings located at Vrbina 16, at a distance of around 450 m from NEK GKY: 539709 GKX: 88551	39.9	39.9	36.8	44.1

Under the legislation in force, the operator of a noise source must ensure that it carries out industrial activities in such a way that the L_{day}, L_{night}, $L_{evening}$ and L_{den} noise indicator values do not exceed the noise indicator limit values at any assessment point, i.e. in front of the nearest buildings with protected areas. The closest assessment points correspond to measurement points 1, 2, 3 and 4.

Table 98: Noise indicators L_{day}, $L_{evening}$, L_{night} and L_{den}. The limit values are shown in brackets. The limit values relate to level III noise protection (source: ZVD /52/)

Location	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Assessment point 1a: Mrtvice 13 residential building	28.0 (58.0)	28.0 (53.0)	20.8 (48.0)	30.2 (58.0)
Assessment point 2a: Brege 3a residential building	24.1 (58.0)	24.1 (53.0)	21.7 (48.0)	28.8 (58.0)
Assessment point 3a: Žadovinek 20a residential building	40.0 (58.0)	40.0 (53.0)	38.6 (48.0)	45.4 (58.0)
Assessment point 4a: Spodnji Stari Grad 2a residential building	36.8 (58.0)	36.8 (53.0)	33.6 (48.0)	41.0 (58.0)

On the basis of measurements and analyses of noise in the surrounding area (the results are described in report no. LOM – 20200588 – KR/M), we find that the sources in question did not exceed the limit values for environmental noise defined in the Decree on limit values for environmental noise indicators (Official Gazette of RS, Nos, 43/18 and 59/19) at any assessment point (in front of the most exposed buildings with safety premises) during the power plant's operation.

The cooling towers were not in operation during the measurement period. Based on the measurements stated in report no. LFIZ – 201500001 – JJ/M of 2015, it was determined that, despite their contribution to overall noise, the sources in question did not exceed the limit values for environmental noise defined in the Decree on limit values for environmental noise indicators (Official Gazette of RS, Nos. 43/18 and 59/19) at any assessment point, as the table below makes clear.

Table 99: Data on measurement points during operational noise monitoring in 2015 (source: ZVD /51/)

Measurement point	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Measurement point 1 Southeastern side (Mrtvice) at a distance of around 650 m from NEK. Latitude: 45.931138°N Longitude: 15.520523°E	39	39	47	53
Measurement point 2 Southern lot boundary at a distance of around 270 m from NEK. Latitude: 45.934950°N Longitude: 15.514570°E	50	50	50	56
Measurement point 3 Southwestern lot boundary (Žadovinek) at a distance of around 1,200 m from NEK. Latitude: 45.934579°N Longitude: 15.501619°E	35	35	42	48
Measurement point 4 Southeastern side in the direction of the settlement of Spodnji Stari Grad at a distance of around 810 m from NEK. Latitude: 45.941869°N Longitude: 15.524462°E	31	31	43	48
Measurement point 5 At the intersection in front of the GEN commercial building at a distance of around 1,000 m from NEK. Latitude: 45.943940°N Longitude: 15.508563°E	39	39	35	43
Measurement point 6 Western lot boundary at a distance of around 600 m from NEK. Latitude: 45.940197°N Longitude: 15.507249°E	36	36	37	44

4.4.13 Vibration pollution

According to estimates, the area is subject to low levels of vibration pollution, with any vibrations mainly coming from road freight and rail transport in the area of the industrial zone and on public access roads. All road surfaces are paved and traffic proceeds at low speeds. The production process at NEK does not include machines, appliances or activities that could be an explicit source of vibrations for the surrounding area.

4.4.14 Electromagnetic radiation pollution

The first measurements of electromagnetic radiation for NEK were performed in 2014 for the 400/110 kV Krško substation and the reconstructed part of the 400 kV switchyard at NEK.

The report on the first measurements of electromagnetic radiation performed in 2014 /53/ shows that the main source of electromagnetic radiation at the edge of the area comes from the 400/110 kV Krško substation and the reconstructed part of the 400 kV switchyard. Measurements were performed at eight measurement points.

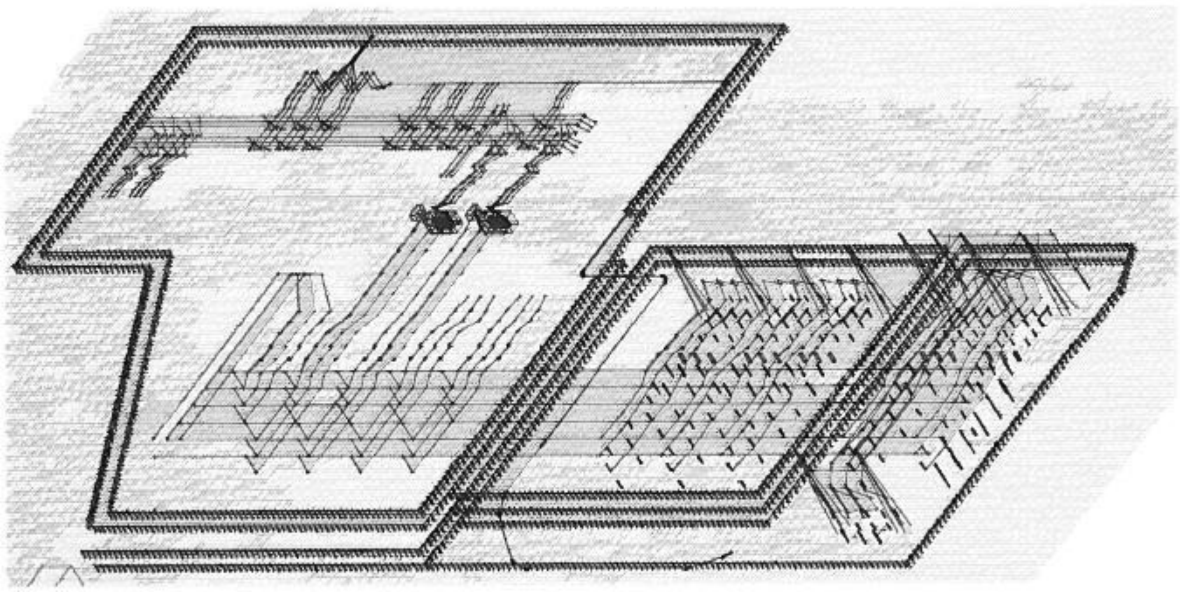

Figure 73: Three-dimensional presentation of the electromagnetic model of the 400/110 kV Krško substation and the reconstructed part of the 400 kV switchyard at NEK (source: EIMV. /53/)

The measurements at the selected measurement points showed that the measured effective values of the electric field strength and the magnetic flux density did not, at any of the selected measurement points, exceed the limit values for Level II radiation protection under the Decree on electromagnetic radiation in the natural and living environment (Official Gazette of RS, Nos. 70/96, 41/04 [ZVO-1]). The results of the measurements are shown in the tables below.

Table 100: Maximum measured and calculated electric field values (E) (source: EIMV. /53/)

Measurement point	Maximum measured value (k=2) E [V/m]	Maximum calculated value E [V/m] (substation's own emissions)
1	2,293.2 ± 91.7	357.6
2	1,947.4 ± 77.9	316.1
3	263.0 ± 10.5	94.8
4	325.8 ± 13.0	75.8
5	643.4 ± 25.7	1,390.8
6	528.7 ± 21.1	1,197.1
7	1,701.7 ± 68.1	4,197.1
8	1,537.9 ± 61.5	4,033.2

Table 101: Maximum measured and calculated magnetic field values (B) (source: EIMV. /53/)

Measurement point	Maximum measured value (k=2) B [μT]	Maximum calculated value B [μT] (substation's own emissions)
1	1.469 ± 0.156	5.833
2	1.325 ± 0.140	4.318
3	1.133 ± 0.120	1.900
4	1.238 ± 0.131	1.600
5	1.555 ± 0.165	8.422
6	1.219 ± 0.129	7.489
7	5.674 ± 0.601	35.661
8	4.445 ± 0.471	34.386

In February 2021 the initial measurements of electromagnetic radiation were repeated as part of the modification of the 1095-XR-L, which includes replacement of the T3 transformer and voltage regulator /194/. The results of the measurements are summarised below.

A 60 MVA, 110/6.3/6.3 kV T3 transformer with a T3 voltage regulator was installed as part of the modifications to the 1095-XR-L at NEK. The T3 transformer is a new transformer that replaced the old T3 transformer. The new T3 transformer performs the same function as the old T3 transformer, which was the last of the big energy transformers that was still in its original form from the time of construction of the power plant.

The existing high-voltage transformers, high-voltage connections and high-voltage NEK switchyard are also part of NEK. The switchyard is connected to the 400/110 kV Krško substation, which is not part of NEK.

The new T3 110/6.3/6.3 kV transformer at NEK is an electromagnetic facility that operates at a nominal voltage higher than 1 kV. Accordingly, is it defined as a source of electromagnetic radiation under point 2 of Article 2 of the Decree.

The basic frequency of the electromagnetic radiation which the T3 110/6.3/6.3 kV transformer emits into the natural and living environment is 50 Hz. This classifies it as a low-frequency radiation source.
Under point 7 of Article 2 of the Decree, the area within the perimeter has been defined as a controlled area, meaning that the provisions of the Decree do not apply to it. The area in which electromagnetic radiation is considered is therefore the area outside the controlled area within a belt 40 m from the external perimeter of NEK. There is a belt between the external perimeter of NEK and the 400/110 kV Krško substation perimeter to which access may only be gained from the neighbouring orchard. However, this area is patrolled by the NEK security service. Unauthorised access to this belt is prohibited, which is why it was also defined as a controlled area.

The levels of protection against electromagnetic radiation have been defined on the basis of the detailed designated use of space as set out in Krško's Municipal Spatial Plan (OPN). Only areas defined as Area II (in which Level II protection against electromagnetic radiation applies) are found in the 40-metre belt in relation to the designated use of space in the OPN. There are no buildings with Level I protection against electromagnetic radiation in the area covered.

The maximum measured effective values of electric field strength (E) and magnetic flux density (B), which result from the overall pollution of the area from the operation of all sources of electromagnetic radiation (110/6.3/6.3 kV T3 energy transformer with T3 voltage regulator at NEK, the existing high-voltage transformers and connections and the NEK high-voltage switchyard, the 400/110 kV Krško substation and the existing DV and KBV connections), and a mathematical model of the calculated effective values of E and B at NEK within the context of the modification of 1095-XR-L, which includes the replacement of the T3 transformer, the T3 voltage regulator and the 400/110 kV Krško substation (own emissions excluding connections), were used to evaluate the electromagnetic radiation pollution in the environment. The maximum measured and calculated effective values of electric field strength (E) and magnetic flux density (B) are collected in the tables below.

Table 102: Maximum measured and calculated electric field values (E) (source: EIMV. /194/)

No	Area of measurements		Maximum measured value E [V/m], (k = 2)	Maximum calculated value E [V/m] (own emissions excluding connections)
1.	At the northern perimeter outside the NEK area	Direction 1	1,611.0 ± 64.4	136.0
		Direction 3	1,602.0 ± 64.1	114.0
2.	At the western perimeter outside the NEK area	Direction 1	53.3 ± 2.1	95.0
		Direction 3	47.7 ± 1.9	51.0
3.	At the eastern perimeter outside the NEK area	Direction 1	*	4.0
		Direction 3	*	2.0

* below the lower threshold of the instrument's measurement range.

Table 103: Maximum measured and calculated magnetic field values (B) (source: EIMV. /194/)

No	Area of measurements		Maximum measured value B [μT], (k = 2)	Maximum calculated value B [μT] (own emissions excluding connections)
1.	At the northern perimeter outside the NEK area	Direction 1	5.850 ± 0.541	3.266
		Direction 3	5.730 ± 0.529	2.804
2.	At the western perimeter outside the NEK area	Direction 1	0.184 ± 0.017	0.541
		Direction 3	0.121 ± 0.011	0.484
3.	At the eastern perimeter outside the NEK area	Direction 1	0.066 ± 0.006	0.145
		Direction 3	*	0.111

* below the lower threshold of the instrument's measurement range.

The maximum calculated value of the T3 transformer's own uninterrupted electric field strength (60 MVA, 110/6.3/6.3 kV) in the area under consideration (outside the enclosed area of NEK) is less than 0.1 kV/m, while the maximum calculated magnetic flux is less than 25 μT.

The evaluation performed of the low-frequency electromagnetic radiation pollution caused by NEK in normal operations as part of the modification of the 1095-XR-L, which includes the replacement of the T3 transformer and voltage regulator, shows the following analysed effective values:

- the electric field strength (E) of the T3 energy transformer (60 MVA, 110/6.3/6.3 kV), which was replaced as part of the modification of the 1095-XR-L, is lower than the permitted limit value of 10,000 V/m applying to an area of Level II protection against electromagnetic radiation;
- the magnetic flux density (B) of the T3 energy transformer (60 MVA, 110/6.3/6.3 kV), which was replaced as part of the modification of the 1095-XR-L, is lower than the permitted limit value of 100 μT applying to an area of Level II protection against electromagnetic radiation;
- the electric field strength (E) of NEK as part of the modification of the 1095-XR-L, which includes the replacement of the T3 transformer, is lower than the permitted limit value of 10,000 V/m applying to an area of Level II protection against electromagnetic radiation;
- the magnetic flux density (B) of NEK as part of the modification of the 1095-XR-L, which includes the replacement of the T3 transformer, is lower than the permitted limit value of 100 μT applying to an area of Level II protection against electromagnetic radiation;
- the overall electrical field strength (E) of all significant sources of electromagnetic radiation is lower than the permitted limit value of 10,000 V/m applying to an area of Level II protection against electromagnetic radiation, and the magnetic flux density (B) of all significant sources of electromagnetic radiation is lower than the permitted limit value of 100 μT applying to an area of Level II protection against electromagnetic radiation.

The evaluation performed of the low-frequency electromagnetic radiation pollution caused by NEK in normal operations as part of the modification of the 1095-XR-L, which includes the replacement of the T3 transformer and voltage regulator, shows that, set against the limit values referred to in the Decree, the natural and living environment is not excessively polluted with low-frequency electromagnetic radiation pollution.

4.4.15 Light pollution

As NEK's external lighting is an integral part of the technical systems for ensuring physical protection, NEK is not bound by the Decree on limit values for light pollution (Official Gazette of RS, Nos. 81/07, 109/07, 62/10, 46/13), but by the Rules on the physical protection of nuclear facilities and nuclear and radioactive material, and the transport of nuclear material (Official Gazette of RS, Nos. 17/13, 76/17 [ZVISJV-1]).

Nevertheless, NEK continuously strives to comply with requirements for reducing light pollution by, for example:

- using the appropriate, horizontally mounted lights with level glass;
- not turning lights upwards to a greater degree more than is foreseen in the project to achieve appropriate illumination levels; and
- installing modern energy-efficient solutions (LEDs, etc.) when lights are being replaced.

Generally speaking, several different types of light have been installed at NEK. These can roughly be divided in terms of their purpose:

- safety lighting at the double perimeter on 12-metre-high pillars with two 250 W VT sodium lamps (yellow light). Total is approximately 60 pillars x 2 lamps = 120 lamps;
- general street lighting (white light);
- reflector pillars: 5 pillars YRD + 4 pillars in SY with a larger number of reflectors VTNA 400W (YRD) and LED (SY);
- emergency lighting 80 W: roadside for emergency evacuation approximately 18 (YRD) + 9 (SY).

A lighting plan showing the number of lamps and their power can be found in **Annex 5**.

4.4.16 Character and features of the landscape

The development location is located on Krško Polje, which is an extensive flat area on alluvial deposits, gravel, clay and loam of the lower courses of the Krka and Sava rivers. It is bounded to the north by the Krško Hills and to the south by the Gorjanci range and the hills of the Podgorje region. The area is typified by a very flat relief. Other features include the forest of Krakovski Gozd, which separates Šentjernejsko Polje in the east from the main part of the Krško Polje/Brežiško Polje area. The area's basic east–west orientation is determined by the course of the Sava. Old roads mainly run along the foothills of the surrounding elevations, while the motorway runs across the basin. An ancient Roman road ran through the area in the direction of Sisak /66/.

The development location is located in the Krško Polje/Brežiško Polje landscape unit (a sub-unit of the Posavje portion of the plain), which in turn is one of the landscapes of the southern sub-Pannonian region. The key characteristics of this landscape unit are:

- plain, flat forest areas, Sava;
- open farmland, clustered settlement;
- little in the way of panoramic views, considerable openness of the plain with hills in the background;
- original forest, loss of natural characteristics;
- old towns, nuclear power plant, military airfield /66/.

The appearance of Krško Polje, or the area along the Sava between Krško and Brežice, underwent a major change with the regulation of the Sava more than 100 years ago. Regulation of the river significantly reduced landscape diversity, since numerous meanders and branches of the Sava were filled in, and the river was directed into a newly regulated channel. The biggest changes in the landscape picture in lowland areas have been caused by hydro-amelioration and regulation measures affecting all major watercourses and their tributaries. Scattered urbanisation is increasing in hill areas while in vineyard areas excessive construction of buildings (so-called vineyard cottages) is occurring and changing spatial structure relations in the area. The unit, in particular its lowland portion, is also under pressure from various infrastructure corridors. NEK is very visible because of its size and position on the plain, and has brought with it the construction of high-voltage transmission lines. Other changes in the area have been caused by the new route of the Ljubljana–Obrežje motorway.

The area around NEK is defined by flat relief on gravelly terrain at a height above sea level ranging from 150 to 155 m. To the north, the flat area continues towards Libna Hill (355 m a.s.l.). The channel of the Sava runs along the southern edge of the complex. Located in the immediate vicinity of the area are vestiges of the geomorphic action of the Sava, which in the past flowed in a branched channel. Besides meadows and riparian vegetation with individual trees, groups of trees and groups of shrubs, the wider area is also characterised by flatland forests.

Existing land use in the area surrounding NEK consists of intensive agriculture, with large field complexes. An extensive commercial orchard is located north, west and east of NEK. Large connected areas with intensive (monoculture) agriculture create a large-scale landscape pattern. A landscape pattern of extensive agriculture appears at the transition into the hilly area. This pattern is characterised by alternating use of fields, meadows, small orchards and vineyards. The narrower area is uninhabited. Across the wider area, small clustered settlements dominate, while there is also a pattern of dispersed settlement outside settlement centres. The two closest settlements are Spodnja Libna and Spodnji Stari Grad.

The Posavje (Sava Valley) part of the Krško Polje/Brežiško Polje has a rating of 3–4 because of the relatively high degree of loss of natural characteristics and urbanisation (intensive agriculture, poplar plantations, gravel pits, nuclear power plant, transmission lines, roads) /74/. The only areas of greater landscape diversity are in the vicinity of some oxbow lakes of the Sava. The area of the site under consideration is not classified among outstanding landscapes or among distinctive landscapes of national importance. The symbolic value of its natural and cultural elements is of purely local importance. NEK has become an important element of the identity of the area in people's minds.

Guidelines for the protection and regulation of the landscape of the Krško Polje/Brežiško Polje area include:
– the conservation of riparian landscapes and wetlands;
– the conservation of lowland wet forests;
– the conservation of traditional settlement patterns and architecture;
– sustainable management in flatland forests;
– revitalisation of watercourses that have lost natural characteristics.

None of the above guidelines relates directly to landscape elements in the strict area of the development.

4.4.17 Cultural heritage in the area of impact of the activity

There are no cultural heritage structures or areas within the area of impact of the activity.

The nearest cultural heritage structures and areas in the vicinity of the activity are shown in Section 4.1.7.2 and, in graphical form, in Section 10.2.

The entire plateau of the nuclear power plant complex stands on an artificial embankment. Any archaeological remains were therefore destroyed during construction four decades ago.

Archaeological research in the surrounding area of NEK (wider area of the Vrbina LILW repository) did not uncover any human settlements. Moreover, the past shifting of the Sava channel along the flood plain indicates that the area was not settled on account of unfavourable conditions. The former village of Vrbina, which was finally abandoned a decade ago on account of its proximity to the power plant, arose on higher-lying terrain and at a greater distance from the current channel of the Sava. We can conclude from this that the likelihood of the presence of archaeological remains at the location was already extremely low when construction started.

The power plant's impact on the surrounding cultural heritage is limited to an aesthetic one, although its distance makes even that impact negligible.

Figure 74: NEK plateau during construction (source: /193/)

Figure 75: Excavation on the NEK plateau during construction (source: /193/)

4.5 BASELINE AND OUTLINE OF LIKELY FURTHER DEVELOPMENT WITHOUT LIFETIME EXTENSION (ZERO VARIANT)

Existing operations at NEK constitute the baseline at the site of the activity (lifetime extension), with plans for a 20-year extension to the plant's operational lifetime (from 2023 to 2043), which will not affect production capacity. This extension is not expected to give rise to any major changes in terms of environmental impact in comparison with the existing situation.

The environmental impacts resulting from the extension of the operational lifetime are set out in detail in Section 5 (Possible impacts of the activity on the environment).

If the planned change (operational lifetime extension) is not made, it will not be possible to continue the activity. This means that operations at NEK will cease (zero variant). The existing power plant with its existing environmental impacts, which are set out in this report, therefore constitutes the "zero variant" in the area in question.

This would be followed by activities to terminate the activity (see Section 2.18) and the decommissioning of the nuclear facility. The decommissioning of a nuclear facility includes all the steps taken to bring a facility into a state in which it no longer needs to be monitored according to the provisions of nuclear and radiation safety regulations, and when the facility can make the transition to unrestricted use. Decommissioning includes procedures of decontamination, demolition and removal of structures, the dismantling of systems and appliances, and the removal of radioactive waste and spent fuel from the facility.[31]

[31] Taken from the Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1 (Official Gazette of RS, Nos. 76/17 and 26/19)), Article 3, paragraph 1, point 85.

5. POSSIBLE IMPACTS OF THE ACTIVITY ON THE ENVIRONMENT

5.1 SELECTION OF EVALUATION APPROACH

The assessment of the impacts of the activity (lifetime extension or LTE) on the environment or parts thereof and the consequences of that activity is based on the objectives and principles of environmental protection, nature conservation, the protection of natural resources and the protection of cultural heritage, taking into account regulations that lay down emission limit values, the rate of reducing environmental pollution and associated measures, waste management codes and other codes of conduct for the prevention and mitigation of the burden on the environment, as well as other prescribed values and practices relating to the permissible burden on the environment or the permissible scope of changes thereto.

Impacts are described and assessed or evaluated[32] for the period of operation and for the case of activity termination. In the case of termination, any removal or reconstruction of buildings is not taken into account; this will be subject to other administrative proceedings applicable to the construction of buildings and environmental protection (see Section 11.1.3 – Warnings).

Plans for the extension of the operational lifetime do not include the construction of new structures or facilities that would change the physical characteristics of NEK.

Impact assessment:

- the impact of the activity relates to the direct and indirect impacts of the intended activity (extension of the operational lifetime from 40 to 60 years, i.e. from 2023 to 2043).
- the overall impact takes into account not only the intended activity but also the connected activity (Vrbina LILW Repository)

The categories for assessing impact are set out in Article 2 of the Decree on the method of drafting and on the content of the report on the effects of planned activities affecting the environment:

Impact categories	Explanation
(5)	no impact or impact is positive
(4)	impact is not significant
(3)	impact is not significant due to the implementation of mitigation measures
(2)	impact is significant
(1)	impact is devastating

A quantitative scale is used to assess the burdens of certain environmental factors and the acceptability of those burdens. This does not therefore involve the direct conversion of quantitative changes in factors into numerical assessments, but rather the appropriate interpretation of expected changes with respect to the state of the environment before the activity and the vulnerability of the environment at the site of LTE and in the wider area. Standards and norms (e.g. limit values) are prescribed for certain factors, while the impact assessment is the subject of the expert judgement of an evaluator for other factors.

One of the advantages of using a quantitative scale is the fact that it facilitates the identification of the factors on which the activity will have the greatest impact or that will change the most as the result of the activity.

[32] Because the extension of NEK's operation from 40 to 60 years does not envisage the construction of buildings, impacts during construction are not described or assessed.

The assessment takes into account the nature and type of impacts, the probability, duration or frequency of their occurrence, the extent of an impact and the potential synergistic effects of several types of impacts.

The assessment is carried out on the assumption that all legally prescribed measures, those planned in the scope of the project and additional measures from this report to prevent, mitigate or rectify the negative impacts of the activity on the environment and human health will be taken into account in full.

5.2 IMPACTS ON SOIL

5.2.1 Operation

The extension of NEK's operational lifetime will not require any construction work, so there will also be no interventions in or on the soil. The manner in which wastewater is discharged will not change with the extension of NEK's operational lifetime. There will be no emission of pollutants into the soil during operation, as all wastewater is already being disposed of properly (see Section 2.10.3).

All waste, including radioactive waste as well as hazardous substances on the NEK site are appropriately stored and do not present a risk of soil contamination.

The impact of the activity and overall impact on the quality and use of soil in the area of the activity during operation are evaluated as **(5)** – no impact.

5.2.2 Termination of the activity

There will be no emissions of pollutants into or other impacts on the soil if the plant ceases operation (see Section 2.18). The status in terms of soil will remain the same as during operation.

The impact of the activity and overall impact on the quality and use of soil if the activity is terminated are evaluated as **(5)** – no impact.

5.3 IMPACTS ON WATER AND FLOOD SAFETY

5.3.1 Impacts on water

5.3.1.1 Operation

Surface water
As presented in Section 2.10.3, the majority of wastewater from NEK is accounted for by cooling water, which is primarily discharged via a flow cooling system (outlet V7-7), while the cooling tower system (outlet V7-10) is used when the flow of the Sava is unfavourable with respect to the heat load on the river. A portion of cooling water is used as a safety supply (outlet V1-1). The proportion of total cooling water accounted for by cooling water in the cooling tower system is less than 5%.

Following a review of the operational monitoring of wastewater in the 2015–2020 period, we can conclude that the results of analyses rarely exceeded prescribed limit values, most frequently for the parameters of undissolved substances and suspended substances. Limits were exceeded at the outlet of the main cooling water system, the outlet of the cooling towers and at the outlet of safety water. The power plant does not release substances into these systems which could be the cause of exceeding limit values for undissolved substances and suspended substances. Namely, in some years individual readings indicated exceeded emission limits for insoluble substances, sediments and chemical oxygen demand (COD), which was not caused by power plant operation but by the general quality of the Sava (see Section 4.4.4.1).

The fact that the composition of water at release points depends on the composition of the river water is also shown by the monitoring of COD and BOD_5 (biochemical oxygen demand) values at three measuring points in and around the NEK site (Figure 76), where it is evident that the water contains a certain composition of these indicators before it enters the power plant. In accordance with the Decree on surface water status (Official Gazette of RS Nos. 14/09, 98/10, 96/13 and 24/16), the BOD_5 limit value is 5.4 mg/l for rivers with a good ecological status, while a COD value of 20.9 mg/l indicates a very good status. The concentration of these indicators in emissions from NEK generally meets the criteria for good river status.

In a period of 6 years, discharges from the water preparation tank (outlet V7-11) occasionally exceeded limit values; once for COD (in 2015), once for BOD_5 (in 2017) and twice for toxicity (in 2016 and 2017), but the quantities of those wastewaters are very small and amount to 4,000 m^3 annually (the maximum permitted quantity is 6,000 m^3/year).

It was determined that NEK does not have a significant negative impact on water, more specifically the Sava Krško–Vrbina water body into which wastewater from the power plant is discharged. This is also evident from the good status of the aforementioned water body, as described in Section 4.1.4. The assessment of the chemical status of water bodies in the period 2014-2019, which was used for the Management Plan 2022-2027 /282/, shows that the chemical status of the water body is good for the water matrix, poor for the biota matrix and poor for the matrices water and biota together. The 'poor' assessments are due to parameters which are not related to NEK emissions; they result from general pollution, namely with mercury and diphenyl ethers (BDE) (see Section 4.1.4). The ecological status of the water body for individual elements of assessment is good, and for specific pollutants it is very good. What definitely contributed to the good status of that water body is the construction of municipal wastewater treatment plants, as well as wastewater treatment in NEK's own plants and at the municipal treatment plants of industrial facilities in the area (see Section 4.4.4.1).

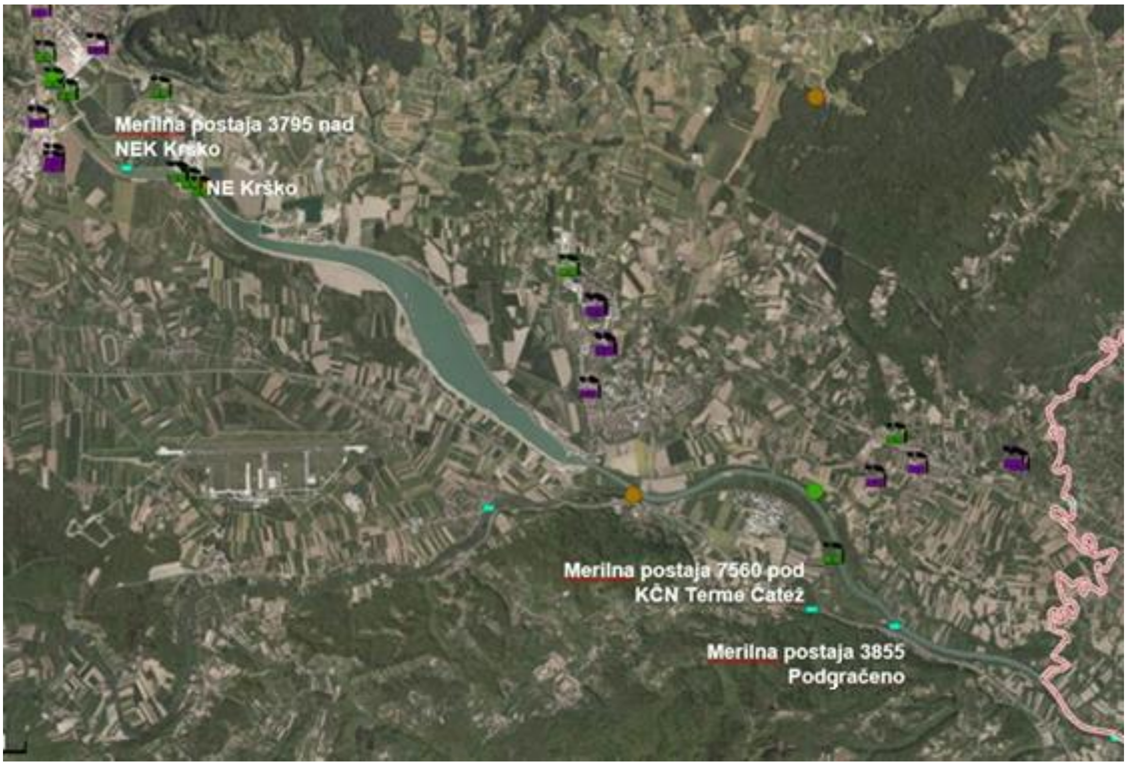

Figure 76: Locations of measuring points for surface water quality monitoring (source: /60/)

Merilna postaja 3795 nad NEK Krško	Measuring point 3795 upstream of NEK
NE Krško	NPP Krško
Merilna postaja 7560 pod KČN Terme Čatež	Measuring point 7560 downstream of the Terme Čatež treatment plant
Merilna postaja 3855 Podgračeno	Measuring point 3855 – Podgračeno

NEK is authorised to use biocides to periodically clean the condensers, but they have not actually been used for many years. The system has been successfully cleaned mechanically by means of the Taprogge system of recycling rubber balls.

As regards the operation of the cooling system, NEK implements measures that were evaluated in accordance with BREF/BAT guidelines for cooling systems.

The extension NEK's operational lifetime will not result in changes in the discharge of wastewater from the current status. There is, however, the possibility of an increase in the proportion of cooling water discharged from the cooling tower system due to climate change. Given the current status of the water body into which wastewater from NEK is discharged, we assess **that the impact will be small, and that it will not change the good ecological and chemical status of water in that area**, as planned in the Management Plan 2022-2027.

Groundwater
The location of the activity in the far southern end (vicinity of the dam), and to a lesser degree in the Drnovo WPA (protection regime II) according to the Decree on the protection of groundwater in the area of protection zones of the Krško pumping station-water supply system (Official Gazette of the SRS, No. 12/85).

NEK's well on the right bank of the Sava cannot affect the quantity of water at the Brege pumping station, given that the formation of groundwater from the construction of the Brežice HPP reservoir increases the possibility of pumping water from the Brege well at the same installations.

NEK does not release harmful materials or polluted water directly into the ground, thereby potentially polluting the groundwater. The manner in which wastewater is discharged will not change with the extension of NEK's operational lifetime. There will be no emission of pollutants into the soil during operation, as all wastewater is already being disposed of properly (see Section 2.10.3). There will be no impact on the water protection area and stocks of potable water.

Substance emissions from NEK into the water are within the legally prescribed limits and will remain so during the power plant's extended operation.

The impact of the activity and overall impact on surface waters and groundwaters during operation are evaluated as **(3)** – impact is not significant, as a result of the mitigation measures implemented (taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation) to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

5.3.1.2 Termination of the activity

After the cessation of NEK's operations (see Section 2.18), the use of water will decrease significantly in comparison with regular operation. The spent fuel pool will still have to be cooled and so will a few other safety components – water will be abstracted and returned to the Sava at a rate of approximately 1.6 m^3/s.

Pumping from the well on the right bank of the Sava and from well BB2 will decrease. Wells that maintain the level of groundwater will remain operational.

Areas where wet works may be done will be equipped with drainage pits. Sampling will be carried out before the pits are emptied. If the limit values for discharge are exceeded, wastewater will be purified, solidified or processed in some other appropriate way, while the radioactively contaminated portion will be disposed of as LILW.

The impact of the activity and overall impact on surface waters and groundwater in the case the activity is terminated are evaluated as **(4)** – no significant impact.

5.3.2 Impacts on the thermal pollution of the Sava

5.3.2.1 Operation

The developer holds environmental permit no. 35441-103/2006-24 of 30 June 2010 regarding emissions into the water, which was amended in three points of the operational part (points 1.1, 1.4 and 1.8 of the environmental permit). Decision no. 35441-103/2006-33 of 4 June 2012 reaffirmed the environmental permit, which was later amended (point 1.5, Table 3) under decision no. 35444-11/2013-3 of 10 October 2013, /49/ according to which operational monitoring is also carried out.

It is evident from Section 4.1.4.1 and reports on the operational monitoring of wastewater from NEK that the latter does not represent an excessive heat load on the Sava.

The heat load on the river caused by NEK will remain at the current level following the extension of its operational lifetime to 2043. This means that its operation will continue to comply with the environmental permit, which dictates that:

- the limit emission share of transmitted heat is 1; and
- the temperature of the Sava does not exceed the river's natural temperature by more than 3°C when mixed with cooling water from NEK

In accordance with the environmental permit, NEK must not heat the Sava at the mixing point by more than 3°C. If this limit is approached, NEK begins to partially close the tertiary circuit and decrease the heat load on the Sava. This is achieved by gradual activation of the cooling towers. In the case that this is not enough, NEK reduces the reactor power as required.

Extending NEK's operation will not increase the heat load on the Sava. The impact shall remain at the present level.

The impact of the activity and overall impact on the thermal pollution of the Sava during operation are evaluated as **(3)** – impact is not significant, as a result of the mitigation measures implemented (taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation) to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

5.3.2.2 Termination of the activity

Following the cessation of NEK's operations (see Section 2.18), there will be no more need for cooling water for the technological process of electricity production. Thus, terminating LTE would result in significantly reduced thermal pollution of the Sava from NEK.

The impact of the activity and overall impact on the thermal pollution of the Sava if the activity is terminated are evaluated as **(4)** – no significant impact.

5.3.3 Impacts on flood safety

5.3.3.1 Operation

As is evident from previous sections (see Sections 2.7.8 and 4.1.9), extending NEK's operational lifetime will not have any impact on the flood safety of buildings. Protection against floods was already implemented during the planning of the power plant and through the construction of embankments 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.

The impact of the activity and overall impact on flood safety during operation are evaluated as **(5)** – no impact.

5.3.3.2 Termination of the activity

Cessation of operations at NEK (See Section 2.18) will have no impact on the flood safety of the nuclear facility and the area, because the structures and flood-protection embankments in that area will remain in the same condition as during operation.

The impact of the activity and overall impact on flood safety if the activity is terminated are evaluated as **(5)** – no impact.

5.4 IMPACTS ON THE AIR

5.4.1 Operation

NEK's existing production capacity will not change as the result of the extension of the power plant's operational lifetime, nor will the types and consumption of raw materials and the scope of road transport.

Emissions of SO_2, NO_x, CO and particulate matter from the auxiliary boilerhouse and diesel generator will be temporary and of a short-term nature. The extended operational lifetime will not result in any new releases causing emission of substances into the air. Existing outlets remain unchanged, and emissions of pollutants at those outlets will not increase.

An occasional source of emission to the air is one of the 8 MW boilers, which is fuelled by gas oil. There are two boilers with the same power in NEK's boilerhouse. The operation of one boiler supplies enough heat in periods when NEK is not in the start-up phase, and the second boiler is used as a back-up. As regards impact on air, only NOx emissions are relevant, whereas emissions of SOx and particles are negligible considering that liquid fuel of good quality is being used.

The AERMOD dispersion model is used to assess the effects of boiler operation on air pollution around NEK. AERMOD is run in what is called the screening mode, which gives the maximum hourly concentrations of polluting substances in the air. The calculation applies a matrix of meteorological data which simulates various combinations of meteorological conditions that affect the dispersion of pollution in the atmosphere (temperatures of air, wind and the dispersion characteristics of the atmosphere). The calculation is additionally conservative because it assumes full conversion of the emitted NOx to NO_2 in the atmosphere.

This conservative calculation shows that the closest populated area, ca. 900 metres to the northwest of NEK, can expect a maximum hourly concentration of NO_2 in the range of 40 micrograms/m^3, which is at the level of 20% limit value (200 micrograms/m^3). The level of NO_2 concentrations in the SIC zone /261/ in the background is between the upper and lower assessment thresholds, i.e. between 50% and 70% of the limit value for hourly concentrations. As the boilerhouse operates less than 2% of the time in the year (150 hours = 1.7%), the impact on mean yearly concentrations of NO_2 is negligible. The impact of emissions from the auxiliary boilerhouse is of short duration and occasional; no exceeded limits are to be expected even during the most adverse meteorological conditions.

Atmospheric releases of radioactive material are discussed in Section 4.4.7.2, which includes a calculation of doses (impact) relative to the limit. In 2020, the assessed dose from atmospheric releases in the village of Spodnji Stari Grad was 0.0066 μSv. The limit is 50 μSv, notably from all contributions and not just from atmospheric releases. It is evident from the tables that contributions to the annual effective dose for an adult inhabitant are 0.0079 μSv at NEK's perimeter fence and 0.0066 μSv in Spodnji Stari Grad.

The production of electricity by the nuclear power plant does not generate emissions of SO_2, NO_x or particulate matter (PM, PM_{10} and $PM_{2.5}$). The aforementioned pollutants are otherwise hazardous to health and the ecosystem, in particular nitrogen oxides and particulate matter, while sulphur dioxide is the main cause of acidification with harmful impacts on forest ecosystems and material assets. Nitrogen dioxide is also a precursor for the formation of ground-level ozone, which is harmful to health. Table 104 below presents an estimate of the amount of emissions that have been avoided due to the operation of NEK. The calculation applied data from the emission counts of Slovenian thermal power plants and their production (combination of fuels).

Table 104: SO_2 and NO_x emissions avoided due to the operation of NEK (source: /153/, /190/, /241/)

	2010	2015		2018	2019
National emissions combined, kt/year					
NOx	48.00	34.90		32.20	29.2
SO_2	10.40	5.46		4.79	4.3
Emissions from the electricity and heat production sector					
NOx	10.8	4.5		4.7	3.5
SO_2	6.1	1.9		2.1	1.6
Net production, TWh/year					
Thermal power plants	5.38	4.50		4.87	4.76
NEK	5.38	5.37		5.49	5.53
Emissions avoided due to NEK, kt/year					
NOx	10.8	5.4		5.3	4.1
SO_2	6.13	2.30		2.35	1.85
Avoided emissions, % of national emission					
NOx	23	15		16	14
SO_2	59	42		49	43

It is evident from Table 104above that avoided emissions account for 16% and 49% of national NO_x and SO_2 emissions respectively. Those values were even higher in 2010. It is notable that when the power plant began operating, avoided SO_2 emissions were more than 140 kt/year, which was a significant contribution, as Europe had a major deforestation problem due to acid rain at the time.

By extending its operational lifetime, NEK contributes to the fulfilment of Slovenia's international obligations regarding the reduction of emissions of SO_2, NO_x and particulate matter in the scope of LRTAP/UNECE commitments from the directive on national emission ceilings (NEC Directive; see table below). Assuming the same annual electricity production of a modern, coal-fired power plant in the amount of 6 TWh (in accordance with the BAT conclusions for LCPs from the Industrial Emissions Directive (IED)), the emissions from a coal-fired thermal power plant with a CO_2 capture device (PC + CCS) would amount to 2.3 kt of SO_2/year, 3.7 kt of NO_x/year and 0.17 kt of particulate matter/year, while the emissions of a high-capacity gas-fired power plant with a CO_2 capture device (CCGT + CCS) would be around 1.9 kt of NO_x/year. NEK's operational lifetime extension prevents the generation of new emissions, which has a positive effect on the quality of air and contributes towards the target reductions of SO_2, NOx in $PM_{2.5}$ emissions from Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants (OJ L No. 309 of 27/11/2001, p. 22; hereinafter: the old NEC Directive). After 2020, those commitments derive from the new NEC Directive, which was transposed into Slovenian law under the Decree on national emission ceilings for atmospheric pollutants (Official Gazette of RS No. 48/18).

Based on the new NEC Directive, Slovenia must significantly reduce its emissions by 2030 as follows: SO_2 emissions by 92%, NO_x emissions by 65% and $PM_{2.5}$ emissions by 60% relative to 2005. The most important source of SO_2 emissions is the production of electricity, followed by industrial processes, while transport contributes the most to NO_x emissions. Small heating plants are the most important source of $PM_{2.5}$ emissions /168/.

Slovenia's national commitments in terms of reducing the emission of atmospheric pollutants for the period 2010–2019 derive from Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants (OJ L No. 309 of 27/11/2001, p. 22; hereinafter: the old NEC Directive). After 2020, those commitments derive from the new NEC Directive, which was transposed into Slovenian law under the Decree on national emission ceilings for atmospheric pollutants (Official Gazette of RS No. 48/18). The tables below (Table 105 and Table 106) illustrate national emissions and targets /168/.

Table 105: National emissions (source: /190/)

	SO_2	NOx	$PM_{2.5}$
National emissions in 2018	4.8 kt	32.2 kt	11.3 kt
National emissions in 2019	4.3 kt	29.2 kt	10.6 kt

Table 106: National emission reduction targets (source: /168/)

National commitments to reduce emissions relative to the base year of 2005*	SO_2	NOx	$PM_{2.5}$
2010–2019	27 kt (-23%)	45 kt (-18%)	
2020–2029	-63%	-39%	-25%
From 2030	-92%	-65%	-60%

*Reference emissions for 2005 in accordance with EU and UNECE guidelines from 2019 on.

It is evident from the data provided above that NEK as a large source of electricity has very low emissions of SO_2, NO_x and $PM_{2,5}$ (0 emission from the technological process of electricity production), which certainly contributes to achieving NEC Directive targets.

The impact of the activity and the overall impact on air quality during operation are evaluated as **(4)** – impact is not significant, primarily on account of existing emissions of radioactive material into the air, which do not reach annual limits, but are actually well below those limits.

5.4.2 Termination of the activity

Following the cessation of NEK's operations (see Section 2.18), pollutants will temporarily be released into the air from the auxiliary boiler room, which will be used for heating premises and for safety purposes (to prevent freezing). The total quantity of fuel used will be reduced as heat will no longer be needed to generate supplementary steam. Temporary emissions will occur as a result of the testing of the diesel generators, which will remain on site as an emergency source of electricity.

The impact of the activity and overall impact on air quality if the activity is terminated are evaluated as **(4)** – impact is not significant.

5.5 IMPACTS ON THE CLIMATE, INCLUDING GREENHOUSE GAS EMISSIONS

5.5.1 Operation

Greenhouse gas emissions accumulate in the atmosphere, resulting in global warming and rising atmospheric temperatures. Nuclear power plants do not generate greenhouse gas emissions in the production of electricity; emissions are generated by on-site ancillary activities: three diesel generators for the emergency supply of electricity, auxiliary steam boilers, on-site transport and SF6 greenhouse gases (a very effective means of electrical insulation at transformer stations). Following the extension of its operational lifetime, the power plant will generate approximately the same annual emissions as it currently generates. Total greenhouse gas emission for the period 2024 to 2043 could amount to around 23.46 kt of CO_2-eq. That amount is negligible compared with national emissions, as it represents 0.13% of total national emissions in 2018 and 0.28% of the total emissions of the electricity and heat production sector.

Extending NEK's operational lifetime will also have a positive impact by contributing to the reduction of greenhouse gas emissions relative to other technologies used to produce electricity. An explanation of that positive effect is given below.

Global context

Nuclear power plants do not generate greenhouse gas emissions during operation, while emissions associated with the entire production cycle are very low, at the level of renewable energy sources. Electricity is produced today by nuclear power plants in 30 countries, and the IAEA estimates that 2 Gt of emissions are avoided annually based on that production, which is close to 3.7% of global greenhouse gas emissions /169/. Nuclear power plants generate around 10% of all electricity, which translates to 30% of low-carbon electricity. NEK supplied 18.1% of Slovenia's electricity in 2019 (50% of production) /243/, which translates to 35.9% of low-carbon energy during that year.

In the scope of the Paris Agreement, the UNFCCC (2015) set the objective of maintaining atmospheric temperature at 2°C above the pre-industrial level or, if feasible, at 1.5°C above that level. Analyses indicate that the more ambitious target of a 1.5°C rise in temperature is urgent, but the achievement of that target is becoming questionable. Global emissions must be reduced by 45% relative to 2010 by 2030, while climate neutrality must be achieved by 2050 /68//170/. Certain regions, including Slovenia, are recording temperatures that are close to the aforementioned limit, and it is unlikely that temperatures will remain within the target range. The target of 1.5°C is a major challenge for the electricity production sector, as electricity is a substitute for all other forms of energy and is also used in the production of hydrogen and other fuels. A report on potential scenarios for achieving the target of 1.5°C includes four scenarios that achieve close to 90% coverage of the need for low-carbon production. In the IPCC 1.5°C scenarios, low-carbon sources include: renewable energy sources, nuclear energy and fossil fuel power plants that use carbon capture and storage (CCS) technology. All four IPCC 1.5°C scenarios include an increase of nuclear energy capacity of 100% by 2050 relative to 2020 /68/. Figure 77 illustrates the change in capacities, expressed as the average for the four IPCC 1.5°C scenarios /68/.

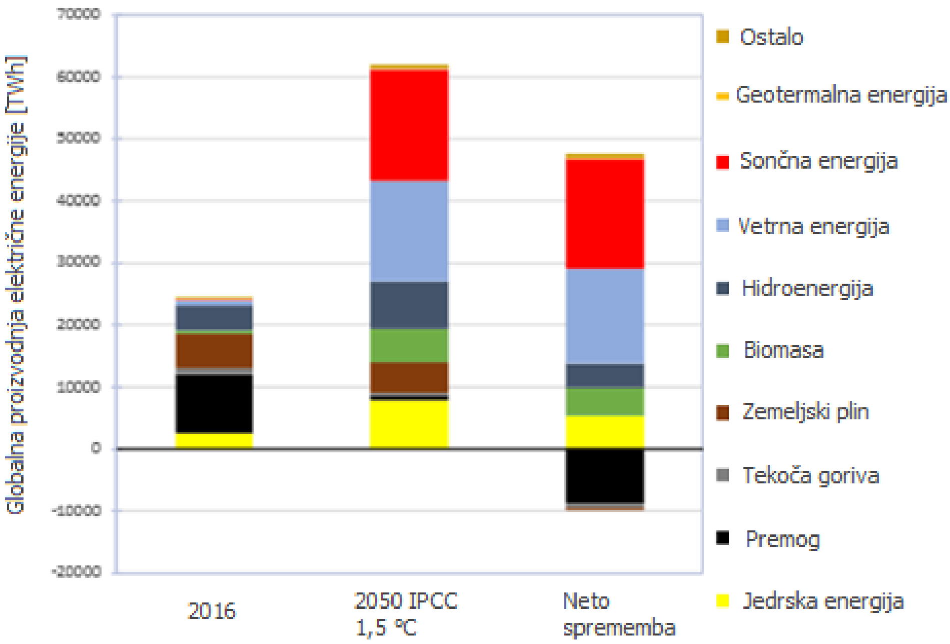

Figure 77: Global electricity production, 2016 and 2050; average of IPCC 1.5 C° scenarios (source:

/68/)

Globalna proizvodnja električne energije [TWh]	Global electricity production [TWh]
Ostalo	Other
Geotermalna energija	Geothermal energy
Sončna energija	Solar energy
Vetrna energija	Wind power
Hidroenergija	Hydropower
Biomasa	Biomass
Zemeljski plin	Natural gas
Tekoča goriva	Liquid fuels
Premog	Coal
Jedrska energija	Nuclear energy
2050 IPCC 1,5 °C	2050 IPCC 1.5°C
Neto sprememba	Net change

EU context

The 2030 climate and energy framework /262/ sets out EU-wide targets by 2030: at least 40% cuts in GHG emissions relative to 1990, at least 32% share for energy from renewable sources and at least 32.5% improvement in energy efficiency. The 2020 European Green Deal /263/ and the 2021 European Climate Law /264/ laid down the long-term objective of achieving climate neutrality by 2050. In accordance with this long-term objective, the European Commission is opening a debate about increasing the ambitions for emission cuts by 2030, which aims to reduce emissions by 55% by 2030 relative to 1990 (Fit to 55% package, COM (2020) 562). The 2030 target is in compliance with the goal of the Paris Agreement, which is to maintain the global rise in temperature well below 2°C, and strives to keep it at 1.5°C.

The EU Energy Charter allows Member States to decide on their own energy strategies, including the role of nuclear energy, which accounted for 26% of production in the EU in 2016. Countries that intend to maintain existing and build new nuclear power plants search for reasons in energy security, competitiveness and clean energy. There were 126 reactors operating in 14 EU countries at the end of 2017. New projects are planned in ten countries. Certain countries have set the goal of freezing the share of nuclear energy (France), while others have decided to shut down nuclear reactors (Germany and Belgium).

The EU's long-term strategic vision to achieve a climate neutral economy, 'A Clean Planet for All', involves eight scenarios /172/. The share of nuclear energy in those scenarios is 12–15% in 2050, 18% in 2030 and 26% in 2015. Figure 78 illustrates the shares of individual energy sources until 2050 for the eight scenarios set out in A Clean Planet for All.

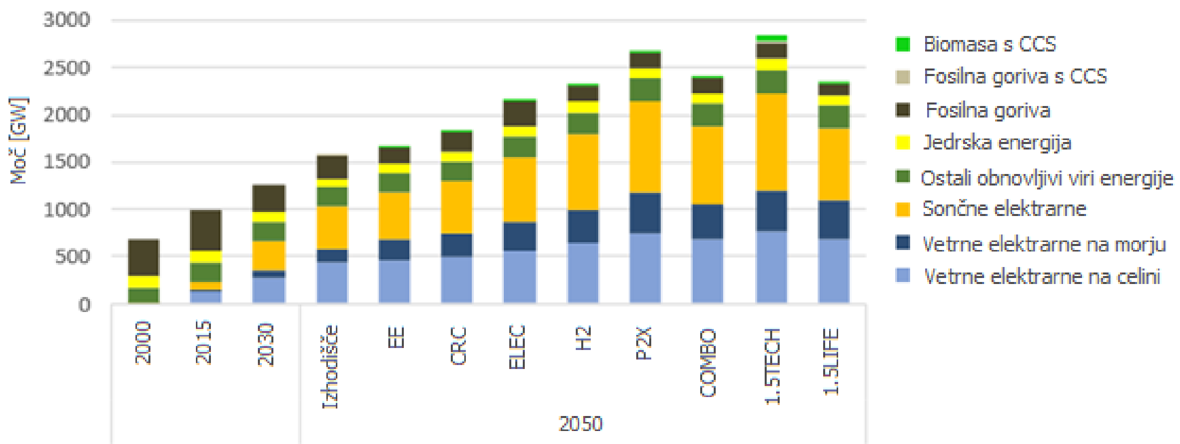

Figure 78: Shares of individual technologies in the production of electricity in accordance with the EU's long-term strategic vision of a climate neutral economy by 2050 (source: /172/

Moč [GW]	Capacity [GW]
Biomasa s CCS	Biomass using CCS

Fosilna goriva s CCS	Fossil fuels using CCS
Fosilna goriva	Fossil fuels
Jedrska energija	Nuclear energy
Ostali obnovljivi viri energije	Other renewable energy sources
Sončne elektrarne	Solar power plants
Vetrne elektrarne na morju	Sea-based wind turbines
Vetrne elektrarne na celini	Land-based wind turbines
Izhodišče	Starting point

Republic of Slovenia

The Energy Concept of Slovenia, as set out in the Strategic Energy Policy until 2030 with a vision until 2050 /173/ and the integrated National Energy and Climate Plan of the Republic of Slovenia (NECP) /20/ envisage the extension of the operational lifetime of NEK until 2043, as well as the possibility of building a new nuclear power plant, regarding which a decision is to be made by 2027.

The environmental report in the NECP estimates the contribution of such a scenario, i.e. of a low-carbon energy source, expressed as the amount of CO_2 emissions from electricity production over the entire lifetime, including CO_2 emissions generated in the preparation of fuel and materials in the energy conversion device /175/. The carbon footprints of RES, nuclear energy, wind-solar power plants and biomass are compared. The environmental report assesses the impact of nuclear energy as positive.

As part of the key objective of decarbonisation (mitigation of and adaptation to climate change), the NECP set the following target until 2030:

- To reduce GHG emissions to the greatest extent possible by 2030, as determined for Slovenia in the Effort Sharing Regulation, i.e. by at least 20% relative to 2005, through the achievement of indicative sectoral targets: +12% for transport; -76% for general consumption; -1% for agriculture; -65% for waste management; -43% for industry; and **-34% for the energy sector** (this applies to the non-ETS sector, i.e. not participating in the emission trading system). Reaching targets via the ETS system is ensured by reducing the total emissions quota by 2.25% at a yearly level in the EU by 2030.

The NECP set the following objective in the scope of the objective of energy security and the internal energy market:

- To continue to exploit nuclear energy and maintain excellence in the operation of nuclear facilities in Slovenia.

The main areas of research in Slovenia in connection with energy will be renewable energy sources, energy efficiency in buildings, nuclear energy, electricity and the electric power grid and electrical systems, heat and heating systems.

The future development of the electricity production sector includes the following:

- by 2030, the sector will still rely primarily on the use of a combination of primary sources from Slovenia, in particular RES and nuclear energy, and the continued use of domestic coal – lignite; and
- maintaining excellence and the safe operation of nuclear facilities; the possibility of introducing new nuclear technologies will be studied and a decision made by 2027 regarding the potential construction of a new nuclear power plant.

After 2030, the development of large facilities for electricity production could take one of two paths: one path is the continued use of nuclear energy with the construction of a new block, while the other is the construction of larger gas-steam units in combination with the use of natural gas or synthetic natural gas. Other power plants that use natural gas as the primary source are also expected to gradually transition to synthetic natural gas. The coverage of consumption by production is assumed to be at the existing level, i.e. coverage from 2017 (Figure 79).

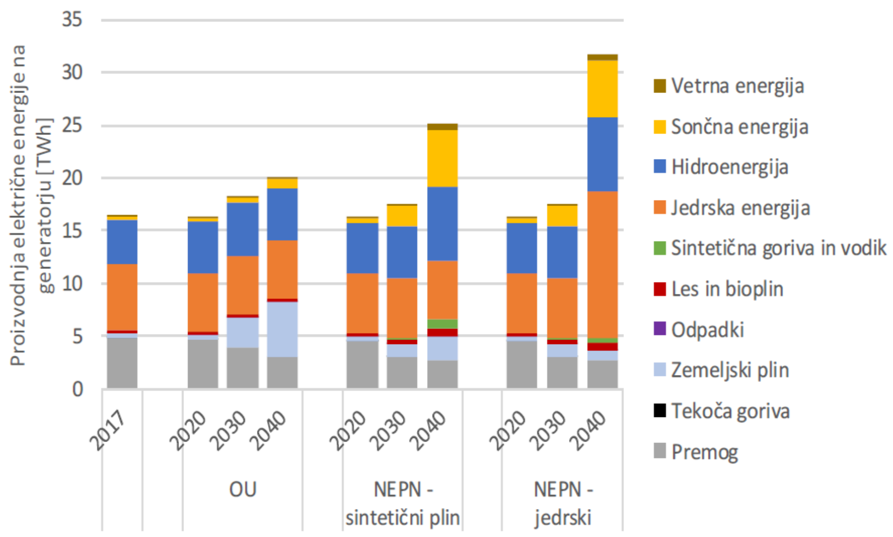

Figure 79: Electricity production according to NECP scenarios /20/

Proizvodnja električne energije na generatorju [TWh]	Electricity production by source [TWh]
OU	Existing measures
NEPN – sintetični plin	NECP – synthetic gas
NEPN – jedrski	NECP – nuclear
Vetrna energija	Wind power
Sončna energija	Solar energy
Hidroenergija	Hydropower
Jedrska energija	Nuclear energy
Sintetična goriva in vodik	Synthetic fuels and hydrogen
Les in bioplin	Wood and biogas
Odpadki	Waste
Zemeljski plin	Natural gas
Tekoča goriva	Liquid fuels
Premog	Coal

Through the scenarios set out in the NECP, a 36% cut in emissions will be achieved by 2030 relative to emissions in 2005 (Figure 80). The indicative scope of total GHG emissions in 2040 is between 8.6 million tCO_{2eq} in the nuclear scenario and 9 million tCO_{2eq} in the synthetic gas scenario, meaning a reduction of between 56% and 58% relative to 2005.

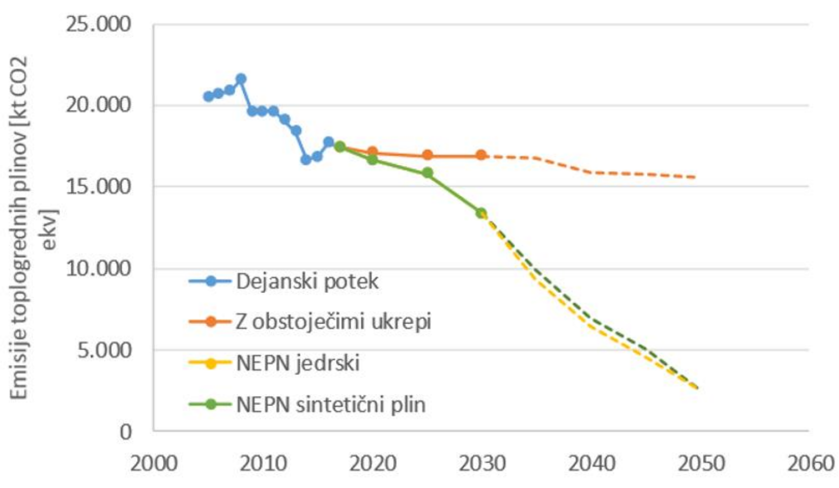

Figure 80: Projection of total GHG emissions for the NECP scenario and the scenario with existing

measures /20/

Emisije toplogrednih plinov [ktCO_2 ekv]	Greenhouse gas emissions [ktCO_{2eq}]
Dejanski potek	Actual situation
Z obstoječimi ukrepi	With existing measures
NEPN jedrski	NECP nuclear
NEPN sintetični plin	NECP synthetic gas

The NECP scenario illustrates the positive contribution of LTE to the reduction of greenhouse gas emissions (Figure 80). Despite an increase in production, greenhouse gas emissions will fall in the electricity production sector according to the NECP scenario on account of renewable energy sources and nuclear energy, and amount to between 6,363 and 6,825 ktCO_{2eq} in 2040. Emissions calculated for the entire cycle of electricity production (life cycle assessment or LCA) are presented below.

NECP and the Slovenian Long-Term Climate Strategy 2050 /255/ are aligned, which means that the same GHG emission projections are used for both documents. NECP targets until 2030 are aligned with the long-term objective of the strategy.

The new Fit to 55% regulatory proposal for the non-ETS sector in Slovenia is to reduce emissions by 27% by 2030 with respect to 2005, which is 7% more than the current national target. At the EU-level, the ETS sector aims for the target trend of a 4.2% annual decrease instead of 2.25% /273/.

The impact of LTE on climate change is assessed below in accordance with methodology from /266/, by analysing:

- absolute GHG emissions (i.e. yearly emissions, assessed for an average year of use, operation or LTE duration),
- baseline GHG emissions (i.e. emissions that would result in the absence of LTE), and
- relative emissions (i.e. the difference between absolute and baseline GHG emissions)

From the perspective of the territorial capture of emissions, three emission levels are to be distinguished:

Scope 1	emission from activity within LTE boundaries
Scope 2	Scope 1 emission, plus indirect emissions resulting from the generation of electricity or heat supplied to the activity
Scope 3	Scope 1 and 2 emission, plus indirect emissions from the activity which are required to enable LTE to function; this includes the full supply chain and chain of post-production activities (product transport from the site, waste removal). This approach is called Life Cycle Assessment.

Absolute emission from LTE, determined for Scope 1, amounts to 0.609 kt eq-CO_2/year. This emission is caused by the occasional operation of the auxiliary boiler room and three backup diesel generators, which are only in operation during testing. Emission caused by the technological process of electricity production is 0 tCO_2-eq. There are around ten transport vehicles on site, and their emissions are negligibly low.

The cooling devices, electrical equipment, heat pumps and fire protection systems all use F-gases. There is a total of 14 devices in the technological part of NEK and 24 devices in the non-technological part which contain cooling agents: fluorinated hydrocarbons and SF6 gas, which serves as a very efficient insulating medium in electrical devices (transformers and switchgear). This gas has very high global warming potential (GWP). The devices are potential sources of emissions resulting from any leaks from closed systems. It has been calculated, applying average leak factors at the national level, that emissions would amount to 0.501 ktCO_2-eq.

As a means of comparison and assessment of the scale of emission from LTE, the table below presents GHG emission for the Republic of Slovenia (Scope 1).

Table 107: Emissions of greenhouse gases in 1990 and 2019 (kt CO_2/year) (source: /152/)

Sector	1990	2019
Energy ind.	6,375	4,576
Manufacturing and construction	3,088	1,728
Transport	2,737	5,635
Other sectors	1,891	1,330
Fugitive emissions	512	378
Industry	1,393	1,261
Agriculture	1,855	1,718
Waste	699	435
Total emissions	18,580	17,065
LULUCF	-4,412	-101
Net emission	14,168	16,964

It is evident that LTE emissions are insignificantly small relative to national emissions. NEK accounts for 0.0035% of total national emission and 0.013% of emission from the energy industry sector. The national emission of F-gases in 2019 was 295 ktCO_2-eq, and potential emission from LTE accounts for 0.16% of national emission of F-gases.

Baseline emission is established for a few likely alternative solutions (also baselines or BL):

- New coal-fired TPP – a modern thermal power plant fuelled by coal dust and using CO_2 capture technology. The planned work characteristics and emission controls for SO_2, NOx, particles and Hg comply with the prescribed guidelines on the best available techniques (BREF-BAT conclusions). Emission 120 gCO-eq/KWh /176/
- New gas-fired TPP – a modern efficient combined cycle plant powered by natural gas with integrated CO_2 capture technology. In addition to low NOx burners, the plant has a DeNOx device for reducing NOx emission, compliant with BREF-BAT conclusions. Emission 57 gCO_2-eq/KWh /176/. A mixture of natural gas and hydrogen can also be used, and GHG emission falls in proportion to the share of hydrogen.
- Electricity import – import of electricity from European countries is envisaged, assuming a mix of present-day production units in EU28 (fossil fuel, RES and nuclear power plants). Emission per generated kilowatt hour is adopted from literature and amounts to 271 gCO_2-eq/KWh, including electricity transmission losses /267/.

Emissions from the said BL solutions are calculated on the assumption that the electricity production is 6 TWh, and the emission factors given above are adopted from /186/.

Table 108: GHG emissions from baselines (BL)

	Annual emission, kt-eqCO_2	Emission in 20 years, kt-eqCO_2
Lifetime extension (LTE)	0.609	12.1
New TPP, coal	720	14,400
New TPP, gas (CCP)	342	6,840
Electricity import	1,626	32,520

Relative emission

Relative emission is the difference between LTE emission and BL emission. Relative emission is indicated for two scopes:

Scope 1 – direct emission from the LTE area

The table below shows the relative emission from LTE; a negative value means that emission savings are ensured in comparison with other variants.

Table 109: Relative emission from LTE (Scope 1)

Baseline variant	Annual emission, kt-eqCO_2	Emission in 20 years, kt-eqCO_2
New TPP, coal	-719.4	-14,388
New TPP, gas	-341.4	-6,828
Electricity import	-1,625.4	-32,507

Scope 3 – LCA approach

Scope 3 denotes emissions from the entire cycle of electricity production (LCA). Scope 3 (LCA) covers the fuel consumption chain, fuel processing, fuel enrichment, the production of fuel rods for power plants, transport, the operation and decommissioning of the power plant, including the footprint from the production of material and equipment for the entire chain. NEK is expected to produce up to 6 TWh of electricity annually. The table below shows the relative emission for Scope 3. The specific emission for LTE is adopted from the same source as used for other technologies to ensure consistency.

Table 110: Absolute and relative emissions from LTE (Scope 3)

		Emission – Scope 3		Relative emission – Scope 3	
	FE LCA*	2023-2043	Yearly	2023-2043	Yearly
	gCO_2/kWh	ktCO_2-eq	ktCO_2-eq/year	ktCO_2-eq	ktCO_2-eq/year
coal	820	98,400	4,920	-96,960	-4,848
biomass – burned with coal	740	88,800	4,440	-87,360	-4,368
natural gas	490	58,800	2,940	-57,360	-2,868
coal using CCS	220	26,400	1,320	-24,960	-1,248
combined natural gas using CCS	170	20,400	1,020	-18,960	-948
geothermal energy	38	4,560	228	-3,120	-156
solar PV – roof	41	4,920	246	-3,480	-174
solar PV power plants	48	5,760	288	-4,320	-216
hydroelectric power plant	24	2,880	144	-1,440	-72
biomass	18	2,160	108	-720	-36
nuclear	12	1,440	72	0	0
wind turbines at sea	12	1,440	72	0	0
wind turbines on land	11	1,320	66	120	6

Relative emission = LTE emission – alternative technology emission
* The emission factor is the median of data from literature for various technologies /176/

The data in the table for a nuclear plant apply to the mean values from literature and range from 3.7 to 110 gCO_{2eq}/kWh. Greenhouse gas emissions from nuclear power plants are at the level of other low-carbon technologies: solar energy, wind power and hydroelectric power plants. The carbon footprint of technologies is expected to change over time, and could be reduced for wind and solar power plants and to a lesser degree for nuclear power plants.

It is evident from the table that in the 2024-2043 period, modern, coal-fired power plants using carbon capture and storage (CCS) would generate 18 times more emissions than nuclear power plants over the entire lifetime, while gas-fired power plants using CCS would generate 14 times more emissions.

It should be noted that NEK does not incur any costs for CO_2 emission allowances because it does not participate in the CO_2 emissions trading system. The price of CO_2 emission allowances is expected to rise from the current level of EUR 25–35/tCO_2 to around EUR 60/tCO_2 by 2043 /174/. A new coal-fired power plant with CCS (120 gCO_2/kWh) would incur annual emission allowance costs of around EUR 30 million, while a gas-fired power plant (57 gCO_2/kWh) would incur costs of around EUR 14.5 million, with additional costs of the investment in CCS, the costs of CCS operation and the costs of CO_2 transport. This indicates an increase in the market competitiveness of the nuclear power plant, which is not directly relevant with respect to the impact on the environment. However, it should be taken into account that new assessments of CO_2 prices indicate several times greater values with the assumption of net zero emissions in 2050 /267/.

Given the above facts, it is assessed that the impact of the extension of NEK's operational lifetime on climate change would be positive because it is a technology that contributes to the achievement of targets set out in the Paris Agreement.

The impact of the activity and overall impact on the climate are assessed as **(5)** – positive impact.

5.5.2 Termination of the activity

Should NEK cease operations (see Section 2.18), there will be no more significant emissions of greenhouse gases (also see Section 5.4.2).

The impact of the activity and overall impact on the climate if the activity is terminated are assessed as **(4)** – impact is not significant. The impact is assessed as not significant because NEK, once it ceases operation, will be replaced by another source of electricity. It is highly likely that the electricity from this other source (or combination of sources) will have a greater total carbon footprint than NEK.

5.6 IMPACT OF CLIMATE CHANGE ON LTE

5.6.1 Operation

This section analyses the impacts of climate change on the operation of NEK in terms of efficiency, total electricity production and the availability of electricity for users, and the associated environmental impacts. The analysis relates to the normal operation of the power plant, which is defined by six possible statuses: power operation, start-up, hot standby, hot shutdown, cold shutdown and refuelling.

Numerous recent studies have studied the impacts of climate change on infrastructure, and assessments are required for all phases of LTE: the preparatory phase, in feasibility studies, and during planning, construction, operation and decommissioning. Nuclear power plants do not generate greenhouse gases and do not contribute to climate change, but they can be sensitive to the latter. The International Atomic Energy Agency (IAEA) published two documents relating to the impact of nuclear power plants on the climate and to the issue of adapting nuclear power plants to climate change (source /169/, /178/, /180/). Statistical data indicate that nuclear power plants lost between 0.01% and 4% of production due to events linked to climate change /178/ in the period from 2004 to 2009.

Analyses of the sensitivity of electricity production sources to climate change in Europe indicate that investments must be made in the energy infrastructure to mitigate vulnerabilities and climate change /181/. Three key production risks have been identified for nuclear power plants in Europe: the threat of floods, the diminishing availability of water and increased air temperature. Thermal power plants are subject to the same primary production risks. At the European level, the consequences of the costs of extreme events could be severest in Central and Southern Europe, while investments in countries along the coast of the North Sea will be practically unnecessary /181/.

The Energy Concept of Slovenia (ECS, draft document) envisages the extension of NEK's operational lifetime until 2043, under the assumption of compliance with all the safety and technical standards related to the power plant's operation. The environmental report for the ECS /173/ concludes that all measures set out in the ECS have the 'positive impact of reducing the vulnerability of the infrastructure and settlements to climate change (adaptation to climate change)'.

The integrated National Energy and Climate Plan of the Republic of Slovenia (NECP) envisages that NEK will operate until 2043 and thus contribute to the objective of increasing energy supply security. This means that NEK also contributes to the resilience of the energy system to the current proven threat of climate change. The environmental report concludes that all NECP scenarios will have an immaterial impact on the environmental sub-objective of 'reduced exposure to the impacts of climate change, the reduced sensitivity and vulnerability of Slovenia, and the increased resilience and adaptability of society' due to the implementation of mitigation measures /174/, /173/.

The national strategy of adapting to climate change is set out in the document "Strategic framework of adapting to climate change", December 2016 /268/. It deals with the goals of reducing exposure to the impacts of climate change and Slovenia's sensitivity and vulnerability to them, and increasing the resilience and adaptability of society. The following section provides an assessment of the ways in which LTE, which has an important economic role, will be exposed to climate change and how vulnerable it is.

Methodological approach to assessment

In connection with the subject of this section, the working group responsible for the drafting of the EIA Report organised a workshop on that subject with NEK employees. This was deemed necessary, as NEK's experts have the best overview and knowledge of all elements of the power plant's operation, while the workshop emphasised the need to clearly separate nuclear safety from the assessment of the vulnerability of the economy and production, and thus associated changes with respect to environmental impacts. Comprehensive deterministic and probabilistic safety analyses are performed in accordance with regulations governing nuclear energy. In combination with other external threats, those analyses identify risks and the potential consequences of extreme meteorological phenomena. It was proposed that quantitative indicators be used to the greatest extent possible in final assessments of probability and potential consequences with respect to the uncertainty of climate change assessments, in particular with respect to frequency and extreme intensity, and the increasing number of changes in the previous decade of this century.

Although there is no generally accepted methodology for assessing the impact of climate change on the infrastructure and environment, there is an increasing number of relevant documents that include methodological recommendations. The approach used here complies with the "Guidance to the drafters of the report on environment impacts to address the climate change aspect" (ARSO 2020). The technical guidelines for methodology are specified in detail in literature /269/ and /184/. The use of methodology will be adapted to LTE specifics. Because the terms 'safety', 'vulnerability' and 'risk' are used in the nuclear energy industry in connection with nuclear safety, ionising radiation and radioactive waste, the following terms will be used here: 'vulnerability of production' and 'risk of a change in production and its impact on the environment', with which (non-radiological) change in environmental impact is linked.

In general terms, the analysis comprises seven modules:
- Module 1: Sensitivity analysis;
- Modules 2a and 2b: Assessment of exposure;
- Modules 3a and 3b: Vulnerability analysis (electricity production);
- Module 4: Risk assessment (changes in electricity production and environmental impacts);
- Module 5: Definition of the ability to adjust;
- Module 6: Assessment of the ability to adjust;
- Module 7: Inclusion of an adjusted action plan into LTE.

An analysis of resilience to climate change follows, spanning the first 4 modules.

<u>Module 1 – Sensitivity analysis of LTE</u>

The availability of facilities at NEK is continuously high, which ranks it in the first quartile of global power plants in terms of availability. This confirms the general resilience of the power plant's infrastructure and business model to external physical events of various types.

According to a review of past events, NEK did not record outages of the power plant due to extreme weather conditions. There were two events in connection with weather conditions that were the result of a combination of the inflow of a large quantity of sediment that treatment systems failed to clean, and the inappropriate closure of the tertiary cooling system. That procedure did not anticipate the timely start-up of the cooling tower system in such conditions (increase in flow rate and rinsing of banks – large quantity of sediment).

The first outage was recorded on 27 November 2003, when a sudden rise in the flow rate of the Sava and the intensive removal of fallen leaves and other sediment in the riverbed increased the burden on treatment plants located at the off-take of the condenser cooling system and TC exchangers (CW). Disruptions in the functioning of treatment plants resulted in a loss of sufficient flow through the condenser, a drop in vacuum pressure and the triggering of automatic back-up turbine systems. The reactor shut down automatically because power exceeded 10%.

The second outage was recorded on 28 October 2012 and lasted for one day and 23 hours. The unplanned shut-down of the power plant was the result of the rapid rise in the flow rate of the Sava, which reached 2,250 m^3/s. That rapid rise in the flow rate, together with the increased volume of debris, resulted in the clogging of the CW system's treatment plants. The result was a rapid rise in pressure differences on travelling screens and the opening of safety valves on the travelling screens of the CW system. This in turn resulted in the clogging of treatment plants on the condenser inlet and the loss of vacuum pressure in the condenser. Due to the latter, operators in the control room began to reduce power and initiated the safe shut-down of the power plant.

Through the design and implementation of design modifications, NEK has **improved** systems that facilitate the treatment of water so that sediment does not have any effect on the operation of NEK.
There are numerous climate parameters (primary and secondary) that can affect the activity and that are linked to climate change:

1) Primary climate parameters: rising mean temperatures, rising extreme temperatures, changes in average precipitation amounts, changes in extreme precipitation, average wind speed, changes in maximum wind speed, humidity, solar radiation, etc.

2) Secondary climate parameters are the result of primary climate parameters: rising sea level, availability of water (drought), rising water/sea temperature, storms, floods, soil erosion, coastal erosion, forest fires, ground instability/landslides, air quality, heat islands in urban centres, etc.

The sensitivity of the activity must be determined with respect to the scope of climate variables and secondary effects. The sensitivity of the activity to key climate variables (primary and secondary) is assessed in four areas:

Property and processes at the site itself	**Electricity production infrastructure and ancillary functions**
Input	water, nuclear fuel, air, raw materials, resources for maintaining power plants, heating oil for diesel generators and the auxiliary boilerhouse
Output	produced electricity and waste
Transport	transport is also linked to the activity: transport of people, equipment, raw materials, other materials and waste

Each of the four above-described areas is assessed separately for every climate variable using the assessments 'highly sensitive', 'moderately sensitive' or 'not sensitive'. The descriptions that follow serve as a guide for avoiding subjective assessments:

- highly sensitive: the climate variable or threat could have a considerable impact on property and processes, inputs, outputs and transport
- moderately sensitive: the climate variable or threat could have a minor impact on property and processes, inputs, outputs and transport

- not sensitive: the climate variable or threat has no impact.

Due to the site of the activity and its planned implementation, the activity has been assessed as not sensitive to certain climate variables and secondary effects, as follows:

*Table 111: Climate variables that **do not affect** the activity*

Average quantity of precipitation	The activity is not sensitive to the average quantity of precipitation.
Average wind speed	The activity is not sensitive in this regard, as only extreme winds can damage the area. High-speed winds are rare in the vicinity of NEK.
Solar radiation	The activity is not sensitive to solar radiation.
Soil erosion	Soil erosion occurs on the banks of the Sava, but is not so intense as to threaten the operation of the power plant. Control and preventive measures are in place in the event of forecasts of high water levels.
Atmospheric discharges (storms)	Such phenomena could affect the emergency external power supply, result in short circuits, affect ground resistance functions, result in 'false' alarms in I&C systems, affect the internal power supply, ICT equipment, switchgear, the meteorological tower, etc. Given the number of lightning strikes in the area between 1998 and 2016, we can conclude that the occurrence of such phenomena is below the Slovenian average (USAR). Based on the frequency and the extent of consequences the risk to production is assessed as low.
Forest fires	Forest fires: the activity is not sensitive in this regard because the area in question is not surrounded by forest vegetation. There is a nearby orchard, but the energy of a potential fire is deemed immaterial and could be extinguished through quick intervention. Smoke from a fire is unlikely to affect the internal atmosphere of the main control centre (MCC), where measures are in place for atmospheric isolation, with the possibility of full air recirculation.
Ground instability/landslides	The activity is not sensitive in this regard because it is not located on unstable ground with a threat of landslides, but is situated on level ground. Embankment erosion is analysed in the event of floods. The site can be accessed by traffic from several directions, while erosion does not pose a threat to roads. Fuel is delivered every 18 months, meaning transport can be precisely planned.
Air quality	The activity is not sensitive to air quality.
Heat islands in urban centres	Heat islands in urban centres: the activity is not sensitive in this regard because it is not located near a major urban centre.
Rising sea level	The activity is not located in the coastal region.

The table below presents an assessment of LTE sensitivity to climate variables (primary) and the associated threats (secondary) through the four previously described topics (Table 112) for the parameters assessed to indicate (moderate or high) sensitivity for at least one of the four observed topics.

Table 112: Assessment of LTE sensitivity to climate variables and the associated impacts on production and the environmental impact

Transport	Input	Output	Property and processes at the site itself	No.	Sensitivity aspect
CLIMATE VARIABLES AND ASSOCIATED DANGERS					
Primary climate impacts					
				1	Increase in average air temperature
				2	Increase in temperature extremes

Transport	**Input**	**Output**	**Property and processes at the site itself**	**No.**	**Sensitivity aspect**
None	None	None	Moderate	3	Increase in extreme precipitation
None	None	None	None	4	Maximum wind speed
Secondary impacts / associated dangers					
None	High	Moderate	High	5	Availability of water (droughts)
None	None	Moderate	High	6	Increase in water temperature
None	None	Moderate	Moderate	7	Storms
Moderate	None	None	Moderate	8	Floods

Key:
Climate sensitivity: None | Moderate | High

Increase in air temperature and temperature extremes. NEK has a cooling system for the cooling of the condenser with water, the cooling of the turbine system and for the cooling system components. If the off-take of water must be reduced due to the lower flow rate of the Sava, some heat is discharged using the cooling towers, so that the impact of NEK on the temperature of the Sava remains in the range ΔT 3°C. The thermodynamic principle of the cooling towers is such that water cooling is achieved through the evaporation of water in the opposite direction of the flow of air from the atmosphere. When the air temperature rises, the efficiency of the cooling towers is reduced. A combination of several hot days and the reduced flow rate of the Sava requires the increased use of the cooling towers, resulting in the increased consumption of energy for the operation thereof. At higher temperatures, more energy is required for cooling units, which are designed to operate in the range of -18 to 35°C, and up to 48°C /3/.

The spent fuel dry storage has a passive air cooling system and rising temperatures will not lead to the failure of the cooling function itself, as proved with analyses.

Increase in extreme precipitation. During the most intensive precipitation, standing water on the ground can reach a depth of 30 mm during the first hour. Rain intensity diminishes after one hour. For this reason, standing water quickly dissipates. The power plant's buildings stand around 300 mm higher than the surrounding ground. Such an event cannot therefore cause a change in its operating regime.

As previously mentioned, the power plant was shut down twice in the past due to a rapid rise in the flow rate of the Sava in combination with the technical response of the power plant. The river became very murky and carried away a large amount of debris (branches, plastic bags, etc.), which caused the clogging of screens on the cooling water inlet and the inflow of mud into the system. Following the aforementioned events, an early warning system was introduced to identify such conditions, as well as the adoption of preventive measures: potential inclusion of the cooling towers and coordination with upstream hydroelectric power plants on the Sava.

Strong winds typically accompany storms. Such phenomena can bring a temporary halt to transport. Thanks to the regular supply of fuel every 18 months, however, strong winds have no special impact because the power plant is able to plan transport in advance. It will also be possible to plan the transport of low- and intermediate-level radioactive waste from the LILW storage facility. The fastest recorded on-site wind speed was 26.5 m/s, which does not pose any particular risk of damage to the infrastructure. It should be emphasised that NEK's safety SSC are designed for much stronger winds of up to 140 km/h, and the new DEC SSC for even stronger winds with maximum speeds of up to 240 km/h.

Availability of water. Water from the Sava is used for cooling the condenser and turbine cycle (large cooling system) and for cooling power plant components (small cooling system), for buildings and water preparation devices, and for the liquid radioactive waste treatment system. Most important in terms of safety is the availability of water for cooling the reactor core in emergencies, a system referred to as ultimate heat sink. This is not a sensitive meteorological variable for the dry storage of spent fuel, as the latter is equipped with passive air cooling.

In accordance with the relevant water permit, NEK may abstract water at a rate of 25 m^3/s for cooling purposes. If the flow rate of the Sava is less than 100 m^3/s, NEK activates the cooling towers, which employ circulation to cool a portion of condenser water. Since HPP Brežice started operating in August 2017, the relevant flow of the Sava for cooling tower activation has been the mean daily flow at HPP Krško, and prior to that, it was the mean daily flow before the NEK dam. The maximum off-take rate of the cooling towers is 15 m^3/s. The towers function at full capacity when the flow rate of the Sava is below 87 m^3/s. In this way, it is possible to monitor the impact on the thermal heating of the Sava up to a ΔT of 3°C. If during operation ΔT cannot be maintained below 3°C, the power plant reduces power. In order to prevent a reduction in production, NEK upgraded the current cooling tower system (six cells) with four additional cells. The upgrade of the cooling towers carried out in 2008 increased cooling capacity by 36% to a total of 627.8 MW. It is assessed that it might be necessary in the future to reduce power two days a year /184/, as power has not been reduced since the upgrade in 2008.

In terms of droughts and the minimum flow rates of the Sava, it is important for the power plant that the water level is sufficiently above the suction channel for cooling and ESW water. It is unlikely that the flow rate would be so low as to create problems.

Increase in temperature of the Sava. When the water of the Sava is colder, it is better for the operation of the power plant, as the entire thermodynamic cycle is more efficient, it is possible to achieve increased vacuum pressure in the condenser and the power plant operates at maximum efficiency. There is a difference in the production of electricity in winter and summer conditions, as the increase in the temperature of the Sava is limited to 3°C, regardless of the starting temperature, under the condition that off-take is no more than 25 m^3/s, where off-take must be less than ¼ of the overall flow rate. This means that the power plant must reduce off-take when the flow rate falls below 100 m^3/s. Water discharged from the cooling system may not exceed 43°C. Water from the Sava is also used in the cooling towers, and warmer water diminishes the cooling effect of the towers. In addition to condenser circulating water, NEK uses water for the cooling of components via the ESW system (1.6 m/s).

Floods. Three major floods have occurred since NEK began operating: in 1990, 1998 and 2007. Due to these events and the fact that several hydroelectric power plants were constructed upstream of NEK, one was located downstream (Brežice HPP) and another was in the phase of obtaining a building permit (Mokrice HPP), a great deal of attention has been given in recent years to studying flood threats, while data regarding the maximum potential flood have been revised. NEK was designed to withstand floods that occur at a frequency of 0.01% per year (the return period of such an event is statistically defined at 10,000 years). The projected maximum flow rate of the Sava in this period is 4,790 m^3/s, which corresponds to an elevation of 155.35 metres above the Adriatic Sea level. The elevation of the plateau on which NEK stands is 155.20 m a.s.l. The entrances and openings of NEK buildings at the centre of the site are above 155.50 m a.s.l. This ensures that water cannot enter the buildings if the embankments along the Sava fail /185/.

Figure 81: Flood in the vicinity of NEK in 1990. The course of the flood wave was in the direction of the right bank, which is lower. (source:/193/)

Modules 2a and 2b: Assessment of LTE site exposure

When the sensitivity of the activity has been determined, the next step is to assess the area's exposure to climate variables. In accordance with the Guidelines, /174/ data for climate variables are collected for Module 2 (Assessment of exposure) where high or moderate sensitivity exists (from Module 1). The following table illustrates current (Module 2a) and future exposure (Module 2b) to primary and secondary climate variables (Table 113).

Current exposure is linked to climate change observed in the period 1961–2010 in Slovenia and at meteorological stations in the vicinity of Krško, and at the nearest hydrological station downstream from NEK. Future exposure relates to forecast climate change in the 21st century for Slovenia and for the 'central climate region' in which the Krško Nuclear Power Plant is located.

Table 113: Current and future exposure of the area to primary and secondary climate variables

No.	Climate parameter	Current exposure	Future exposure
		Primary climate variables	
	Average annual air temperature	The most characteristic climate change in Slovenia in the 1961–2011 period was a rise in average air temperature of around 0.36°C per decade. /72/ Warming, which is reflected in rising annual air temperatures, accelerated in the late 20th and early 21st centuries. Bizeljsko (Tmean) /73/: +0.38°C/10 years (1961–2010) +0.57°C/10 years (1981–2010)	RCP2.6 and RCP4.5 temperature initially rises and then levels off at the end of the 21st century. According to RCP8.5, the rise in temperature surges at the end of the century/72/. The change in the annual temperature in all three climate scenarios is 0.8°C for the 'central region' in the period 2011-2040, while the rise in annual air temperature is 1.1°C for RCP2.6, 1.4°C for RCP 4.5 and 1.8°C for RCP 8.5 for the period 2041-2070. /75/
	Highest average daily	The rise in highest and lowest daily temperatures by season is similar to the rise in average temperature. A general rise in air temperature has	The increase in the highest daily temperature in the summer is 1.0°C under the RCP2.6 scenario and 0.8°C under the RCP4.5 and RCP8.5

No.	Climate parameter	Current exposure	Future exposure
	temperature; hot days	changed the frequency and number of characteristic days: the number of hot and warm days has risen, while the number of cool, cold and frigid days has fallen, but less significantly. /72/ Warming is seen in an increase in the heat index and a decrease in the cold index.	scenarios for the 'central region' in the period 2011–2040. The increase in the highest daily temperature in the summer is 1.2°C under the RCP2.6 scenario and 1.7°C under the RCP4.5 scenario and 1.8°C under the RCP8.5 scenario for the 'central region' in the period 2041–2070. /75/ Warming will be seen in the continued rise in the number of 'warm' days, a decrease in the number of 'cold' days, and in the duration of 'heat waves'.
	Maximum daily precipitation	The Bizeljsko meteorological station recorded a drop in maximum daily precipitation of 2 to 4%/10 years in the area during the period 1961–2010. Other meteorological stations in the vicinity of Krško did not record a similar trend in the period 1961–2010 or recorded a minor negative trend. /72/	The forecasts for all three climate scenarios indicate an increase in maximum daily precipitation per month (Rx1day indicator) for the 'central region' in both climate periods. The increases for RCP2.6, RCP4.5 and RCP8.5 in the period 2011–2040 are 3%, 4.8% and 4.4% respectively. The increases for RCP2.6, RCP4.5 and RCP8.5 in the period 2041–2070 are 6.9%, 9.3% and 12.4% respectively. /76/
	Maximum wind speed	Strong winds frequently occur in the high mountains, primarily as the result of changes in the weather. Elsewhere in the country, strong winds accompany storms, but apart from that local winds are predominant and develop due to the varied orography and temperature differences.	There are no climate forecasts in available literature /72/ regarding changes in maximum wind speed.
3	Availability of water (droughts)	The trend in minimum 30-day flow rates is negative across the country. There is a statistically significant falling trend at the majority of stations for the period 1961–2013. /72/	We can expect increases and decreases for all three emission scenarios for moderate-low flow rates. /72/ In both climate periods (2011–2040 and 2041–2070), climate forecasts in the Sava-Čatež area indicate changes in low flow rates of up to 5%. Those changes are not statistically significant. /77/
4	Increase in water temperature	The increase in surface water temperature (Sava) at the Čatež measuring station ranges from 0.2 to 0.25°C/10 years. /72/	The increase in the average annual temperature of surface waters ranges from 0.11 to 0.26°C per decade, while the average increase is 0.19°C per decade. Statistically significant seasonal trends on surface waters indicate the highest increase of temperature in the spring and summer. /72/
5	Storms	Storms are a rare occurrence in Slovenia. Storms in central Slovenia typically bring extreme quantities of precipitation.	There are no climate forecasts in available literature /72/ regarding changes in the frequency of storms.
6	Floods	According to the flood risk map, NEK lies outside of the area of floods with a 500-year return period.	For annual high-water peaks with a 100-year return period in the comparable period, an increase in annual 100-year-flood levels in all emission scenarios is expected for all periods in the future relative to the period 1981–2010, throughout the majority of the country. /72/

Key: Exposure to climate change	None	Moderate	High

Module 3: Vulnerability analysis for electricity production

Based on the assessed sensitivity of the activity (LTE) to climate parameters, and its existing and future exposure to climate parameters, the vulnerability of electricity production is determined as follows:

V = S x E

where S represents the level of sensitivity and E represents exposure to basic climate parameters/secondary effects.

The vulnerability of electricity production is determined using a simple matrix algorithm (Table 114).

Table 114: Matrix of the categorisation of vulnerability for electricity production

		Exposure		
		None	Moderate	High
Sensitivity	None	(green)	(orange)	(orange)
	Moderate	(orange)	(orange)	(red)
	High	(orange)	(red)	(red)

Level of vulnerability	
(green)	None
(orange)	Moderate
(red)	High

Table 115 presents an analysis of the vulnerability (current and future) of electricity production.

Table 115: Analysis of the vulnerability of activity

Climate parameters	No.	Transport	Input	Output	Property and processes at the site itself	Transport	Input	Output	Property and processes at the site itself
		Current vulnerability of electricity production				Future vulnerability of electricity production			
Increase in average air temperature	1	(green)	(green)	(green)	(orange)	(green)	(green)	(green)	(orange)
Increase in temperature extremes	2	(green)	(green)	(orange)	(orange)	(green)	(green)	(red)	(red)
Increase in extreme precipitation	3	(green)	(green)	(green)	(orange)	(green)	(green)	(green)	(orange)
Maximum wind speed	4	(green)	(green)	(green)	(green)	(green)	(green)	(green)	(green)
Availability of water (droughts)	5	(orange)	(red)	(orange)	(red)	(orange)	(red)	(orange)	(red)
Increase in water temperature	6	(orange)	(orange)	(orange)	(red)	(orange)	(orange)	(orange)	(red)
Storms	7	(green)	(green)	(orange)	(orange)	(green)	(green)	(orange)	(orange)
Floods	8	(orange)	(green)	(green)	(orange)	(orange)	(green)	(green)	(orange)

Module 4: Risk assessment for electricity production

The risk assessment for electricity production and the environment derives from Module 3 with an emphasis on the identification of risks that derive from highly vulnerable aspects (red assessment in Module 3) with respect to climate variables and their associated impacts on the environment.
Risk in connection with electricity production is defined as the combination of the probability of an event occurring and the consequences of such an event, and is calculated using the formula R = P x S, where

P represents the probability of occurrence and S represents the severity of the consequences of a given threat.

The probability of the occurrence and severity of consequences are assessed according to a point scale with five categories(Table 116 and Table 129). The severity of consequences of climate impacts is the first criterion used to assess the probability that a specific consequence will arise in a given period (e.g. the lifetime of the activity).

Table 116: Scale for assessing the severity of the consequences of a threat, with respect to the risk of damage to facilities

	1 **Negligible**	2 **Low**	3 **Moderate**	4 **High**	5 **Catastrophic**
Meaning:	Minimum impact that can be mitigated through ordinary measures.	Event that affects the normal functioning of the system and results in localised temporary impacts.	Serious event that requires additional control measures; has moderate impact.	Critical event that requires extraordinary activities; has significant, broad or long-term impacts.	A catastrophe that could result in the shutdown or failure of the power plant/grid; causes serious damage and long-term impacts.

Table 117: Scale for assessing the probability of an adverse event

	1 **Almost impossible**	2 **Low probability**	3 **Possible**	4 **High probability**	5 **Almost certain**
Meaning:	Highly improbable that incident will occur.	Incident is unlikely to occur taking into account current experience and procedures.	Incident has occurred in comparable country/facility.	Highly probable that incident will occur.	Almost certain the incident will occur, possibly several times.

The scores for the severity of consequences and the probability of each risk are expressed in accordance with the risk classification matrix presented in Table 118 and they are defined in Table 119.

Table 118: Risk matrix

	Probability of phenomenon	Almost impossible	Low probability	Possible	High probability	Almost certain
Severity of consequences		1	2	3	4	5
Negligible	1	1	2	3	4	5
Low	2	2	4	6	8	10
Moderate	3	3	6	9	12	15
High	4	4	8	12	16	20
Catastrophic	5	5	10	15	20	25

Table 119: Definition of risk level

Risk level	
	Negligible risk
	Low risk
	Moderate risk
	High risk
	Extremely high risk

The results are given in Table 120 below, which presents the final classification of risks in connection with electricity production and the associated impacts on the environment.

Table 120: Assessment of risk level with respect to an increase in the environmental impacts of NEK

	Probability of phenomenon	Almost impossible	Low probability	Possible	High probability	Almost certain
Severity of consequences		1	2	3	4	5
Negligible	1				Increase in air temperature (4) Increase in water temperature (4)	
Low	2			Availability of water (6)		
Moderate	3					
High	4					
Catastrophic	5					

An **increase in air temperature** of 0.8°C from 2011 to 2040 is assessed as highly probable, and could lead to an increase in the number of hot days and the highest temperature. Data from measurements at the NEK site (tower; 2 m) from 2010 indicate that the highest daily temperatures in all months were higher than the average in the period 1961–2010, by as much as 3.1 to 4.5°C during the summer months. The absolute daily maximum temperature since 2010 was 28.7°C. Rising air temperature reduces the effect of the cooling towers. Expected changes will have consequences/impacts that are within planned variations of -18 to 35°C. The consequences of that impact were therefore assessed as immaterial and 'highly probable'. The final assessment is that the risk to electricity production and the environment is low. The impact of air temperature on the cooling towers is discussed in more detail in the text below.

An **increase in the temperature of the Sava** in combination with low flow rates could lead to an increase in the number of operating hours of the cooling towers, while the temperature of cooling water discharged from NEK will be higher. However, the heat load on the Sava will remain within the present limit of ΔT 3°C. Figure 82 presents the key parameters from 2010 to 2020 as the relative change compared with 2010 (except for ΔT, which is given as the annual absolute value). The aforementioned period is statistically too short to draw a conclusion regarding the future trend, and is presented here in order to determine the resilience of the activity and define the consequences of a potential increase in the temperature of the Sava. It is also a fact that the intensity of climate change has increased in recent years. The temperature of the Sava rose from an 1984-1993 average of 10.9°C (Table 31) to an average of 12.6°C in the period 2011-2020 (NEK data).Despite the rise in temperature, electricity production has remained stable and unchanged. The combination of the rising temperature of the Sava and a change in flow rate caused a slight increase in ΔT. In the period 2010 to 2020, ΔT was 1.98 ° C, which means an average of 65% of the maximum permitted value. It was determined that the risk to electricity production is low.

NEK is not changing the total thermal power of the nuclear reactor and it will remain the same up to 2043. The plant has an efficiency rate of around 36.5% (at the generator terminals), which means that 63.5% of the heat is discharged into the environment. In the period 2010-2020, 91.4% of this heat was discharged into the Sava from the condenser and 2.66% through the cooling tower assembly, and 5.97% of the heat was discharged into the air from the cooling towers (Figure 86).

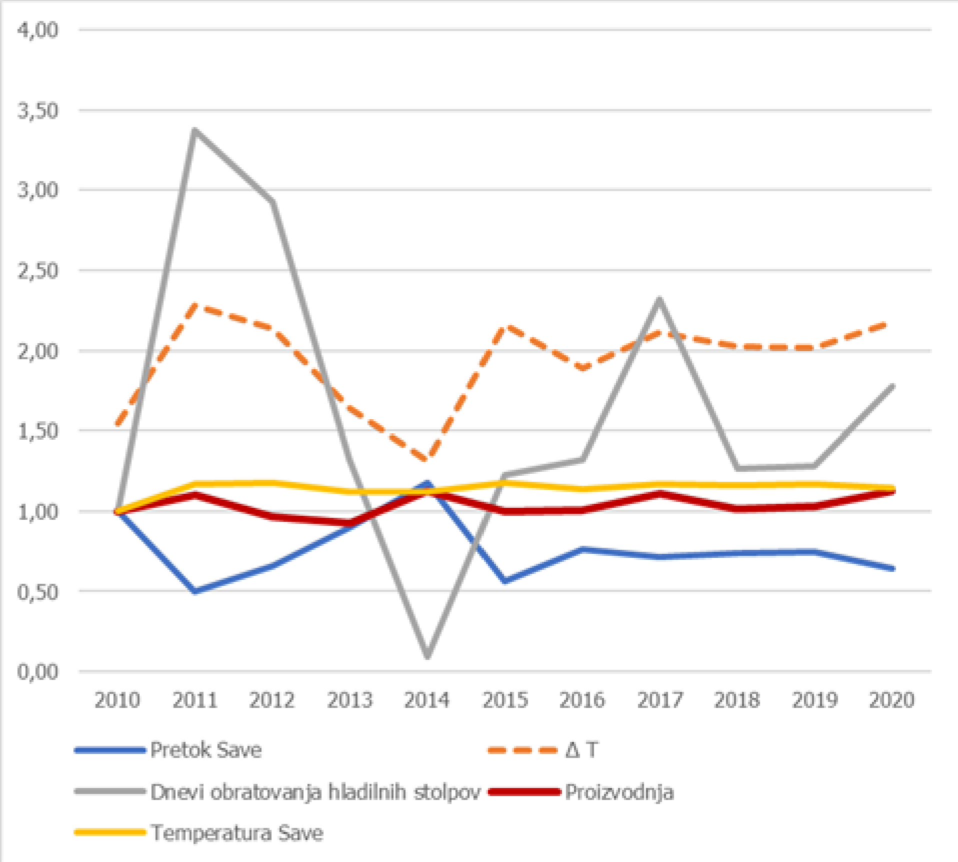

Figure 82: Change in key parameters in the period 2010-2020 relative to 2010 (annual averages), except ΔT (°C) (source: NEK measurements)

Pretok Save	Flow rate of the Sava
Dnevi obratovanja hladilnih stolpov	Operation of cooling towers in days
Temperatura Save	Temperature of the Sava
Δ T	ΔT
Proizvodnja	Production

The **availability of water** is a variable with a low level of risk because the power plant has flexible measures in place (cooling towers) and can operate in the event of low flow rates of the Sava. Regardless of the Sava's flow rate, NEK's impact remains within the limit of ΔT 3°C. The construction of hydroelectric power plants and dams on the Sava upstream from NEK ensures the improved regulation of conditions, while flow-rate measurements indicate that changes in the flow rate have diminished since 2015. If the availability of water is reduced, the cooling towers compensate for that reduction. Figure 82 shows that the cooling towers are not at full capacity because NEK increased their capacity, and a backup system is in place.

The following section gives an assessment of the impact of changes in Sava flow rates on NEK's operation and changes to the cooling tower operating regime, i.e. the frequency of operating in recirculation mode.

According to data from /72/, '*major changes in mean annual flow rates in Slovenia for various emission scenarios (RCP2.6, RCP4.5, RCP8.5) until the end of the century in comparison with the baseline period 1981–2010 are not to be expected, except in the northeast of the country, where a partially significant increase in flows is indicated*'. The scenario leading to the fulfilment of the Paris Agreement goal, RCP4.5, corresponds to a change of -5% - +5% in medium annual flows, +5% - +20% in high flows and -5% - +5% in low flows, for the period 2011-2040. For the pessimistic RCP8.5 scenario, the projected changes are the same as for RCP4.5 (Table 25, /77/).

The observed changes in flow rates in Slovenia show that the annual quantity of available water in watercourse channels is falling, as indicated by the environmental indicator for the annual river balance /72/, /283/. The net runoff in the Slovenian river balance dropped in the period 1961-2015 by about 12% (about 0.22% annually). If this trend extrapolates until 2043, the change in Sava flows could be -4.6%, which matches RCP4.5 and RCP8.5 projections for the lower assessment threshold, which is -5%.

The cooling towers can discharge 49.5% of the power plant's total waste heat, which means it has large reserve capacity for heat removal. The capacity of the towers is dimensioned to meet short-term needs and bridge situations in which the power plant would have to decrease production due to the heat load on the Sava.

NEK's cooling towers start up on the basis of three criteria:

1) when the flow rate of the Sava is less than 100 m^3/s (for the purpose of maintaining ΔT within 3°C),
2) in the case of increased Sava river flow (700 m^3/s), when the increase in Sava's flow rate is rapid or dirt is deposited, the CT system starts up to reduce the intake of CW water from the Sava
3) the CT system must be started up once a month. Start-up is carried out after the weekly rinsing of sediment in the intake basin of the CW pumps and the downcomer to prevent the excessive accumulation of silt in the downcomer.

The limit flow of 100 m^3/s is not laid down in the OVD; it is a technical operating parameter which is determined by the limit for ΔT. The cooling towers operated 122 days a year in the period from 2010 to 2020, ranging from a minimum of 72 days a year to a maximum of 207 days a year. Looking at the number of equivalent days that represent the time of operation, on the assumption of maximum power, the towers on average operated 53.6 equivalent days a year, which is 14.7% of the total time of power plant operation. Criterion 1) accounted for an average 75.5% of tower operation in the period 2010-2020. Criteria 2) and 3) account for a minor portion of operating days and are thus less important for the assessment of the heat load on the Sava (Figure 83).

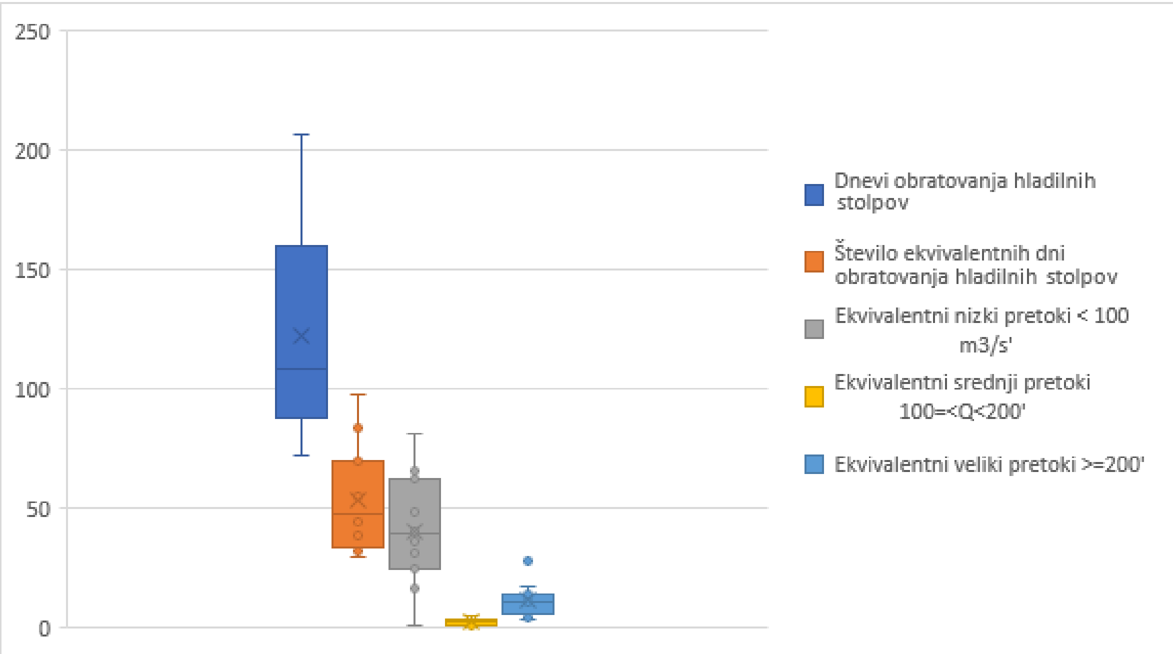

Figure 83: The number of cooling tower operating days per year, statistics for 2010-2020

	Days of cooling tower operation
	Number of equivalent days of cooling tower operation
	Equivalent low flow rates <100m^3/s'
	Equivalent medium flow rates 100=<Q<200'

	Equivalent high flow rates >=200'

The projections for the number of cooling tower operating days are made up to 2043, assuming a change in low and medium flows of -5% and a change in high flows of +5%, and the simulation was performed using the corrected curve of daily flow distribution from the period 2011-2020. The results of the projections are given in Table 121.

Table 121: Projected operation of cooling towers up to 2043 and the change in Sava flow rates of -5% for medium flows, -5% for minimum flows and +5% for high flows (days of operation)

	2010-2020			up to 2043		
	11-year average	Year of hydrologically low flow rates 2011	Year of hydrologically high flow rates 2014	Average year	Year of hydrologically low flow rates	Year of hydrologically high flow rates
Flows <100 m3/s	113	160	4	+16.5	+20.0	+3.0
Other	9	47	68	+0.4	+2.3	+3.4
Total	122	207	72	+16.9	+22.3	+6.4

In the years up to 2043, the increased number of cooling tower operating days will increase the discharge of waste heat into the atmosphere on average by approximately 0.87 percentage points, amounting to 5.79+0.87=6.66% of NEK's total waste heat. In a year of low hydrological flow, it would amount to 12.56+1.57=14.13% of NEK's waste heat. Heat discharge into the Sava will decrease in the same extent, but the reduced Sava flow rates will cause a certain increase in the average ΔT and WHER (see below).

Longer times of cooling tower operation due to climate change result in increased noise levels, since the fans of the cooling towers are a major source of noise in the NEK area. This is further discussed in Section 5.7.

Combined impact of climate change indicators

The following section presents an analysis of the change in the waste heat emission ratio (WHER) and ΔT.

Some of the major factors that will impact the change in the Sava's heat load include:

- the change in the flow rate of the Sava
- the change in the temperature of the Sava
- the change in air temperature
- the change in air humidity

The change in the flow rates of the Sava is analysed above. The analysis assumed a change in low and medium flows of -5%, and a change in high flows of +5%. The change in share of emitted heat and the average ΔT 3°C will be inversely proportional to the change in the Sava's flow rate, which means that WHER and ΔT will increase by 5% at the same heat discharge into the Sava. The power plant must not exceed the limit WHER=1 and 3°C ΔT.

An increase in the average annual temperature of surface waters of 0.11 to 0.26°C per decade is expected in Slovenia, with an average increase of 0.19°C per decade /72/ (Table 105). A change in the temperature of cooling water impacts the operation of the facility. Here, the impacts were assessed using research results, which showed that a change of one degree in the cooling medium causes a reduction in electric power of 0.444% /284/. It can be calculated that an increase in the temperature of the Sava by 2043 of 0.253-0.598°C would increase waste heat by 0.064-0.152%, and the equivalent loss of electric power would be 0.7-1.7 MW.

The change in air temperature, the temperature of cooling water and the change in relative humidity will impact the efficacy of the cooling towers. The RCP4.5 scenario anticipates a change in temperature of about 1°C by 2040, and the RCP8.5 scenario a change of 1.5°C by 2040 (Table 105). The temperature of cooling water for the cooling towers will rise, as previously stated for the Sava.

Relative humidity in Europe indicates a falling trend at a level of about 1% in the last thirty years /285/. Globally, for the period 2046-2065, this part of Europe is projected to see a change between -1 and -2% in 2046 /286/. The change in air temperature has a significant effect on the efficacy of the cooling towers at temperatures above 35°C. Their sensitivity to the temperature of cooling water and relative humidity begins above 25°C and above 60%, respectively, with a 1.5% change in efficacy for a 1% change in relative humidity. The data is based on research from /287/. The strongest impact comes from the change in relative humidity, which is set to decrease, and this could offset potential changes due to air temperature and cooling water temperature in a considerable degree.

Changes in cooling tower efficacy due to the change in air temperature, cooling water temperature and the change in relative humidity could decrease emissions of heat into the atmosphere, if relative humidity falls by 1-1.5%; the overall decrease could range from 0.08% to 0.17%.

Table 121shows the projected impact of the factors discussed above on WHER and ΔT. The potential change in the mentioned indicators for the Sava is 4.186-4.262%.

Table 122: Estimated increase in WHER and ΔT due to climate change up to 2043 (Scenario: medium flows -5 %, low flows -5 %, high flows +5 %, temperature of the Sava 0.25-0.6°C, air temperature 1-1.5°C)

Due to Sava flow rate	Due to Sava temperature	NEK response, increased cooling tower operation	Overall change
%	%	%	%
+5 %	0.056-0.132	-0.87	4.186-4.262

2010-2020 average		2043	
WHER	ΔT /°C/	WHER	ΔT /°C/
0.646	1.94	0.673-0.674	2.021-2.022

ΔT and WHER will reach about 2/3 of the limit value in 2043.

The above analysis applies to the large cooling system which uses 97.5% of the total amount of water taken from the Sava. ΔT and WHER are likewise monitored for the small cooling system (plant component cooling). The values inLonger times of cooling tower operation due to climate change result in increased noise levels, since the fans of the cooling towers are a major source of noise in the NEK area. This is further discussed in Section 5.7.

Combined impact of climate change indicators

The following section presents an analysis of the change in the waste heat emission ratio (WHER) and ΔT.

Some of the major factors that will impact the change in the Sava's heat load include:

- the change in the flow rate of the Sava
- the change in the temperature of the Sava

- the change in air temperature
- the change in air humidity

The change in the flow rates of the Sava is analysed above. The analysis assumed a change in low and medium flows of -5%, and a change in high flows of +5%. The change in share of emitted heat and the average ΔT 3°C will be inversely proportional to the change in the Sava's flow rate, which means that WHER and ΔT will increase by 5% at the same heat discharge into the Sava. The power plant must not exceed the limit WHER=1 and 3°C ΔT.

An increase in the average annual temperature of surface waters of 0.11 to 0.26°C per decade is expected in Slovenia, with an average increase of 0.19°C per decade /72/ (Table 105). A change in the temperature of cooling water impacts the operation of the facility. Here, the impacts were assessed using research results, which showed that a change of one degree in the cooling medium causes a reduction in electric power of 0.444% /284/. It can be calculated that an increase in the temperature of the Sava by 2043 of 0.253-0.598°C would increase waste heat by 0.064-0.152%, and the equivalent loss of electric power would be 0.7-1.7 MW.

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Changes in cooling tower efficacy due to the change in air temperature, cooling water temperature and the change in relative humidity could decrease emissions of heat into the atmosphere, if relative humidity falls by 1-1.5%; the overall decrease could range from 0.08% to 0.17%.

Table 121shows the projected impact of the factors discussed above on WHER and ΔT. The potential change in the mentioned indicators for the Sava is 4.186-4.262%.
can also be applied to the small cooling system, bearing in mind that cooling tower operation is not relevant to the small cooling system.

What follows is an analysis of whether the existing capacity of the cooling towers is sufficient and what is the likelihood that production will have to be decreased.

A reduction of power would be necessary in case of:

- failure to achieve a 24-hour ΔT below 3°C and WHER <1 (OVD)
- failure to achieve water T at the exit point of less than 43°C (OVD)

Since the upgrade of the cooling towers was implemented (in 2007), the power plant has not reduced power due to the heat load on the Sava. The daily Sava temperature in the period 2010-2020 did not exceed 25°C and the minimum Sava flow rate was not below 49 m^3/s.

The statistics of power plant operation in this period approaching limit values for WHER and ΔT are given in Table 123. The data in Table 123 gives reason to conclude that the possibility of having to reduce power due to climate changes is not excluded, but the likelihood of this happening based on the climate change projections available at the moment is relatively small. This likelihood is not reason enough to plan an upgrade of the cooling towers.

Table 123: Statistics of power plant operation approaching limiting conditions

ΔT °C, WHER %	Power of cooling towers %	No. of days in the period 2010-2020	Likelihood of occurrence %	Year of occurrence
≥99, ≤100	≥99	1	0.025	2019
≥99, ≤100	≥97.5	2	0.05	2018, 2019
≥99, ≤100	≥95	14	0.35	2018, 2019
≥99, ≤100	≥90	19	0.47	2018, 2019, 2020
≥99, ≤100	≥85	20	0.49	2018, 2019, 2020
≥97.5	≥99	2	0.05	2019
≥97.5	≥97.5	2	0.05	2019, 2019
≥97.5	95	19	0.47	2018, 2019
≥97.5	90	25	0.62	2018, 2019, 2020
≥97.5	85	26	0.64	2018, 2019, 2020

It is evident from the above that the cooling towers can ensure power plant operation within the heat limits ΔT = 3°C and WHER<1 even in the climate change conditions which are projected up to 2043. As mentioned before, the power plant has not reduced power due to heat load conditions on the Sava in the last ten years. Climate change could only rarely cause the occurrence of such situations, on average 1-2 days a year in 2043. However, in the case of an unfavourable year (projection of the year 2019 in the future), the number of days necessitating power reduction could be up to ten times greater.

If NEK extended the operating time of the cooling towers by 5-7 days each year, this would neutralise the impacts from climate change. Less heat would be discharged into the Sava than today (absolute amount of discharged heat), which means that with decreasing Sava flow rates and rising Sava temperature and air temperature, WHER and ΔT would remain at the current level. The limit for cooling tower activation should be raised by about 5 m^3/s per year: 105 m^3/s, 110 m^3/s and so on, to implement the described increase in the scope of cooling tower operation. Clearly, this is based on the assumption of the existing load factor for the cooling towers (equivalent days of tower operation/total days of tower operation).

The periodic safety review of NEK planned in 2030 will provide an opportunity to use the latest data from climate projections for Slovenia to update the assessment of the likelihood of the occurrence of situations where the power plant would have to reduce power due to ΔT limitations.

This section provides comments on the anticipated change in specific types of wastewater. Figure 84 below depicts the changes in the quantity of wastewater effluent.

Figure 84: Overview of wastewater quantities for specific discharges (the lefthand y axis is the scale for columns and the righthand y axis is the scale for curves)

	m^3/s
	V7-10 – discharge from cooling towers
	V9 – discharge from treatment plant
	V1-1 – discharge of essential service water
	V2, V3, V4, V5 and V6
	V7-7 – cooling water
	V7-11 – outlet from the water preparation tank

The greatest quantities of wastewater come from the condenser cooling system (CW) (91.4%), followed by the cooling towers (CT) (5.2%) and the small component cooling system (SW) (3.2%). These quantities would remain approximately the same; while the quantities of wastewater from cooling towers might slightly increase, this would lead to decreased quantities of wastewater from the condenser cooling system. The water permit stipulates the maximum quantities of water effluent. The annual quantities of wastewater are considerably below limits, and in the year with maximum utilisation, they were at 80% of permissible quantities.

Following the completion of the analysis, we can conclude that the stable production and high availability of the power plant indicate that the changes so far and changes in climate variables have had no significant impact on electricity production or the environment. This was confirmed by the in-depth analysis in this section. The expansion of the cooling towers has increased the functional capacity in the combined cooling cycle, which enhanced climate resilience, while the ΔT limit of 3°C prevents a more significant impact than expected. The construction of reservoirs for hydroelectric power plants upstream from NEK has reduced the flow-rate and temperature differences of the Sava, which reduces the risk of adverse events in the future.

5.6.1.1 Impact of cooling towers

The cooling towers are used for the cooling of condensers when the flow rate of the Sava is too low for the discharge of the necessary heat flux from the condenser, taking into account limits on the discharge of water into the Sava. Such operating regimes are employed whenever the flow rate of the Sava is less than 100 m^3/s. Three cooling towers are situated southeast of the reactor building: two older towers sitting parallel to one another, each with six in-line cells, and a newer tower situated between the older towers, with four cells in a square configuration, as shown in the picture below. All on-site towers are forced (mechanical) draught counterflow cooling towers, where the air flows directly opposite to the water flow through fill material (upwards). That flow is ensured through the functioning of a fan at the top of the cooling tower. The total capacity of all cooling towers is 627.8 MW /185/.

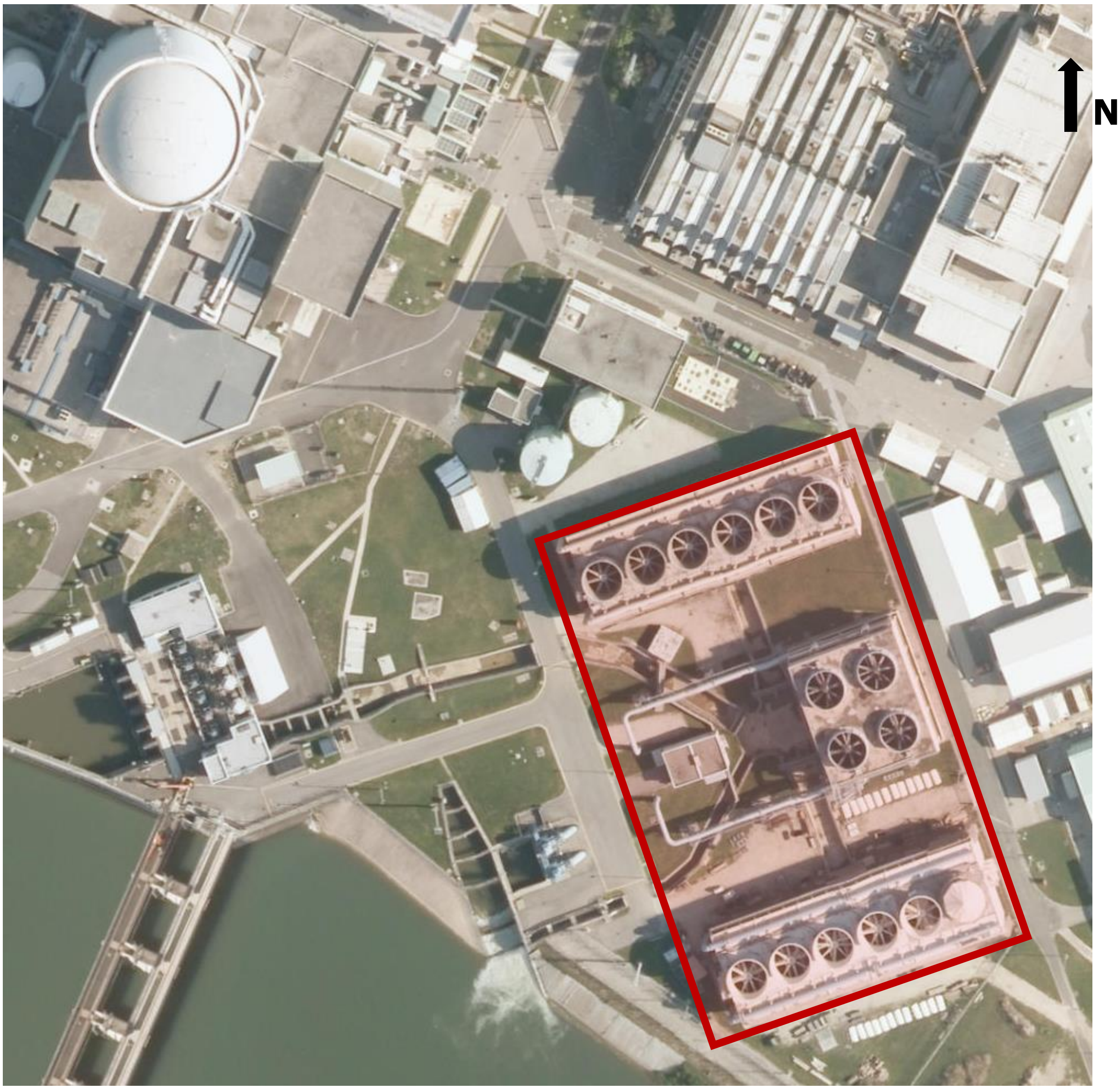

Figure 85: Position of cooling towers within the power plant complex (source: /60/

Operation of cooling towers

Cooling towers operate according to the principle of evaporative cooling: water (the medium that must be cooled) passes over the fill in a thin layer and comes into contact with air flow. The transfer of heat into the atmosphere takes two forms: there is convective heat transfer due to the difference between the temperature of (warmer) water and (colder) air, while there is also heat transfer through the evaporation of water because air can absorb steam up to the point of saturation. The loss of cooling water also occurs as the result of evaporation. That loss must be compensated for by the introduction of fresh water into the cooling system.

The on-site cooling towers operate in a way that supports the functioning of the flow-through cooling system: the towers discharge a portion of the flow-through cooling system's water via the condenser and additionally cool it. After that cooling, a portion of the water is returned to the pre-condenser agitator where fresh water from the Sava is mixed with water from the cooling towers, while a portion of the water is released to discharge point V7-10, which additionally cools water in the flow system, which is discharged into the Sava from the condenser. This satisfies cooling needs if the flow rate of the Sava is too low or if the water discharge temperature is too high, which would have a negative impact on the Sava.

It is evident from an analysis of data regarding the operation of cooling towers and the flow rates of the Sava for the period 2010–2019 that the cooling towers account for a higher proportion of total heat discharge in years when the average flow rate of the Sava is lower (Figure 86). On average, they account for 4.48% of annual waste heat.

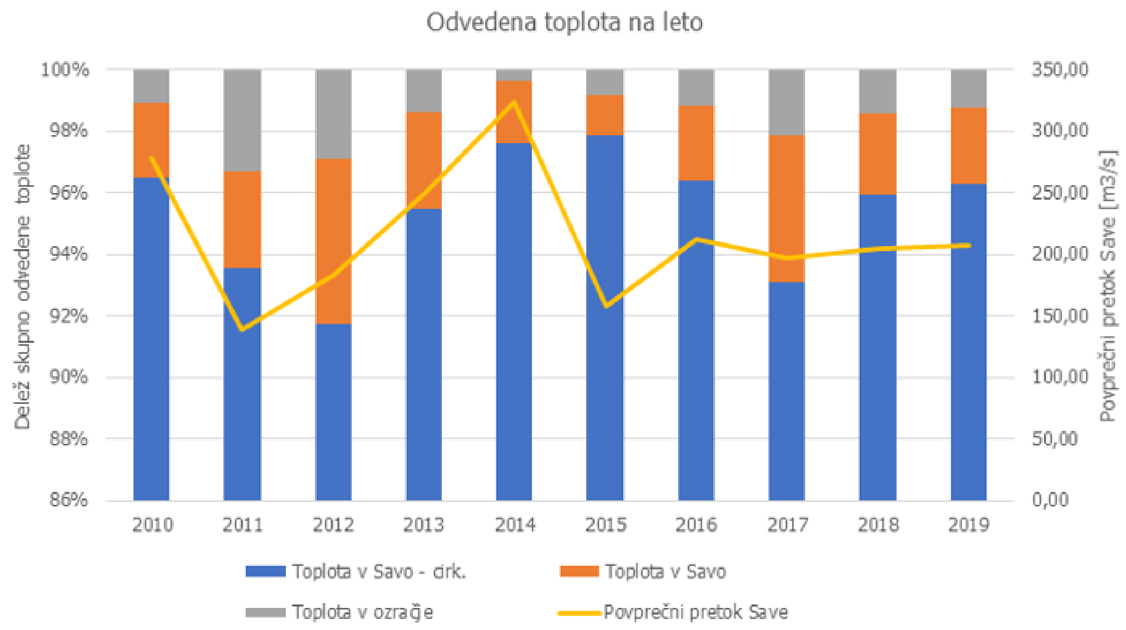

Figure 86: Proportion of annual heat discharge with respect to method of discharge and thermal reservoir

Odvedena toplota na leto	Annual heat discharge
Delež skupno odvedene toplote	Proportion of total heat discharge
Povprečni pretok Save [m^3/s]	Average flow rate of the Sava [m^3/s]
Toplota v Savo – cirk.	Heat discharged into the Sava – circ.
Toplota v ozračje	Heat discharged into the atmosphere
Toplota v Savo	Heat discharged into the Sava
Povprečni pretok Save	Average flow rate of the Sava

Environmental impact of cooling towers

The impact of the cooling towers depends to a large extent on the weather conditions around the towers themselves. There are generally six types of impacts:

- the spread of steam plumes, which could cause local icing or fogging;
- shading due to steam plumes;
- increase in ground-level humidity;
- an aesthetic impact due to visible steam plumes in certain weather conditions; and
- heat load on the environment.

An analysis of the operation of cooling towers from 2010 to 2019 indicated that those towers operated most frequently during summer and winter months. Temperatures below 0°C can be expected in colder months which, in combination with the operation of towers, can lead to icing of surfaces at the NEK site and in the surrounding areas. Model simulations of the impact of mechanical cooling towers indicate that such icing is limited to 1 km from the cooling towers themselves in extreme conditions /187/. At

the NEK site, icing has been seen to occur in the area around the perimeter fence. For that reason, there is a heating system in place for access routes in the direct vicinity of the towers. That system is activated in situations when the potential for icing exists.
The depositing of drops is limited to the same areas as icing. The content of drops is the same as the content of cooling water, which has been determined to be within all legally prescribed limits.

During colder months of the year, relative humidity is high and the temperature is low, which means that the mixing of warm, saturated air from the cooling towers with such air could result in fog or visible steam (in the form of a plume). An example of a visible plume is shown in the picture below. The power plant is located on the bank of the Sava, where radiation fog frequently occurs.

Figure 87: Visible plume from NEK's cooling towers (source: /116/)

The cooling towers release warm humid air into the atmosphere, resulting in a heat load. As it passes through the towers, air warms by between 3 and 5°C /188/ and mixes with outside air when discharged. On average, 1.57% of the plant's waste heat is discharged into the atmosphere annually, while the remaining waste heat is channelled into the Sava.

5.6.1.2 The impact of extreme weather events and climate change on the safety aspects of LTE

The safety functions of the power plant have to be ensured during extreme meteorological events, which may also occur in combination with other natural hazards characteristic of the location (geological, seismotectonic, hydrological, biological phenomena and forest fires.) The Rules on radiation and nuclear safety factors JV5 /35/ stipulate that natural hazards must be taken into consideration when proving the safety of the power plant, including its spent fuel storage. Threats from natural hazards during normal and abnormal operation must be eliminated or contained, if this is practically applicable. It is also necessary to assess the effect of natural hazards on the development of accidents and identify the needs and possibilities for improvement /35/.

The periodic safety review (PSR) is conducted every ten years to systematically analyse and assess the safety of the power plant and compliance with the requirements set out in ZVISJV-1 and JV-5 (see Section 2.7.14). *Ad hoc* checks are carried out as necessary, depending on the events and experiences around the world (post-Fukushima analyses /26/). In keeping with requirements NEK successfully carried out two periodic safety reviews, the first one in 2003 and the second one in 2013. The third periodic safety review is currently underway and will be completed in 2023. The assessment process also follows the guidance of the International Atomic Energy Agency (IAEA) on the approach to safety analyses related to external risks, and the contents of PSR, which includes a risk analysis with regard to climate change /177/.

Section 2.7 describes how the safety of power plant operation is ensured, and Sections 2.7.8 and 2.7.9 describe operation in relevant extreme conditions (flooding and other extreme weather situations). The area is built to withstand extremely heavy local rain and storms by means of its basic design and a built-in drainage system. A design basis flood (DBF) is defined with a 10,000-year return period and a flow of 3,470 m^3/s at such a time, which corresponds to an elevation of 155.35 metres above the Adriatic Sea level[33]. The elevation of the plateau on which NEK stands is 155.20 m a.s.l. The entrances and openings of NEK buildings at the centre of the site are above 155.50 m a.s.l. This ensures that water cannot enter the buildings if the embankments along the Sava fail. The power plant is also protected against probable maximum floods (PMF) with a flow of 6,500 m^3/s. PMF is a hypothetical flood considered to be the most severe, reasonably possible flood, based on maximum probable precipitation and other hydrological factors, contributing to maximum water outflow, such as successive storms and simultaneous snowmelt. A cliff edge analysis was conducted within stress testing to examine the level of safety in the case of a 1,000,000-year return period flow/26/. Source /26/ recommends as possible additional safety improvements measures, which were indeed implemented within the safety upgrade programme (Section 2.8.5). In connection with flooding, design solutions were prepared in 2012 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 included passive and active flood protection elements. NEK's flood protection is designed and sized so as to provide functional protection also in the event of an earthquake (see Section 2.8.5.3).

Access to water for cooling is one of the fundamental safety requirements for power plant operation. Water is used for the cooling of structures, systems and components and for fire protection purposes. An analysis of data from 1926 to 2013 shows that in this period the minimum flow of the Sava was 41 m^3/s (USAR /3/). Minimum daily flows of the Sava are decreasing; over the past twenty years, the trend of decline was 0.15 m^3/s per year. The lowest measured daily flow in the last ten years was 45 m^3/s (NEK working data). The lowest level of the Sava required for essential service water (ESW) system operation is 147.85 m a.s.l., which corresponds to a flow rate of 32 m^3/s, which is extremely low and may occur with a 620-year return period (USAR). The mentioned lowest required level during a flow rate of 32 m^3/s is ensured by the concrete river dam spillway crest at an elevation of 147.50 m a.s.l. At this flow rate, the ESW system, which ensures ultimate heat sink (UHS), still operates without lowering the sluice gates of the dam on the Sava. If the flow is smaller or non-existent, UHS operates through ESW via the circulation and cooling of water in the pool/lake formed behind the lowered gates. In dry periods, the decrease in flow is predictable and changes take place gradually. Upstream, the construction of hydroelectric power plants on the Sava increased the capacities for water reserves, which is a positive effect.

Detailed information about the assessment of impacts of extreme weather events is given in the stress testing document /26/, which includes analyses of floods as well as other weather extremes: strong winds, intensive 24-hour precipitation, hail, frost, high snow cover, cyclone storms. In the same context, it was assessed that there is no chance of hurricanes occurring in this region. All building structures in which safety-class equipment is installed are designed not to be sensitive to extreme weather events: safety systems sensitive to ambient temperature, air and water coolers, ingoing water abstraction systems and piping, the essential service water system (ESW) for component cooling and emergency cooling, and heating systems. Safety limits were examined for the structures, systems and components in the scope of /26/ and it is concluded from the examination that no measures were identified or need to be implemented. NEK also prepared a technical report entitled Screening of External Hazards /34/, which provides a review of external hazards, specifically all external hazards except earthquakes, and all other hazards not included in internal events, internal floods, internal fires and high-energy pipe breaks.

The safety systems and buildings which are associated with the management of the severest postulated accidents (design extension conditions – DEC) are designed for minimum/maximum external temperatures of -28°C/46°C, in comparison with design basis temperatures of -28°C/40°C. DEC must be designed for extreme winds with a maximum speed of 240 km/h /3/. These parameters are conservative given the historical record of measurements and existing projections. The reference here

[33] At the national level, on the basis of analyses carried out in the flood risk assessment which also took into account climate change, it has been determined that the majority of floods occur in a return period range of 2-500 years, and predominantly in the range of 5 to 100-year return periods (Flood risk assessment, Ministry of the Environment and Spatial Planning, November 2016, Chapter 8 Conclusion).

is /252/, which provides weather data for Slovenia. Section 6.4 describes the selected scenarios and impacts from a range of design basis accidents and DEC accidents.

NEK has an automatic weather station with a 70-metre tall tower, with instruments for measurement in three altitude layers, and additional equipment for altitude measurement of atmospheric parameters using SODAR. Annual reports include monitoring of the trends and changes of climate variables, and calculations of the dispersion characteristics of the atmosphere X/Q which are important in examining and simulating dispersion from projected accidents in the atmosphere. In connection with the changes in the hydrological conditions on the Sava, an applicable document is the "Agreement on measures and obligations to ensure unchanged, safe and uninterrupted operation of NEK during the operation of the hydroelectric power plants on the lower Sava by implementing additional monitoring on the Sava" (2018).

A reference should also be made to the general global experience as regards the impacts of extreme weather conditions on power plant operation. Since 1980, IAEA has maintained a database for reporting nuclear plant incidents (IRS). IRS may be considered a relevant primary source of information on the sensitivity of power plants to extreme weather events. Of the 3,665 reports registered in the database in the period from 1980 to 2010 for various types and intensities of nuclear power plant events, only 2% involve weather or climate events. The largest portion of reported extreme weather conditions (88%) primarily relate to the following systems: cooling systems (28%), instrumentation and control systems and systems for electricity transmission to the grid /178/.

Based on the above, the following conclusion may be made: both the legal framework relating to nuclear safety and international practice point to the fact that extreme weather events, including the effects of climate change must be taken into consideration, also in combination with other natural events and events resulting from human activity. The analyses carried out within the Periodic Safety Review every ten years encompass a suitable weather period for making an assessment of the significance of climate-related changes. Comprehensive reporting in accordance with the Paris Agreement is carried out in ten-year review cycles. Consensual global scientific findings on climate change are updated every seven years (Climate Change Assessment Reports – IPCC). The last report was adopted in 2018 (AR 5) and publication of the next is expected in the course of 2021, though it may take several years to receive approval from UNFCCC member states /253/. The predictions of climate models available today are best suited to predicting average meteorological variables, whereas predictions of the intensity of extreme events and the frequency of their occurrence and duration will become increasingly precise. Nuclear safety limits are based on a conservative approach, which covers for all the existing uncertainties which are present in predicting weather changes. Extreme weather conditions are predictable from the perspective of prognosis, whether it is heat waves, cold days or storm cyclones, which enables timely preparation for them.

It may be concluded that in view of the existing measures and the standard operation review carried out in the PSR process, climate change associated with extreme weather conditions has no significant impact on LTE.

The <u>impact of the activity</u> and <u>overall impact</u> in terms of the impact of climate change on the activity during operation are evaluated as **(3)** – impact is not significant, on account of the implementation of mitigation measures that NEK already implements and must continue to implement during extended operation.

Measures that NEK already implements are as follows:

- if the flow rate of the Sava is less than 100 m^3/s, NEK includes the cooling towers, which employ circulation to cool a portion of condenser water;
- the structures, systems and components of the power plant are dimensioned to withstand extreme weather events and meteorological parameters with highly conservative margins, in view of nuclear legal framework requirements, global practices and Best Available Techniques (BAT);

- the periodic safety review, which is performed every 10 years, includes a deep analysis of the impact of extreme weather events on the safety of the power plant. Two reviews will be performed in the period to come (2021-2023 and 2031-2033);
- measures from the environmental permit related to limitation of the heat load and water collection through the use of a combined cooling system (flow system and cooling towers). In all river flow conditions of the Sava, the power plant maintains a temperature difference of no more than ΔT 3°C, which will not change in the power plant's future operation. In 2008, NEK supplemented its cooling facilities with the construction of a third block of cooling towers;
- NEK has preparation procedures in place for the event of hydrological conditions that may affect the plant's operation: activation of cooling towers at high water levels due to the risk of inflow of debris (branches, plastic etc.);
- NEK has procedures in place for cooperation with other energy facilities on the Sava – the Agreement on measures and obligations to ensure unchanged, safe and uninterrupted operation of NEK during the operation of HPP on the lower Sava with additional monitoring activities on the Sava;
- on-site measurements of meteorological parameters are carried out at the automatic station with the 70-metre-tall meteorological tower and the use of SODAR for high-altitude atmospheric measurements. The measurements are reported on a yearly basis.

5.6.2 Termination of the activity

Should NEK cease operations (see Section 2.18), there will no longer be any potential impacts of climate change on production. The impact of climate change from the perspective of power plant safety will be smaller when LTE is terminated than during the plant's operation. In terms of safety, water will still have to be ensured for the cooling of spent fuel, as described in the other sections (see Section 5.3.1.2).

The impact of the activity and overall impact of climate change on the activity if the activity is terminated are evaluated as **(4)** – no significant impact.

5.7 IMPACTS ON NOISE POLLUTION

5.7.1 Operation

No new noise sources are foreseen due to the extension of NEK's operational lifetime. NEK's production capacity also remains unchanged, and the power plant will continue to operate 24 hours a day, every day of the year, even after the extension of the operational lifetime. A potential increase of noise in the area could result from a higher number of operating days for the cooling towers, in relation to climate change, as explained below.

Primarily the following external sources of noise contribute to environmental noise:

- cooling towers;
- transport and delivery;
- warning signals (primarily from the internal communication system – 'page');
- the functioning of transformers; and
- the functioning of the turbine generator.

The main sources of external noise are shown in Figure 88 below.

Sources of noise at NEK are neither permanent nor continuous, and operate more or less intensively, depending on needs.

Given that production capacity remains unchanged, the noise pollution caused by the aforementioned sources will remain at the current level. In the context of climate change, there could be a rise in air temperature and a fall in the flow of the Sava, which could lead to an increase in the operation of cooling towers, but given the trend of climate variables, we estimate that the number of days that the cooling towers operate will not change significantly. The average number of days that the cooling towers operate has fluctuated from 5 to 179 over the last ten years, and from 0 to 104 days annually at full capacity. It follows that noise emissions will remain within the range of existing levels. The contribution of cooling towers to noise pollution in the area is explained below.

As evident from measurements of environmental noise that NEK performs every five years and that were performed in 2015 (report no. LFIZ – 201500001 – JJ/M of 11 September 2015) and 2020 (report no. LOM – 20200588 – KR/M of 29 December 2020), the readings indicate that the area surrounding NEK is not subject to excessive noise pollution. Specifically, as follows from the measurements, noise from the operation of NEK did not exceed the limit values for environmental noise indicators set out in the Decree on limit values for environmental noise indicators (Official Gazette of RS Nos. 43/18 and 59/19).

The most recent measurements in 2020 did not include noise pollution from the operation of cooling towers, because the towers were not operating at the time of the measurements. While it is evident from the measurements in 2015 that the cooling towers contribute to the increased values of noise indicators, the latter are still well below the limit values.

Presented below are two tables with the results of measurements in 2015 and 2020 (Table 124 and Table 125).

It is evident from measurements in 2015 at measuring point 2, which is closest to the cooling towers, that the latter contribute around 12 dB(A) (of the measured value of 50 dB(A)) during the day and evening, and 14 dB(A) (of the measured value of 50 dB(A)) at night. The measured noise indicator values are still well below the relevant limit values for Level IV noise protection where the measuring point is also located, and amounts to 73 dB(A) L_{day}, 68 dB(A) $L_{evening}$ and 63 dB(A) L_{night}.

Figure 88: Main sources of noise at the NEK site. The NEK site is marked in blue[34]; areas of increased transport are marked in yellow; the turbine building, which houses

[34] The NEK site in the figure differs from the site of the activity considered by the EIA report. Namely, the northern area is not subject to LTE.

transformers and the turbine generator, is marked in orange; the diesel generators are red; and the cooling towers are marked in green (source: /52/)

Based on the measurements stated in report no. LFIZ – 201500001 – JJ/M of 11 September 2015, it was determined that, despite their contribution to overall noise, the sources in question did not exceed the limit values for environmental noise defined in the Decree on limit values for environmental noise indicators (Official Gazette of RS Nos. 43/18 and 59/19) at any assessment point.

Table 124: Data from measuring points in the scope of operational noise monitoring in 2015 (source: ZVD /51/)

Measurement point	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Measuring point 1 South-eastern side (Mrtvice) at a distance of around 650 m from NEK. Latitude: 45.931138°N Longitude: 15.520523°E	39	39	47	53
Measuring point 2 Southern lot boundary at a distance of around 270 m from NEK. Latitude: 45.934950°N Longitude: 15.514570°E	50	50	50	56
Measuring point 3 South-western lot boundary (Žadovinek) at a distance of around 1,200 m from NEK. Latitude: 45.934579°N Longitude: 15.501619°E	35	35	42	48
Measuring point 4 South-eastern side in the direction of the settlement of Spodnji Stari Grad at a distance of around 810 m from NEK. Latitude: 45.941869°N Longitude: 15.524462°E	31	31	43	48
Measuring point 5 At the intersection in front of the GEN commercial building at a distance of around 1,000 m from NEK. Latitude: 45.943940°N Longitude: 15.508563°E	39	39	35	43
Measuring point 6 Western lot boundary at a distance of around 600 m from NEK. Latitude: 45.940197°N Longitude: 15.507249°E	36	36	37	44

Table 125: Data from measuring points in the scope of operational noise monitoring in 2020 (source: ZVD /52/)

Measurement point	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Measuring point 1 South-eastern area (Mrtvice) at a distance of around 580 m from NEK. GKY: 540583 GKX: 87559	40.7	40.7	33.5	42.9
Measuring point 2	38.1	38.1	35.7	42.8

Measurement point	L_{day} (dBA)	$L_{evening}$ (dBA)	L_{night} (dBA)	L_{den} (dBA)
Southern lot boundary at a distance of around 270 m from NEK. GKY: 540236 GKX: 87803				
Measuring point 3 Western area (Žadovinek) at a distance of around 1,350 m from NEK. GKY: 538797 GKX: 88409	40.5	40.5	39.1	45.9
Measuring point 4 South-eastern side in the direction of the settlement of Spodnji Stari Grad at a distance of around 440 m from NEK. GKY: 541023 GKX: 88749	39.6	39.6	36.4	43.8
Measuring point 5 Northern area, in front of the nearest commercial building of Saramati Adem d.o.o., at a distance of around 130 m from NEK. GKY: 540133 GKX: 88941	47.5	47.5	40.9	50
Measuring point 6 Western area, in the direction of buildings located at Vrbina 16, at a distance of around 450 m from NEK. GKY: 539709 GKX: 88551	39.9	39.9	36.8	44.1

As evident from Section4.4.12, the last measurements (report no. LOM – 20200588 – KR/M of 29 December 2020) also assessed noise level indicators in front of the most exposed buildings with protected areas. The sources in question did not exceed the limit values for environmental noise defined in the Decree on limit values for environmental noise indicators (Official Gazette of RS Nos. 43/18 and 59/19) at any assessment point (in front of the most exposed buildings with protected areas) during the power plant's operation.

On the basis of measurements and analyses of noise in the surrounding area (the results are described in report no. LOM – 20200588 – KR/M), we find that the sources in question did not exceed the limit values for environmental noise defined in the Decree on limit values for environmental noise indicators (Official Gazette of RS, Nos, 43/18 and 59/19) at any assessment point (in front of the most exposed buildings with protected premises) during the power plant's operation.

Impact of climate change on the cooling tower operation

As mentioned in the introduction to this section, an increase in the scope of cooling tower operation may be expected in the future due to climate change impacts. Measurements in 2015 /51/ included the operation of cooling towers, where **equivalent** noise levels were measured in the day, evening and night at 6 measuring points.

During the day, the greatest equivalent value of noise indicator L_{day} was detected at measuring point 2, which is located 270 m from NEK's southern lot boundary. The average equivalent value of three readings was 49.6 dB(A), which is considerably lower than the limit values of noise indicator L_{day} for noise protection areas III and IV, which are 58 and 73 dB(A), respectively.

In the evening, the greatest equivalent value of noise indicator $L_{evening}$ was detected at measuring point 2, which is located 270 m from NEK's southern lot boundary. The average equivalent value of three readings was also 49.6 dB(A) and therefore below the limit values of noise indicator $L_{evening}$ for noise protection areas III and IV, which are 53 and 68 dB(A), respectively.

In the night time, the greatest equivalent value of noise indicator L_{night} was detected at measuring point 2, which is located 270 m from NEK's southern lot boundary. The average equivalent value of three readings was 50.2 dB(A), which is higher than the limit value of noise indicator L_{night} for noise protection area III, which is 48 dB(A), and lower than the 53 dB(A) limit value of noise indicator L_{night} for noise protection area IV.

At all the other measuring points the values of noise indicators were lower, which is normal as the measuring points are further away. Measuring point 2 is located in a level IV noise protection area. The locations of measuring points are given in Table 125 above.

The nearest building with protected premises (Spodnji Stari Grad 2) is more than 920 m from the location of the cooling towers. Measuring point 4 is situated in the direction towards this building at 700 m distance from the cooling towers and thus 220 m closer than the nearest building with protected premises.

The equivalent values of noise indicators at measuring point 4 were: L_{day} 31.2 dB(A), $L_{evening}$ 31.2 dB(A) and L_{night} 42.7 dB(A). All the readings were significantly lower than the limit values of noise indicators, which are 58 dB(A) for L_{day}, 53 dB(A) for $L_{evening}$ and 48 dB(A) for L_{night}. This means that the noise from NEK operations, which is present at the nearest building with protected premises, is imperceptible on account of background noise (impact from traffic).

On the basis of the above, it is concluded that even in the case of the blackest scenarios of climate change that in theory necessitated the cooling towers to operate 365 days a year, the area of NEK and its immediate surroundings (the area of measuring points) would not be exposed to excessive noise pollution.

The impact of the activity and overall impact on environmental noise pollution during operation are evaluated as **(4)** – impact is not significant.

It is evident from reports on the operational monitoring of noise in 2015 and 2020 /51/, /52/ (described in Section 4.4.12), which included the area of the activity and the immediate vicinity, that no excessive noise pollution was identified in 2015 and 2020 at any of the aforementioned measuring points during the day, evening and night as the result of the operation of NEK.

5.7.2 Termination of the activity

After NEK ceases operation, most of the devices on the NEK site will stop operating as well. Activities that cause noise will be significantly reduced.

The impact of the activity and overall impact on environmental noise pollution if the activity is terminated are evaluated as **(4)** – impact is not significant.

5.8 IMPACTS OF ELECTROMAGNETIC RADIATION

5.8.1 Operation

No new sources of electromagnetic radiation (e.g. transformer stations) are foreseen due to the extension of NEK's operational lifetime. Likewise, there are no plans to fit the existing transformer stations with new transformers or replace them with greater capacity transformers. On the basis of the above, we estimate that the electromagnetic radiation load will remain unchanged, i.e. as shown by the last EMR measurements in 2021.

The entire NEK site is classified as a level II electromagnetic radiation protection area, while nearby residential areas that are more sensitive to radiation are deemed level I electromagnetic radiation protection areas. The main sources of low frequency EMR on the NEK site are transformers and power lines. The developer operates several transformer stations (description in Sections 2.5.5 and 2.10.5). It is evident from the 2020 report on measurements of low frequency electromagnetic fields /53/ that the limit values for level II radiation protection at the NEK site and on the site's boundaries were not exceeded (description in Section 4.4.14). All transformer stations are regularly checked and serviced, with appropriate records kept.

The impact of the activity and overall impact in terms of the environmental burden of electromagnetic radiation during operation are evaluated as **(4)** – impact is not significant.

5.8.2 Termination of the activity

In the case of activity termination, the plan is to shut down the transformers in transformer stations managed by the developer.

The impact of the activity and overall impact in terms of the environmental burden from electromagnetic radiation if the activity is terminated are evaluated as **(5)** – no impact.

5.9 IMPACTS OF VIBRATIONS

5.9.1 Operation

Vibrations that are transmitted directly into the environment in the form of occasional tremors or constant fluctuations could be the result of road freight transport, rail transport, the functioning of certain machines and devices, or certain activities (e.g. blasting, demolition, drilling, cargo handling, etc.). The transmission of vibrations into the environment depends on a number of factors (the structure of the ground, the installation of machines and devices, road conditions, etc.).

The site of the activity covered by this report is at least 500 m away from the nearest residential building or other buildings that are sensitive to vibrations (e.g. cultural heritage structures, kindergartens, schools, etc.). Road transport in the scope of the activity flows along public regional and state roads, while local roads in densely populated areas are not used for the delivery of raw materials and ancillary materials, and the transport of products. The scope of road transport for operational needs is and will continue to be small, and will also flow along public regional roads outside densely populated areas. The production process inside NEK does not include machines, devices or activities that could be a significant source of vibrations in the environment.

There are also no regulations in Slovenia that directly address vibrations from the operation of facilities in terms of environmental impacts.

The impact of the activity and overall impact in terms of the environmental impact of vibrations during operation are evaluated as **(5)** – no impact.

5.9.2 Termination of the activity

After NEK ceases operation, the majority of devices that may cause vibrations to the environment will stop operating. This means that the activities that cause vibrations at the NEK site will be significantly reduced.

The impact of the activity and overall impact in terms of the environmental burden from vibrations if the activity is terminated are evaluated as **(5)** – no impact.

5.10 IMPACTS OF WASTE

The quantities and types of waste are discussed in more detail in Sections 2.19.4, 4.4.9 and 4.4.10.

5.10.1 Operation

Radioactive waste

The types and annual quantities of waste (including radioactive) produced by NEK will not change substantially as a result of NEK's extended operational lifetime relative to the existing status. The dynamics of waste generation remain **unchanged** and compliant with the provisions of the USAR /3/ and RETS /7/.

Due to the extension of the operational lifetime from 2023 to 2043, there will be an extra 547 m^3 or 884 t of operational LILW.

Data regarding the generation of radioactive waste during the extended operational lifetime, data regarding the functioning of the gaseous waste processing system, the liquid radioactive waste processing system and the solid radioactive waste processing system, the operation of which will be unchanged during the extended operational lifetime, and data regarding processing, packaging, storage and disposal preparation, on which the extension of the operational lifetime has no impact, are presented in Section 4.4.10. Likewise, the disposal of LILW will be unchanged.

Spent fuel

The environmental burden on account of spent fuel during the extended operational lifetime of NEK will be the same as the current burden in terms of scope and form, i.e. the burden in the years prior to the extension of the operational lifetime.

The introduction of dry storage will change the technology of storing spent fuel (SF) from wet to dry. 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. An environmental impact assessment was carried out for the SF dry storage and the building permit for it was acquired (building permit no. 35105-25/2020/57 of 23 December 2020).

Spent fuel is being temporarily stored in the spent fuel pool in the fuel handling building. Because the fuel is underwater, the aforementioned pool is considered wet storage where the water needs to be continuously cooled. Dry storage introduces a new, technologically safer way of storing spent fuel that leads to a gradual reduction in the number of spent fuel elements in the pool, which in turn increases the level of nuclear safety significantly.

The planned construction of a dry storage facility ensures a safer and completely passive way of storing spent fuel. That facility will accommodate the storage of 2,600 fuel elements.

There was a total of 1,444 fuel elements stored at NEK at the end of 2020, of which:

- 1,323 in the spent fuel pool (SFP) inside the fuel handling building (FHB), including two special containers with fuel rods and a fission chamber from 2017, and
- 121 in the reactor pressure vessel (core) in the reactor building.

If NEK operates until the end of 2023, a total of 1,553 elements of spent fuel will be generated, and if it 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.

Data on SF generation and SF management procedures, which will be same during the power plant's extended operational lifetime as in the previous period, are presented in Section 4.4.11. The disposal of spent fuel will also be unchanged.

Management of other waste

There are around 36 existing types of waste (2020) that are generated in all production and support processes, of which 19 are hazardous types of waste (description in Section 2.19.4.1). The total volume of waste generated in 2019 was around 2,302 tonnes, including 2,192 tonnes of construction waste from works performed in 2019. The hazardous waste amounted to approximately 12.3 tonnes.

All waste, except for radioactive waste, is handed over for treatment to a contractor. NEK does not treat the other waste. Waste is separated by type at the source, while waste is stored temporarily in accordance with valid regulations. A closed area is used for the temporary storage of hazardous waste. Waste is removed regularly. Continuous records are kept of the quantities of hazardous waste in temporary storage.

The company continuously implements various technical and organisational measures to reduce the quantities of generated waste and to improve the management thereof, i.e. improved waste separation at the source. NEK also holds the ISO 14001:2015 certificate.

The impact of the activity and overall impact in terms of the generation and environmental burden of waste during operation are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, specifically measures that NEK already implements and will continue to implement during extended operation, particularly in the area of radioactive waste management.

5.10.2 Termination of the activity

After the cessation of NEK operations (see Section 2.18), the maintenance and emptying of fluid systems, and the decontamination of appliances and facilities will produce the same form and quantity of radioactive waste as during operation.
Due to the extension of the operational lifetime from 2023 to 2043, there will be an extra 547 m^3 or 884 t of operational LILW.

Due to the extension of the operational lifetime from 2023 to 2043, an extra 728 spent fuel elements will be generated.

The impact of the activity and overall impact in terms of the generation and environmental burden of waste if the activity is terminated are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, specifically measures that NEK already implements in the area of waste management.

5.11 IMPACTS OF IONISING RADIATION

5.11.1 Operation

During NEK's operation, the emission of radioactive material into the environment will be equal to the existing rate. NEK is continuously upgrading and improving its safety and process systems, which means that the environmental burden is constantly decreasing. The estimated annual effective dose to an inhabitant most affected by NEK's impacts in 2020 was less than 0.1 µSv (0.071 µSv). Compared to the annual effective dose from natural background radiation in Slovenia, which amounts to ca. 2,500 µSv, the contribution of NEK is negligible, as well as more than 100 times lower than the 50 µSv dose limit.

Several figures (Figure 50, Figure 51, Figure 52 and Figure 53) in Section 4.4.6.1, which describes the current situation, are comparisons of annual radioactive emissions into the air. Average radioactive emissions into the air for the 2010–2020 period are presented in Table 126 below. Similar or lower airborne radioactive emissions are also expected after 2020.

Table 126: Average annual airborne radioactive emissions in the period 2010–2020

	Average annual value	% of annual limit
Noble gases	1.4 E12 Bq	0.16
Iodines (I-131 equivalent)	3.6 E07 Bq	0.19
H-3 in airborne discharges	5.2 E12 Bq	n.a.
C-14 in airborne discharges	8.1 E10 Bq	n.a.
Aerosols	3.2 E05 Bq	0.0017

The data above leads to the conclusion that on average, airborne emissions of noble gases and iodines **do not amount** to a single percent of the annual limit. Liquid effluents of H-3 only amount to **slightly over a quarter** of the annual limit (45 TBq). For all other radionuclides, emissions amount to only a few percent of the annual limit. This is an indication of the good control and management of discharges of radioactive material. Similar or lower radioactive emissions are also expected in the future.

A spent fuel storage facility is planned and is currently under construction. The level of ionising radiation in the surrounding area will be elevated during the operation of this facility. This involves external radiation. The document Krško SFDS site boundary and outside wall dose calculations /2/ summarises the results of calculations of ionising radiation levels in the vicinity of the storage facility. Spent fuel elements will be relocated from the spent fuel pool to dry storage in four campaigns, as follows:

- a. Campaign I in 2023: up to 592 fuel elements;
- b. Campaign II in 2028: around 592 fuel elements;
- c. Campaign III in 2038: around 444 fuel elements; and
- d. Campaign IV in 2048: remaining fuel elements.

The doses are calculated on conservative assumptions:

- The modelling of neutron absorption in the fuel was done *for fresh and not spent fuel*, which means that the calculated dose rates resulting from neutron radiation are higher than they will actually be. Fresh fuel contains no fission products that absorb neutrons. Hence, there are fewer n-gamma reactions and a smaller contribution of gamma radiation.
- Calculations considered the lowest densities of materials from which storage facility walls and containers can be made. Lower densities mean poorer protection, which again means that the estimated dose rates are higher than they will really be.
- For radiation source, fuel is assumed to be in the reactor for the maximum length of time as regards enrichment. This means that the dose rates for neutron and gamma radiation are conservative.
- For stainless steel, it is assumed that the content of Co-59 as an impurity is 0.8 g/kg in non-fuel components of fuel elements. This means higher calculated dose rates of gamma radiation caused by Co-60, which arises due to the activation of Co-59.
- When calculating doses, it is assumed that a person is next to the NEK perimeter fence all year, i.e. for 8,760 hours, which is an extremely conservative assumption.

The results of calculations of radiation levels on the NEK perimeter fence resulting from the operation of dry storage are presented in the table below:

Table 127: Results of calculations of dose rates and doses on the NEK fence

Campaign	Highest dose rates (μSv/h)	Annual effective dose (mSv)	Annual limits from the technical specification (mSv)
After Campaign IV (full storage)	5.622 E-03	0.0492	0.05
After Campaign IV (full storage), realistic estimate	4.525 E-03	0.0396	0.05
After Campaign II	5.369 E-03	0.0470	0.05
After Campaign I	4.315 E-03	0.0378	0.05

The results of calculations of radiation levels on the exterior wall of the dry storage building for spent fuel are presented in the table below.

Table 128: Results of calculations of dose rates on the exterior wall of the spent fuel dry storage building

Campaign	Highest dose rates (μSv/h)	Limits from the technical specification (μSv/h)
After Campaign IV (full storage)	0.028	3

Campaign	Highest dose rates (μSv/h)	Limits from the technical specification (μSv/h)
After Campaign II	0.022	3
After Campaign I	0.020	3

All calculations of radiation levels show that the dose rates and the doses of ionising radiation under realistic assumptions will be within the very strict limits set out in the technical specifications of the project for the construction of dry storage, and that they are lower than the permitted levels.

Likewise, the annual effective dose of external radiation on the NEK perimeter fence from all contributors, including SF dry storage, will not, during operation, exceed the radiation load that currently applies to the NEK perimeter fence, which is 200 μSv /7/.

The impact of the activity and overall impact in terms of the environmental burden of ionising radiation during operation are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, including measures that NEK already implements for protection against ionising radiation and measures that will be implemented due to the dry storage of SF.

5.11.2 Termination of the activity

After NEK ceases operation (see Section 2.18), the fuel will no longer be in the reactor, but stored safely in the spent fuel pool and/or in the dry storage for spent fuel.

Ionising radiation due to the dry storage will be present on the NEK fence, as evident in Table 127, while the gaseous and liquid emissions will be substantially smaller or completely non-existent.
To that end, it will be necessary to implement all protective measures to prevent the leakage of ionising radiation into the environment.

The impact of the activity and overall impact in terms of the environmental burden of radiation if the activity is terminated are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, specifically measures that NEK already implements for protection against ionising radiation and will continue to implement once the activity is terminated.

5.12 IMPACT OF LIGHT POLLUTION

5.12.1 Operation

As NEK's external lighting is an integral part of the technical systems for ensuring physical protection, NEK is not bound by the Decree on limit values for light pollution (Official Gazette of RS, Nos. 81/07, 109/07, 62/10, 46/13), but by the Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13, 76/17 [ZVISJV-1]).

Nevertheless, NEK continuously strives to comply with requirements for reducing light pollution, for example by:

- using the appropriate, horizontally mounted lights with level glass;
- not turning lights upwards more than is foreseen in the project to achieve appropriate illumination levels; and
- upgrading lights with modern, energy efficient solutions such as LEDs, etc.

Installation of additional lights on the NEK site **is not foreseen** in the scope of operational lifetime extension, so the illumination of the area and the light emitted to the surroundings will be **equal** to the existing state.

The impact of the activity on environmental light pollution during operation is evaluated as **(4)** – impact is not significant, because the number and total electrical power of all lights will not change as the result of the extension of NEK's operational lifetime.

The overall impact on environmental light pollution during operation is evaluated as **(4)** – impact is not significant. Here, we take into account the fact that the NEK site is located in an area intended for energy-related activities, that lighting from the production facilities of other operators and street lights is present in the vicinity, and that nature conservation areas lie outside of the area affected by NEK's exterior lighting.

5.12.2 Termination of the activity

In the case of terminating the activity, light sources will be the same as in the existing situation, since the NEK site will continue to be a controlled area.

The impact of the activity and overall impact in terms of the environmental burden of light emissions if the activity is terminated are evaluated as **(4)** – impact is not significant.

5.13 IMPACT ON THE LANDSCAPE

5.13.1 Operation

Since its construction at the beginning of the 1980s, NEK has been a spatially dominant element of the Krško-Brežice plain and serves as a point of orientation for inhabitants and visitors. The NEK complex is bordered on three sides by intensive orchards, while a fully open view of the complex is only afforded from the south, i.e. the right bank of the Sava.

Figure 89: View of NEK from Libna (source: /193/)

The silhouette of NEK is not typical of the majority of nuclear power plants, whose image is burned into the consciousness of people around the world and reflected in popular culture, because it does not have any high and massive cooling towers.

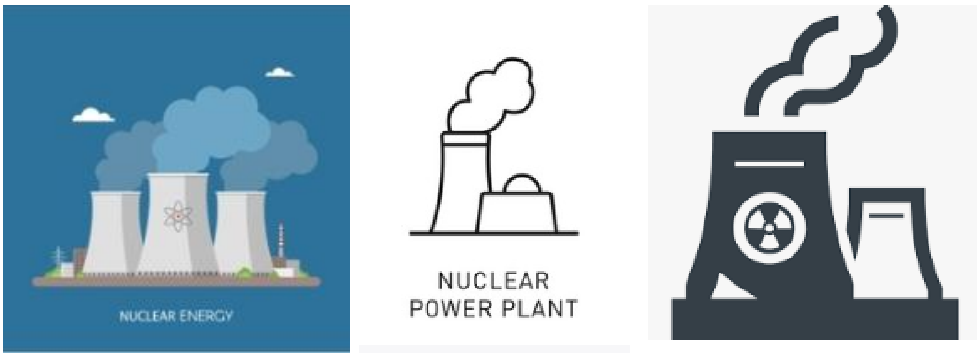

Figure 90: Examples of logos for nuclear power plants /113/, /114/, /115/

Figure 91: View of NEK from the southeast (source: /193/)

The central and highest part of the power plant is the nuclear island. Situated at the heart of the nuclear island is the reactor building in the shape of a cylinder with a domed roof, which at a height of 62.5 metres is by far the tallest building in the NEK complex and is visible from the wider surrounding area. It is surrounded by the auxiliary reactor building, the intermediate building and control building. On the north side of the nuclear island is the second-tallest building in the complex, the turbine building, at a height of 37.6 m. East of the reactor building is the fuel-handling building, which stands 34 m tall and is the third highest building at the power plant. All other buildings making up the nuclear island are 25 m in height or less.

From the nuclear island, the height of buildings descends towards the complex's perimeter fence. The SF dry storage building is (or will be) 20.5 m tall, while all other buildings are lower.

NEK's cooling towers are located in three elongated buildings and are around 16.8 m tall. In comparison, the cooling towers at existing nuclear power plants around the world reach a height of as much as 180 m. NEK's towers are used for cooling when the water level of the Sava is low or too high, and are for the most part idle. For this reason, the power plant does not draw attention to itself with a constant plume of steam when observed from larger distances.

Figure 92: View of NEK with functioning cooling towers (source:/116/)

The following characteristics play an important role in the visibility of buildings in the surrounding landscape: size, shape, colour and transparency of buildings, as well as the distance between the buildings and the observer, and the contrast between buildings and the background. Another important factor is the reduced visibility of the complex from the surrounding area due to physical barriers (relief forms, high vegetation and buildings). Visibility is also heavily affected at any given moment by atmospheric conditions, such as fog, precipitation, cloud cover, vapours, light and the angle of illumination. Also worthy of note is the psychological-social aspect of the perception of an observed object as the process of receiving, organising and interpreting information. The visual impact is also conditional on the intensity of observation, which depends on the frequency of observation and the number of observers.

The visibility of NEK buildings is thus affected by the location and distance of the observer, and barriers between them and the buildings. In an open space, an observer sees entire buildings or parts of buildings that extend above the line of vegetation, and that project upwards towards the sky or onto a relief background. In an area with nearby vegetation or buildings, an observer's view of NEK buildings is at least partially blocked by barriers between them and the buildings. This applies to observation from the plain and surrounding slopes.

The power plant cannot be seen in full from the majority of locations; primarily the reactor building, which stands out due to its height, is visible. The nuclear power plant is visible from the slope in Libna, the Krško–Brežice regional road, from the main rail line, from the edge of Sp. Libna and the edge of Sp. Stari Grad, from the edge of Žadovinek, from the sloped area of Krško on the right bank, from the edge of Drnovo, from the sloped area of Leskovec, from the edge of Kerinov Grm and from the edge of Gorica. NEK is visible from the surrounding flat farmland, from roads on the left and right banks of the Sava, and from the Krško–Brežice motorway. The power plant is not visible or noticeable from other settlements and areas due to the lie of the land, distance and swaths of vegetation that lie between those areas and NEK.

Figure 93: View of NEK from the Krško–Brežice regional road (source:/112/)

Figure 94: View of NEK from the Krško – Brežice motorway (source: /112/)

Also visible in addition to NEK buildings are the high-voltage power lines that connect to the Krško substation on the north-western corner of the complex:

- 2 x 400 kV Beričevo–Krško power line, 400 kV Mihovci–Krško power line and 400 kV Zagreb–Krško power line; and
- 110 kV Krško–Brežice power line, 110 kV Brestanica–Krško power line and 110 kV Krško–Hudo power line.

Figure 95: View of NEK and connecting power lines from the north (source: /112/)

The current appearance of the power plant differs considerably from the original appearance. Prior to renovation, nuclear island buildings were mainly the colour of raw concrete, while some of the piping and protective fences were painted yellow. Several sheds (auxiliary and service structures) were located in the complex. The façades of buildings were pale yellow or light grey, while some doors were painted light green. Canopy roofs were brown or grey-green. The posts of the outer protective fence were painted yellow.

Figure 96: Original appearance of the power plant before renovation (source: /117/)

In the late 1990s, NEK commissioned a comprehensive architectural redesign, the aim of which was to conceptually link buildings that differed in terms of importance, content, size, location, architectural style, period of construction, façade texture and condition at the time of the planned renovation. The selection of 16 pastel colour shades from the Manual on the comprehensive architectural redesign of NEK (IBE, 1999) includes shades of blue, grey, green and brown, and is still used today when designing the exterior of buildings in the complex.

The appearance of the power plant will not change during the lifetime extension in the period 2023–2043. At the beginning of the extended operational lifetime, dry storage building for spent fuel will have already been built, while no other construction works are foreseen. Due to climate change and the resulting more frequent occurrence of high and low flow rates of the Sava, it is expected that the cooling towers will operate more often, which will be reflected in a slight increase in the frequency of steam discharges that will be visible from greater distances. The occasional appearance of steam will not have a significant effect on NEK's visibility in the surrounding area. The construction of an LILW repository east of NEK and the planting of a forest belt alongside the repository will result in a slight decrease in the power plant's visibility from the east and south-east.

NEK has been a spatial constant for several decades. The comprehensive renovation two decades ago, resulting in a uniform appearance, made the power plant blend in better with the landscape. The extension of the power plant's lifetime does not envisage changes in its appearance, except for the slightly more frequent release of steam discharges.

The impact of the activity and overall impact during operation are evaluated as **(4)** – impact is not significant.

5.13.2 Termination of the activity

Terminating LTE (see Section 2.18) does not include the removal of any structures or the option of re-establishing the previously existing use. This is to be carried out in the scope of decommissioning, which will be subject to a separate administrative procedure. Except for the steam from the cooling towers which will be gone if LTE is terminated, the impact from LTE termination on the landscape will be the same as during operation.

Figure 97: View of NEK from the south, i.e. from farmland on the right bank of the Sava (source: /112/)

Figure 98: View of the NEK site and LILW repository, photomontage (source: /193/)

The impact of the activity and overall impact on the landscape while the activity is terminated are assessed as **(4)** – impact is not significant.

5.14 IMPACTS ON NATURE

5.14.1 Operation

5.14.1.1 Flora and habitat types

During operation, safety requirements will dictate the need to maintain tree and shrub vegetation in the NEK buffer zone (prevention of overgrowth). The impact will be direct, medium-term and localised, and will only entail preserving the current situation. Because NEK will operate with its existing infrastructure, there will be no other direct impacts on vegetation and land habitat types. During operation, NEK does not emit ionised radiation into the environment that could have a significant impact on the flora and fauna in the area surrounding the power plant. Safety systems prevent the uncontrolled release of radioactive material into the environment. The design of safety systems provides safety functions in all operational states, even in the event of specific equipment failure. The release of radioactive material into the environment is prevented by four successive safety barriers. The basic objective of the first three barriers is to prevent radioactive material from passing to the next barrier, while the fourth barrier prevents radioactive material from being released directly into NEK's surroundings. 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. We therefore assess the impact as insignificant.

A sustained impact on the vegetation and types of habitat in the vicinity of NEK could occur in the event of a serious accident resulting in the discharge of radioactive material into the environment. Numerous safety upgrades have been implemented at NEK. For this reason, the possibility of core damage is very small. NEK was designed to withstand design basis accidents and to manage them using its safety systems. NEK can use the DEC-A equipment to prevent reactor core meltdown. The DEC-B equipment, however, was intended for managing an event which might lead to the very unlikely core meltdown and focuses on protecting the final barrier before release, i.e. the integrity of the containment. The passive filter system serves to relieve the pressure in the containment, while environmentally harmful substances remain trapped in the filters. Direct release into the environment is therefore unlikely.

The impact of the activity on vegetation and habitat types during operation is evaluated as **(4)** – impact is not significant.

The overall impact on vegetation and habitat types during operation is evaluated as **(4)** – impact is not significant.

5.14.1.2 Fauna

Impacts on fauna will not change relative to the current situation. The duration of those impacts will, however, be extended.

During operation, NEK does not emit ionised radiation into the environment that could have a significant impact on the fauna in the surrounding area (see Section 5.11). Safety systems prevent the uncontrolled release of radioactive material into the environment. The design of safety systems provides safety functions in all operational states, even in the event of specific equipment failure. The release of radioactive material into the environment is prevented by four successive safety barriers. The basic objective of the first three barriers is to prevent radioactive material from passing to the next barrier, while the fourth barrier prevents radioactive material from being released directly into NEK's surroundings. 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. We therefore assess the impact as insignificant.

The entire exterior of NEK is illuminated for the purpose of ensuring physical protection, i.e. security. As NEK's external lighting is an integral part of the technical systems for ensuring physical protection, NEK is not bound by the Decree on limit values for light pollution (Official Gazette of RS, Nos. 81/07, 109/07, 62/10, 46/13), but by the Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13, 76/17 [ZVISJV-1]). Light pollution primarily impacts insects that are active at night, i.e. stag beetles (*Lucanus cervus*), which are attracted by artificial light sources and remain fixated on light instead of searching for food or a mate. The illumination of NEK will not change with the extension of its operating lifetime. According to the cataloguing of beetles (CKFF, 2008 /136/), the densest populations of stag beetles are on the left bank of the Sava, in a wooded area around 2.5 km from the NEK complex. The impact will be insignificant.

NEK uses water from the Sava and holds the relevant water permit /50/. NEK returns the used water to the Sava, and therefore has no impact on the river's hydrological regime. Only emissions of substances and heat by NEK represent potential impacts on the Sava. Such impacts are of a long-term nature (over the entire operational lifetime) and remote. Discussed below are the impacts of various discharges from NEK on the Sava and the organisms that live in the river.

During operation, NEK occasionally releases liquids from discharge tanks into the environment in a controlled manner. Liquids with low activity levels are discharged into the Sava via the essential service water channel which is located upstream from the power plant's dam. Radioactive liquids from waste monitoring tanks and the steam generator blowdown system are released via that channel. Liquid radioactive waste from NEK is treated in a treatment plant that comprises reservoirs, pumps, filters, an evaporator and two demineralisers. Blowdown water from the steam generators is treated separately. Tritium (H-3) is regularly present in liquid discharges from NEK. Tritium is an isotope that emits non-penetrating beta radiation, but it is only slightly radiotoxic (the limit value for tritium in potable water is 100 Bq/l). In 2020, the average monthly activity concentration of H-3 in Krško before NEK (natural background) was slightly below 0.6 kBq/m^3. The long-term average (since 2002) of monthly H-3 activity concentrations in Brežice is 4.0 kBq/m^3. The average over several months (since July 2017) of monthly H-3 activity concentrations at the sampling station in front of the Brežice HPP dam is 2.9 kBq/m^3. The concentrations of tritium activity in Jesenice na Dolenjskem are lower as a result of the additional dilution of the Sava by the Krka and the Sotla rivers. The long-term average of monthly H-3 activity concentrations in Jesenice na Dolenjskem is 2.4 kBq/m^3, and in 2020 it was below 1 kBq/m^3 (IJS, 2021 /87/), which is well below the limit value for potable water. The total annual C-14 activity discharged into the Sava was 0.3 GBq in 2020. However, the measured C-14 activities in the Sava waters and in fish were lower than current atmospheric activities. I-131 was not detected in liquid effluents from NEK in 2020. Average concentrations of I-131 in the Sava in Brežice are similar to those in the Sava in Ljubljana (3.4 Bq/m^3). The presence of I-131 in the Sava is attributed to discharges from hospitals into the rivers that flow into the Sava upstream from the NEK dam (Ljubljanica, Savinja). I-131 was not detected in fish samples in 2020 (IJS, 2021/87/). The annual liquid discharge of Cs-137 from NEK into the Sava in 2020 was 0.9 MBq, but the contribution of NEK cannot be distinguished from the non-homogeneously distributed global contamination (IJS, 2021 /87/). In 2020, the activity of radioactive strontium (Sr-90) discharged into the Sava was 0.04 MBq, but the contribution of NEK cannot be distinguished from the non-homogeneously distributed global contamination (IJS, 2021 /87/). Other fission and activation products (Co-58, Co-60, Mn-54, Ag-110m, Cs-134, Sb-125) appear regularly in liquid effluents from NEK. The total activity of these radionuclides in 2020 was at least six orders of magnitude lower than for tritium, and in the last few years none of the said radionuclides were detected in the environment (IJS, 2021 /87/). Therefore, when the nuclear plant in Krško is in operation, the concentrations of discharged radionuclide activity – with the exception of the very low-radiotoxic H-3 – in the environment are significantly below the limits of detection (IJS, 2021 /87/). A significant impact on the fauna in the Sava is thus not expected.

The pretreatment of water generates wastewater in the counter-flow rinsing of filters for the mechanical treatment of raw water, and in the cleaning of membranes and the reverse osmosis system. Wastewater accumulates in the wastewater pool (PW wastewater pool) at outlet no. 11, with final outflow from discharge 7. If the system is rinsed using corrosive chemicals, water from the wastewater pool is pumped into a neutralisation tank where the pH value is continuously measured and pH balanced before water is discharged into the Sava. That path is temporary and only used exceptionally, while water quantities are small. For this reason, we do not expect a significant impact on the fauna in the Sava in the future.

Before being discharged into the Sava, wastewater from NEK is treated at a small municipal treatment plant (SMTP) with a capacity of 700 PE. The SMTP has primary and secondary treatment systems. A total of 10,000 m^3 of wastewater was treated at the treatment plant in 2020, and the measured values of COD and BOD at the discharge point from the SMTP were well below the permitted values /237/. The yearly quantity of and burden from municipal wastewater from NEK will not change due to the extension of the power plant's operational lifetime, as there is no plan to connect any new users. We therefore do not expect a significant impact on the fauna in the Sava.

NEK did not introduce biocides into any system in 2020. The quality of water from the Sava improved significantly following the closure of the VIPAP cellulose plant. For this reason, NEK is not planning to introduce biocides into the tertiary coolant circuit in the future. Thus no impact on the fauna in the Sava is expected.

The thermal load could have an impact on fauna in the watercourse indirectly through the impact on oxygen content or directly due to the impact on organisms, as life processes evolve more rapidly at warmer temperatures, while different organisms function optimally at different temperatures. A change in water temperature could lead to a change in the biocenosis of the river. The impact of temperature on macroinvertebrates is somewhat less on the lower course of rivers than it is on the middle and upper courses. Maximum temperatures in the summer months have the most significant impact on fish, as they could lead to deteriorating oxygen conditions or even the overheating of organisms at extremely high temperatures (in excess of 30°C). Fish can avoid this impact to some extent by moving to cooler, better-oxygenated parts of the river.

NEK uses water from the Sava for cooling the condensers and turbines, and for cooling safety components. Safety components are cooled via the component cooling system. That system represents an additional safety barrier against the potential discharge of radioactive material and is cooled by the reserve service water system, which extracts water from the Sava. The discharge from that system is at point V1. The average temperature at discharge V1 in July 2020 was 22.16°C /237/. The impact of that discharge is localised and is insignificant because it accounts for a low proportion of transmitted heat.

The secondary coolant circuit system (for the condenser and turbine) also uses water from the Sava, which is returned in a heated state at point V7-7 to discharge V7. The most significant impact of the thermal load is localised at discharge point V7. The warmer water that flows from discharge V7 primarily remains near the surface due to lower density. Taking into account the temperature scheduling model at the Brežice HPP's reservoirs, /44/ this is an area around 100 m downstream from discharge V7, but not along the entire width of the riverbed, where the mixing of water occurs. In 2020, the daily average of the proportion of transmitted heat accounted for by discharge V7 never exceeded the limit value set out in the environmental permit /237/. NEK routinely carries out measurements which ensure that the requirements from the applicable environmental permit are met /49/. The environmental permit stipulates that NEK must ensure that the synergetic action of the discharge of industrial cooling waters and other discharged wastewaters does not cause the Sava to exceed its natural temperature by more than 3 K at any time during the year. NEK must activate the cooling water recirculation system in a timely manner via the cooling towers to prevent the temperature of the Sava from exceeding its natural temperature by more than 3 K. If the combined cooling system is insufficient to fulfil this condition, the power of the power plant must be reduced accordingly. The change in the temperature of the Sava (ΔT) at the point of full mixing (a hypothetical point defined approximately at the location of the old steel bridge in Brežice) is calculated with a formula that is explained in more detail in Section 4.4.4.1.

According to data from NEK, the average temperature of the Sava at the point of full mixing (calculated as the temperature of the Sava at point of entry SW/CW + Δ T) in July and August 2020 was 22-23°C. Between 2010 and 2020, the average temperature of the Sava at the point of full mixing rarely exceeded 27°C in one day (four times in July 2015, once in August 2017 and four times in August 2018), but it never exceeded 28°C, which is the limit for an excessive thermal load on cyprinid waters pursuant to the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15). Data on the average temperature of the Sava at the point of full mixing for the years 2018-2020 is given in **Appendix 6** of this report. To mitigate the impact of thermal pollution, NEK must continue to comply with OVD provisions. Therefore, we do not expect a significant impact due to NEK's operational lifetime extension as long as OVD provisions are complied with.

The foaming of water occurred in the Sava following discharges in 2017. The appearance of foam on the Sava downstream from the release point of NEK was examined in the document /45/ 'Joint final report on investigations and analysis at HPP Brežice, HPP Krško, HPP Arto-Blanca and HPP Boštanj reservoirs, and studies of the causes of water foaming, Limnos d.o.o., 10 September 2017'. The report found that organic pollution of the Sava upstream from NEK contributed significantly to the appearance of foam, which was proven by the high values of BOD_5 and COD at sampling locations upstream from NEK. The result of organic pollution is the increased quantity of bacteria that produce CO_2, which in turn cause the foaming of water. Water that is used to cool the condenser and turbine is released into the Sava at discharge V7 unchanged, except that it is warmer. There are thus no substances in NEK discharges that might contribute to foaming. However, following discharge from NEK, the release of gases (CO_2) is more intense due to the drop and mixing of water. Carbon dioxide is more soluble in cold water and is released into the atmosphere when it comes into contact with warmer water. For this reason, foam can appear on the water's surface. It thus seems that foam on the Sava is a natural phenomenon and the result of the bioproduction processes of microorganisms in the river. The sampling of algae in foam in discharge from NEK indicated the presence of primarily green algae and diatoms, while traces of cyanobacteria, which can produce toxins, were rare. Foam is thus not expected to pose a direct danger to water organisms. Certain types of algae that cause algal bloom were also present in samples taken, but this phenomenon did not occur during the study. Following the filling of the reservoir at the Brežice HPP, foaming was no longer so evident and has not reoccurred in recent years. Given the results of the assessment of the ecological status of the Sava in the area of the Brežice HPP's reservoir, the saprobic condition, which is based on benthic invertebrates, was good in 2018 (website of HESS, 2019). As evident from the national monitoring of the ecological status of the Sava in Jesenice na Dolenjskem, the ecological status of the Sava was assessed as good in the period 2012–2019. The trophic condition and saprobic condition for phytobenthos and macrophytes, and for benthic invertebrates were actually assessed as 'very good' in 2016 and 2018 (/95/, /96/, /97/, /98/, /99/, /100/, /101/, /102/). We therefore believe the potential localised appearance of foam has no significant impact on the Sava's ecosystem. If foam should reappear on the Sava, an analysis of its content could be performed and its decomposition monitored.

Monitoring of the Sava /103/, which is carried out at three points (at the off-take point for cooling water at NEK, upstream from NEK on the right bank of the Sava and in Brežice at the road bridge), indicates that organic pollution was down slightly in 2019 relative to the long-term trend. The highest measured value of COD in 2019 was in November at the sampling location upstream from NEK on the right bank of the Sava, at 10.63 mg/l. The highest measured value of BOD_5 in 2019 was in March, likewise at the sampling location upstream from NEK on the right bank of the Sava, at 1.60 mg/l. According to the Decree on surface water status (Official Gazette of RS, Nos. 14/09, 98/10, 96/13 and 24/16), the limit value of BOD_5 for the very good ecological status of rivers is 1.6 to 2.4 mg/l. According to the Decree on the quality required of surface waters supporting fresh-water fish life (Official Gazette of RS, Nos. 46/02 and 41/04 – ZVO-1), the recommended value for salmonid waters is less than 3 mg/l, while the value for cyprinid waters is less than 6 mg/l. Cyprinid fish species, for which the measured parameters are completely appropriate, are predominant in the Sava downstream from NEK. Incidentally, the aforementioned section of the Sava is not designated as important for freshwater fish species according to the Rules on the designation of surface water sections important for freshwater fish species (Official Gazette of RS, Nos. 28/05 and 8/18). For this reason, monitoring of the quality of water supporting fresh-water fish life is not envisaged in this area. According to Article 8 of the Decree on the quality required of surface waters supporting fresh-water fish life (Official Gazette of RS, Nos. 46/02 and 41/04 – ZVO-1), the ministry responsible for environmental protection must ensure that monitoring.

Periodic national monitoring of the ecological status of rivers is carried out downstream of discharges from NEK on the Sava–border section water body (SI1VT930), where the measuring point is located in Jesenice na Dolenjskem. The ecological status was assessed as moderate in 2009 and 2011 (the phytobenthos and macrophytes parameter of trophic condition was assessed as moderate in 2009, while the phytobenthos and macrophytes parameter of saprobic condition was assessed as moderate in 2011), while the ecological status was assessed as good in 2010 and in the period 2012–2019. The trophic condition and saprobic condition for phytobenthos and macrophytes, and for benthic invertebrates were actually assessed as very good in 2016 and 2018 (/95/, /96/, /97/, /98/, /99/, /100/, /101/, /102/). The operation of NEK thus does not have a significant impact on the ecological status of the Sava.

A sustained impact on fauna in the vicinity of NEK could occur in the event of a major accident resulting in the release of radioactive material into the environment. Numerous safety upgrades have been implemented at NEK. For this reason, the possibility of core damage is very small. NEK was designed to withstand design basis accidents and to manage them using its safety systems. NEK can use the DEC-A equipment to prevent the reactor core meltdown. The DEC-B equipment, however, was intended for managing an event which might lead to the very unlikely core meltdown and focuses on protecting the final barrier before release, i.e. the integrity of the containment. The passive filter system serves to relieve the pressure in the containment, while environmentally harmful substances remain trapped in the filters. Direct release into the environment is therefore unlikely.

The impact of the activity on fauna during operation is evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

A chain of hydroelectric power plants (Vrhovo, Boštanj, Arto-Blanca, Krško and Brežice) has been built on the lower course of the Sava. The completion of that chain is planned with HPP Mokrice in the special area of conservation called the Lower Sava SAC. The potential cumulative impact on the temperature of the Sava as a result of NEK's heat emissions and Sava's slower flow in HPP reservoirs has been examined in the study Thermal loads on the Sava (interactions of energy buildings along and on the Sava from the perspective of the heat load on the Sava – Revision A. IBE 2012). The study found that the increase in the Sava's temperature most likely results from a natural rise in the temperature of river water and not from the construction of HPPs. This analysis was completed in 2012, before HPP Krško was built, so another thermal analysis of the Sava was conducted for the extended HPP chain, which also included the above-average warm summer of 2019 (Energy buildings along and on the Sava. Analysis of river temperatures in the lower reaches of the Sava in July and August 2019 and the verification of past studies – Revision A. IBE, April 2020) /104/. Measurements in this latest study showed that there was a drop in the temperature of the Sava between NEK and the discharge from HPP Brežice of 0.54°C in July 2019. The HPP Brežice reservoir thus has a cooling effect on water that flows into the Lower Sava SAC. According to the latest study by IBE /104/, increases in the mean monthly temperatures of the Sava in the Čatež area were lower during the last 18 years than in the previous period. It has thus been concluded that the chain of HPPs does not increase the mean temperatures of the river. The study also anticipates that the mean monthly temperature in the flow-through reservoir of the planned HPP Mokrice during the summer will only rise by around 0.1 to 0.2°C relative of the current situation, which is minimal. We therefore do not expect a cumulative or synergetic impact on the temperature of the Sava due to heat discharges from NEK and due to the slow flow rate of the Sava in existing HPP reservoirs and the planned Mokrice HPP flow-through reservoir.

The overall impact on fauna during operation is evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

5.14.1.3 Important ecological areas (EIA) and valuable natural features (VNF)

Important ecological area: Sava from Radeče to the national border (ID 63700)
One part of the important ecological area is the section of the Sava on the Krško-Brežice plain, from Krško to the mouth of the Sotla. The activity in question physically affects the area in the form of a dam on the Sava. Following the construction of the Brežice HPP, the water level in the area of NEK rose by 3 m. As a result, the regulation of the water level at the NEK dam is no longer required and the sluice gates are always raised. The NEK dam is now entirely passable for fish. NEK also discharges wastewater into the Sava. A detailed description of the impact of wastewater from NEK on the Sava and the organisms that live in it is presented in Section 5.14.1.2 Fauna above. Based on national monitoring, the ecological status of the Sava downstream from NEK is assessed as good. NEK operates in compliance with the environmental permit /49/. To mitigate the impact of thermal pollution, NEK will have to continue to comply with OVD provisions. Therefore, we do not expect a significant impact due to NEK's operational lifetime extension as long as OVD provisions are complied with.

VNF in Libna – linden tree next to the church (ID 7860)
During operation, NEK does not emit ionising radiation into the environment that could have a significant impact on VNF in Libna (linden tree next to the church). Measurements of radioactivity in the vicinity of NEK indicate that the impact is already insignificant in apples harvested in the direct vicinity of NEK. That impact is even less due to the great distance between the VNF in Libna (linden tree next to the church) and NEK.

VNF in Stari Grad – gravel pit (ID 7861)
NEK stands right next to the Sava and uses water from the river for cooling. During operation, it releases some radioactive material in a controlled manner into the Sava, which in part feeds the underground aquifers of the Krško-Brežice plain. The quantities of synthetic radionuclides from NEK's liquid and atmospheric discharges into the groundwater are negligible compared with the contribution due to synthetic radionuclides from general contamination and natural radionuclides on account of natural radiation /87/. The impact on water at the VNF in Stari Grad (gravel pit) is therefore insignificant.

The impact of the activity on valuable natural features during operation is evaluated as **(4)** – impact is not significant.
The impact of the activity on the important ecological area during operation is evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

The overall impact on valuable natural features during operation is evaluated as **(4)** – impact is not significant.
The overall impact on the important ecological area during operation is evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

5.14.1.4 Protected areas

Pursuant to the Decree on Special Protection Areas (Natura 2000 Areas) (Official Gazette of RS, Nos. 49/04, 110/04, 59/07, 43/08, 8/12, 33/13, 35/13 – corrigenda, 39/13 – Constitutional Court Decision, 3/14, 21/16 and 47/18), the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206 of 22 July 1992, p. 7), as last amended by Council Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of the environment, by reason of the accession of the Republic of Croatia (OJ L No 158 of 10 June 2013, p. 193), and Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (OJ L 20 of 26 January 2010, p. 7), as last amended by Council Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of the environment, by reason of the accession of the Republic of Croatia (OJ L 158 of 10 June 2013, p. 193), are transposed into the legislation of the Republic of Slovenia. To assess the acceptability of impacts on protected areas, the Appendix for assessment of the acceptability of the impacts on protected areas was formulated pursuant to the Rules on the assessment of the acceptability of effects caused by the execution of plans and activities affecting nature in protected areas (Official Gazette of RS, Nos. 130/04, 53/06, 38/10 and 3/11) and is annexed to the EIA Report. The impacts on protected areas are summed up below.

Vrbina SAC (SI3000234)
During operation, NEK does not emit ionised radiation into the environment that could have an impact on the Vrbina SAC. Safety systems prevent the uncontrolled release of radioactive material into the environment. The design of safety systems provides safety functions in all operational states, even in the event of specific equipment failure. The release of radioactive material into the environment is prevented by four successive safety barriers. The basic objective of the first three barriers is to prevent radioactive material from passing to the next barrier, while the fourth barrier prevents radioactive material from being released directly into NEK's surroundings. 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. We therefore do not expect impacts from ionising radiation on the Vrbina SAC following the extension of the operational lifetime of NEK.

Light pollution primarily impacts insects that are active at night, which are attracted by artificial light sources and remain fixated on light instead of searching for food or a mate. That impact is of a long-term nature and remote. For the qualifying species of stag beetle (*Lucanus cervus*), the Management Programme for Natura 2000 Areas (MPN) sets the objective of maintaining the current state without permanent light bodies. The illumination of NEK will not change with the extension of its operating lifetime, the current state will be maintained, and therefore there will be no impact on the aforementioned conservation objective. According to the cataloguing of beetles (CKFF, 2008 /136/), the densest populations of stag beetles in the Vrbina SAC are on the left bank of the river, around 2.5 km from the NEK complex. Due to that distance, the impact on stag beetles will be insignificant. We do not expect any impact on other qualifying species due to light pollution.

A sustained impact on habitat types and qualifying species in the Vrbina SAC could occur in the event of a serious accident resulting in the discharge of radioactive material into the environment. Numerous safety upgrades have been implemented at NEK. For this reason, the possibility of core damage is very small. NEK was designed to withstand design basis accidents and to manage them using its safety systems. NEK can use the DEC-A equipment to prevent reactor core meltdown. The DEC-B equipment, however, was intended for managing an event which might lead to the very unlikely core meltdown and focuses on protecting the final barrier before release, i.e. the integrity of the containment. The passive filter system serves to relieve the pressure in the containment, while environmentally harmful substances remain trapped in the filters. Direct release into the environment is therefore unlikely.

Lower Sava SAC (SI3000304)

The Lower Sava SAC is around 8 km downstream from discharges from NEK. Only emissions of substances and heat into the Sava represent a potential impact from NEK on the Lower Sava SAC and the qualifying species of cactus roach. During normal operation, NEK occasionally releases liquids from discharge tanks into the environment in a controlled manner. Liquids with low activity levels are discharged into the Sava via the essential service water channel which is located upstream from the power plant's dam. Radioactive liquids from waste measurement tanks and the steam generator blowdown system are released via that channel. Liquid radioactive waste from NEK is treated in a treatment plant that comprises reservoirs, pumps, filters, an evaporator and two demineralisers. Blowdown water from the steam generators is treated separately. NEK regularly monitors the content of radioactive material in the tissues of fish. That monitoring is included in the Programme of measurements of radioactivity in the vicinity of NEK. Those measurements are performed by external contractors (Jožef Stefan Institute, Institut Ruđer Bošković and the Institute of Occupational Safety), and the results are presented in annual reports on the monitoring of radioactivity in the vicinity of NEK. Tritium (H-3) is regularly present in liquid discharges from NEK. Tritium is an isotope that emits non-penetrating beta radiation, but it is only slightly radiotoxic (the limit value for tritium in potable water is 100 Bq/l). In 2020, the average monthly activity concentration of H-3 in Krško before NEK (natural background) was slightly below 0.6 kBq/m^3. The long-term average (since 2002) of monthly H-3 activity concentrations in Brežice is 4.0 kBq/m^3. The average over several months (since July 2017) of monthly H-3 activity concentrations at the sampling station in front of the HPP Brežice dam is 2.9 kBq/m^3. The concentrations of tritium activity in Jesenice na Dolenjskem are lower as a result of the additional dilution of the Sava by the Krka and the Sotla rivers. The long-term average of monthly H-3 activity concentrations in Jesenice na Dolenjskem is 2.4 kBq/m^3, and in 2020 it was below 1 kBq/m^3 (IJS, 2021), which is well below the limit value for potable water. The total annual C-14 activity discharged into the Sava was 0.3 GBq in 2020. However, the measured C-14 activities in the Sava waters and in fish were lower than current atmospheric activities.

I-131 was not detected in liquid effluents from NEK in 2020. Average concentrations of I-131 in the Sava in Brežice are similar to those in the Sava in Ljubljana (3.4 Bq/m^3). The presence of I-131 in the Sava is attributed to discharges from hospitals into the rivers that flow into the Sava upstream from the NEK dam (Ljubljanica, Savinja). I-131 was not detected in fish samples in 2020 (IJS, 2021). The annual liquid discharge of Cs-137 from NEK into the Sava in 2020 was 0.9 MBq, but the contribution of NEK cannot be distinguished from the non-homogeneously distributed global contamination (IJS, 2021). In 2020, the activity of radioactive strontium (Sr-90) discharged into the Sava was 0.04 MBq, but the contribution of NEK cannot be distinguished from the non-homogeneously distributed global contamination (IJS, 2021). Other fission and activation products (Co-58, Co-60, Mn-54, Ag-110m, Cs-134, Sb-125) appear regularly in liquid effluents from NEK. The total activity of these radionuclides in 2020 was at least six orders of magnitude lower than for tritium, and in the last few years none of the said radionuclides were detected in the environment (IJS, 2021). Therefore, when the nuclear plant in Krško is in operation, the concentrations of discharged radionuclide activity – with the exception of the very low-radiotoxic H-3 – in the environment are significantly below the limits of detection (IJS, 2021). The impact from radioactive effluent on cactus roach and the Lower Sava SAC is therefore assessed as not significant.

The pretreatment of water generates wastewater in the counter-flow rinsing of filters for the mechanical treatment of raw water, and in the cleaning of membranes and the reverse osmosis system. Wastewater accumulates in the wastewater pool (PW wastewater pool) at outlet no. 11, with final outflow from discharge 7. If the system is rinsed using corrosive chemicals, water from the wastewater pool is pumped into a neutralisation tank where the pH value is continuously measured and pH balanced before water is discharged into the Sava. That path is temporary and only used exceptionally, while water quantities are small. For this reason, we assess that the impact on cactus roach and the Lower Sava SAC is and will continue to be insignificant, even after the extension of NEK's operational lifetime.

Before being discharged into the Sava, wastewater from NEK is treated at a small municipal treatment plant (SMTP) with a capacity of 700 PE. The SMTP has primary and secondary treatment systems. A total of 10,000 m^3 of wastewater was treated at the treatment plant in 2020, while the measured values of COD and BOD at the discharge from the SMTP were well below the permitted values. The quantity of and burden from municipal wastewater from NEK will not change due to the extension of the power plant's operational lifetime, as there is no plan to connect any new users. We therefore do not expect any impact on cactus roach and the Lower Sava SAC.

NEK did not introduce biocides into any system in 2020. The quality of water from the Sava improved significantly following the closure of the VIPAP cellulose plant. For this reason, NEK is not planning to introduce biocides into the tertiary coolant circuit in the future. We therefore do not expect any impact on cactus roach and the Lower Sava SAC, even after the extension of NEK's operational lifetime.

NEK uses water from the Sava for cooling condensers and turbines, and for cooling safety components. Safety components are cooled via the component cooling system. That system represents an additional safety barrier against the potential discharge of radioactive material and is cooled by the reserve service water system, which extracts water from the Sava. The secondary coolant circuit system (for the condenser and turbine) uses water from the Sava. However, if sufficient cooling is not possible with water from the Sava, NEK uses cooling cells (two batteries per six cells and one battery per four cells). It thus only takes a portion of required water directly from the Sava, while the remaining water is recirculated through the cooling cells where it is air cooled. Waste cooling water is not treated before it is discharged into the Sava. NEK routinely carries out measurements which ensure that the requirements from the applicable environmental permit are met /49/. The environmental permit stipulates that NEK must ensure that the synergetic action of the discharge of industrial cooling waters and other discharged wastewaters does not cause the Sava to exceed its natural temperature by more than 3 K at any time during the year. NEK must activate the cooling water recirculation system in a timely manner via the cooling towers to prevent the temperature of the Sava from exceeding its natural temperature by more than 3°C. If the combined cooling system is insufficient to fulfil this condition, the power of the power plant must be reduced accordingly. In 2020, the daily averages of the emission share of transmitted heat at discharges from the large and small cooling system and the total emission share of transmitted heat never exceeded the limit value set out in the environmental permit /237/. To mitigate the impact of thermal pollution, NEK will have to continue to comply with OVD provisions. Periodic national monitoring of the ecological status of rivers is carried out downstream of NEK discharges on the water body designated Sava – border section (SI1VT930), where the measuring point is located in Jesenice na Dolenjskem. The ecological status was assessed as moderate in 2009 and 2011 (the phytobenthos and macrophytes parameter of trophic condition was assessed as moderate in 2009, while the phytobenthos and macrophytes parameter of saprobic condition was assessed as moderate in 2011), while the ecological status was assessed as good in 2010 and in the period 2012–2019. The trophic condition and saprobic condition for phytobenthos and macrophytes, and for benthic invertebrates were actually assessed as very good in 2016 and 2018, which indicates that the Sava is not organically polluted at that point (/95/, /96/, /97/, /98/, /99/, /100/, /101/, /102/). Monitoring of the Sava /103/, which is carried out at three points (at the off-take point for cooling water at NEK, upstream from NEK on the right bank of the Sava and in Brežice at the road bridge), indicates that organic pollution was down in 2019 relative to the long-term trend. The highest measured value of COD in 2019 was in November at the sampling location upstream from NEK on the right bank of the Sava, at 10.63 mg/l. The highest measured value of BOD_5 in 2019 was in March, likewise at the sampling location upstream from NEK on the right bank of the Sava, at 1.60 mg/l. According to the Decree on surface water status (Official Gazette of RS, Nos. 14/09, 98/10, 96/13 and 24/16), the limit value of BOD_5 for the very good ecological status of rivers is 1.6 to 2.4 mg/l. According to the Decree on the quality required of surface waters supporting fresh-water fish life (Official Gazette of RS, Nos. 46/02 and 41/04 – ZVO-1), the recommended value for salmonid waters is less than 3 mg/l, while the value for cyprinid waters is less than 6 mg/l. Heat discharges from NEK thus do not cause any deterioration in the living conditions of cactus roach, which is a cyprinid species, in the Lower Sava SAC. Therefore, we do not expect a significant impact due to NEK's operational lifetime extension as long as OVD provisions are complied with.

A sustained impact on the environment and Lower Sava SAC could occur in the event of a major accident resulting in the release of radioactive material into the environment. Numerous safety upgrades have been implemented at NEK. For this reason, the possibility of core damage is very small. NEK was designed to withstand design basis accidents and to manage them using its safety systems. NEK can use the DEC-A equipment to prevent reactor core meltdown. The DEC-B equipment, however, was intended for managing an event which might lead to the very unlikely core meltdown and focuses on protecting the final barrier before release, i.e. the integrity of the containment. The passive filter system serves to relieve the pressure in the containment, while environmentally harmful substances remain trapped in the filters. In the event of the accidents discussed (DBA and DEC-B) there will be no liquid releases into the Sava. All cooling water will be contained inside the containment vessel and auxiliary building, which is designed for systems and components that contain radioactive material (contaminated radioactive water).

A chain of hydroelectric power plants (Vrhovo, Boštanj, Arto-Blanca, Krško and Brežice) has been built on the lower course of the Sava. The completion of that chain is planned with HPP Mokrice in the special area of conservation called the Lower Sava SAC. A study by IJS /105/ put forth the opinion that eutrophication could occur due to the increased concentration of phosphates in the Sava from the construction of HPP Brežice on account of the slowed flow rate of the river and higher temperatures in the surface layer of the water in HPP Brežice reservoir. Eutrophication could diminish the quality of the Sava. NEK has no emissions that could increase the nutrient content of the Sava and does not represent a source of eutrophication. According to calculations in the study by IBE (2019), the confinement time in the planned HPP Mokrice reservoir will be the shortest of all reservoirs on the lower course of the Sava, while the flow rates will be highest, meaning the reduced possibility of eutrophication in the Lower Sava SAC. The potential cumulative impact on the temperature of the Sava as a result of NEK's heat emissions and Sava's slower flow in HPP reservoirs has been examined in the study Thermal loads on the Sava (interactions of energy buildings along and on the Sava from the perspective of the heat load on the Sava – Revision A. IBE 2012). The study found that the increase in the Sava's temperature most likely results from a natural rise in the temperature of river water and not from the construction of HPPs. This analysis was completed in 2012, before HPP Krško was built, so another thermal analysis of the Sava was conducted for the extended HPP chain, which also included the above-average warm summer of 2019 (Energy buildings along and on the Sava. Analysis of river temperatures in the lower reaches of the Sava in July and August 2019 and the verification of past studies – Revision A. IBE, April 2020) /104/. Measurements in this latest study showed that there was a drop in the temperature of the Sava between NEK and the discharge from HPP Brežice of 0.54°C in July 2019. The HPP Brežice reservoir thus has a cooling effect on water that flows into the Lower Sava SAC. According to the latest study by IBE /104/, increases in the mean monthly temperatures of the Sava in the Čatež area were lower during the last 18 years than in the previous period. It has thus been concluded that the chain of HPPs does not increase the mean temperatures of the river. The study also anticipates that the mean monthly temperature in the flow-through reservoir of the planned HPP Mokrice during the summer will only rise by around 0.1 to 0.2°C relative of the current situation, which is minimal. According to calculations in the study by IBE (2019), the confinement time in the planned HPP Mokrice reservoir will be the shortest of all reservoirs on the lower course of the Sava, while the flow rates will be the highest, meaning a reduced possibility of eutrophication. Given that no significant deterioration in ecological status parameters in the HPP Brežice reservoir was identified /46/ and that it is evident from the national monitoring of the ecological status of the Sava in Jesenice na Dolenjskem (see description above regarding the impact of heat discharges from NEK) that there was also no deterioration in the downstream ecological status of the Sava following the construction of the chain of HPPs, it is concluded that there will also be no significant deterioration in the ecological status in the case of the HPP Mokrice reservoir. We therefore do not expect any significant cumulative impact on the Lower Sava SAC.

The impact of the activity and overall impact on protected areas during operation are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, taking into account the measures that NEK is already implementing and will have to continue implementing during extended operation to prevent excessive burdens due to the discharge of wastewaters into the Sava (wastewater parameters below the limit values set out in the environmental permit with respect to emissions into water).

5.14.2 Termination of the activity

After NEK ceases operation (see Section 2.18), the fuel will no longer be in the reactor, but stored safely in the spent fuel pool and/or in the dry storage for spent fuel. Cooling of the reactor will thus no longer be required and heat emissions into the Sava will greatly decrease. However, the spent fuel pool will still have to be cooled by means of the essential service water system. The impact of the discharge from this system is localised, and in view of its low emission share of transmitted heat, it is not significant. Operation of cooling towers will no longer be needed. NEK will still ensure control over nuclear materials, and the impact of ionising radiation will be insignificant.

The impact of the activity and overall impact on nature if the activity is terminated are evaluated as **(4)** – impact is not significant.

5.15 IMPACTS ON LAND

5.15.1 Operation

The site of the planned activity is located in an area of building land on which mainly industrial buildings classified as E – energy infrastructure have been built (the intended use is presented in Section 1.8.1). The planned change (expansion) does not reach beyond the area presently occupied by NEK, and it complies with the applicable spatial planning documents, while the planned and actual land use are not to change with the planned extension of NEK's operational lifetime.

In terms of wooded land, an opinion has been given by the Ministry of Agriculture, Forestry and Food (no. 3401-43/2020/4). On the basis of a review of materials, the aforementioned ministry finds that there is no wooded land on the NEK site. There will thus be no direct impact on wooded land. There will also be no indirect or remote impacts on the forest, as the wooded land is more than 450 m away from the site of the planned activity. No additional negative impact on wildlife is expected either.

In terms of agricultural land, an opinion has also been given by the Agriculture Directorate of the Ministry of Agriculture, Forestry and Food (no. 351-77/2020/5). The competent ministry believes that the planned extension of NEK's operational lifetime from 40 to 60 years will not have any particular impact on agricultural land.

The impact of the activity and overall impact on land are evaluated as **(5)** – no impact.

5.15.2 Termination of the activity

In the case of activity termination (see Section 2.18), the intended and actual use of land remains the same as during operation.

The impact of the activity and overall impact on land if the activity is terminated are evaluated as **(5)** – no impact.

5.16 IMPACTS ON NATURAL ASSETS

According to the definition set out in the Environmental Protection Act (ZVO-1), a natural asset is a part of nature and may be a natural public asset, natural resource or natural value.

5.16.1 Operation

The direct use of natural resources in production comprises the use of water from the public water network for sanitary needs and fire safety, and river water and groundwater, which is taken from wells and the Sava for technological needs on the basis of water permits. River water and groundwater is not used as a raw material (it is not incorporated into products), but is used in supportive cooling processes.

Following use and appropriate treatment, all water is returned to the environment, i.e. to the Sava. The water pumped from three temporary wells returns directly into the Sava via the rainwater drainage system /163/.

LTE will not impact valuable natural features in the vicinity during operation (description in Section 5.14.1).

The impact of the activity and overall impact on natural assets during operation are evaluated as **(4)** – impact is not significant.

5.16.2 Termination of the activity

In the case of activity termination (see Section 2.18), the use of natural resources will be considerably reduced in comparison with regular operation. The spent fuel pool will still have to be cooled and so will a few other safety components – water will be abstracted and returned to the Sava at a rate of approximately 1.6 m^3/s.

If it is terminated, the activity will not impact protected areas of nature in the vicinity of the LTE site (description in Section 5.14.2).

The impact of the activity and overall impact on natural assets if the activity is terminated are evaluated as **(4)** – not significant.

5.17 IMPACTS ON MATERIAL ASSETS

5.17.1 Operation

The extension of NEK's operational lifetime will not have a significant impact in terms of increasing existing burdens on the environment. The state will remain unchanged. The annual effective dose of external radiation on the NEK perimeter fence from all contributors, including the spent fuel dry storage, will not exceed, during operation, the radiation load that currently applies to the NEK perimeter fence.

As evident from the findings in previous sections of this report that address NEK's impacts on the environment, now and following the change, all burdens are within permitted values. The extension of NEK's operational lifetime is not expected to result in excessive environmental burdens or impacts that could cause a deterioration in living conditions, the use or utilisation of buildings and land outside of the NEK site. The company performs an activity in the Vrbina industrial zone where other industrial buildings are present (see Section 2.2.1) and where it has been present for decades. It is thus not the only source of environmental burden in that area, but is one of the most important. That facility is not classified as an activity or installation that can cause large-scale environmental pollution and does not pose a minor or major risk to the environment. NEK is a nuclear facility. Its presence in the area could therefore pose the direct threat of an environmental or other accident that could impact material assets, i.e. land and buildings in the vicinity (see Section 5.18.1). On account of the technology used and the implementation of protective measures, however, the possibility of an accident is reduced to the lowest possible level. In accordance with the Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13 and 76/17), NEK buildings are classified to categories I, II and III. The facility will therefore be protected in accordance with requirements for physically controlled areas and physically controlled facilities. Reporting on stored fuel will be carried out in accordance with the Decree on the safeguarding of nuclear materials (Official Gazette of RS, Nos. 34/08 and 76/17 – ZVISJV-1).

The impact of the activity and overall impact on material assets during operation are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, where those measures primarily comprise regulatory measures that NEK already implements, as well as other mitigation measures that are not set out in regulations and that the company implements to reduce impacts on the surrounding area, and mitigation measures laid down for other environmental components (waters, waste, ionising radiation etc.).

5.17.2 Termination of the activity

At the time of activity termination, the environmental burden from NEK's emissions of pollutants and other loads will be significantly reduced in comparison with regular operation.

The impact of the activity and overall impact on material assets if the activity is terminated are evaluated as **(4)** – impact is not significant.

5.18 IMPACTS ON THE RISK OF ENVIRONMENTAL AND OTHER ACCIDENTS

5.18.1 Operation

Extending NEK's operational lifetime means prolonging its operation by 20 years (2023–2043) under the same environmental and radiation conditions as specified in the existing operating licence.

Although NEK was designed for a minimum period of 40 years, the power plant has carried out all the necessary analyses and upgrades which ensure that it can operate for another 20 years. On the basis of a series of studies and analyses, the Slovenian Nuclear Safety Administration (URSJV) confirmed in decision no. 3570-6/2009/32 of 20 June 2012 that the state of equipment at NEK is appropriate, despite aging, and that all safety margins and operating functions are guaranteed.

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

- the power plant has built-in materials and equipment that provide sufficient safety reserves;
- all equipment that affects the reliability of operation has been replaced;
- the operation of the power plant is stable;
- 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;
- NEK has a comprehensive aging management programme (AMP) in place to monitor the aging of all passive structures and components (reactor pressure vessel, concrete, underground pipelines, steel structures, electrical cables, etc.).

Safe and reliable operation in all conditions is NEK's top priority. Since it began operating, NEK has carried out a series of modernisations that have increased the site's safety and efficiency.

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

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

A more detailed description of missions can be found in Section 1.2.2.

NEK operates in accordance with all the laws of the Republic of Slovenia and within the operating limits set out in the ZVISJV-1, the water permits, the environmental permit, the NEK Technical Specifications (TS) /5/, the Radiological Effluent Technical Specification (RETS) /7/ and the Design Extension Conditions Technical Specifications (DECTS) /6/ 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 exact same limits, and not exceed any existing legal requirements or restrictions.

The continual upgrades and modifications that are being carried out ensure a level of safety that is significantly higher than when the plant was first built. Given the modernisations and upgrades completed in the past (see Section 2.8), and the safety systems and safety functions in place, NEK will not pose a risk of environmental or other accidents during its extended operational lifetime. Ensuring the safe operation of NEK is described in detail in Section 2.7, where all aspects of ensuring safe operation are addressed.

NEK has built-in systems and components for preventing and mitigating the consequences of accidents, as well as predefined statuses of the power plant. See Sections 2.12 and 2.13 for more details. The types of emergencies and the planned management thereof are described in detail in the aforementioned sections. A probabilistic safety assessment (see Sections 2.13.1 and 2.13.2) was also completed.

NEK also formulated an emergency classification (see Section 2.13.3) that is based on predetermined threat levels, and a methodology and guidance on how to classify an incident to the appropriate threat level according to its actual or foreseen consequences at the power plant and in the environment.

NEK is a nuclear facility. Its presence in the area could therefore pose the direct threat of an environmental or other accident. However, on account of the technology used and the implementation of protective measures, the likelihood of an accident is reduced to the lowest possible level.

The crucial document for the operation of NEK is the operating licence which relates directly to the NEK Updated Safety Analyses Report (USAR), and contains the conditions and limits for the power plant's safe operation.

NEK operates in accordance with the following: Approval to Commence NEK Operation, 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 (URSJV) No. 3570-8/2012/5 of 22 April 2013, and NEK Updated Safety Analyses Report (USAR) /3/.

In all operational states, NEK ensures a controlled chain reaction in the reactor, the continuous discharge of thermal energy from the reactor, and safety barriers that prevent the release of radioactive material.

Ensuring the comprehensive safety of NEK and in-depth defence requires both numerous safety measures to ensure safe operations and continuous preparedness for conditions that deviate from the power plant's normal operational state.

NEK plans for and maintains preparedness for emergencies in accordance with Slovenia's protection and disaster relief concept, and the principles of ensuring the nuclear safety of the power plant. NEK is responsible for managing emergencies at the power plant.

The main purpose of planning and maintaining preparedness is to ensure the protection, health and safety of power plant employees and the population in the surrounding areas by preventing emergencies, eliminating or mitigating the consequences of emergencies and ensuring conditions for the re-establishment of the normal state of the power plant.

Ensuring preparedness and managing emergencies at the power plant are laid down in the NEK Protection and Rescue Plan (NEK PRP) /224/. The NEK PRP and the protection and rescue plans in the event of a nuclear disaster of the municipalities of Krško and Brežice, the Posavje region and the Republic of Slovenia represent an organisationally and functionally integrated system that ensures the coordinated management of emergencies at the power plant and in the environment, and between the power plant and the environment.

Measures that will be implemented in the event of an emergency at the power plant include operational-technical measures in the power plant's technological process, notification of the general public, professional and administrative institutions about an emergency, and the proposal of immediate protective measures for the population, if required, and radiological and other protective measures at the site of the power plant. The organisational structure of the power plant and the aforementioned measures are set out in the NEK Protection and Rescue Plan for emergencies, which is coordinated with local municipalities, and the national protection and rescue plan in case of a nuclear or radiological accident.

The impact of the activity and overall impact on the risk of environmental and other accidents during operation are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, where those measures primarily comprise legally prescribed measures that NEK already implements, as well as other mitigation measures that are not laid down in regulations and that the company implements to mitigate impacts on the surrounding area and prevent accidents, and mitigation measures for other components of the environment (waters, waste, ionising radiation).

5.18.2 Termination of the activity

After NEK ceases operation (see Section 2.18), the fuel will no longer be in the reactor, but stored safely in the spent fuel pool and/or in the dry storage for spent fuel. The decommissioned area will still have limited access, be marked out and considered a radiologically monitored area.

All activities associated with activity termination will be carried out in accordance with the requirements of regulations, the management system and written work procedures and instructions.

After NEK ceases operation, measurements of radiation parameters and all the protective measures that prevent radiation leakage into the environment will continue to be implemented.

The impact of the activity and overall impact on the risk of environmental and other accidents in the case of activity termination are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, where those measures primarily comprise legally prescribed measures that NEK already implements, as well as other mitigation measures that are not laid down in regulations and that the company implements to mitigate impacts on the surrounding area and prevent accidents, and mitigation measures for other components of the environment (waters, waste, ionising radiation).

5.19 IMPACTS ON THE POPULATION AND HUMAN HEALTH

5.19.1 Operation

As follows from the findings in previous chapters of this report, which deal with the impacts of lifetime expansion (LTE) on all relevant environmental factors it might affect, NEK's current level of production does not exceed the limit values for emissions of substances and radiation into the environment. It is not expected that the limit values will be surpassed during the planned extension of operational lifetime of NEK either. The limit value is the prescribed level whose aim is to avoid, prevent or reduce harmful effects on human health or the environment as a whole. NEK implements, and will continue to implement after the changes, all the measures to reduce burdens and prevent pollution of the environment and the impact on human health, which stem from regulations. Regular monitoring is also carried out in keeping with applicable prescriptions and permits.

The change in the current activity (extension of the operational lifetime) will not cause changes to natural and other conditions of life and habitation near the site of the activity and further afield.

During the extended operational lifetime, there will be regular monitoring throughout NEK, which is already being carried out now – measurements of river water pumping for technological purposes, measurements and analyses of wastewater discharged into the sewage system, and measurements of radiation.

The impact of the activity and the overall impact on the population and human health during operation are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, where those measures primarily comprise regulatory measures that NEK already implements, as well as other mitigation measures that are not laid down in regulations and that the company implements to mitigate impacts on the surrounding area, and mitigation measures for other environmental components (waters, waste and ionising radiation).

5.19.2 Termination of the activity

In the case of activity termination (see Section 2.18), emissions of substances and radiation will be significantly lower than described for the period of operation. The fuel will no longer be in the reactor, but stored safely in the spent fuel pool and/or in the dry storage for spent fuel. After NEK ceases operation, measurements of radiation parameters and all the protective measures that prevent radiation leakage into the environment will continue to be implemented.

The impact of the activity and overall impact on the population and human health in the case of activity termination are evaluated as **(3)** – impact is not significant due to the implementation of mitigation measures, where those measures primarily comprise regulatory measures that NEK already implements, as well as other mitigation measures that are not laid down in regulations and that the company implements to mitigate impacts on the surrounding area and prevent accidents, and mitigation measures for other components of the environment (waters, waste, ionising radiation).

5.20 CHANGES IN THE TOTAL AND COMBINED BURDEN ON THE ENVIRONMENT

5.20.1 Changes in the total burden on the environment

The changes in the total burden on the environment, bearing in mind the effects of the planned lifetime extension and the plant's current operation, have already been evaluated for all the considered factors in Sections 5.2 - 5.19. The table below therefore presents only a summary of the evaluated effects of the lifetime extension (LTE) on the factors discussed in this report.

Table 129: Summary of the evaluated impacts of LTE and overall impacts on environmental factors

Environmental component/ environmental aspect	Phase of the extended lifetime	Impact of the lifetime extension	Total impact
Impacts on soil	operation	**5**	**5**
	termination of activity and after	**5**	**5**
Impacts on water	operation	**3**	**3**
	termination of activity and after	**4**	**4**
Flood safety	operation	**5**	**5**
	termination of activity and after	**5**	**5**
Impact on the thermal pollution of water	operation	**3**	**3**
	termination of activity and after	**4**	**4**
Impact on air	operation	**4**	**4**
	termination of activity and after	**4**	**4**
Climate impact	operation	**5**	**5**

Environmental component/ environmental aspect	Phase of the extended lifetime	Impact of the lifetime extension	Total impact
	termination of activity and after	4	4
Impact of climate change on the activity	operation	3	3
	termination of activity and after	4	4
Impact on noise pollution	operation	4	4
	termination of activity and after	4	4
Impact of electromagnetic radiation	operation	4	4
	termination of activity and after	5	5
Vibration pollution	operation	5	5
	termination of activity and after	5	5
Impact of waste	operation	3	3
	termination of activity and after	3	3
Impact of ionising radiation	operation	3	3
	termination of activity and after	3	3
Impact of light pollution	operation	4	4
	termination of activity and after	4	4
Impact on the landscape	operation	4	4
	termination of activity and after	4	4
Impacts on biodiversity and nature reserves	operation	3	3
	termination of activity and after	4	4
Impact on land	operation	5	5
	termination of activity and after	5	5
Impact on natural assets	operation	4	4
	termination of activity and after	4	4
Impact on material assets	operation	3	3
	termination of activity and after	4	4
Impact on the population and human health	operation	3	3
	termination of activity and after	3	3
Impacts due to the risk of environmental and other accidents	operation	3	3
	termination of activity and after	3	3

5.20.2 Changes in the combined burden on the environment

In estimating and evaluating the change in the combined burden on the environment we base our calculations on the estimates of total impacts, i.e. the impact on individual environmental factors by the intended and current activity.

5.20.2.1 Operation

During the extended operational lifetime the combined burden on the environment will not be exacerbated in relation to the existing state of the environment. Operation will be conducted under the same environmental and radiation conditions as specified in the existing operating licence.

We would like to emphasise that NEK closely follows the latest approaches and projects stemming from the events at the Fukushima-Daiichi power plant in March 2011 and is aware of the associated potential interactions. One such project they are following is the IAEA's "Multiunit Probabilistic Safety Assessment" as well as other similar international projects. In compliance with the development of these methodologies throughout the world, NEK will appropriately include the processing of possible mutual influences of reactor operation and the temporary spent fuel depot in NEK's model of probabilistic safety assessments.

With the extension of the operational lifetime, the existing burdens on the environment that are a consequence of NEK's current production process will not increase for any of the factors examined, except for the slightly larger quantity of radioactive waste (operation extended by 20 years).

Changes in the combined burden on the environment during operation in comparison with the existing state of burdens is evaluated as **(4)** – impact is not significant.

5.20.2.2 Termination of the activity

Changes in the combined burden on the environment in the case of activity termination is evaluated as **(5)** - a positive impact, taking into account particularly the decrease in releases of substances and radiation into the environment.

6. TRANSBOUNDARY IMPACTS

The aim of this chapter is to provide neighbouring countries with information about significant transboundary impacts as required by Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment /278/, also called the Environmental Impact Assessment Directive, which includes special provisions for cases when a project carried out in a Member State is likely to have a significant effect on the environment in another Member State (Article 7). The 1991 UNECE Convention on Environmental Impact Assessment in a Transboundary Context /277/, known as the Espoo Convention, similarly introduces special rules for environmental impact assessment (EIA) for activities carried out in the territory of a Party, defined as the Party of origin, and which are likely to have a significant transboundary impact on another Party, defined as the affected Party (Article 2).

The first section of this chapter presents a summary of the results of the assessment of transboundary impacts during normal operation (Section 6.3). Next, this chapter describes the simulation of the migration model in relation to emissions in the case of an incident which constitutes an accident, and the transboundary impact in the case of such an event (Section 6.4).

It has been found that, on the basis of the environmental factors analysed, **there would be no** significant harmful transboundary environmental impacts during normal operation. In the event of a nuclear accident, with a range of scenarios described below (see Section 6.4), significant transboundary impacts on the environment might occur. However, the analyses and models below show that the impact would be restricted to the territory of Croatia and have a very limited extent.

Section 2 of this chapter sets out the answers to the questions and comments received in the prior consultation document – the notification of neighbouring countries.

6.1 DEFINING THE CONTENTS AND SCOPE OF INFORMATION

Pursuant to Article 5, Paragraph 2 of Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, the developer must include the following information in the EIA:

a) a description of the project comprising information on the site, design, size and other relevant aspects of the project (see Chapters 1 and 2);
b) a description of any likely significant effects of the project on the environment (see Section 5);
c) a description of project characteristics and/or measures envisaged in order to avoid, reduce and, if possible, remedy the likely significant adverse effects on the environment (see Chapter 7);
d) an outline of reasonable alternatives studied by the developer and appropriate to the project and its special characteristics, and an indication of the main reasons for the solution selected, taking into account the environmental effects of the project (see Chapter 3);
e) a non-technical summary of the information referred to in points (a) to (d) (see Chapter 10) and
f) any further information set forth in Annex IV with regard to the special characteristics of a project or the type of project, including aspects of the environment likely to be affected (see report in its entirety).

This Environmental Assessment Report contains all of the required information set out in points (a) to (f).

Poročilo je usklajeno tudi z vsebinami skladno z Zakonom o ratifikaciji konvencije o presoji čezmejnih vplivov na okolje (MPCVO) (UL RS - Mednarodne pogodbe, št. 11/98, 17/13, 2/17, 8/17) s katerim se je ratificiralo Konvencijo o presoji čezmejnih vplivov na okolje, ki je bila sprejeta 25. februarja 1991 v Espooju.

The report is also coordinated with the contents pursuant to the Act Ratifying the Convention on Environmental Impact Assessment in a Transboundary Context (MPCVO) (Official Gazette of RS –

International Treaties, Nos. 11/98, 17/13, 2/17, 8/17), which ratified the Convention on Environmental Impact Assessment in a Transboundary Context, adopted on 25 February 1991 in Espoo.

In particular, this report discusses the extension of NEK's operational lifetime from 40 to 60 years, i.e. from 2023 to 2043, (Nuklearna elektrarna Krško, d.o.o.) located at Vrbina 12, 8270 Krško. The project of extending NEK's operation will be carried out entirely in Slovenia, with the exception of long-term radioactive waste storage, which will also be performed in the territory of Croatia.

Relationships between Slovenia and Croatia concerning the disposal of radioactive waste (RAW) from NEK are regulated by BHRNEK[35]. In accordance with Point 3, Article 10 of BHRNEK, disposal of LILW will be managed as set out in the programme for the disposal of RAW and spent fuel. Point 6, Article 10 of BHRNEK goes on to stipulate that the location of NEK may be used to store RAW only temporarily until the end of its lifetime, and Point 7 sets out that if the Parties fail to agree on a joint solution for radioactive waste and spent fuel disposal by the end of the regular lifetime, they undertake to complete the acceptance of RAW, with each side taking half, within two years of that deadline (for a detailed description, see Section 6.3.5).

In accordance with 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), the report discusses the direct and indirect impacts of the activity on the following factors:

- soil,
- water (underground, surface, thermal pollution, flood safety),
- air,
- land,
- landscape,
- climate impact,
- biodiversity,
- material assets,
- population and human health (noise, vibration, waste, risks for environmental and other accidents, radioactive radiation, electromagnetic radiation),

also taking into account any interaction between the listed factors.

In accordance with Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (OJ L 26, 28.1.2012, p. 1), last amended by Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (OJ L 124, 25.4.2014, p.1), 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 the contents of such a report in detail.

6.2 INTRODUCTORY NOTES

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) /4/ 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.

The operation of NEK was thus extended from the projected year 2023 to 2043, provided that it successfully passes the periodic safety reviews in 2023 and 2033. Based on the URSJV decisions, Slovenia and Croatia as the owners of NEK gave their support - on the basis of the Intergovernmental Treaty /11/ - to the decision to extend NEK's operational lifetime until 2043 /33/.

[35] Act Ratifying the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations regarding Investment in and the Exploitation and Decommissioning of the Krško Nuclear Power Plant (Official Gazette of RS [International Treaties], 5/2003; signed 19 December 2001, KK; effective as of 11 March 2003, Official Gazette of RS [International Treaties], 8/2003–35/2003).

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 455617.556 (north) and 153055.037 (east) in WGS-84 coordinates, and by Gauss-Kruger coordinates x = 88353.76 m and y = 540326.67 m.

The narrow area of the site of activity (lifetime extension) is shown on the figure in section 11.2.

The distance of NEK from the closest border is:

- 10 km from the border with Croatia;
- more than 75 km from the border with Austria;
- more than 129 km from the border with Italy;
- more than 100 km from the border with Hungary.

6.3 TRANSBOUNDARY IMPACTS DURING NORMAL NEK OPERATION

Transboundary impacts are given for the operating period only since no construction work is planned as a result of the extension of the operational lifetime. Transboundary impact is described for those environmental factors which are relevant to transboundary impacts and are listed below. A detailed description of the impacts is given in sections 5.2 to 5.19. The area in which lifetime extension (LTE) may cause environmental burdens that can affect human health or property during the operating period is shown in section 9. Section 9 shows that the impact is localised on the site of NEK.

6.3.1 Impact on soil

The extension of NEK's lifetime will not require any construction work, so there will also be no interventions in or on the soil. The way wastewater is discharged will not change with the extension of NEK's operational lifetime. There will be no emission of pollutants into the soil during operation, as all wastewater is already being disposed of properly (see section 2.9.3).

All waste, including radioactive waste, on the NEK site is appropriately stored and does not present a danger for soil contamination. There will be no transboundary impact on the soil during operation given the distance of the borders with neighbouring countries.

6.3.2 Impact on water

It was determined that NEK has no significant negative impact on surface waters, more specifically the Sava Krško–Vrbina water body into which wastewater from the power plant is discharged. This is proved with the yearly operational monitoring of wastewater.

NEK does not release harmful substances or polluted water directly into the ground that could result in the pollution of groundwater. The only way is indirect pollution via discharges into the Sava and by means of infiltration into the groundwater. The discharge of materials by NEK into the Sava is within prescribed limits and will remain so in the power plant's extended operation.

The heat load on the river caused by NEK will remain at the current level following the extension of the power plant's operational lifetime to 2043. This means that its operation will continue to comply with the environmental permit, which dictates that:

- the emission share of transmitted heat is 1; and
- the temperature of the Sava does not exceed the river's natural temperature by more than 3°C when mixed with cooling water from NEK.

According to the water framework directive (2000/60/EC, preamble 35) it would be necessary to coordinate demands for the attainment of environmental targets, determined in this directive, and especially all programmes of measures in the whole basin in which water use can have transboundary impacts.

According to the Water Management Plan 2016-2021, the state of watercourse CSRI0001_021 Sava upon entering Croatia (4.65 km + 11.8 km) is as follows: general state 'good', chemical state 'good' and ecological state 'good', specific polluting substances 'very good' and hydromorphological characteristics 'very good'.

At low and medium flow rates, the Sava mainly drains groundwater from the left and right waterside areas, while at high flow rates it maintains them and increases the groundwater reserves. The groundwater status at the groundwater watercourse CSGI_27-Zagreb is: chemical state 'good', quantity 'good' and overall state 'good'.

There will be no transboundary impact on surface waters and groundwater during operation given the distance of the borders with neighbouring countries.

6.3.3 Impact on air

Existing emissions remain unchanged, while emissions of air pollutants at existing release points will not increase by extending the operational lifetime. Likewise, NEK's existing production capacity will not change as a result of the extension of the power plant's operational lifetime, nor will the types and consumption of raw materials and the scope of road transport.
There will be no transboundary impact on air quality during operation given the distance of the borders with neighbouring countries.

6.3.4 Impact on environmental burden from noise

During operation noise will be localised in the immediate surroundings of NEK. There will be no transboundary impact on the environmental noise burden during operation because of the distance of the borders with neighbouring countries.

6.3.5 Impact on environmental waste load

The types of waste and the dynamic of waste generation (including radioactive) in NEK will not change in comparison with the existing situation as a result of LTE. All waste, except for radioactive waste, is handed over for treatment to a contractor. NEK does not treat the other waste.

The operation of NEK will result in ca. 2,458 m^3 or ca. 5,141 t of LILW by the end of 2023. Due to the operational lifetime being extended from 2023 to 2043, there will be an extra ca. 547 m^3 or ca. 884 t of operating LILW.

The operation of NEK will result in ca. 1,553 elements of spent fuel by the end of 2023. Due to the extension of the operational lifetime from 2023 to 2043, an extra 728 elements of spent fuel will be produced.

Relationships between Slovenia and Croatia concerning the disposal of radioactive waste (RAW) from NEK are regulated by BHRNEK[36]. In accordance with Point 3, Article 10 of BHRNEK, disposal of LILW will be managed as set out in the programme for the disposal of RAW and spent fuel. Point 6, Article 10 of BHRNEK goes on to stipulate that the location of NEK may be used to store RAW only temporarily until the end of its lifetime, and Point 7 sets out that if the Parties fail to agree on a joint solution for radioactive waste and spent fuel disposal by the end of the regular lifetime, they undertake to complete the acceptance of RAW, with each side taking half, within two years of that deadline.

[36] Act Ratifying the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations regarding Investment in and the Exploitation and Decommissioning of the Krško Nuclear Power Plant (Official Gazette of RS [International Treaties], 5/2003; signed 19 December 2001, KK; effective as of 11 March 2003, Official Gazette of RS [International Treaties], 8/2003–35/2003).

Coordinated performance of BHRNEK provisions in Slovenia and Croatia is ensured by an Intergovernmental Commission (BHRNEK, Article 18). The commission is the successor of the Inter-Republic Coordination of Slovenia and Croatia for RAW, established in 1989. In its 11th meeting on 21 November 2017, the Intergovernmental Commission established a coordination committee to monitor the implementation of the third revision of the Programme for the Disposal of RAW and SF from NEK and the NEK Decommissioning Programme. The Committee's responsibility is also to prepare a joint proposal for the construction of a LILW repository. In its 13th meeting on 30 September 2019, the Intergovernmental Commission adopted a resolution taking into account the findings of the Coordination Committee, declaring that a joint solution for LILW disposal is not feasible.

The programme of NEK RAW disposal was, along with NEK's Decommissioning Programme, first drafted in 2004, and its second revision was prepared in 2011. However, the latter was not taken under consideration or approved by the Intergovernmental Commission monitoring BHRNEK implementation and performing other responsibilities pursuant to the treaty. In 2017, the approval of the terms of reference initiated the third revision of NEK's Decommissioning Programme and the NEK RAW and SF Disposal Programme (PO3)[23]. Both programmes were ratified at the 14th meeting of the Intergovernmental Commission on 14 July 2020.

In accordance with PO3, the parties will manage LILW disposal separately: the Slovenian half of LILW from NEK will be disposed of at the Vrbina LILW Repository, not far from NEK, and the Croatian half of LILW will be disposed in a repository the location of which has yet to be specified. Until such disposal starts in 2050, LILW will be stored at the planned Centre for Radioactive Waste Management in Čerkezovac. Radioactive waste will be collected in compliance with the Rules on Radioactive Waste and Spent Fuel Management (Official Gazette of RS No. 125/21), which sets forth that the waste holder and public service provider shall agree on the location of radioactive waste or spent fuel collection for storage or disposal. If no agreement is reached, the collection shall take place at the holder's location. The provisions do not apply to the disposal of LILW generated in the process of decommissioning the dry storage for NEK's SF. This LILW will be disposed of at the deep geological repository for SF, which is the joint project of Slovenia and Croatia. The owners' decision on joint SF management for the duration of NEK's operation was adopted along with the decision on LTE[37].

The exact location of disposal is unknown at this point of preparing the report.

Considering the above, transboundary impacts in Croatia during LTE cannot be discussed, and it is therefore concluded that there will be no transboundary impact in the territory of neighbouring countries.

6.3.6 Impacts of electromagnetic radiation

No new sources of electromagnetic radiation such as transformer stations are planned as a result of NEK's operational lifetime extension. Likewise, there are no plans to fit the existing transformer stations with new transformers or replace them with greater capacity transformers. On the basis of the above, we estimate that the burden from EMR will remain the same, i.e. as shown by the last EMR measurements in 2021.

The entire NEK site is classified as a Level II electromagnetic radiation protection area, while the nearby residential areas and other nearby radiation-sensitive areas constitute Level I electromagnetic radiation protection areas. The main sources of low frequency EMR on the NEK site are transformers and power lines. The developer operates several transformer stations. The 2020 report on measurements of low frequency electromagnetic fields /53/ shows that the limit values for Level II radiation protection were not exceeded on the NEK site and on the site's boundaries. All transformer stations are regularly checked and serviced, with appropriate records kept.

[37] Joint minutes of the 10th meeting of the Intergovernmental Commission for the monitoring of the implementation of the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations regarding Investment in and the Exploitation and Decommissioning of the Krško Nuclear Power Plant (MDU), NEK, 20 July 2015; Ad.2.

There will be no transboundary impact on the environmental burden from electromagnetic radiation during operation given the distance of the borders with neighbouring countries.

6.3.7 Impacts of ionising radiation

During NEK's operating period the emission of radioactive material into the environment will be equal to the existing rate. NEK is continuously upgrading and improving its safety and process systems which means that the burden on the environment is constantly decreasing. The estimated annual effective dose for an inhabitant most affected by NEK's impacts in 2020 was less than 0.071 μSv.

A spent fuel storage facility is planned and is currently under construction. The level of ionising radiation in the surrounding area will be elevated during the operation of this storage facility. This involves external radiation. The document Krško SFDS site boundary and outside wall dose calculations /2/ summarises the results of calculations of ionising radiation levels in the vicinity of the storage facility. Spent fuel elements will be relocated from the spent fuel pool to dry storage in four campaigns, as follows:

- a. Campaign I in 2023: up to 592 fuel elements;
- b. Campaign II in 2028: around 592 fuel elements;
- c. Campaign III in 2038: around 444 fuel elements; and
- d. Campaign IV in 2048: remaining fuel elements.

The doses are calculated using conservative assumptions:

- The modelling of neutron absorption in the fuel was done *for fresh and not spent fuel*, which means that the calculated dose rates resulting from neutron radiation are higher than they will actually be. Fresh fuel contains no fission products that absorb neutrons. Hence, there are fewer n-gamma reactions and a smaller contribution of gamma radiation.
- Calculations considered the lowest densities of materials from which storage facility walls and containers can be made. Lower densities mean poorer protection, which again means that estimated dose rates are higher than they will really be.
- For radiation source, fuel is assumed to be in the reactor for the maximum length of time as regards enrichment. This means that the dose rates for neutron and gamma radiation are conservative.
- For stainless steel, it is assumed that the content of Co-59 as an impurity is 0.8 g/kg in non-fuel components of fuel elements. This means higher calculated dose rate of gamma radiation caused by Co-60, which arises due to the activation of Co-59.
- When calculating doses, it is assumed that a person is next to the NEK perimeter fence all year, i.e. for 8,760 hours, which is an extremely conservative assumption.

The results of calculations of radiation levels on the NEK perimeter fence resulting from the operation of dry storage are presented in the table below:

Table 130: Results of calculations of dose rates and doses on the NEK fence

Campaign	Highest dose rates (μSv/h)	Annual effective dose (mSv)	Annual limits from the technical specification (mSv)
After Campaign IV (full dry storage)	5.622 E-03	4.92 E-02	0.05
After Campaign IV (full dry storage), realistic estimate	4.525 E-03	3.96 E-02	0.05
After Campaign II	5.369 E-03	4.70 E-02	0.05
After Campaign I	4.315 E-03	3.78 E-02	0.05

The results of calculations of radiation levels on the exterior wall of the dry storage building for spent fuel are presented in the table below.

Table 131: Results of calculations of dose rates on the exterior wall of the dry storage for spent fuel

Campaign	Highest dose rates (μSv/h)	Limits from the technical specification (μSv/h)
After Campaign IV (full dry storage)	0.028	3
After Campaign II	0.022	3
After Campaign I	0.020	3

All calculations for radiation levels show that the dose rates and ionising radiation doses using realistic assumptions will be within the stringent limits required in the technical specification of the project for dry storage construction, and are lower than the limits allowed.

Likewise, the effective annual dose of external radiation on the NEK perimeter fence from all contributors, including the dry storage of spent fuel, will not, during operation, exceed the radiation load that currently applies to the NEK perimeter fence, which is 200 μSv /7/. Dry storage operation will not cause the allowed dose rate at the NEK fence to be exceeded.

In view of the above, due to the distance of borders, there will be no transboundary impacts of ionising radiation on the area of neighbouring countries.

6.3.8 Impacts on natural and material assets

Impact during operation

The direct use of natural resources in production includes water from the public water supply network for sanitary purposes and fire safety, river water and underground water, which is taken from wells and the Sava in compliance with water permits for technological purposes. The river and underground water is used in supporting cooling processes and is not used as a raw material (is not incorporated in products). Following use and appropriate treatment, all water is returned to the environment, i.e. to the Sava. The water pumped from three wells returns directly into the Sava via the rainwater drainage system.

LTE will not impact valuable natural features in the vicinity during operation (description in section 5.14.1).

As is evident from the findings in previous sections of this report that addressed NEK's impacts on the environment, now and following the change, all burdens are within permitted values. The extension of NEK's operational lifetime is not expected to result in excessive environmental burdens or impacts that could cause a deterioration in living conditions, consumption or the use of buildings and land outside of the NEK site. The company performs an activity in the Vrbina industrial zone where other industrial buildings are present (see section 2.2.1) and where it has been present for decades. It is thus not the only source of environmental burden in that area but is one of the most important. That facility is not classified as an activity or installation that can cause large-scale environmental pollution and does not pose a minor or major threat to the environment. NEK is a nuclear facility. Its presence in the area could therefore pose the direct threat of an environmental or other accident that could impact material assets, i.e. land and buildings in the vicinity (see section 5.18.1). Because of the technology used and the implementation of protective measures, however, the possibility of an accident is reduced to the lowest possible level. In accordance with the Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13 and 76/17), NEK buildings are classified to categories I, II and III. The facility will therefore be protected in accordance with requirements for physically controlled areas and physically controlled facilities. Reporting on stored fuels will be carried out in accordance with the Decree on the safeguarding of nuclear materials (Official Gazette of RS, Nos. 34/08 and 76/17 – ZVISJV-1).

Republic of Croatia – energy, climate and economic aspects of the impact

The Krško Nuclear Power Plant (NEK) is owned by GEN Energija d.o.o., (Slovenia) and Hrvatska elektroprivreda (Croatia). The power plant's management is governed by 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 (BHRNEK) /11/. 50% of its electricity supply goes to Slovenia and 50% to Croatia.

Thus, NEK is a stable source of electricity for both Croatia and Slovenia with continuous and reliable production. At the end of 2019, the total available power of power plants in Croatia stood at 4,711.8 MW. Of this, 1,781 MW in thermal power plants, 2,199.7 MW in hydroelectric power plants, 646.3 MW in wind turbines and 84.8 MW in solar power plants. The capacity of NEK available to Croatia (348 MW) amounts to an additional 7.4% production capacities, with continuous supply. Between 2014–2019, NEK covered 15.2% of Croatia's electricity consumption /248/.

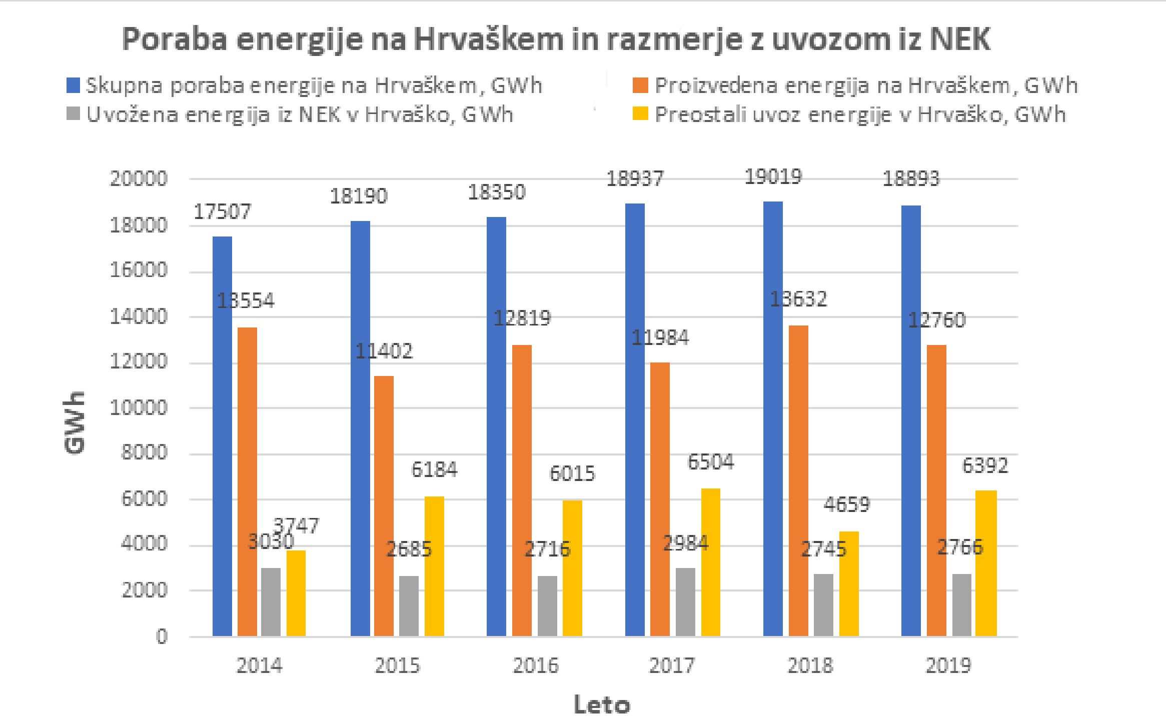

Figure 99: Energy consumption in Croatia and the proportion with export from NEK /248/

Poraba energije na Hrvaškem in razmerje z uvozom iz NEK	Energy consumption in Croatia and the proportion with export from NEK
Skupna poraba energije na Hrvaškem, GWh	Total energy consumption in Croatia, GWh
Uvožena energija iz NEK v Hrvaško, GWh	Energy imported from NEK to Croatia, GWh
Proizvedena energija na Hrvaškem, GWh	Energy produced in Croatia, GWh
Preostali uvoz energije v Hrvaško, GWh	Remaining energy imported to Croatia, GWh
GWh	GWh
Leto	Year

The climate and energy strategic planning documents of the Republic of Croatia for the period up to 2030 with projections up to 2050 envisage electricity production in NEK until 2043, which contributes to the reduction of greenhouse gases in accordance with the Paris Agreement and the European Green Deal /249/, /250/ and /251/. Based on calculations, it is estimated that in order to replace the production in NEK, approximately 1,200 MW capacities will have to be constructed as wind turbines, or approximately 2,700 MW as solar power plants, which poses a challenge in terms of encroachment and inclusion in spatial plans. Extending NEK's operation enables the continuance of economic activities linked to its services, helps to maintain the human potential in the nuclear field, and also helps to maintain capabilities in the scientific and academic community.

Given the above, due to the distance of neighbouring countries, there will be no transboundary impact on natural and material assets during operation, or, in the case of Croatia, the impact will be positive.

6.3.9 Impact on the population and human health

Impacts during operation
As follows from the findings in previous chapters of this report, which deal with the impacts of lifetime expansion (LTE) on all relevant environmental factors it might affect, NEK's current level of production does not exceed the limit values for substance emissions and radiation into the environment. It is not expected that the limit values will be surpassed during the planned extension of operational lifetime of NEK either. The limit value is the prescribed level whose aim is to avoid, prevent or reduce harmful effects on human health or the environment as a whole. NEK implements, and will continue to implement after the changes, all the measures to reduce burdens and prevent pollution of the environment and the impact on human health, which stem from regulations. Regular monitoring is also carried out in keeping with applicable prescriptions and permits.

The change in the current activity (extension of the operational lifetime) will not cause changes to natural and other conditions of life and habitation near the site of the activity and further afield. There will be no impact on the area of neighbouring countries.

Conclusion
As evident from sections 1.1 and 8, the area in which LTE causes environmental burdens that may affect human health or property during operation, will be limited to the narrow site of NEK, specifically to the following parts of land:

- plots owned by NEK: 1197/44, 1204/192, 1197/397, 1246/2, 1197/398 (partly) and 1204/206 (partly), all cadastral municipality (1321) Leskovec,

- parts of plots, on which NEK holds building rights: 1204/209, 1246/6, 1249/1, 1246/33, 1195/107, 1195/109, 1195/111, all cadastral municipality (1321) Leskovec.

Based on the above, under **normal operation**, the planned activity will have no transboundary effects on the factors discussed in this report that would stem from individual impacts or their mutual effects.

6.4 TRANSBOUNDARY IMPACT IN THE EVENT OF AN EMERGENCY – ACCIDENT

This section presents the results of calculations of doses at certain distances for the case of Design Basis (DB) or Beyond Design Basis (BDB) accidents at NEK, and the monitoring in the event of an accident with releases into the atmosphere /196/.

Radioactive inventory (source term)
The source term released from the core in cases of design basis accidents and design extension conditions is based on the methods given in NUREG-1465 /197/.

NUREG-1465 /197/ gives realistic estimates of releases in terms of release timing, nuclide types, quantities and chemical form. These methods are incorporated into the latest computer codes for accident analyses (MAAP, MELCOR, ASTEC etc.).

The estimated releases from the core into the containment are shown in the table below (Table 132). The releases given in the first two columns for release percentages are used for design basis accidents, and all four columns for release percentages are used in calculations for design extension conditions.

Table 132: Estimated releases from the core into containment (source: /197/)

Groups of fission products	Representative element	Release percentages			
		Gap release (0 hours)	Early in-vessel release (1.3 hours)	Ex-vessel release (2 hours)	Late in-vessel release (10 hours)
1	Noble gases	0.05	0.95	0	0
2	I	0.05	0.35	0.25	0.1
3	Cs	0.05	0.25	0.35	0.1
4	Te	0	0.05	0.25	0.005
5	Sr	0	0.02	0.1	0
6	Ba	0	0.02	0.1	0
7	Ru	0	0.0025	0.0025	0
8	Ce	0	0.0005	0.005	0
9	La	0	0.0002	0.005	0

The analytical method of releases to the environment considers the removal or reduction of fission products by using safety systems (containment spraying, passive filtration and venting) and by natural processes such as aerosol deposition.

Selection of representative accidents

The representative design basis accident (DBA), selected as the worst case scenario in terms of estimated releases and doses to NEK employees and people in the immediate vicinity, is an accident involving loss of primary coolant, called large break loss of coolant accident (LB LOCA), which includes the assumption of fuel damage (Ref. USAR Chapter 15) /3/ and NUREG-1465 /197/.

Doses resulting from damage to the fuel element in the spent fuel pool (fuel element drop) are smaller than in a large break loss of coolant accident (Ref. USAR Chapter 15).

The probability of design extension conditions for the spent fuel pool (fuel uncovery in the spent fuel pool) is very small or insignificant (ca. 1E-9/year /196/). As part of upgrading NEK's safety and in addition to its design basis systems, an alternative cooling system was installed (alongside the two existing, completely redundant systems), as well as an alternative spray system, to be used in the event of losing design basis cooling systems or losing coolant/water in the spent fuel pool. This has further reduced the already small likelihood of fuel damage in the spent fuel pool.

The selected representative accident in design extension conditions, category DEC-B, was an accident with loss of all AC power supply and loss of operating crew for 24 hours. The yearly probability of total loss of AC power supply is 4.13E-07/year. It is further conservatively assumed that it will not be possible to restore the power supply in the first 24 hours and that no actions will be taken by the operating staff. Loss of pressure barrier in the reactor building under representative design extension conditions is not assumed, since the HCLPF capacity of structures ensuring the pressure barrier in the reactor building is equal to 1.11 g and approximately two times greater than the HCLPF capacity of AC power supply systems. Maximum ground accelerations with a non-negligible probability of containment failure are therefore considerably greater than 1.0 g, and the mean annual frequency of AC power supply loss in combination with loss of containment integrity is considerably smaller than the probability of the assumed representative accident. The representative DEC-B accident would involve core melting, reactor vessel meltdown and core melt relocation to the containment sump. This leads to increased pressure in the containment vessel and operation of the passive filter system, which depressurises the containment to ensure its long-term integrity. This accident was also selected as a design basis accident for designing the passive filter system of the containment and the passive autocatalytic recombiners (PARs), in order to maximise the quantity of fission products released into the atmosphere of the reactor containment.

In the event of the accidents discussed (DBA and DEC-B) there will be no liquid effluent released into the Sava. All cooling water will be contained inside the containment vessel and auxiliary building, which is designed for systems and components that contain radioactive material (contaminated radioactive water).

There will also be spent fuel dry storage on the site of NEK. Based on all the design basis events and design extension conditions it was proved that the container into which fuel is inserted maintains its integrity without leaking. Nevertheless, for the purposes of obtaining integrated building permission for dry storage of spent fuel as part of the transboundary assessment process, an analysis of the radiological consequences of container leakage was conducted as well. Results of the radiological analysis confirm that in the hypothetical case of container leakage, the 30-day dose to an individual from the population would be lower than the dose resulting from a large break loss of coolant accident (LB LOCA), which poses a limiting design basis accident in terms of estimated releases and doses to the employees of NEK and people in its immediate vicinity.

Large break loss of coolant accident (LB LOCA)

For the case of a large break loss of coolant accident (LB LOCA), the isotope inventory released into the environment was calculated using the assumptions set out in the safety report (USAR), and the radioactive inventory is based on specific ORIGEN2 calculations for NEK. The timing of the release is in keeping with NUREG-1465 /197/.

Leakage from the containment to the environment was analysed by using a model of the part of the containment volume which is exposed to spraying, and the part of its volume which is not exposed to spraying. The model also includes direct leakage from the containment, leakage via the annulus, filtration of the annulus and filtered leakage. The anticipated paths of release are shown in the figure below (Figure 100).

A design basis leakage from the containment directly to the environment is assumed, in which case radionuclides are not filtered. Direct containment leakage to the environment decreases as recirculation begins, but leakage is present until the end of the accident. As recirculation begins, most of the containment leakage is redirected into the containment annulus. The leakage is assumed to be a ground release.

Containment leakage is assumed in keeping with the safety report as indicated in USAR, Table 15.6.5-11 /3/.

It is assumed that up until 1,200 s, direct leakage to the environment with design basis leakage is 0.2 vol.%/day. The leakage rate between 1,200 s and 1 day is 0.02 vol.%/day, and after that 0.01 vol.%/ day. Between 1,200 s and 1 day, the rate of containment leakage to the annulus is 0.18 vol.%/day and 0.09 vol.%/day after this interval. Overall leakage from the containment in the first 24 hours is 0.2 vol.%/day, and after that 0.1 vol.%/day. When making calculations in the RADTRAD programme /218/, leakage was divided into the leakage of sprayed and unsprayed volumes. However, the overall quantity of effluent released was equal to the quantity based on the total volume of the containment vessel. The respective paths of release (3, 6 and 2, 5) are shown in the figure below (Figure 100).

Power plant model used in the RADTRAD programme for LB LOCA

The reactor containment is divided into the sprayed part of the volume (1) and the unsprayed part of the volume (2). Paths (1) and (4) are used to model the mixing between them. Paths (3) and (6) represent direct leakage to the environment. Paths (2) and (5) represent leakage to the annulus (3) (when vacuum is established). The annulus is fitted with a recirculation filter. The filtered release path (7) is a component of this filter.

Path (11) represents direct leakage from the annulus to the environment. Volume (5) represents the main control room (MCR). It is connected to the environment through an unfiltered path (9) and via a filtered supply path (8). This path is a component of the main control room's recirculation filter. Path

(10) is a release from MCR (flow rate is equal to the sum of paths 8 and 9) MCR is included in the model even though it does not affect the calculation of doses in the environment.

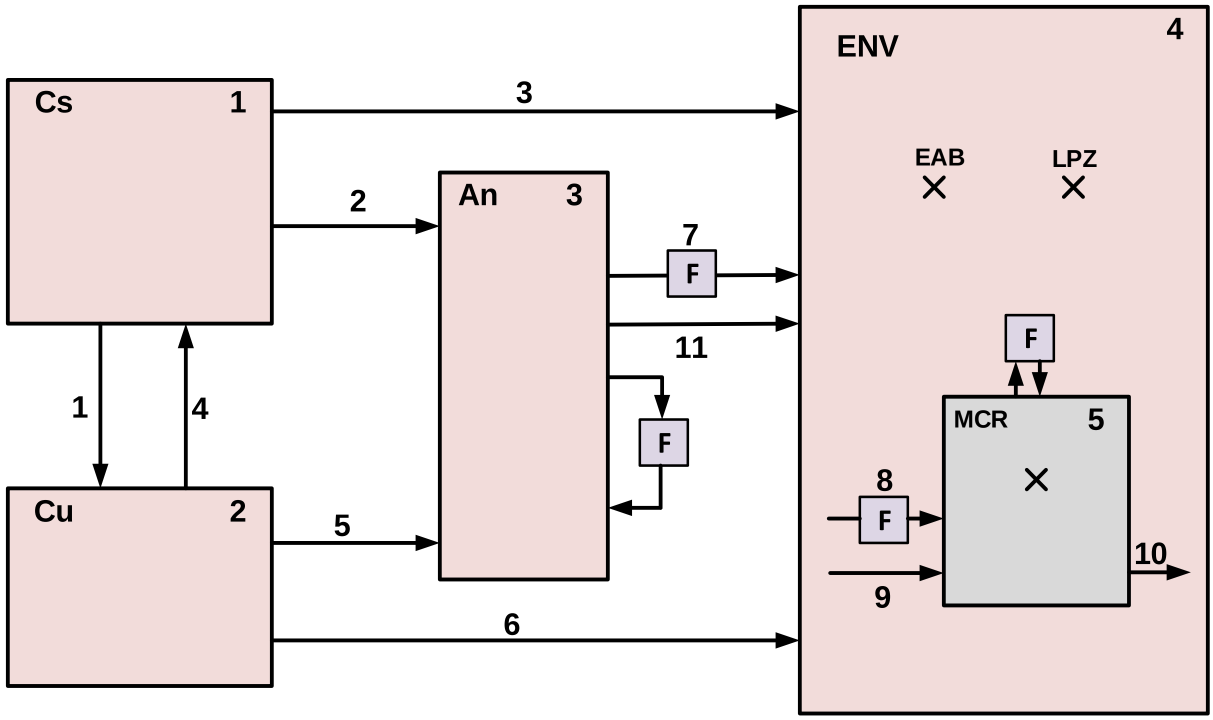

Figure 100: RADTRAD model for large break loss of coolant accident at NEK (source: /196/)

Key to RADTRAD model abbreviations:
Cs…………..sprayed part of the containment volume
Cu…………..unsprayed part of the containment volume
An…………..annulus
ENV…………environment
F………………filter
EAB………...exclusion zone
LPZ………… precautionary action zone
MCR…………main control room

Design extension conditions (DEC-B)

An accident involving the loss of all AC power supply and a 24-hour loss of operating crew was selected as a case of the most severe design extension conditions (DEC-B). Therefore, no actions are carried out by the operating crew within the first 24 hours. This scenario assumes the loss of off-site power supply, the failure of back-up diesel generators, a failure to restore the power supply and leakage of the reactor coolant pump (RCP) valves, all of which results in a loss of coolant accident. Coolant leakage through RCP valves constitutes a minor loss of coolant accident (LOCA) and the assumed inability to compensate leads to core uncovery and heating, and eventually core damage. This results in core meltdown, reactor vessel meltdown and the spilling of molten fuel into the containment. Spillage of molten fuel into the containment causes an interaction between concrete and molten core (MCCI), which releases various gases, leading to an increase of pressure in the containment.

A rise in pressure above 6 bars activates the operation of the passive filter system for containment depressurisation. This system retains more than 99.9993% (decontamination factor of 137,000) of fission products in particulate form in the filters of the containment, and more than 99.9997% (decontamination factor of 370,000) of elementary iodine and 93% (decontamination factor of 14.53) of organic iodine on the iodine filters. Calculations for elementary iodine were made by using a conservatively lower decontamination factor of 100,000. Noble gases, however, are not filtered out by the filter system and are released into the atmosphere. This is to protect the pressure boundary of the containment and fully prevent any long-term contamination of the environment. It should be emphasised that in the case of core meltdown, the above release of radioactive material is the most probable one in comparison with other release categories, and that this accident was selected as a design basis accident for designing the passive filter system of the containment in order to maximise the quantity of fission products released into the containment atmosphere.

Mitigating measures are assumed to take place after 24 hours from the beginning of the accident. Before this, there is a single release through the passive filter system of the containment (release time is 3 hours). This is a very conservative assumption, since it is assumed that for 24 hours, there will be no operating staff in the power plant, no power supply and that, consequently, none of the safety systems will operate. After 24 hours, heat removal from the containment is foreseen through the Alternative Residual Heat Removal (ARHR) system. It is also assumed that the containment vessel will be sprayed by means of the ARHR system.

The analysis was made using the MELCOR computer programme. Basic design leakage from the containment is also assumed.

RADTRAD model for design extension conditions (DEC-B)

The power plant model used in the RADTRAD programme for LB LOCA is adjusted with the passive filter system (PCFVS) – path (12). The alternative source term (AST) is determined based on adjusted percentages of releases from NUREG-1465 /197/.

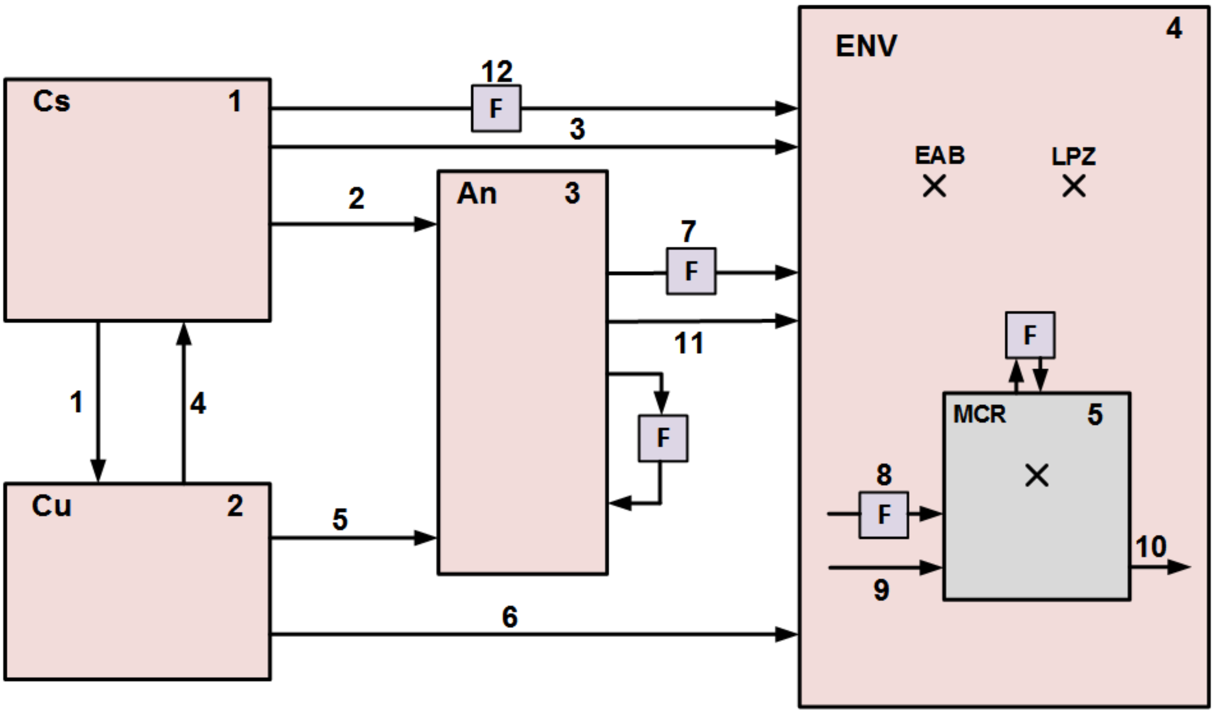

Figure 101: RADTRAD model for NEK DEC-B accident (source: /196/)

Key to RADTRAD model abbreviations:

Cs...............sprayed part of the containment volume
Cu...............unsprayed part of the containment volume
An...............annulus
ENV............environment
F..................filter
EAB............exclusion zone
LPZ............ precautionary action zone
MCR............main control room

Meteorological section

Description of the modelling system

This section explains how the diluting capacities of the atmosphere in the event of an accidental release from NEK are calculated for the wider area, for distances up to 100 km from the source, based on a sample month. The constructed modelling system is a tool for the realistic estimation of what is going on in the atmosphere.

For the broader surroundings of NEK, the sources of NEK's emissions into the atmosphere are treated as point sources. Lagrangian particle models combined with a spatial 3D visualisation of the meteorological state of the atmosphere are most appropriate for a realistic study of dispersion from point sources. Lagrangian particle models can realistically depict the rising of smoke and turbulence in the atmosphere in a 3D space with an appropriate time resolution.
The atmosphere's dispersion capacities are presented with relative concentrations also called diffusion coefficients X/Q, which use constant emission for a selected emission period.

The modelling system for the 200 km x 200 km area whose centre is NEK is built with WRF /198/ and ARIA Industry models. ARIA Industry consists of the meteorological SURFPro preprocessor, the Minerve mass-consistent wind model and the Spray Lagrangian particle model /199/.

The Spray Lagrangian particle model has been used to calculate dispersion. A 3D spatial description of weather variables and a physical description of the characteristics of the source that emits radionuclides from NEK, are the input data for the model which calculates the dispersion of radionuclides in the atmosphere.

Numerical weather prediction model (WRF)

The model is configured as follows:

- WRF version: 4.2.1,
- large domain: horizontally 89 cells x 89 cells, each cell being a square with 12 km sides,
- small domain: (marked with no. 2) horizontally 85 cells x 85 cells, each cell being a square with 4 km sides,
- yellow circle marked with no. 2 shows where the centre of the internal (second) domain is,
- the time increment is 0.5 h,
- vertical levels: type = ETA, there are 45 levels.

Figure 102: Large and small domains of the chosen configuration from the WRF model (source: /196/)

Aria Industry dispersion modelling system (SURFPro, Minerve and Spray)

Input data and settings of the Minerve and Spray models:

- 200 km x 200 km domain with a 2 km resolution and centre at NEK, 100 x 100 cells horizontally,
- domain coordinates, left lower corner UTM33: 440000, 4987000,
- digital relief model from 2012, (original resolution 25 m, converted to the resolution of the 2 km model),
- land use (Corine land cover) from 2018, (original resolution 100 m, converted to the resolution of the 2 km model),
- derived statistical data for different seasons from terrain use: surface roughness length, Bowen ratio, albedo and soil heat flux,
- spatial partitioning of the cells horizontally: 2 km, vertically: layers that conform to the terrain, first layer above the ground has a thickness of 10 m, then a sigma coordinate system that conforms to the terrain up to a height of 3,000 m,
- the input weather data are the results of the WRF weather model,
- the time increment is 0.5 h, average values,
- we display results for the ground layer,
- months processed: February, May, August and November 2020.

Physical characteristics of emission sources

Three sources have been considered: the plant vent, ground releases and releases from the PCFVS chimney.

Releases from the plant vent:

- at the NEK containment location,
- height of the chimney: 60 m.

Ground release:

- at the NEK containment location,
- height of the release: 1 m.

Releases from the PCFVS chimney:

- at the NEK containment location,
- height of the chimney: 58 m.

Validation of the models used

The models we used in the modelling system were originally designed to simulate weather conditions of the atmosphere and the dispersion of light pollutants in the atmosphere over challenging, complex terrain. The manufacturers validated them (compared them with measurements in the natural environment) on various sets of data /211/,/212/.

Before being used for NEK EIA, the models were also abundantly validated on an area of Slovenia positioned in a challenging part of the target 200 km x 200 km domain.

The WRF model was tested in the areas of Zasavje, Šoštanj and Krško. The terrain in all these areas is very complex. We compared forecasts with measurements at ground meteorological stations in the hills and basins and wind measurements with SODAR in Šoštanj (vertical wind profile up to 1,000 m above terrain). WRF was likewise extensively tested in the area of NEK. We compared forecasts and measurements at ground meteorological stations in the broader area, measurements on a 70 m tall tower near NEK and measurements with SODAR and RASS (vertical wind profile and temperatures up to 500 m above terrain).

The WRF model proved to be a very good model for forecasting weather in this area /202/,/203/,/204/.

The ARIA Industry model system (SURFPro, Minerve, Spray) was also abundantly tested in the area of Šoštanj and partly in the area of Zasavje. For the Šoštanj area, we have a scientifically recognised data set at our disposal for testing dispersion models over the very complex terrain of Velenje basin surroundings with weak winds and temperature inversions. This data set is from the Šoštanj-91 measurement campaign, where SO2 from the Šoštanj Thermal Power Plant was used as a tracer in model testing. The emission and environmental concentrations, and meteorological measurements are available in half hour increments /205/. The model system was additionally tested on Šoštanj-91 data in combination with reanalyses of meteorological fields performed with the WRF model. The model system was used with success to illustrate concentrations of pollutants, and good congruence was determined for location and time. The validations were carried out within Slovenian research projects and within the task of testing models for modelling dispersion into the surroundings of nuclear power plants, where MEIS was guiding the task in MODARIA I and MODARIA II programmes at the IAEA /207/,/208/. In addition, we calculated relative concentrations from the Šoštanj-91 measurement campaign data. The values are in the same range as calculated for the area surrounding NEK.

Linking EIA calculations with the validated placements of the model

The ARIA Industry models (SURFPro, Minerve, Spray) used together showed a satisfactory congruence of the measured and calculated concentrations on the Šoštanj-91 set of validation data /205/, /206/, /207/, /208/. The calculations were performed using measured meteorological data from 6 ground meteorological stations located in the basin and in the hills and SODAR measurements for a 15 km x 15 km area.

We call such a local layout of the modelling system a reference modelling system. We did not carry out tracking tests at the NEK site. As the complexity of the terrain and the meteorology are a little less demanding than in Šoštanj, we can reasonably assume that the model used in a similar way will give similarly good results. That is why we also made calculations for the 25 km x 25 km area using meteorological measurements (RASS and ground stations) taken around NEK. We call this use the NEK reference modelling system /200/. Then in two further steps we added expansions which illustrate by how much the results of the dispersion change statistically if we use forecast meteorology /200/, /201/, /204/, /205/ from WRF and/or if we expand the area to 200 km x 200 km. All the details about the NEK reference modelling system are gathered in article /200/.

We used meteorological data from 4 ground stations and data on the vertical wind and temperature profiles (SODAR, RASS) up to a maximum of 500 m above the level of the basin.

By using this measured meteorological data from the 200 km x 200 km area as an intermediate result, we checked the congruence in the vicinity of NEK between the results of the NEK reference modelling system and the 200 km x 200 km system.

The following figures show these results. They display the average monthly X/Q values calculated from half-hour values. A comparison of the values in the cells with the highest values shows that the congruence is satisfactory. The congruence is valid for the vicinity of NEK where the highest values occur, which is evident from the displayed results.

In the NEK reference modelling system in the small domain, it is found that for the studied months (February, May, August and November 2020, which were selected on the criterion of representing the last month of the meteorological season) the monthly average X/Q for May 2020 according to the flat sample, which simulates the directions and areas where the radionuclide cloud spreads, is most similar to the annual average X/Q for 2020. That is why further processing of the large domain was carried out for May 2020.

In the following figures the following results are given for comparison for X/Q for the ground layer for May 2020:

- The NEK reference result X/Q (25x25, measured meteorology) (upper left),
- X/Q results for 25 km x 25 km, with forecast meteorology (upper right),
- X/Q results for 200 km x 200 km, with measured meteorology (lower left) and
- X/Q final results for 200 km x 200 km, with forecast meteorology (lower right) for the whole area.

The figures displaying the results are laid out as follows:

	DIAGNOZA	**PROGNOZA**
25 x 25	**meteorološke meritve EIS NEK** **25 km x 25 km** **referenčni modelirni sistem NEK**	**WRF napoved vremena** **25 km x 25 km**
200 x 200	**meteorološke meritve EIS NEK** **200 km x 200 km**	**WRF reanaliza vremena** **200 km x 200 km** **končni rezultat**

DIAGNOZA	DIAGNOSIS
PROGNOZA	PROGNOSIS
meteorološke meritve EIS NEK 25 km x 25 km referenčni modelirni sistem NEK	EIS NEK meteorological measurements 25 km x 25 km NEK reference modelling system
WRF napoved vremena 25 km x 25 km	WRF weather forecast 25 km x 25 km
meteorološke meritve EIS NEK 200 km x 200 km	EIS NEK meteorological measurements 200 km x 200 km
WRF reanaliza vremena 200 km x 200 km končni rezultat	WRF weather reanalysis 200 km x 200 km final result

The inscription below each figure contains the following values:

- Max - maximum value,
- x - location of maximum value (Max) in the cells from west to east (W→E),
- y - location of maximum value (Max) in the cells from south to north (S→N),
- Avg - average value,
- MxR - maximum value at the edge of the domain (figures),
- x - location MxR in the cells from west to east (W→E),
- y - location MxR in the cells from south to north (S→N),
- % scale - MxR value / greatest limit value on the scale.

Primary results - monthly average for May 2020 for X/Q for NEK from 25k x 25km to 200 km x 200 km:

Three sources were considered: the plant vent, ground releases and releases from the PCFVS chimney:

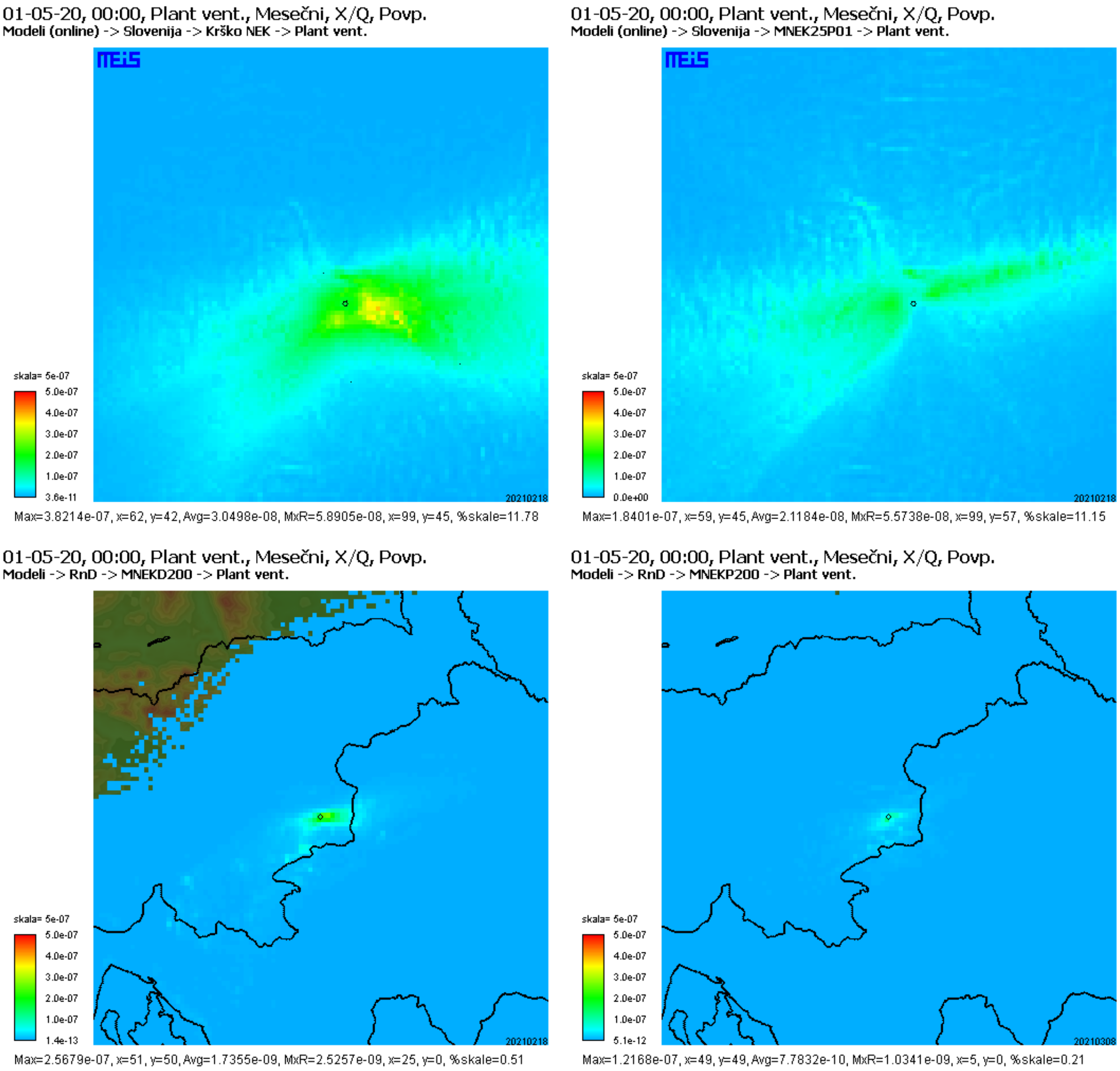

Figure 103: Comparison of monthly average X/Q for plant vent releases (source: /196/)

01-05-20, 00:00, Plant vent., Mesečni, X/Q, Povp.	01-05-20, 00:00, Plant vent., Monthly, X/Q, Avg.
Modeli (online) -> Slovenija -> Krško NEK -> Plant vent.	Models (online) -> Slovenia -> Krško NEK -> Plant vent.
skala = 5e-07	scale = 5e-07
Max=3.8214e-07, x=62, y=42, Avg=3.0498e-08, MxR=5.8905e-08, x=99, y=45, % skale=11,78	Max=3.8214e-07, x=62, y=42, Avg=3.0498e-08, MxR=5.8905e-08, x=99, y=45, % scale=11.78
Modeli (online) -> Slovenija -> MNEK25P01 -> Plant vent.	Models (online) -> Slovenia -> MNEK25P01 -> Plant vent.
Max=1.8401e-07, x=59, y=45, Avg=2.1184e-08, MxR=5.5738e-08, x=39, y=57, % skale=11.15	Max=1.8401e-07, x=59, y=45, Avg=2.1184e-08, MxR=5.5738e-08, x=39, y=57, % scale=11.15
Modeli -> RnD -> MNEKD200 -> Plant vent.	Models -> RnD -> MNEKD200 -> Plant vent.
Max=2.5679e-07, x=51, y=50, Avg=1.7355e-09, MxR=2.5257e-09, x=25, y=0, % skale=0.51	Max=2.5679e-07, x=51, y=50, Avg=1.7355e-09, MxR=2.5257e-09, x=25, y=0, % scale=0.51
Modeli -> RnD -> MNEKP200 -> Plant vent.	Models -> RnD -> MNEKP200 -> Plant vent.
Max=1.2168e-07, x=49, y=49, Avg=7.7832e-10, MxR=1.0341e-09, x=5, y=0, % skale=0.21	Max=1.2168e-07, x=49, y=49, Avg=7.7832e-10, MxR=1.0341e-09, x=5, y=0, % scale=0.21

The processed month is written in the titles of the 2D figures displaying results. The first column presents the results of diagnostic modelling and the second column forecast modelling. The first line shows the results of the model on the smaller 25 km x 25 km domain while the second line shows the results of the model on the larger 200 km x 200 km domain.

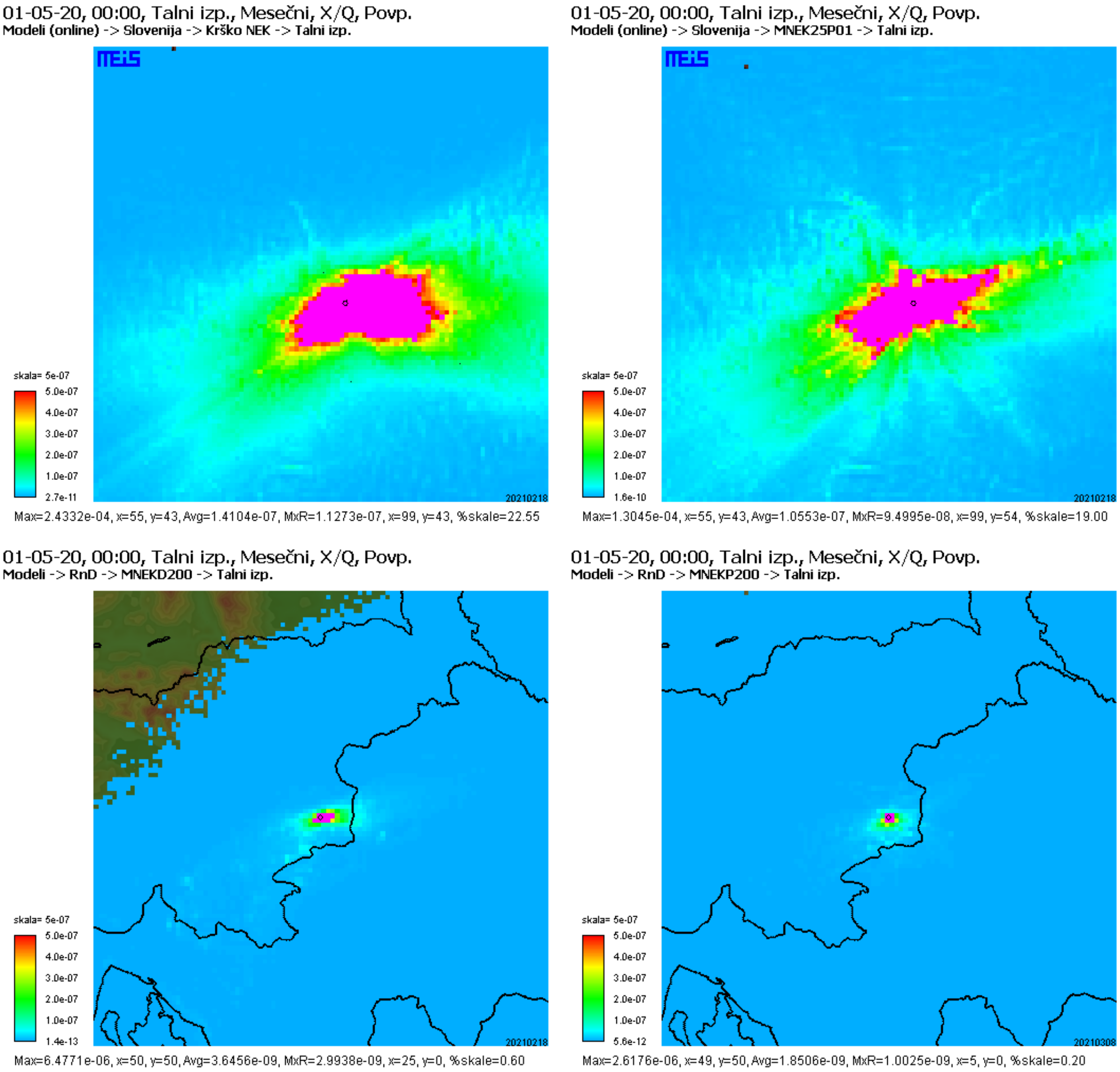

Figure 104: Comparison of monthly average X/Q for ground releases (source: /196/)

01-05-20, 00:00, Talni izp., Mesečni, X/Q, Povp.	01-05-20, 00:00, Ground releases, Monthly, X/Q, Avg.
Modeli (online) -> Slovenija -> Krško NEK -> Talni izp.	Models (online) -> Slovenia -> Krško NEK -> Ground releases
skala = 5e-07	scale = 5e-07
Max=2.4332e-04, x=55, y=43, Avg=1.4104e-07, MxR=1.1273e-07, x=99, y=43, % skale=22.55	Max=2.4332e-04, x=55, y=43, Avg=1.4104e-07, MxR=1.1273e-07, x=99, y=43, % scale=22.55
Modeli (online) -> Slovenija -> MNEK25P01 -> Talni izp.	Models (online) -> Slovenia -> MNEK25P01 -> Ground releases
Max=1.3045e-04, x=55, y=43, Avg=1.0553e-07, MxR=9.4995e-08, x=99, y=54, % skale=19.00	Max=1.3045e-04, x=55, y=43, Avg=1.0553e-07, MxR=9.4995e-08, x=99, y=54, % scale=19.00
Modeli -> RnD -> MNEKD200 -> Talni izp.	Models -> RnD -> MNEKD200 -> Ground releases
Max=6.4771e-06, x=50, y=50, Avg=3.6456e-09, MxR=2.9938e-09, x=25, y=0, % skale=0.60	Max=6.4771e-06, x=50, y=50, Avg=3.6456e-09, MxR=2.9938e-09, x=25, y=0, % scale=0.60
Modeli -> RnD -> MNEKP200 -> Talni izp.	Models -> RnD -> MNEKP200 -> Ground releases
Max=2.6176e-06, x=49, y=50, Avg=18506e-09, MxR=1.0025e-09, x=5, y=0, % skale=0.20	Max=2.6176e-06, x=49, y=50, Avg=18506e-09, MxR=1.0025e-09, x=5, y=0, % scale=0.20

The processed month is written in the titles of the 2D figures displaying results. The first column presents the results of diagnostic modelling and the second column forecast modelling. The first line shows the results of the model on the smaller 25 km x 25 km domain while the second line shows the results of the model on the larger 200 km x 200 km domain. The values shown in pink (magenta) are values greater than the highest values marked red in the key.

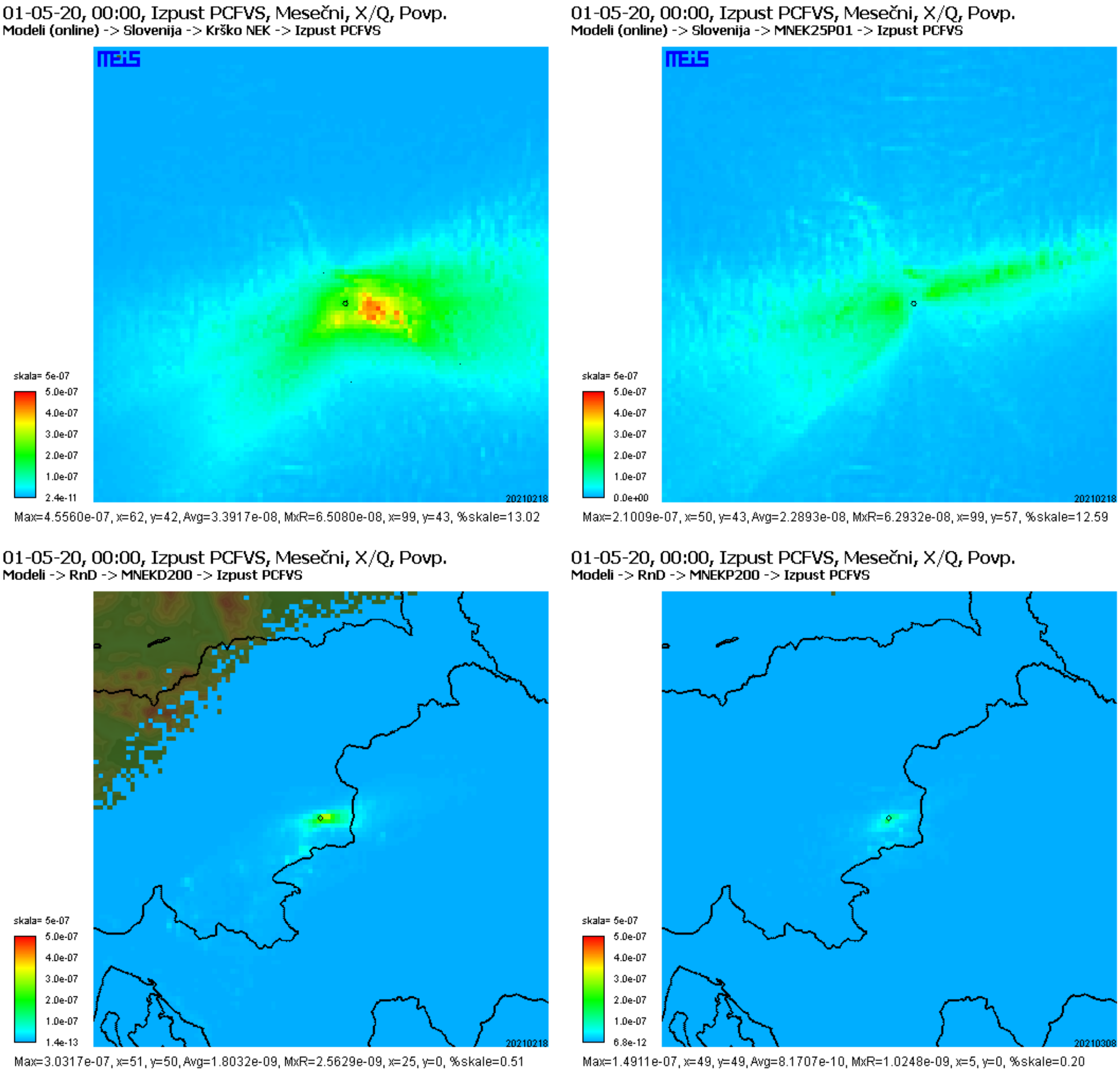

Figure 105: Comparison of monthly average X/Q for PCFVS releases (source: /196/)

01-05-20, 00:00, Izpust PCFVS, Mesečni, X/Q, Povp.	01-05-20, 00:00, PCFVS releases, Monthly, X/Q, Avg.
Modeli (online) -> Slovenija -> Krško NEK -> Izpust PCFVS	Models (online) -> Slovenia -> Krško NEK -> PCFVS releases
skala = 5e-07	scale = 5e-07
Max=4.5580e-07, x=62, y=42, Avg=3.3917e-08, MxR=6.5080e-08, x=99, y=43, % skale=13.02	Max=4.5580e-07, x=62, y=42, Avg=3.3917e-08, MxR=6.5080e-08, x=99, y=43, % scale=13.02
Modeli (online) -> Slovenija -> MNEK25P01 -> Izpust PCFVS	Models (online) -> Slovenia -> MNEK25P01 -> PCFVS releases
Max=2.1009e-07, x=50, y=43,Avg=2.2893e-08, MxR=6.29326-08, x=99, y=57, % skale=12.59	Max=2.1009e-07, x=50, y=43, Avg=2.2893e-08, MxR=6.29326-08, x=99, y=57, % scale=12.59
Modeli -> RnD -> MNEKD200 -> Izpust PCFVS	Models -> RnD -> MNEKD200 -> PCFVS releases
Max=3.0317e-07, x=51, y=50, Avg=1.8032e-09, MxR=2.5629e-09, x=25, y=0, % skale=0.51	Max=3.0317e-07, x=51, y=50, Avg=1.8032e-09, MxR=2.5629e-09, x=25, y=0, % scale=0.51
Modeli -> RnD -> MNEKP200 -> Izpust PCFVS	Models -> RnD -> MNEKP200 -> PCFVS releases
Max=1.4911e-07, x=49, y=49, Avg=8.1707e-10, MxR=1.02486-09, x=5, y=0, % skale=0.20	Max=1.4911e-07, x=49, y=49, Avg=8.1707e-10, MxR=1.02486-09, x=5, y=0, % scale=0.20

The processed month is written in the titles of the 2D figures displaying results. The first column presents the results of diagnostic modelling and the second column forecast modelling. The first line shows the results of the model on the smaller 25 km x 25 km domain while the second line shows the results of the model on the larger 200 km x 200 km domain.

Statistical processing of results for X/Q

Simulations and statistical processing are carried out for May 2020.

Dispersion simulations are carried out in half-hour increments. A half-hour relative concentration or diffusion coefficient (X/Q) is the primary result.

Each cell in the ground layer (for 10,000 cells arranged in the form of a 2D matrix) is analysed chronologically and statistically independently of all the others.

Results:

- primary results are half-hour X/Q,
- additionally, moving averages for 2, 8, 16, 72 and 624 hours are calculated in each cell of the given area,
- then the 95th percentiles are calculated for each cell of the given area.

In this way a statistical estimate is acquired of how much the dispersive capacities of the atmosphere vary in an individual cell (influence of the weather in connection with the physical properties of the source).

X/Q for an individual cell anywhere in the 200 km x 200 km domain represents a standardised criterion of the portion of dose rate which an inhabitant living in the selected cell would receive when a cloud passes over in the event of an accidental release from NEK.

For a chosen month for the whole 2D area, all values of 95 percentiles in all the cells are determined in rings for selected classes of distance from NEK. One distance class contains all the locations that are a certain distance from NEK, regardless of the direction. Then all 95 percentiles of X/Q are statistically analysed for each separate class of distances. For the further calculation of doses, the spatial 95th percentile value of the temporal 95th percentile in each class of distances are chosen.

The calculations are carried out for X/Q tables for the plant vent, ground and PCFVS releases, and represent input data for calculating doses.

Table 133: Plant vent - spatial 95th percentile of the temporal 95th percentile X/Q [s/m^3] for the selected class of distances and selected temporal moving average (source: /196/)

Razred [km]	polurne vrednosti	2 urno drseče	8 urno drseče	16 urno drseče	72 urno drseče	624 urno drseče
3	4.62E-07	4.15E-07	3.59E-07	3.27E-07	2.58E-07	1.48E-07
10	2.43E-07	2.74E-07	2.28E-07	1.87E-07	1.43E-07	5.22E-08
15	1.34E-07	1.37E-07	1.26E-07	1.03E-07	7.23E-08	2.99E-08
20	7.11E-08	7.12E-08	6.76E-08	6.39E-08	4.89E-08	1.80E-08
25	4.16E-08	4.53E-08	4.56E-08	3.84E-08	2.90E-08	1.12E-08
30	2.65E-08	2.72E-08	2.72E-08	2.51E-08	1.96E-08	6.59E-09
35	1.95E-08	2.08E-08	2.30E-08	2.07E-08	1.41E-08	6.00E-09
40	1.63E-08	1.85E-08	2.09E-08	1.93E-08	1.36E-08	5.04E-09
45	1.21E-08	1.32E-08	1.25E-08	1.10E-08	8.32E-09	3.12E-09
50	1.06E-08	1.18E-08	1.20E-08	1.01E-08	7.34E-09	2.75E-09
55	7.88E-09	8.44E-09	8.25E-09	7.71E-09	5.65E-09	2.03E-09
60	6.73E-09	7.36E-09	8.09E-09	7.61E-09	5.25E-09	1.66E-09
65	5.99E-09	6.64E-09	6.34E-09	6.03E-09	3.95E-09	1.50E-09
70	5.12E-09	5.43E-09	5.37E-09	4.89E-09	3.55E-09	1.23E-09
75	4.52E-09	5.08E-09	4.72E-09	4.11E-09	3.35E-09	1.21E-09
80	4.06E-09	4.18E-09	4.14E-09	3.90E-09	3.08E-09	1.08E-09
85	3.34E-09	3.78E-09	3.38E-09	3.04E-09	2.39E-09	8.66E-10
90	3.15E-09	3.22E-09	3.00E-09	2.58E-09	2.25E-09	7.08E-10
95	2.75E-09	2.80E-09	2.56E-09	2.29E-09	1.83E-09	6.26E-10
100	2.78E-09	2.73E-09	2.39E-09	2.14E-09	1.81E-09	5.65E-10

Datoteka: Plant_vent_95perc_95perc-v5.xlsx

Razred [km]	Class [km]
polurne vrednosti	half-hour value
2 urno drseče	2-hour moving
8 urno drseče	8-hour moving
16 urno drseče	16-hour moving
72 urno drseče	72-hour moving
624 urno drseče	624-hour moving
Datoteka: Plant_vent_95perc_95perc-v5.xlsx	File: Plant_vent_95perc_95perc-v5.xlsx

Table 134: Ground release - spatial 95th percentile of the temporal 95th percentile X/Q [s/m^3] for the selected class of distances and the selected temporal moving average (source: /196/)

Razred [km]	polurne vrednosti	2 urno drseče	8 urno drseče	16 urno drseče	72 urno drseče	624 urno drseče
3	9.18E-06	8.44E-06	6.75E-06	5.23E-06	4.73E-06	2.40E-06
10	6.23E-07	6.84E-07	6.81E-07	6.78E-07	4.07E-07	1.45E-07
15	1.49E-07	1.86E-07	2.12E-07	1.98E-07	1.23E-07	4.28E-08
20	6.75E-08	8.46E-08	9.51E-08	9.28E-08	6.33E-08	2.45E-08
25	4.29E-08	4.87E-08	5.84E-08	5.01E-08	3.89E-08	1.31E-08
30	2.59E-08	2.75E-08	3.28E-08	3.04E-08	2.19E-08	8.37E-09
35	1.85E-08	2.05E-08	2.54E-08	2.29E-08	1.61E-08	7.27E-09
40	1.66E-08	1.87E-08	2.04E-08	1.93E-08	1.51E-08	6.18E-09
45	1.20E-08	1.30E-08	1.37E-08	1.21E-08	8.74E-09	3.43E-09
50	1.03E-08	1.17E-08	1.24E-08	1.10E-08	7.76E-09	3.17E-09
55	7.95E-09	8.62E-09	8.79E-09	7.75E-09	5.79E-09	2.18E-09
60	6.90E-09	7.50E-09	8.22E-09	7.58E-09	5.33E-09	1.82E-09
65	6.27E-09	6.36E-09	6.55E-09	6.09E-09	3.95E-09	1.57E-09
70	4.84E-09	5.29E-09	5.40E-09	4.87E-09	3.56E-09	1.23E-09
75	4.79E-09	5.18E-09	4.74E-09	4.12E-09	3.19E-09	1.19E-09
80	3.85E-09	4.04E-09	4.05E-09	3.59E-09	2.82E-09	1.05E-09
85	3.51E-09	3.81E-09	3.39E-09	2.85E-09	2.34E-09	8.65E-10
90	2.97E-09	3.02E-09	2.78E-09	2.50E-09	2.07E-09	7.23E-10
95	2.78E-09	2.78E-09	2.53E-09	2.24E-09	1.70E-09	6.34E-10
100	2.69E-09	2.65E-09	2.40E-09	2.01E-09	1.70E-09	5.75E-10

Datoteka: Talni izpust_95perc_95perc-v5.xlsx

Razred [km]	Class [km]
polurne vrednosti	half-hour value
2 urno drseče	2-hour moving
8 urno drseče	8-hour moving
16 urno drseče	16-hour moving
72 urno drseče	72-hour moving
624 urno drseče	624-hour moving
Datoteka: Talni izpust_95perc_95perc-v5.xlsx	File: Talni izpust_95perc_95perc-v5.xlsx

Table 135: PCFVS release - spatial 95th percentile of the temporal 95th percentile X/Q [s/m³] for the selected class of distances and the selected temporal moving average (source: /196/)

Razdalja [km]	polurne vrednosti	2 urno drseče	8 urno drseče	16 urno drseče	72 urno drseče	624 urno drseče
3	5.24E-07	4.89E-07	4.21E-07	3.88E-07	3.13E-07	1.81E-07
10	2.93E-07	3.05E-07	2.69E-07	2.18E-07	1.49E-07	5.89E-08
15	1.38E-07	1.45E-07	1.39E-07	1.13E-07	7.35E-08	3.17E-08
20	7.09E-08	7.09E-08	7.39E-08	6.45E-08	4.92E-08	1.88E-08
25	4.39E-08	4.64E-08	4.87E-08	4.02E-08	3.01E-08	1.17E-08
30	2.69E-08	2.79E-08	2.86E-08	2.57E-08	2.01E-08	6.86E-09
35	2.01E-08	2.14E-08	2.42E-08	2.13E-08	1.41E-08	6.23E-09
40	1.70E-08	1.87E-08	2.10E-08	2.00E-08	1.41E-08	5.16E-09
45	1.26E-08	1.32E-08	1.25E-08	1.14E-08	8.37E-09	3.27E-09
50	1.07E-08	1.20E-08	1.21E-08	1.04E-08	7.47E-09	2.75E-09
55	7.82E-09	8.31E-09	8.91E-09	8.20E-09	5.50E-09	2.12E-09
60	6.84E-09	7.83E-09	8.43E-09	7.68E-09	5.55E-09	1.70E-09
65	5.78E-09	6.38E-09	6.63E-09	6.29E-09	4.00E-09	1.52E-09
70	5.23E-09	5.46E-09	5.45E-09	5.12E-09	3.59E-09	1.19E-09
75	4.56E-09	4.93E-09	4.89E-09	4.23E-09	3.35E-09	1.22E-09
80	4.11E-09	4.34E-09	4.26E-09	3.88E-09	3.08E-09	1.09E-09
85	3.51E-09	3.63E-09	3.38E-09	2.93E-09	2.39E-09	8.97E-10
90	3.15E-09	3.21E-09	3.01E-09	2.56E-09	2.16E-09	7.09E-10
95	2.78E-09	2.72E-09	2.56E-09	2.34E-09	1.77E-09	6.37E-10
100	2.78E-09	2.77E-09	2.45E-09	2.14E-09	1.76E-09	5.73E-10

Datoteka: PCFVS_95perc_95perc-v5.xlsx

Razred [km]	Class [km]
polurne vrednosti	half-hour value
2 urno drseče	2-hour moving
8 urno drseče	8-hour moving
16 urno drseče	16-hour moving
72 urno drseče	72-hour moving
624 urno drseče	624-hour moving
Datoteka: PCFVS_95perc_95perc-v5.xlsx	File: PCFVS_95perc_95perc-v5.xlsx

Dispersion model for calculations for distances over 100 km from the site of release

The RODOS model, comprising the DIPCOT and LASAT dispersion models, was used to make further calculations. They were made for distances exceeding 100 km and, for the purpose of comparison with RADTRAD and SPRAY results, for the distance range of 50 to 100 km from the source.

RODOS /214/ makes calculations using 5 nested grids of varied density ranging from 1 km x 1 km at the centre, to 16 km x 16 km at the edge. The total number of cells is 8,056. RODOS uses terrain smoothed to the resolution of 1 km x 1 km. Meteorological input data for RODOS was prepared by the Croatian Meteorological and Hydrological Service for 2016 and 2020. The spatial resolution of the data varies for each year. The 2016 data was prepared for every 12 hours. Each data set includes 55 hourly files (1 hour based on measurements and 54 hours of weather forecast). The entire area covered by the meteorological input data - weather forecast, is a rectangle centred on the NEK site, 36 cells wide in the east - west direction and 26 cells high in the north - south direction (each cell is 8 km x 8 km large, and the area covers 288 km x 208 km). The 2020 data was presented in cell size 4 km x 4 km, with additional 13 vertical levels and covering a larger area (144 cells in the east - west direction and 104 cells in the north - south direction, and the overall area covered is 576 km x 416 km). Computations are available every 6 hours (each consists of 1 hour based on measurements and 54 hours of weather forecast).

Results of dose calculations for the case of design basis loss of coolant accident (LOCA)

Based on the results of the release of radioactive inventory, the results of the meteorological conditions calculations (diffusion factors) and with the help of the RADTRAD program, doses are calculated at certain distances from NEK. Doses are calculated and shown for the ground layer. The following two figures show results for the effective dose (Figure 106) and for the thyroid gland (Figure 107). The table below (Table 136), results are given as the effective 30-day dose (TEDE – Total Effective Dose Equivalent) based on the distance from NEK and the thyroid dose. Deposition was not included in X/Q calculations, so the values in the cloud are maximum values. The dose calculations took into account all types of exposure with the exception of food.

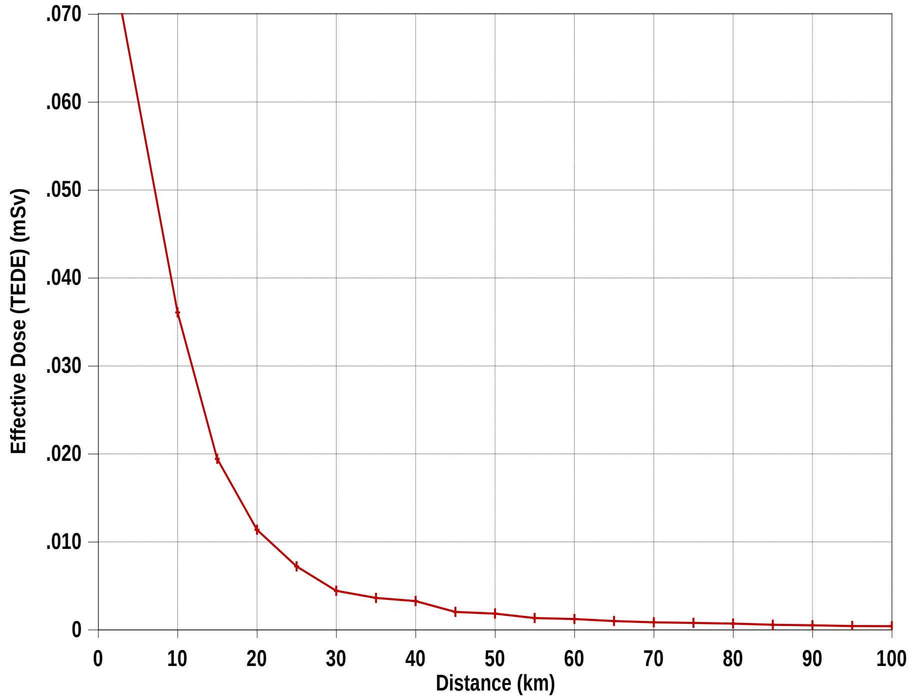

Figure 106: Effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distance from NEK for a design basis accident (source: /196/)

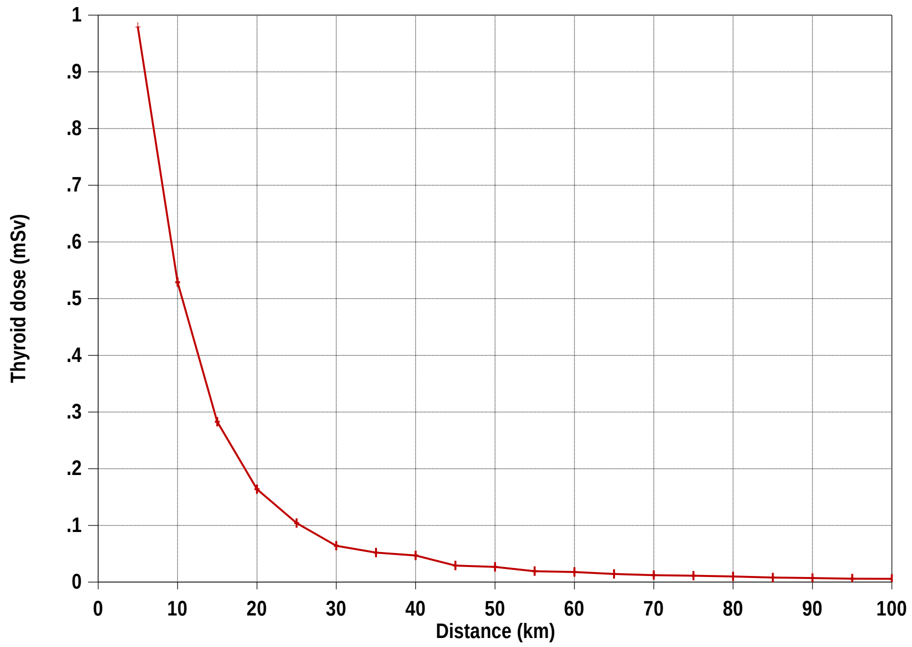

Figure 107: 30-day thyroid dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distance from NEK for the case of a design basis accident (source: /196/)

Table 136: 30-day thyroid dose and effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distance from NEK for a design basis accident (source: /196/)

Distance (km)	Thyroid gland (mSv)	TEDE (mSv)	City
3	9.79E-01	7.01E-02	Krško
10	5.29E-01	3.61E-02	closest border with Croatia
15	2.83E-01	1.94E-02	
20	1.64E-01	1.14E-02	
25	1.04E-01	7.20E-03	
30	6.42E-02	4.43E-03	Novo mesto
35	5.20E-02	3.62E-03	Zagreb (HR)
40	4.71E-02	3.26E-03	Celje
45	2.93E-02	2.02E-03	
50	2.67E-02	1.84E-03	Karlovac (HR)
55	1.93E-02	1.33E-03	
60	1.77E-02	1.22E-03	Kočevje
65	1.44E-02	9.92E-04	
70	1.23E-02	8.43E-04	Maribor
75	1.13E-02	7.84E-04	Varaždin (HR), closest border with Austria
80	1.00E-02	6.95E-04	Ljubljana
85	8.16E-03	5.63E-04	Sisak (HR)
90	7.20E-03	4.95E-04	
95	6.12E-03	4.22E-04	Kranj, Murska Sobota, Lipnica/Leibnitz (A)
100	5.81E-03	3.99E-04	Postojna, closest border with Hungary

Results of calculations for design extension conditions (DEC-B)

The results are shown in the figures below (Figure 108 and Figure 109) and in the table below (Table 137).

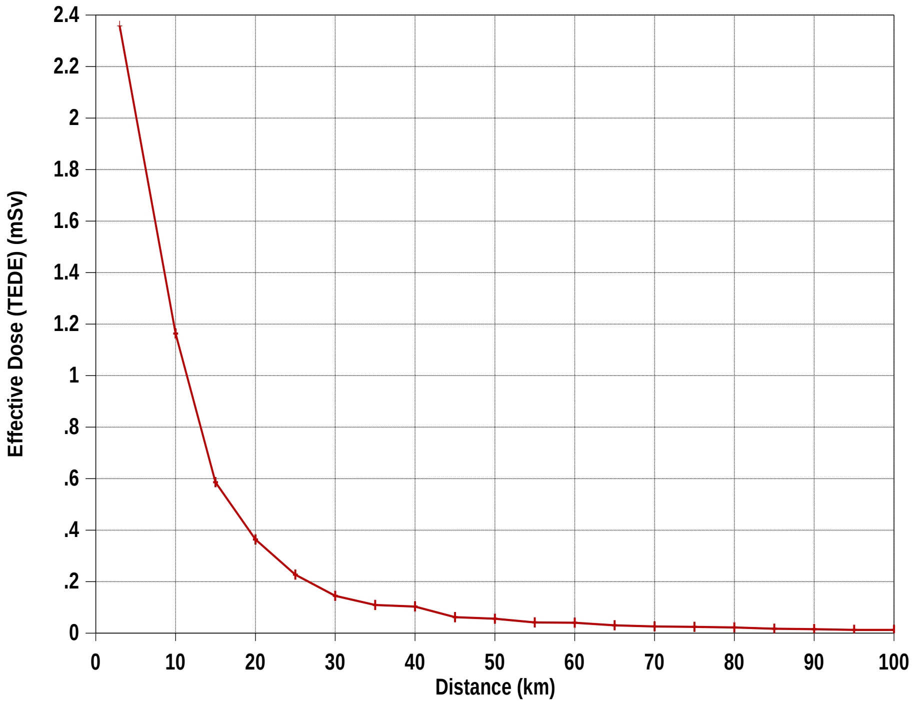

Figure 108: Effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distance from NEK for design extension conditions (source: /196/)

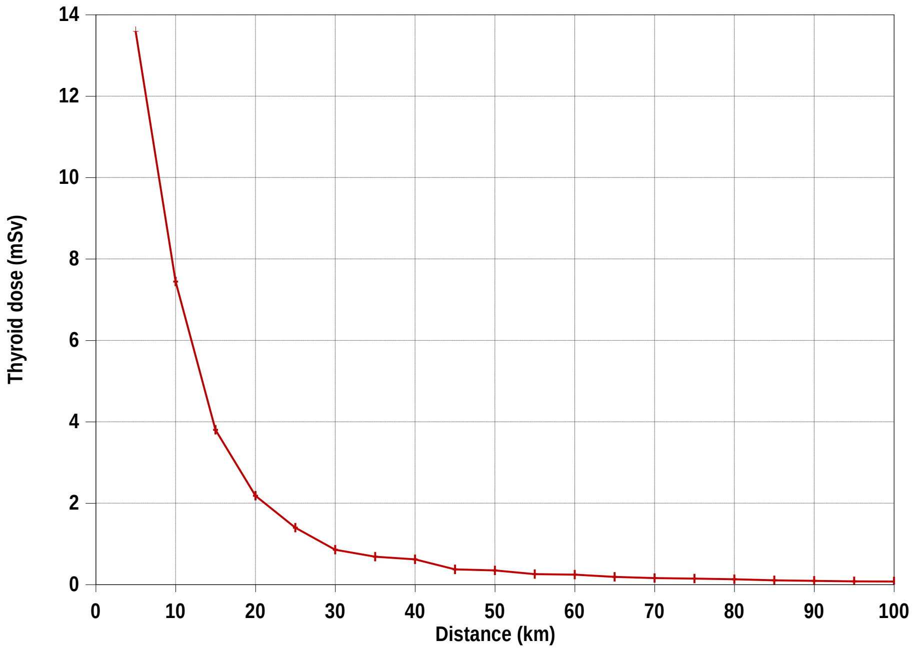

Figure 109: 30-day thyroid dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distance from NEK for design extension conditions (source: /196/)

Table 137: 30-day thyroid dose and effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distance from NEK for design extension conditions (source: /196/)

Distance (km)	Thyroid gland (mSv)	TEDE (mSv)	City
3	1.35E+01	2.36E+00	Krško
10	7.44E+00	1.16E+00	closest border with Croatia
15	3.80E+00	5.86E-01	
20	2.18E+00	3.64E-01	
25	1.40E+00	2.27E-01	
30	8.56E-01	1.45E-01	Novo mesto
35	6.85E-01	1.09E-01	Zagreb (HR)
40	6.19E-01	1.04E-01	Celje
45	3.71E-01	6.19E-02	
50	3.46E-01	5.62E-02	Karlovac (HR)
55	2.55E-01	4.15E-02	
60	2.44E-01	4.04E-02	Kočevje
65	1.88E-01	3.03E-02	
70	1.59E-01	2.63E-02	Maribor
75	1.46E-01	2.45E-02	Varaždin (HR), closest border with Austria
80	1.29E-01	2.22E-02	Ljubljana
85	1.02E-01	1.74E-02	Sisak (HR)
90	9.08E-02	1.55E-02	
95	7.65E-02	1.29E-02	Kranj, Murska Sobota, Lipnica/Leibnitz (A)
100	7.39E-02	1.26E-02	Postojna, closest border with Hungary

Calculations of doses at distances above 100 km from the source included additional calculations using the JRodos programme for a design basis accident (LOCA) and design extension conditions (DEC-B). The calculated doses at 100 km are comparable to the doses calculated with the model used for distances up to 100 km. At distances greater than 100 km, the results showed an expected further decrease of doses with increasing distance from the source.

Calculations for design basis accidents LOCA using JRodos

The same source term was used as described above in the explanation of the design basis accident LOCA. The released activities (in Bq) for important isotopes were assimilated into three intervals (for day 1, from days 1 to 3 and from days 3 to 30) and are presented in the table below (Table 138).

Table 138: Activities of important released isotopes for a design basis LOCA accident (source: /196/)

0.0 – 24.0 h	24.0 – 72.0 h	72.0 – 720 h	Total
Kr-85 1.7749E+13	Kr-85 4.4774E+13	Kr-85 5.2844E+14	Kr-85 5.9096E+14
Kr-85m 7.1662E+13	Kr-85m 5.3687E+12		Kr-85m 7.7031E+13
Kr-87 1.0941E+13			Kr-87 1.0941E+13
Kr-88 8.6110E+13	Kr-88 1.1840E+12		Kr-88 8.7294E+13
I-131 1.4780E+13	I-131 8.9780E+12	I-131 2.6292E+13	I-131 5.0050E+13
I-132 3.5760E+12	I-132 9.6204E+08		I-132 3.5770E+12
I-133 2.2692E+13	I-133 5.1112E+12	I-133 1.1104E+12	I-133 2.8914E+13
I-134 2.3094E+12			I-134 2.3094E+12
I-135 1.1870E+13	I-135 3.6149E+11		I-135 1.2231E+13
Xe-133 3.2447E+15	Xe-133 6.9147E+15	Xe-133 1.9532E+16	Xe-133 2.9691E+16
Xe-135 3.2902E+14	Xe-135 1.1702E+14		Xe-135 4.4604E+14
Cs-134 1.7926E+12	Cs-134 1.1960E+12	Cs-134 7.3445E+12	Cs-134 1.0333E+13

0.0 - 24.0 h	24.0 - 72.0 h	72.0 - 720 h	Total
Cs-136 5.5574E+11	Cs-136 3.4288E+11	Cs-136 1.2735E+12	Cs-136 2.1721E+12
Cs-137 1.1723E+12	Cs-137 7.8310E+11	Cs-137 4.8545E+12	Cs-137 6.8099E+12

The 60 released isotopes for a continuous release in RADTRAD are organised in 8 intervals with a constant release rate. The same quantity of radioactive material was released in the RODOS programme. Standard lengths of intervals were used: from 0 h to 0.5 h, from 0.5 h to 2 h, from 2 h to 4 h, from 4 h to 8 h, from 6 h to 12 h, from 12 h to 24 h, from 24 h to 48 h and from 48 h to 72 h. The first interval is considered as a direct release from the containment at low temperature and at the ground. All the following intervals are considered as plant vent releases, with medium temperature and starting speed.

This scenario was selected in order to emphasize transport over greater distances. The whole calculation in RODOS covers 72 hours of activity. The design basis accident calculation assumes continuous leakage of up to 30 days. To make computing with RODOS manageable, the releases in the last interval (from 48 h to 72 hours) were increased for all activities that would be released until the last, 30th day. In order to examine the consequences of such an assumption, some additional calculations were made (by using the DIPCOT model in RODOS, where the internal computing intervals between individual packages released were additionally increased from 10 to 30 seconds).

Using a 30-day period of overall release tended to slightly decrease doses for near locations and increase doses at more remote locations, in comparison to the use of a release period of merely 3 days. In view of the fact that effective 30-day doses at distances above 100 km are low, this does not pose a problem. Calculations of the effective 30-day dose were made without including protective measures. All mechanisms that cause a dose from radioactivity were taken into account except for nutrition. The starting times of atmospheric releases were selected randomly within every day, one per day, for each day in 2016.

Once the starting times of releases were selected, they were used for all further calculations, and the source term was identical for all starting times for the same type of accident. This allows comparisons between doses from both types of accidents under consideration. Calculations for 2020 were used to determine any distinctive difference between doses due to different weather in the surroundings of NEK in the two years. It was shown that the calculated percentile values (95th percentile values by studied weather scenarios and then 95th percentile values spatially) are similar. The charts for correlation between effective 30-day dose and distance from the source are shown in the figure below (Figure 110). The designation "95%" is used in the figures as an abbreviation for "95th percentile".

For 2016, calculations were first made by using the DIPCOT dispersion model, and then with the (approximately two times slower) LASAT model. This was done to examine the effect of different dispersion models. LASAT predicted lower doses neat the source and higher doses at distances over 100 km from the source. However, the difference is not so significant because both models predicted low 95th percentile values. LASAT was not used in calculations for 2020 (with a larger amount of weather data for a greater area) because of its slowness and because it generally predicted low effective 30-day doses for greater distances.
The effect of different meteorological data in 2016 and 2020 on the calculation of doses from a design basis accident was thus only tested using the DIPCOT model. As shown, the doses are similar, and the difference between the years is smaller than the differences between results of different dispersion models for the same year. For design extension conditions, the LASAT dispersion model was used for both years. In this case, the difference in doses between the years is even smaller than in the comparison using the DIPCOT dispersion model.

The effective 30-day doses calculated with RODOS are higher than those calculated with RADTRAD and SPRAY X/Q values. This difference was expected, since the models used different spatial resolutions for depicting both the terrain and the meteorological data. Furthermore, the approach to dose calculation is different; RODOS has intervals with an average release and temporally correlated dispersion, whereas RADTRAD has a temporally correlated release and moving temporal averages. Since the spatial area covered by the meteorological data for 2016 in RODOS is smaller, the results for 2016 for RODOS are only given for distances up to 100 km. For 2020, the meteorological data used in RODOS was for distances up to 200 km from the source.

The 95th percentile values for the effective 30-day dose for distances from 60 to 200 km from the source calculated by using the DIPCOT dispersion model for 2020 are given in the table below (Table 139). All the calculated values under 0.1 mSv are within regulatory limits for 30-day exposure (limits for the general population were applied). The associated 30-day thyroid doses are given in the figure below (Figure 111). In this case, RADTRAD doses are somewhat higher due to the different rate of breathing in comparison to RODOS (RODOS uses a normal breathing rate, whereas RADTRAD uses the values given in USAR, Chapter 15).

Table 139: Percentile values (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distances from NEK for the effective 30-day dose and the 30-day thyroid dose, for a design basis accident for 2020, calculated using the DIPCOT dispersion model (source: /196/)

Distance (in km)	Effective 30-day dose (mSv)	Distance (in km)	30-day thyroid dose (mSv)
60	0.23565E-02	60	0.20746E-01
70	0.16788E-02	70	0.10919E-01
80	0.10622E-02	80	0.78567E-02
90	0.79108E-03	90	0.60579E-02
100	0.50768E-03	100	0.48695E-02
110	0.42034E-03	110	0.43225E-02
120	0.34378E-03	120	0.32201E-02
130	0.29657E-03	130	0.24816E-02
140	0.25708E-03	140	0.22004E-02
150	0.22758E-03	150	0.19823E-02
160	0.19650E-03	160	0.18572E-02
170	0.16058E-03	170	0.16895E-02
180	0.14483E-03	180	0.16557E-02
190	0.13271E-03	190	0.14988E-02
200	0.11365E-03	200	0.13520E-02

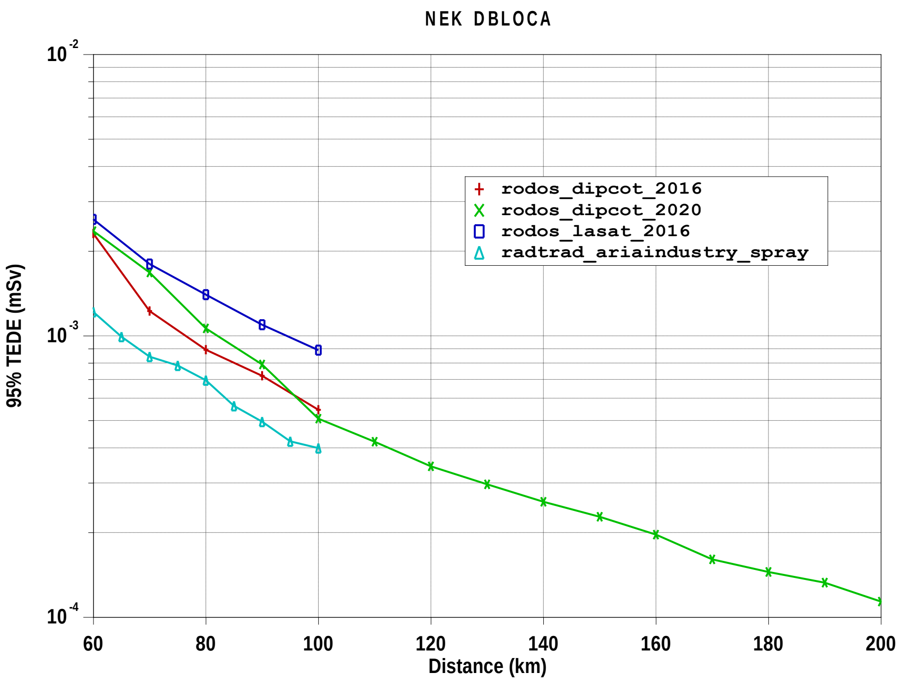

Figure 110: Effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) in relation to distance from NEK for a design basis accident (source: /196/)

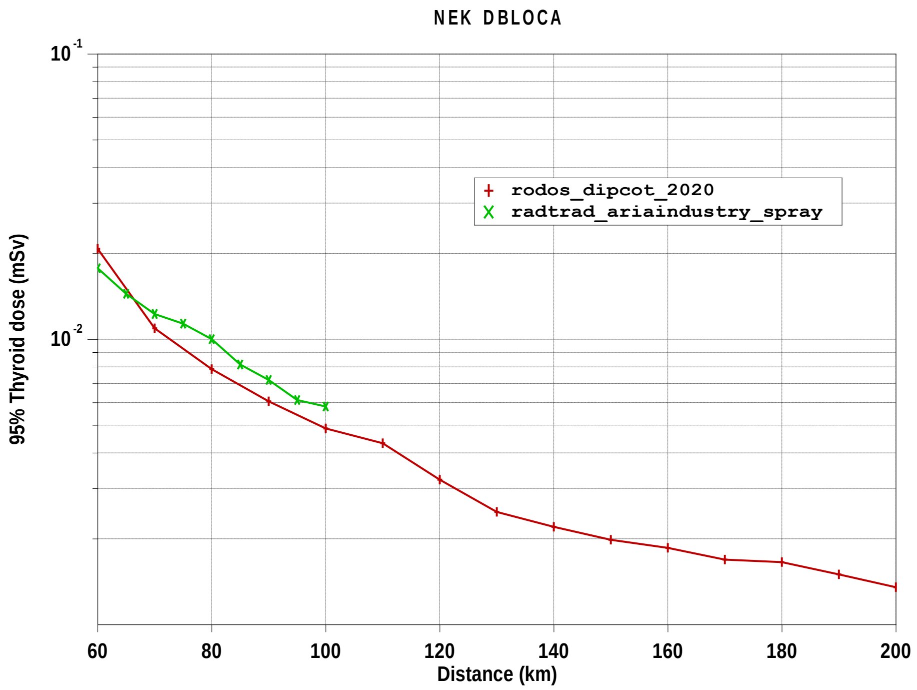

Figure 111: 30-day thyroid dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) in relation to distance from NEK for a design basis accident (source: /196/)

In the case of using RODOS, the correlation of the effective 30-day dose and thyroid dose (in both cases 95th percentile values by studied weather scenarios and then 95th percentile values spatially) in relation to distance from NEK is calculated from a set of 2D cases of individual doses (Figure 112 and Figure 114). Each individual case is assigned to a randomly selected release start, where one release was selected for each day at random times of the day. This was done to encompass the different weather situations that dispersion is conditioned by. First, the 95th percentile was calculated at each point from the set of all the scenarios studied (this could be called the percentile of captured weather situations). Next, the 95th percentile was also calculated by distances from the source.

The results shown are from calculations using the DIPCOT dispersion model in RODOS. The set of results for statistical processing contained a single weather situation for each day for 311 days in the year 2020. The same course of release starts at different times in the associated weather conditions, which determine dispersion.

The 95th percentile value on 2D distribution is determined for the chosen cell in a way whereby the value in the cell can only exceed it in 5% of all the weather scenarios studied. The circles in the figures are mapped at 100 km and 200 km from NEK. To illustrate the difference between a statistically processed 2D result (95th percentile value) and dose distribution for one release, we also present 2D distribution for the effective 30-day dose for a release starting on 19 Dec 2020 at 08:00 and 2D distribution for the thyroid dose for a release starting on 25 August 2020 at 18:00 in the figures below (Figure 113 and Figure 115).

To calculate the correlation of dose with distance for distances between 10 km and 200 km from NEK, the (spatial) 95th percentile value is calculated from all doses in cells on 2D distribution for the selected ring for a particular distance from the source. Again, the 95th percentile means that only 5% of all the cells have higher values than the latter.
Additional understanding of the environmental effects of releases is achieved by calculating integrated concentrations of isotope activity (Bq*s/m^3) for selected isotopes (Cs-134, I-131, Xe-133), shown in the figures below (Figure 116, Figure 117, Figure 118). The results of calculations with RADTRAD and SPRAY, and with RODOS (for 2016 and 2020) are presented together. They are statistically processed

in the same way as doses. Integral concentrations are temporally integrated values which appear in the selected location without taking into account radioactive decay.
An inhabitant that is outdoors at the selected location for the entire duration of the cloud passing through, would be exposed to such concentrations in temporal succession for each computing interval. However, these are not concentrations in the environment for the selected time. In the case of RADTRAD and SPRAY calculations, they are products of release speed and X/Q value with no delay due to transport. Considering the different methodologies, the differences shown in the chart are expected. As also expected, the differences between the years are small.

The values in the charts for correlation of integrated concentrations of isotope activities in the air with distance from the source were calculated following the same statistical method as described for doses. 2D distributions of 95th percentile values for integrated concentrations of isotope activities calculated with the DIPCOT dispersion model in RODOS for 2020 for isotopes Cs-134, I-131 and Xe-133 are shown in the figures below (Figure 119, Figure 121, Figure 123). For illustration, 2D distributions for randomly selected weather scenarios were also added. These are shown in the figures below (Figure 120, Figure 122, Figure 124).

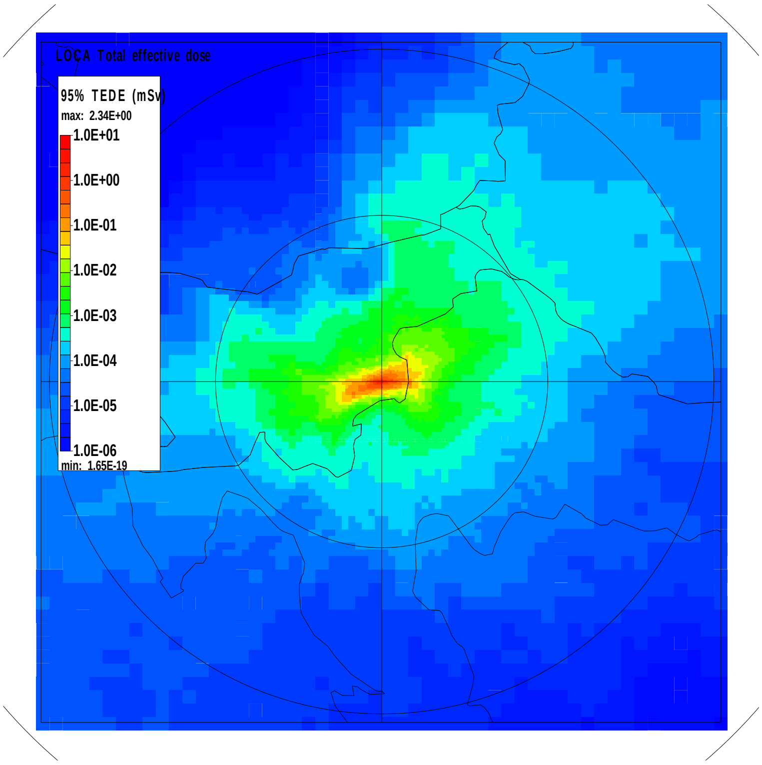

Figure 112: 95th percentile values of the effective 30-day dose for a design basis accident for distances up to 200 km, DIPCOT for the year 2020 (source: /196/)

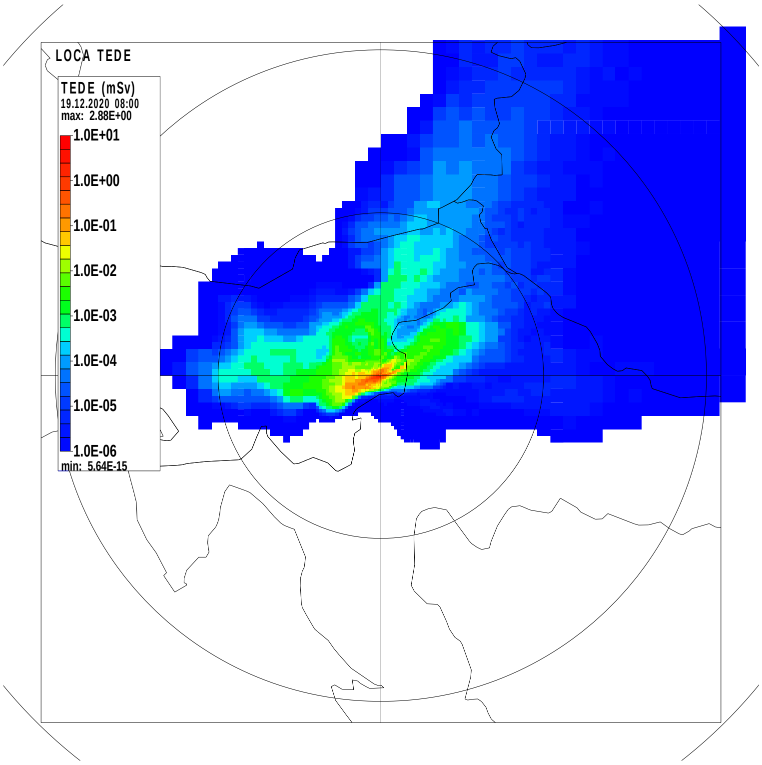

Figure 113: Effective 30-day doses for distances up to 200 km, release started on 19 Dec 2020 at 08:00 (source: /196/)

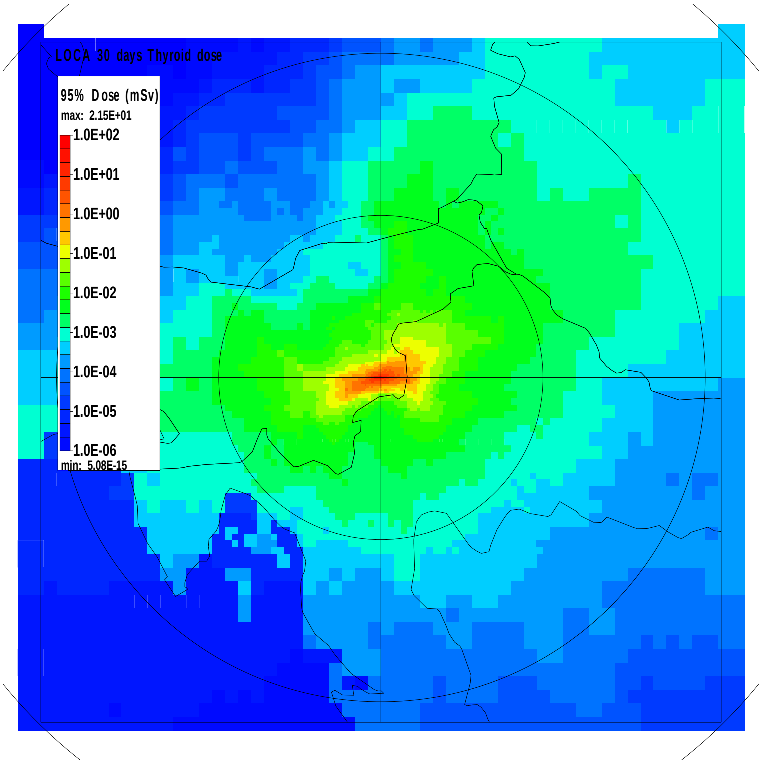

Figure 114: 95th percentile values of the 30-day thyroid dose for a design basis accident for distances up to 200 km, DIPCOT for the year 2020 (source: /196/)

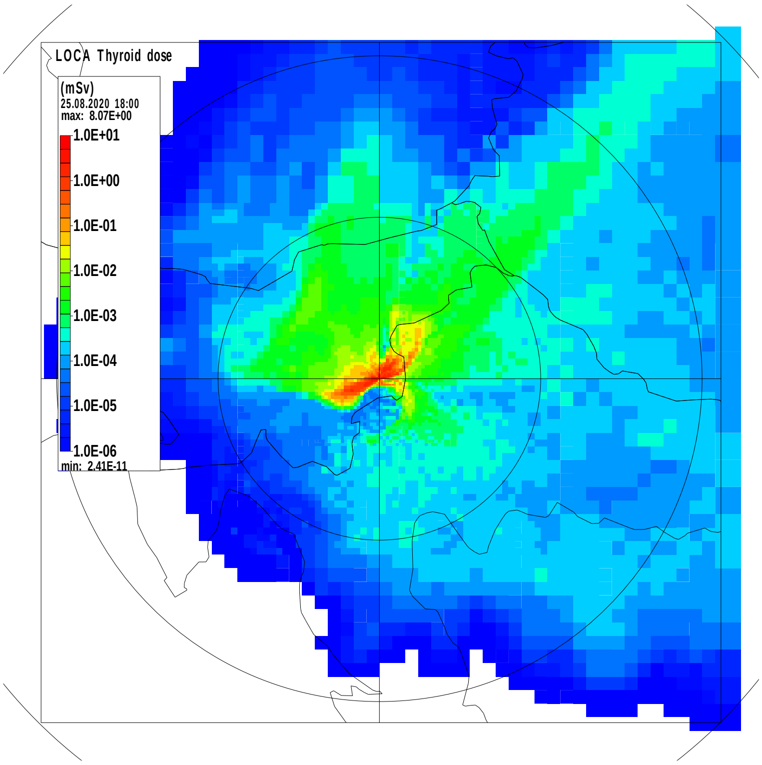

Figure 115: Values for the 30-day thyroid dose for a design basis accident for distances up to 200 km, release started on 25 Aug 2020 at 18:00 (source: /196/)

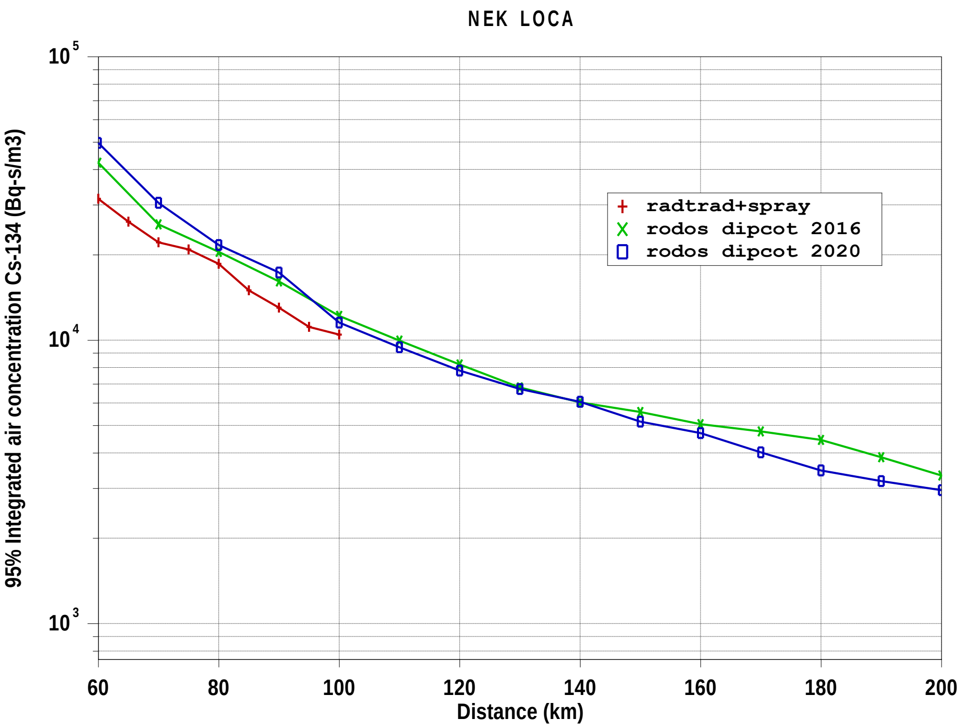

Figure 116: Integrated concentrations of isotope activity (95th percentile values by studied weather scenarios and then 95th percentile values spatially) for Cs-134 (Bq-s/m^3) for a design basis accident (source: /196/)

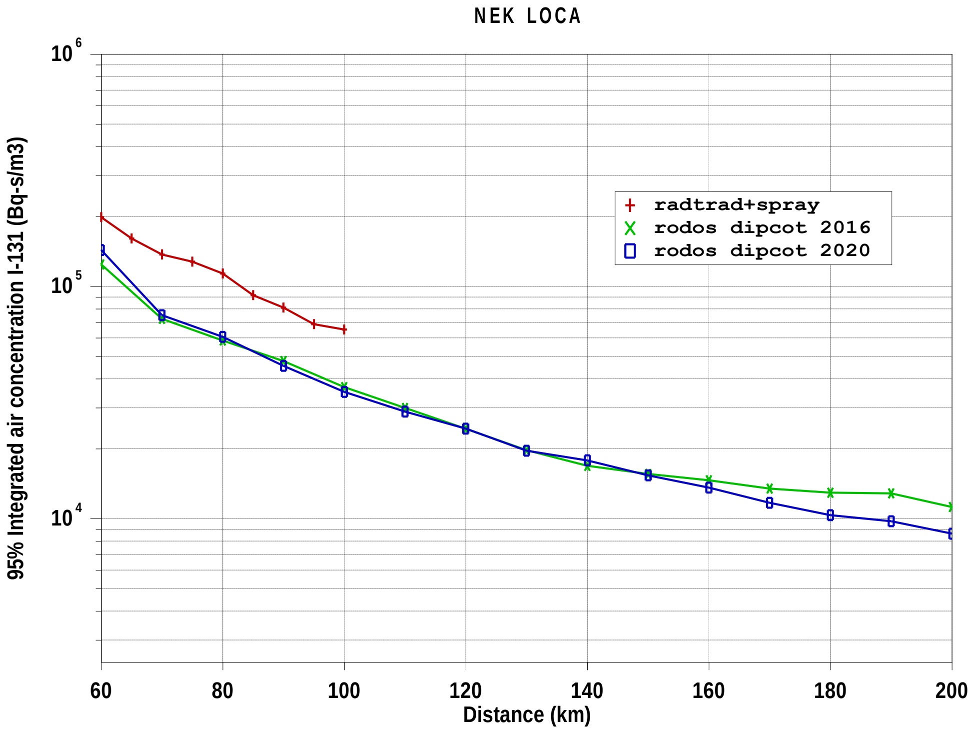

Figure 117: Integrated concentrations of isotope activity (95th percentile values by studied weather scenarios and then 95th percentile values spatially) for I-131 (Bq-s/m^3) for a design basis accident (source: /196/)

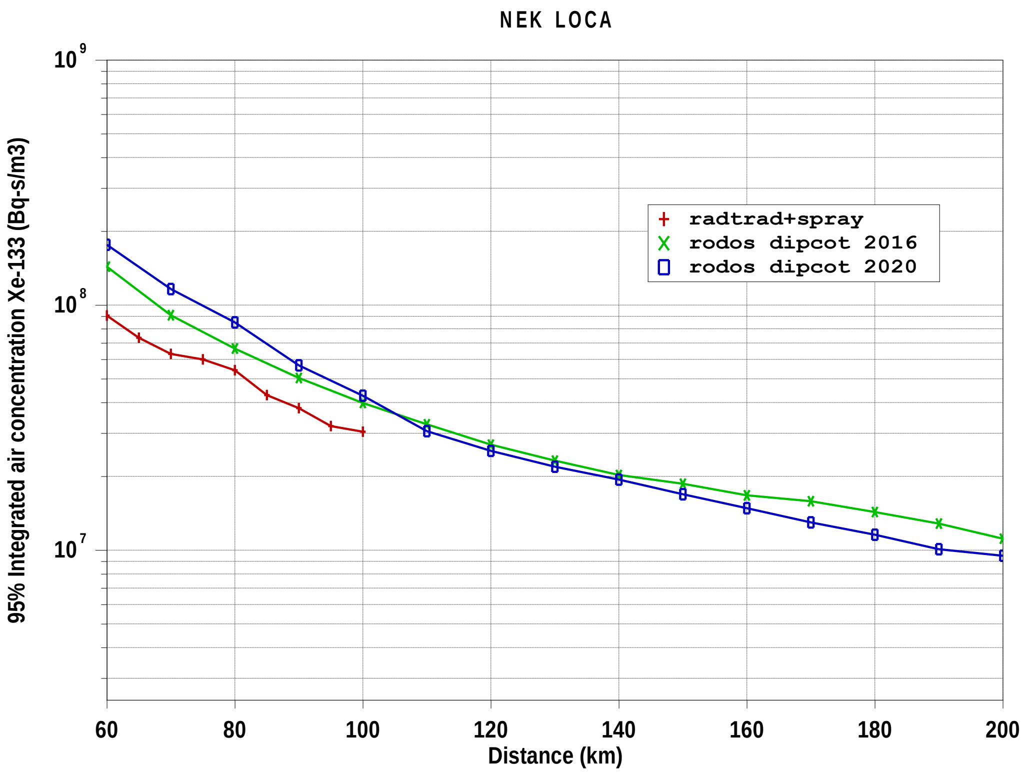

Figure 118: Integrated concentrations of isotope activity (95th percentile values by studied weather scenarios and then 95th percentile values spatially) for Xe-133 (Bq-s/m^3) for a design basis accident (source: /196/)

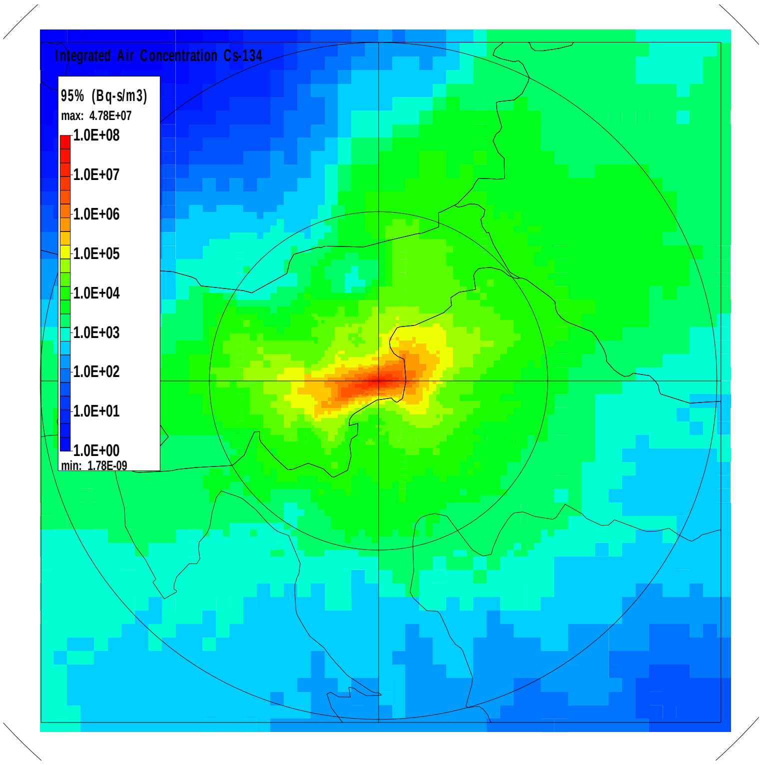

Figure 119: 95th percentile values for integrated concentrations of isotope activity for Cs-134 (Bq-s/m^3) for a design basis accident, DIPCOT for the year 2020 (source: /196/)

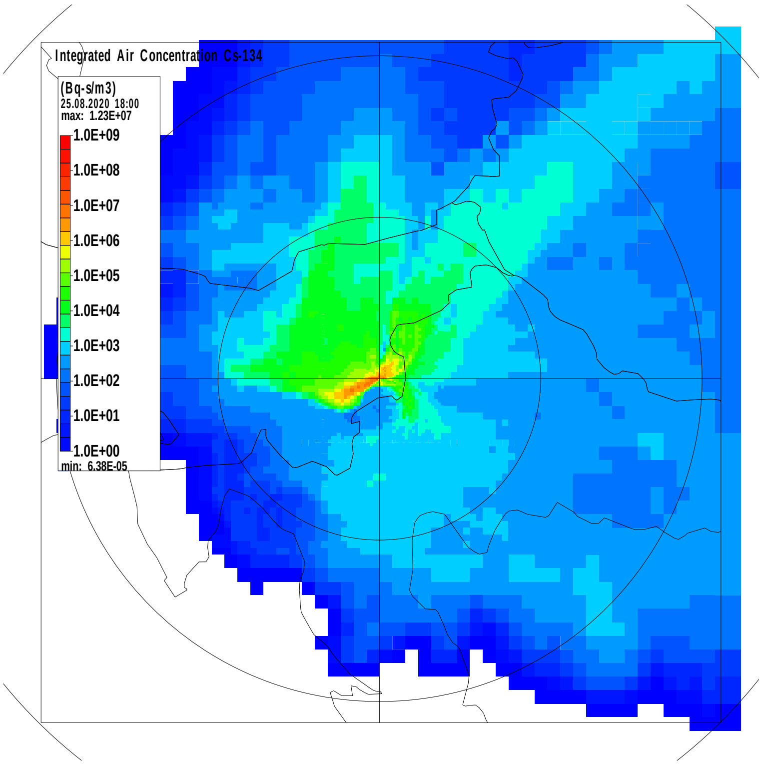

Figure 120: Integrated concentrations of isotope activity for Cs-134 for distances up to 200 km, release started on 25 Aug 2020 at 18:00 (source: /196/)

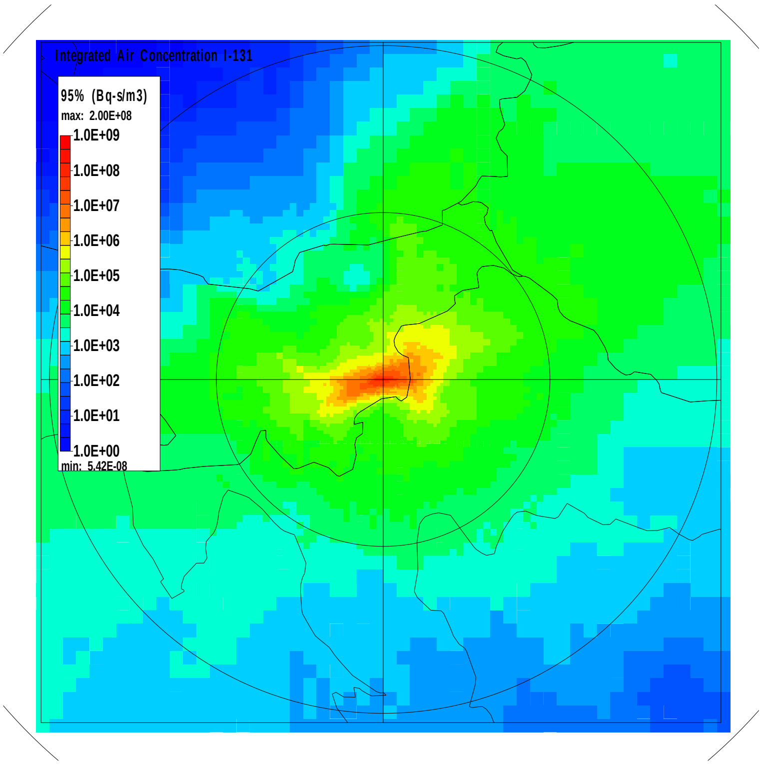

Figure 121: 95th percentile values for integrated concentrations of isotope activity for I-131 (Bq-s/m³) for a design basis accident, DIPCOT for the year 2020 (source: /196/)

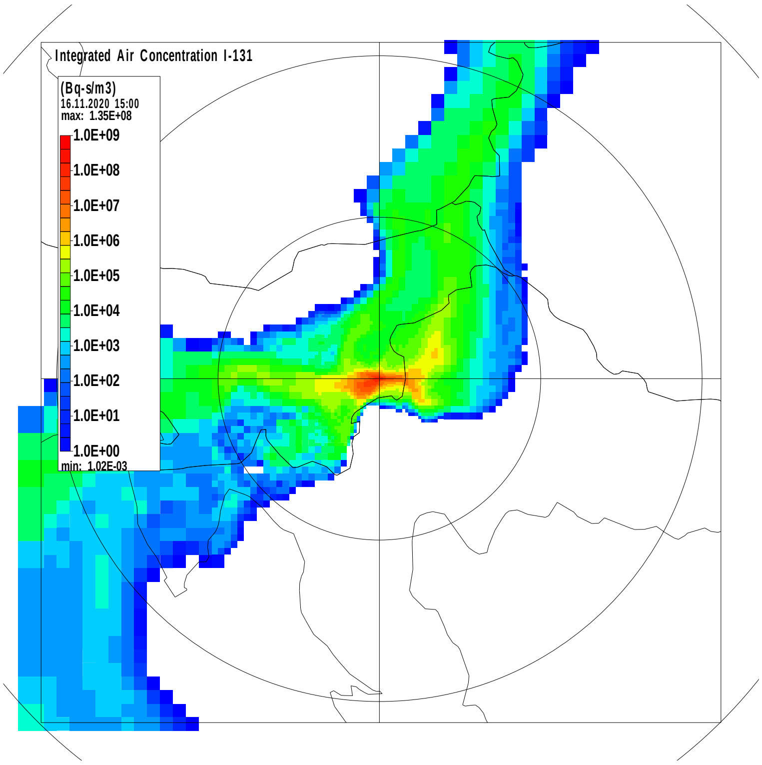

Figure 122: Integrated concentrations of isotope activity for I-131 for distances up to 200 km, release started on 16 Nov 2020 at 18:00 (source: /196/)

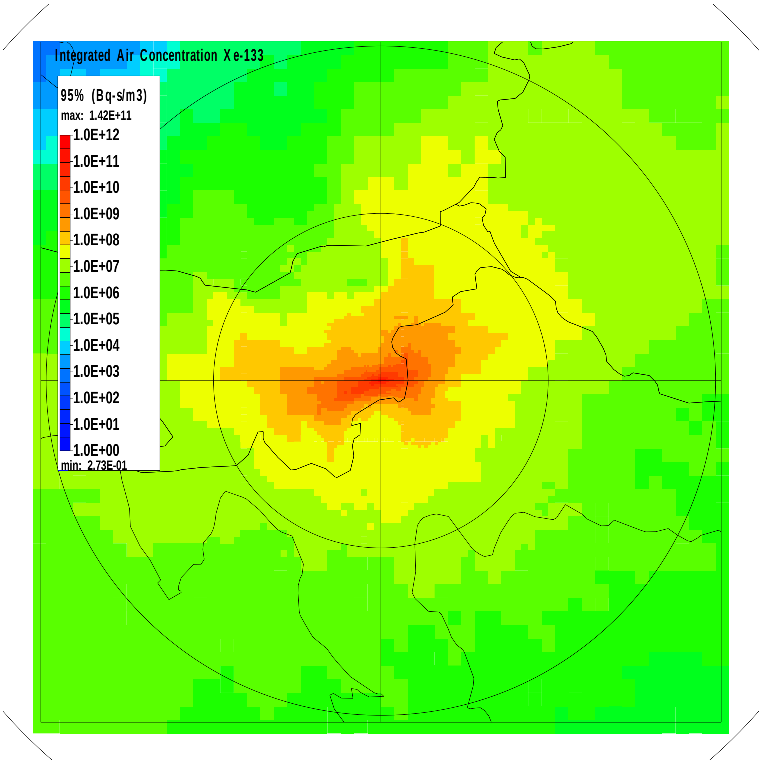

Figure 123: 95th percentile values for integrated concentrations of isotope activity for Xe-133 (Bq-s/m^3) for a design basis accident, DIPCOT for the year 2020 (source: /196/)

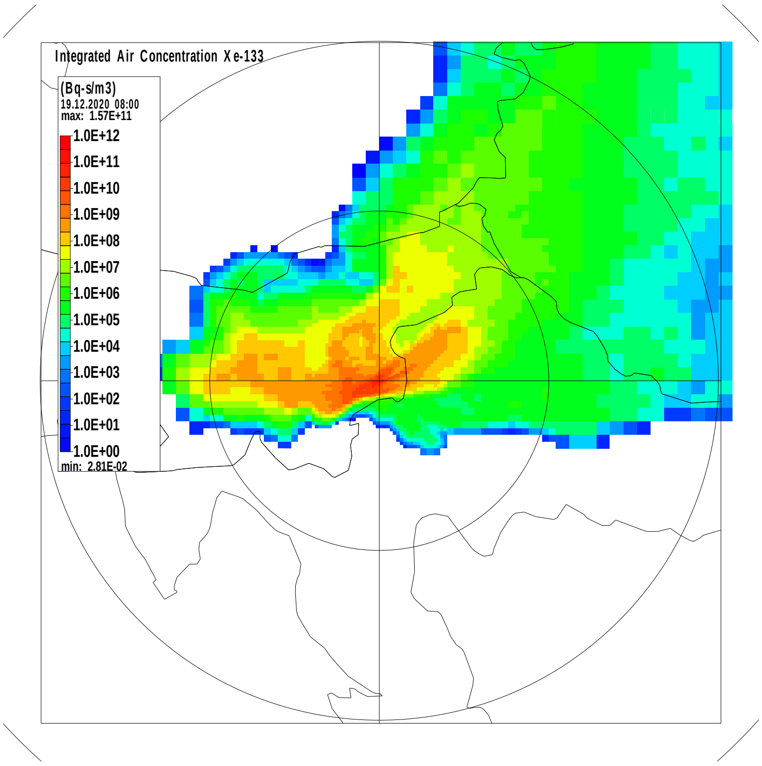

Figure 124: Integrated concentrations of isotope activity for Xe-133 for distances up to 200 km, release started on 19 Dec 2020 at 08:00 (source: /196/)

Calculations for SBO design extension conditions using JRodos

This section evaluates the radiological impacts of a very unlikely severe accident at NEK on the environment. The calculations will be shown for distances over 100 km from the NEK site. The selected accident type is SBO design extension conditions with no action taken in the first 24 hours (the core is damaged and leaking into the containment sump), followed by measures involving the use of alternative safety systems. The same source term was used for calculations with JRodos as described above for RADTRAD SBO calculation. The released activities (in Bq) for important isotopes were assimilated into three intervals (for day 1, from day 1 to day 3 and from day 3 to day 30) and are presented in the table below (Table 140).

Table 140: Activities of important released isotopes for SBO design extension conditions, PCFV release (source: /196/)

0.0 - 24.0 h	24.0 - 72.0 h	72.0 - 720 h	Total
Kr-85 8.2517E+15	Kr-85 5.9200E+12	Kr-85 9.5090E+13	Kr-85 8.3527E+15
Kr-85m 1.0247E+16	Kr-85m 7.4000E+11		Kr-85m 1.0248E+16
Kr-87 1.2790E+13			Kr-87 1.2790E+13
Kr-88 4.5806E+15			Kr-88 4.5806E+15
I-131 3.1798E+14	I-131 6.2008E+13	I-131 1.2321E+14	I-131 5.0320E+14
I-132 2.2709E+13	I-132 8.8796E+09		I-132 2.2718E+13
I-133 4.1803E+14	I-133 4.4918E+13	I-133 8.8800E+11	I-133 4.6384E+14
I-134 4.3778E+12			I-134 4.3778E+12
I-135 1.5476E+14	I-135 3.9368E+12		I-135 1.5870E+14
Xe-133 1.4637E+18	Xe-133 8.8800E+14	Xe-133 2.8490E+15	Xe-133 1.4674E+18
Xe-135 9.3407E+16	Xe-135 1.4800E+13		Xe-135 9.3422E+16
Cs-134 4.0356E+13	Cs-134 1.0578E+13	Cs-134 6.6593E+13	Cs-134 1.1753E+14
Cs-136 1.2399E+13	Cs-136 3.1002E+12	Cs-136 9.1986E+12	Cs-136 2.4698E+13
Cs-137 2.6396E+13	Cs-137 6.9223E+12	Cs-137 4.4182E+13	Cs-137 7.7500E+13

The released radioactive inventory was drawn up in RODOS with ten intervals. We used 60 isotopes which are available in RADTRAD. The full length of a release interval is 72 hours. In this time, approximately 99% of the total activity in the first 30 days this type of accident is released. In the first interval between 0 h and 0.5 h, containment leakage is studied. The release takes the form of a ground release at 10 m, with low buoyancy due to temperature and with low mass flow. The isotopic composition corresponds to the containment composition at this stage.

The next five intervals, between 0.5 h and 2 h, between 2 h and 4 h, between 4 h and 8 h, between 8 h and 12 h and between 12 h and 19.3 h, have similar release characteristics (design basis containment leakage). Pressure changes in the containment and changes of the isotopic composition of the containment atmosphere are taken into account. The seventh release interval describes the use of the PCFV system. It lasts from 19.3 h to 22.3 hours and most of the radioactive material is released into the environment during this time interval.

In view of the high-capacity aerosol filters and iodine filters, only noble gases are mostly released, but there are also some other volatile products. The height of release is the top of the PCFV flue, and the release temperature and release speed of flue gases were taken into account. The remaining three intervals for releases, between 22.3 h and 24 h, between 24 h and 48 h and between 48 h and 72 hours, are again intervals with nothing but containment leakage, which is considered as a ground release with low buoyancy due to temperature. The effective 30-day dose was calculated without using any protective measures.

All mechanisms that cause a dose from radioactivity were taken into account except for nutrition.

The starting times of weather scenarios are the same as used for scenarios in a design basis accident. This allows comparisons between doses from both types of accidents under consideration. Reference calculation was carried out using meteorological data from 2016, because the data from this year is the most comprehensive of the data available. The starting times of atmospheric releases were selected randomly within every day, one per day, for each day in 2016.

Calculations for 2020 were used to determine any distinctive difference between doses due to different weather in the surroundings of NEK in the two years. For both years, calculations were first made by using the DIPCOT dispersion model, and then with the (approximately two times slower) LASAT model. This was done to examine the effect of different dispersion models on doses at distances over 100 km.

The calculated percentile values for the effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) are shown in the figure below (Figure 125). The doses for the two different years are very similar. The doses calculated with the LASAT dispersion model are greater than those calculated with DIPCOT, and both calculations give low values for the effective 30-day dose. The doses calculated with RADTRAD and SPRAY X/Q, and the doses calculated with DIPCOT are similar. Since the spatial area covered by the meteorological data for 2016 in RODOS is smaller, the results for 2016 for RODOS are only given for distances up to 100 km, just like in the case of a design basis accident.

Doses in design extension conditions are more than an order of magnitude greater than in a design basis accident. However, they are still lower than the doses an inhabitant is allowed to receive in the same interval, calculated in view of the annual limit for the general population. The 30-day effective thyroid dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) calculated with the DIPCOT dispersion model in RODOS for cases of weather situations in 2020 are shown in the figure below (Figure 126). The thyroid doses calculated for distances up to 100 km with RADTRAD and SPRAY X/Q, and the doses calculated with DIPCOT for such distances and greater distances are very similar. In this case, RADTRAD doses are also somewhat higher due to the different rate of breathing in comparison to RODOS (RODOS uses a normal breathing rate, whereas RADTRAD uses the values given in USAR, /3/ in Chapter 15).

Percentile values (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distances from NEK for the effective 30-day dose and thyroid dose for 2020 in the case of design extension conditions are given in the table below (Table 141)

The use of two approaches to calculating doses, and the use of three different dispersion models and meteorological data for two different years helped us to show that all calculations, despite the expected differences, yield acceptably low doses for the distances shown.

Table 141: Percentile values (95th percentile values by studied weather scenarios and then 95th percentile values spatially) based on distances from NEK for the effective 30-day dose and the 30-day thyroid dose, for design extension conditions for 2020, calculated using the DIPCOT dispersion model (source: /196/)

Distance (in km)	Effective 30-day dose (mSv)	Distance (in km)	30-day thyroid dose (mSv)
60	0.45409E-01	60	0.20873
70	0.36120E-01	70	0.13382
80	0.24227E-01	80	0.10587
90	0.20095E-01	90	0.82083E-01
100	0.13355E-01	100	0.63963E-01
110	0.96018E-02	110	0.54931E-01
120	0.78952E-02	120	0.45049E-01
130	0.67965E-02	130	0.34239E-01
140	0.60897E-02	140	0.29741E-01
150	0.52293E-02	150	0.28601E-01
160	0.42910E-02	160	0.26377E-01
170	0.36935E-02	170	0.23328E-01
180	0.32673E-02	180	0.21455E-01
190	0.28944E-02	190	0.20482E-01
200	0.26690E-02	200	0.18132E-01

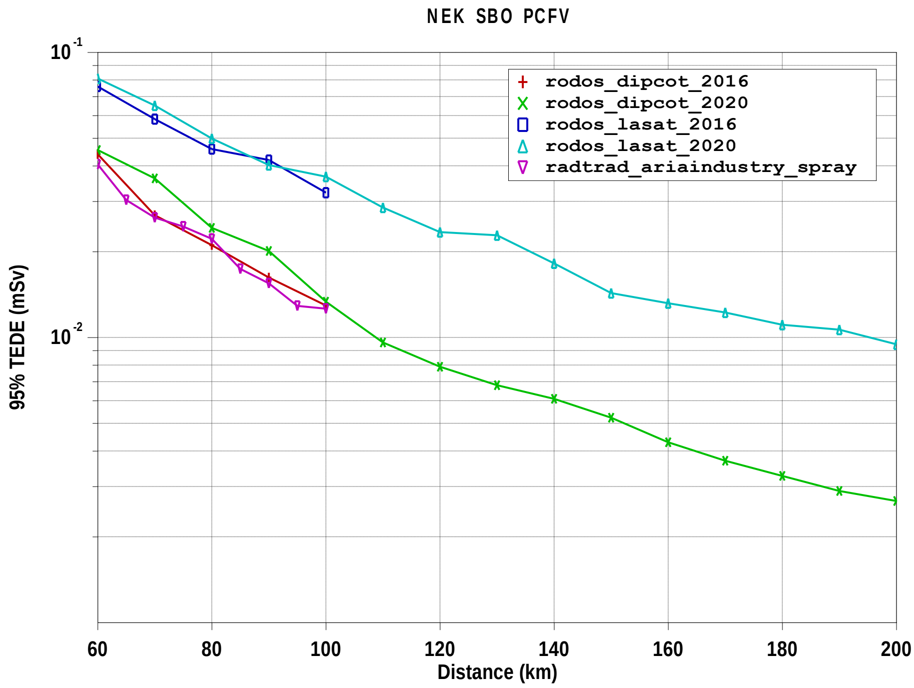

Figure 125: Effective 30-day dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) in relation to distance from NEK for design extension conditions (source: /196/)

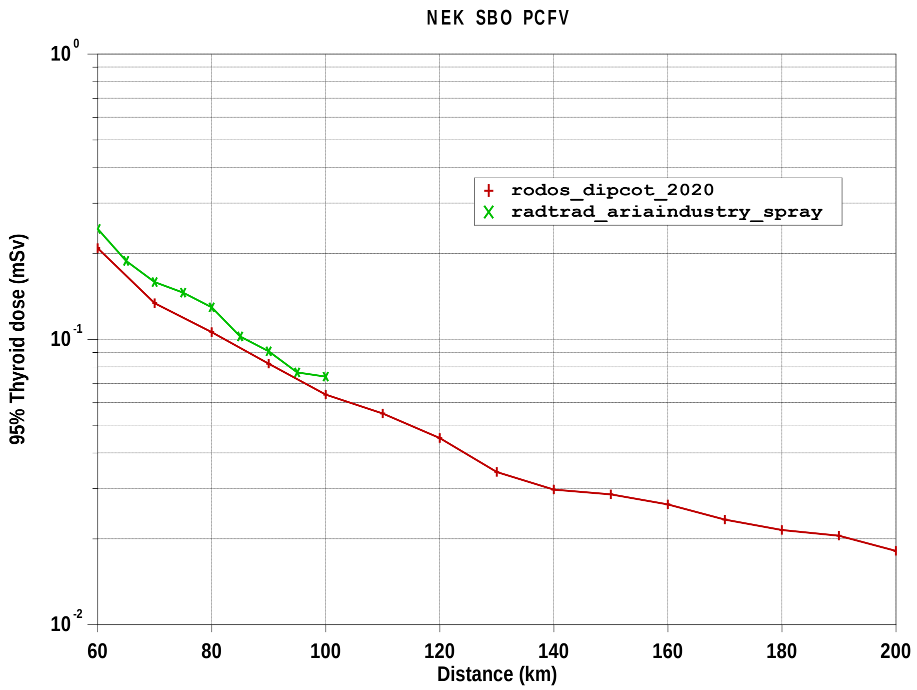

Figure 126: 30-day thyroid dose (95th percentile values by studied weather scenarios and then 95th percentile values spatially) in relation to distance from NEK for design extension conditions (source: /196/)

Like in the case of a design basis accident, the correlation between distance and the effective 30-day dose and thyroid dose for design extension conditions shown in the figures below (Figure 127, Figure 129) are calculated from 2D distribution of associated doses. 2D distribution is calculated for each cell as the 95th percentile of all the weather situations studied (364 situations for 2016 and 311 situations for 2020). The 2D distributions shown are calculated by using the RODOS DIPCOT dispersion model and by using data for the 311 starting times selected and the associated weather situations in 2020.

The 95th percentile value on 2D distribution is determined for the chosen cell in a way whereby the value in the cell can only exceed it in 5% of all the weather scenarios studied. The circles in the figures are mapped at 100 km and 200 km from NEK. To further illustrate the difference between a statistically processed 2D result (95th percentile value) and a 2D dose for a single release, the 2D distribution for the effective 30-day dose for a release starting on 12 Jan 2020 at 23:00 and the 2D distribution for the thyroid dose for a release starting on 30 May 2020 at 09:00 is shown in the figures below (Figure 128, Figure 130).

To calculate the correlation of dose with distance for distances between 10 km and 200 km from NEK, the (spatial) 95th percentile value is calculated from all doses in cells on 2D distribution for the selected ring for a particular distance from the source. Again, the 95th percentile means that only 5% of all the cells have higher values than the latter. The calculation is performed in the same way as above for a design basis accident.

An additional insight into the environmental consequences of effluent from design extension conditions is provided by calculating the integrated concentrations of isotope activity (Bq*s/m^3) for selected isotopes (Cs-134, I-131, Xe-133). They are shown in the figures below (Figure 131, Figure 132, Figure 133). The results calculated in RADTRAD and SPRAY, and in RODOS (for 2016 and 2020) are again displayed together. They are statistically processed in the same way as doses. Integral concentrations are temporally integrated values which appear in the selected location without taking into account radioactive decay.

An inhabitant that is outdoors at the selected location for the entire duration of the cloud passing through, would be exposed to such concentrations in temporal succession for each computing interval. However, these are not concentrations in the environment for the selected time. In the case of RADTRAD and SPRAY calculations, they are products of release speed and X/Q value with no delay due to transport. Considering the different methodologies, the differences shown in the chart are expected. As also expected, the differences between the years are small. The differences are similar to the difference in calculations for a design basis accident.

The values in the charts for correlation of integrated concentrations of isotope activities in the air with distance from the source were calculated following the same statistical method as described for doses (95th percentile values by the studied weather scenarios and then 95th percentile values spatially). 2D distributions of 95th percentile values for integrated concentrations of isotope activities calculated with the DIPCOT dispersion model in RODOS for 2020 for isotopes Cs-134, I-131 and Xe-133 are shown in the figures below (Figure 134, Figure 136, Figure 138). For illustration, 2D distributions for randomly selected weather scenarios were also added. These are shown in the figures below (Figure 135, Figure 137, Figure 139).

The time intervals chosen for illustration are selected randomly with no particular significance. The point of illustrating the difference between 2D distribution of 95th percentile results for doses or the integrated concentration of isotopic activity in all studied weather scenarios, and 2D distribution of results for each individual situation was to show the practical benefit of such statistical processing for the set of weather scenarios studied and the associated dispersions of radioactive material and radiological consequences.

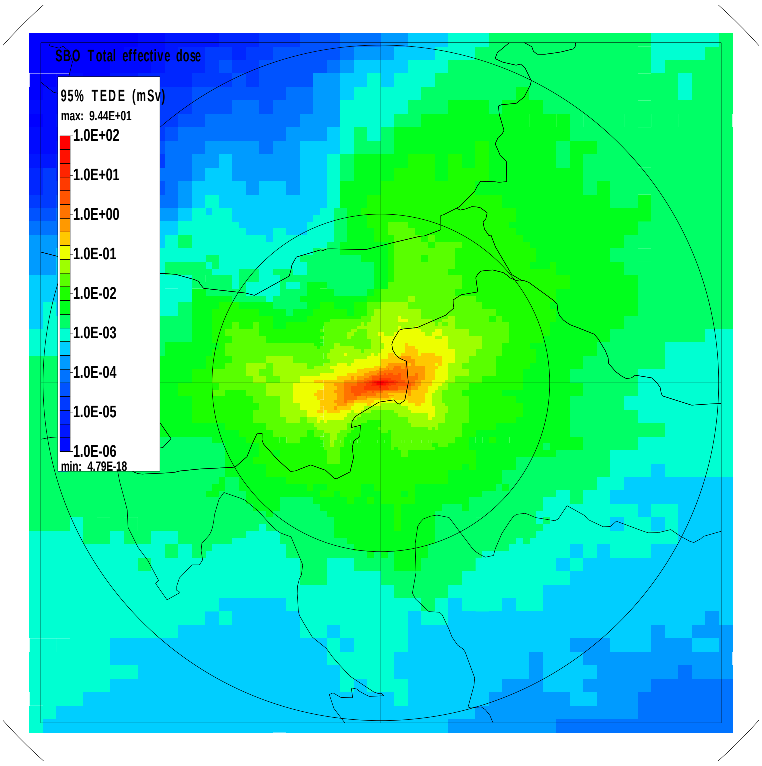

Figure 127: 95th percentile values of the effective 30-day dose for design extension conditions for distances up to 200 km, DIPCOT for the year 2020 (source: /196/)

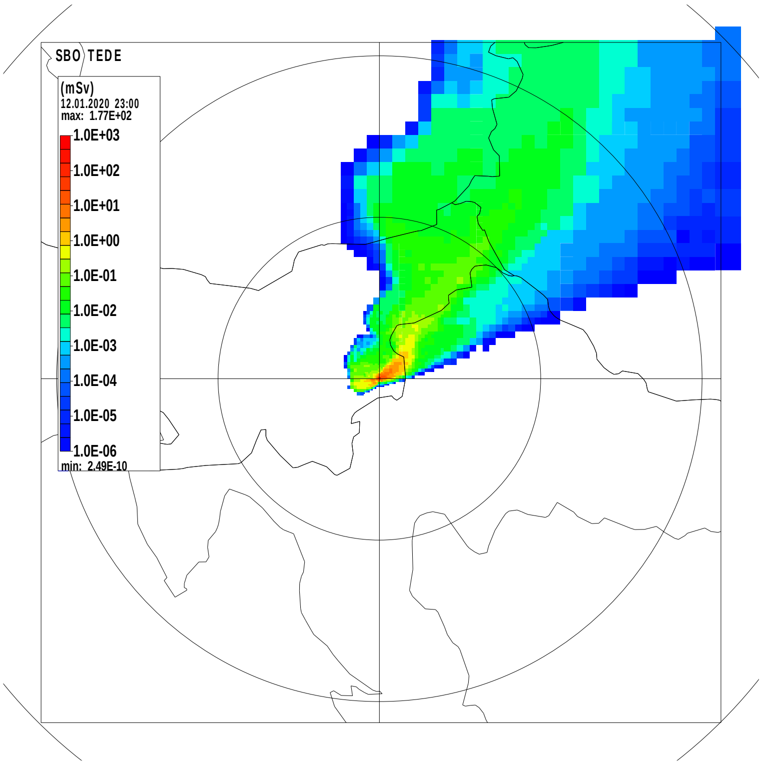

Figure 128: Effective 30-day doses for distances up to 200 km, release started on 12 Jan 2020 at 23:00 (source: /196/)

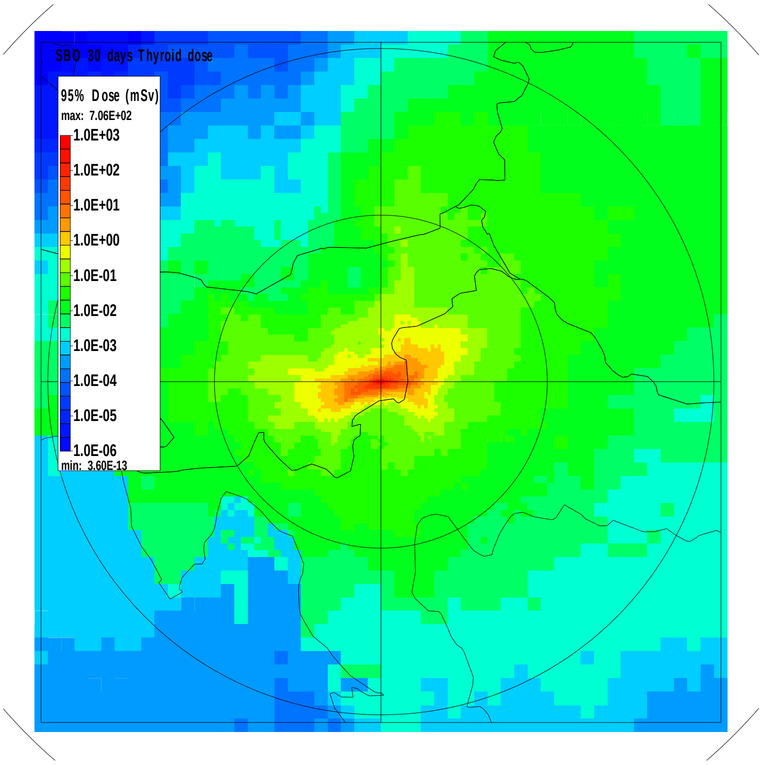

Figure 129: 95th percentile values of the 30-day thyroid dose for design extension conditions for distances up to 200 km, DIPCOT for the year 2020 (source: /196/)

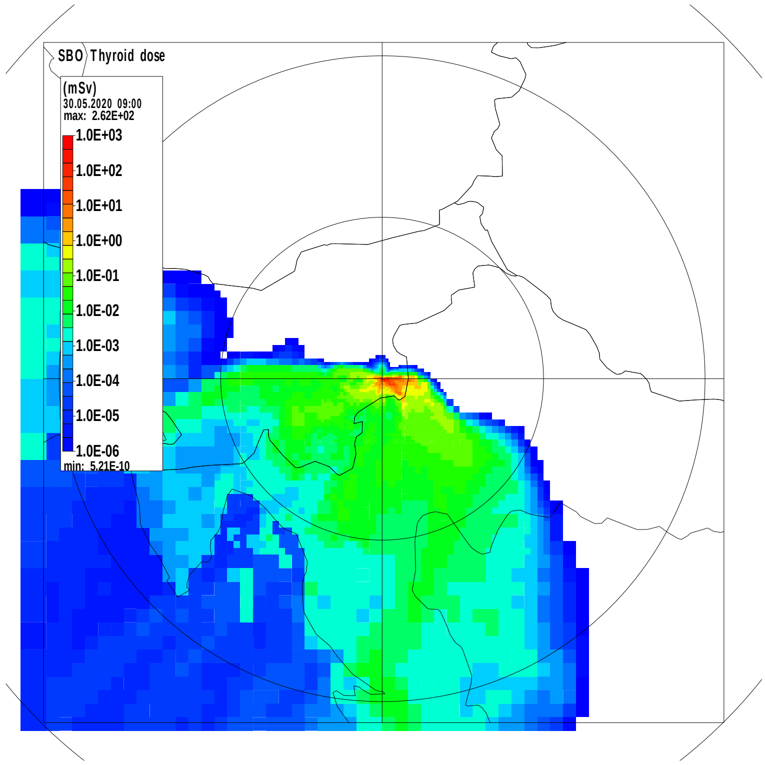

Figure 130: Values for the 30-day thyroid dose for design extension conditions for distances up to 200 km, release started on 30 May 2020 at 09:00 (source: /196/)

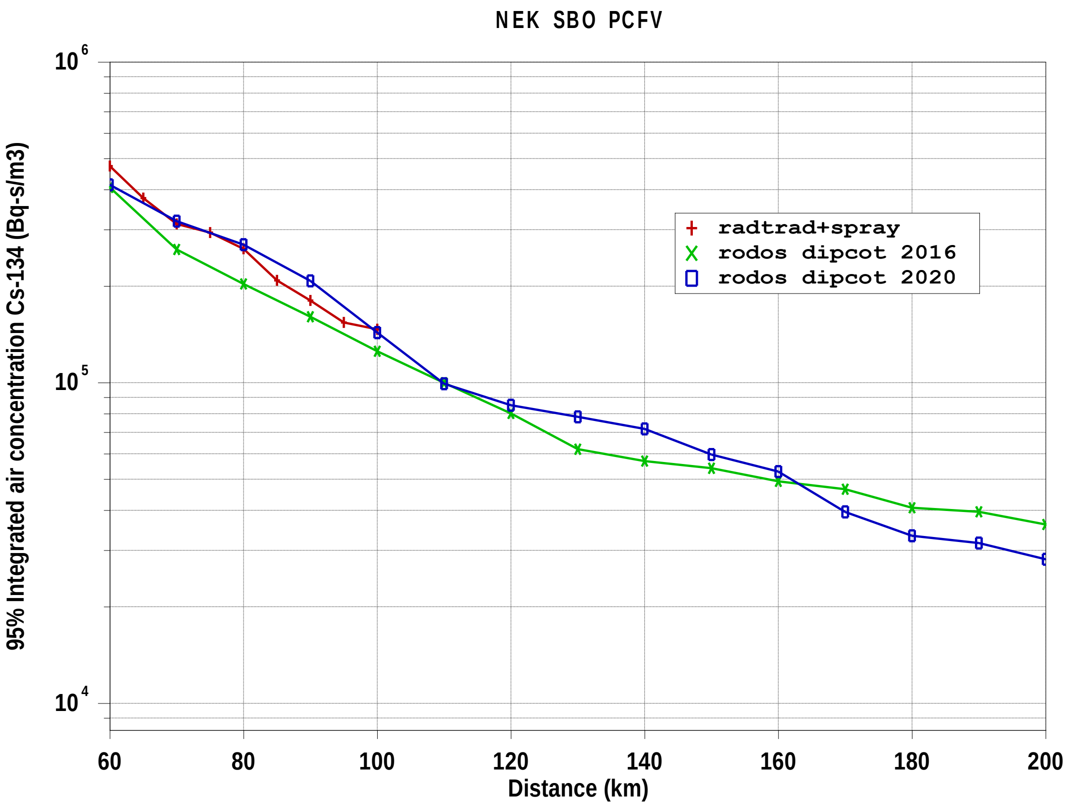

Figure 131: Integrated concentrations of isotope activity (95th percentile values by studied weather scenarios and then 95th percentile values spatially) for Cs-134 (Bq-s/m^3) for design extension conditions (source: /196/)

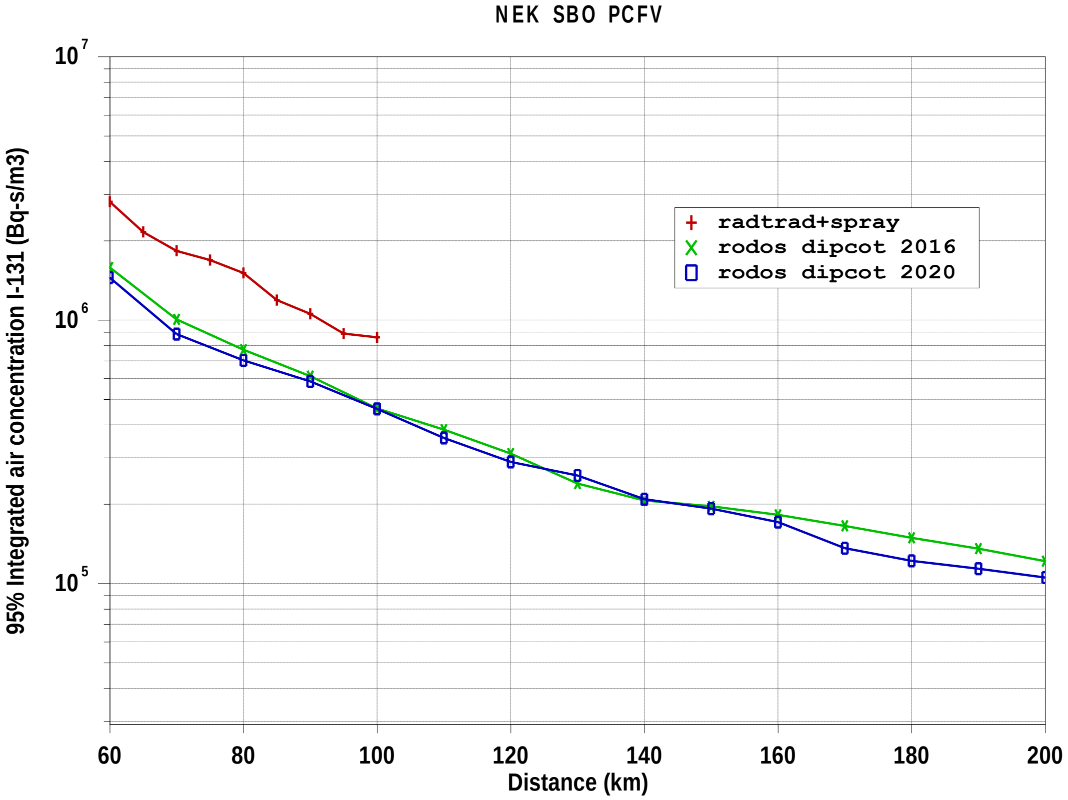

Figure 132: Integrated concentrations of isotope activity (95th percentile values by studied weather scenarios and then 95th percentile values spatially) for I-131 (Bq-s/m^3) for design extension conditions (source: /196/)

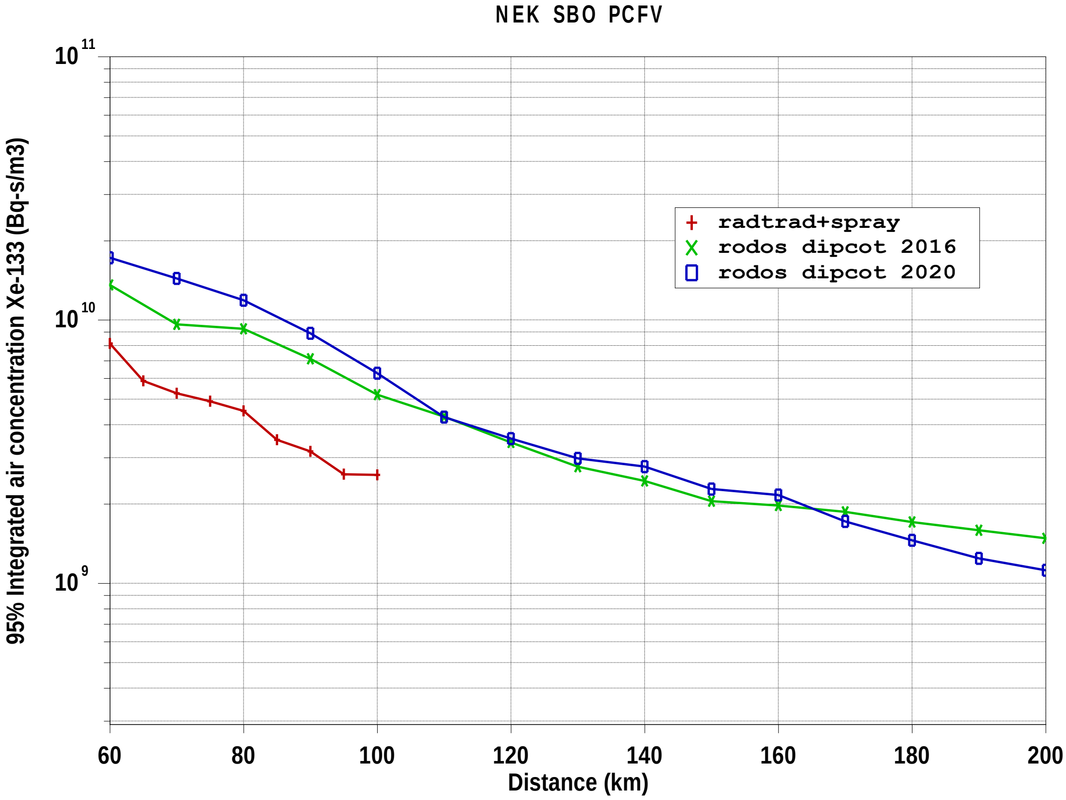

Figure 133: Integrated concentrations of isotope activity (95th percentile values by studied weather scenarios and then 95th percentile values spatially) for Xe-133 (Bq-s/m^3) for design extension conditions (source: /196/)

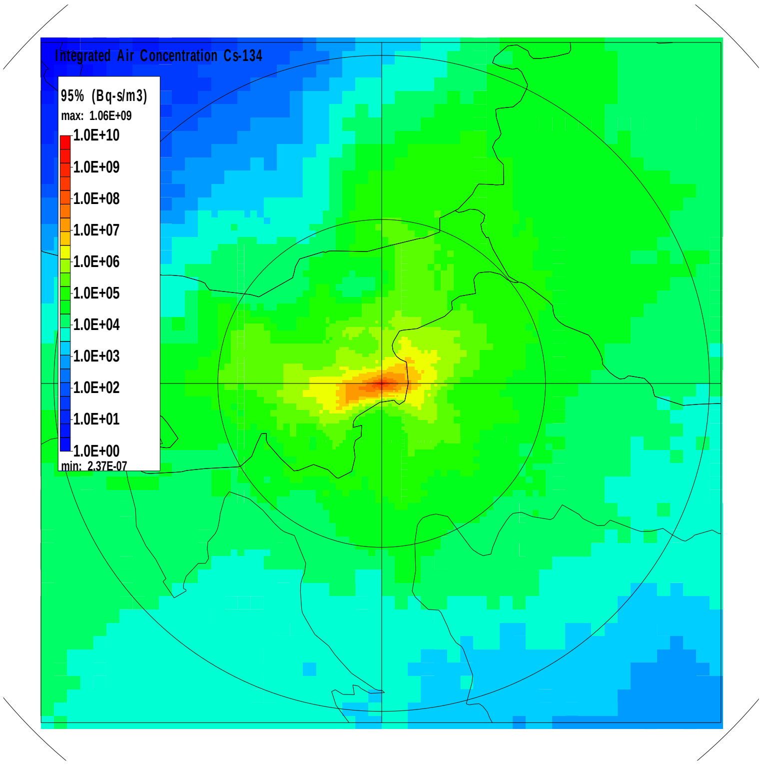

Figure 134: 95th percentile values for integrated concentrations of isotope activity for Cs-134 (Bq-s/m^3) for design extension conditions, DIPCOT for the year 2020 (source: /196/)

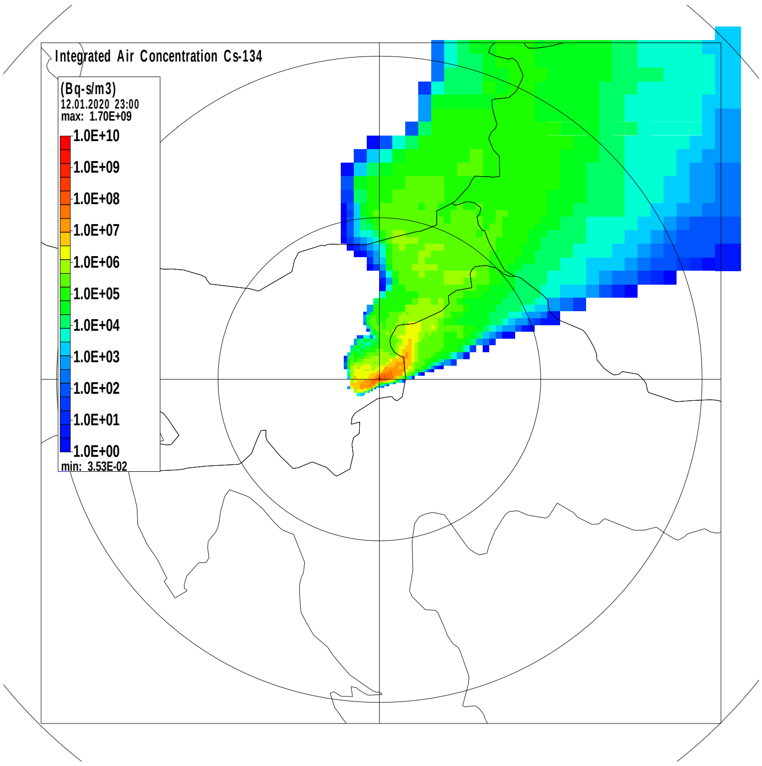

Figure 135: Integrated concentrations of isotope activity for Cs-134 for distances up to 200 km, release started on 12 Jan 2020 at 23:00 (source: /196/)

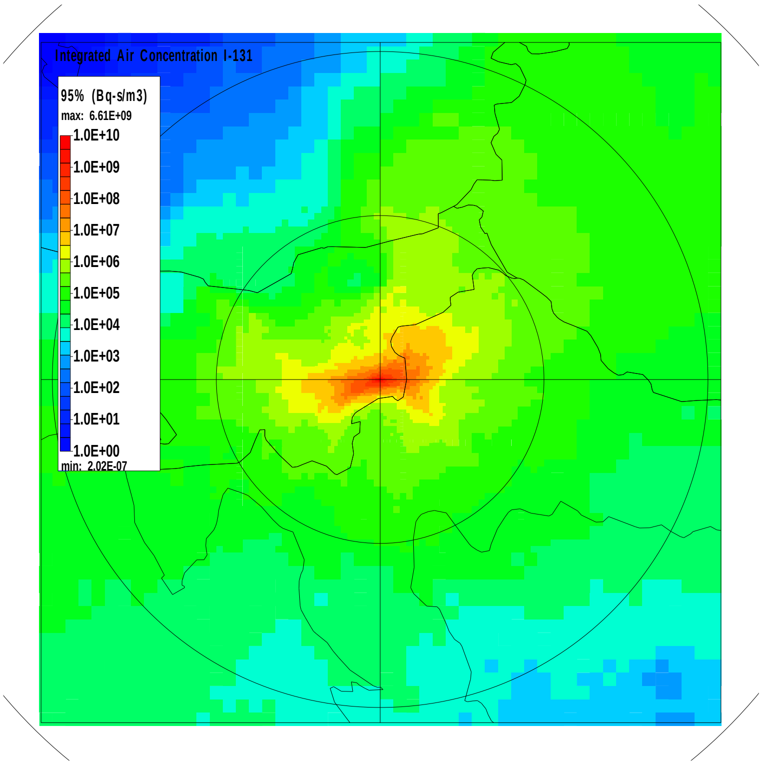

Figure 136: 95th percentile values for integrated concentrations of isotope activity for I-131 (Bq-s/m^3) for design extension conditions, DIPCOT for the year 2020 (source: /196/)

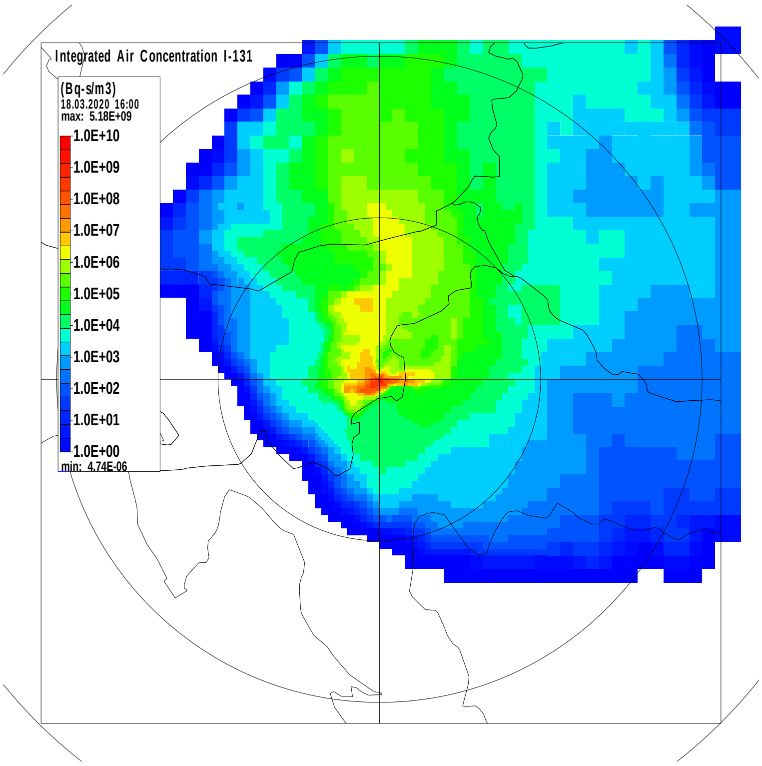

Figure 137: Integrated concentrations of isotope activity for I-131 for distances up to 200 km, release started on 18 Mar 2020 at 16:00 (source: /196/)

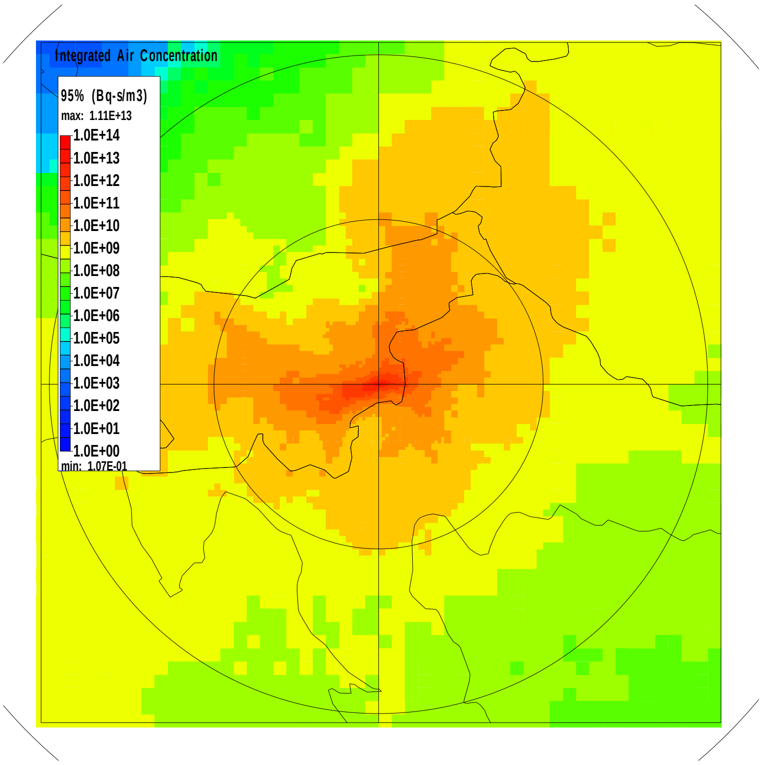

Figure 138: 95th percentile values for integrated concentrations of isotope activity for Xe-133 (Bq-s/m^3) for design extension conditions, DIPCOT for the year 2020 (source: /196/)

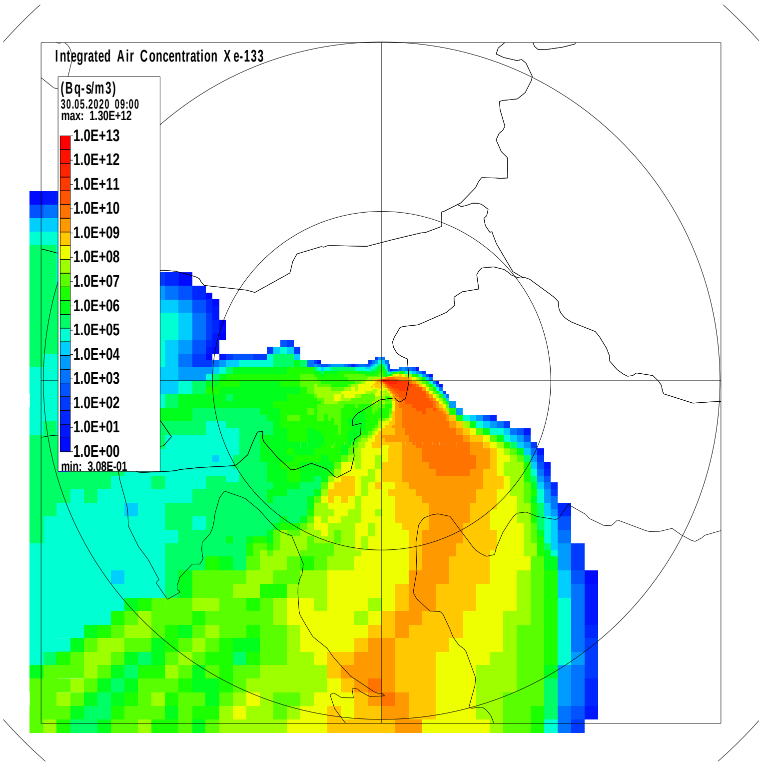

Figure 139: Integrated concentrations of isotope activity for Xe-133 for distances up to 200 km, release started on 30 May 2020 at 09:00 (source: /196/)

Concluding findings of the study authors

As evident from the results shown above, the effective 30-day dose for design extension conditions (DEC-B) at 10 km from the power plant is 1.16 mSv. It is more than two times lower than the annual natural background radiation dose, which is around 2.5 mSv in Slovenia. The thyroid gland dose (13.5 mSv) at 3 km from NEK is under the limit (50 mSv for 7 days) prescribed by law for iodine prophylaxis /224/. The reference level for action (sheltering, evacuation) in the event of an emergency is an effective dose of 100 mSv (UV2, Article 27). Notwithstanding the calculated doses on the border of the 3 km area (OPU), which are below the reference level for action, the population would be preventively evacuated in the event of DBA or DEC-B accidents in compliance with the general hazard criteria /224/, /220/.

Considering the above results of analyses, it follows that DBA and DEC-B accidents are not expected to have a major impact outside the 10 km perimeter around the power plant. It can also be concluded that the effective 30-day dose on the border with neighbouring countries for the worst accident (DEC-B) studied is lower than the dose received by an individual from natural sources of radiation in one year[38]. The average contribution of natural radiation in Austria is 3.86 mSv per year /214/, which amounts to approximately 0.32 mSv for 30 days.

This means that an inhabitant of Lipnica/Leibnitz in Austria (95 km from NEK) would in the event of a DEC-B accident receive an effective 30-day dose (0.0129 mSv), which is approximately 25 times smaller than the dose due to natural radiation in the same period.

Following the implementation of the Safety Upgrade Programme, the doses calculated for a DEC-B accident are comparable with the doses calculated for contemporary, Generation III nuclear power plants /217/.

To calculate doses from releases into the atmosphere in the accidents studied, three dispersion models and two approaches to dose calculation were used /196//196/:

- The Spray model /199/ was used in combination with RADTRAD /218/ to calculate doses (we are taking about spatially and temporally 95th percentile values) for distances of up to 100 km. Calculations of the values of relative concentrations in the cloud were conservative particularly for longer distances, because deposition was not taken into account. The results are shown above.

- Additionally, doses were calculated for distances of up to 200 km using the RODOS /219/ dispersion models - DIPCOT and LASAT - which do not include the details specific to the terrain of the Krško basin around the power plant and involve a different approach to using the meteorological data and calculating doses. Deposition was taken into account in these calculations.

Even though the models and methods of dose calculation differ, the doses at distances from 60 to 100 km from NEK show good congruence /196/. Considering the expected errors of the dispersion models and the varied approaches to dose calculation, the said congruence between models is excellent.
The dose calculations using three different models and two methods of dose calculation differ from each other by less than a factor of 3 at a distance of 60 km from the power plant, and by less than a factor of 4 at 100 km.
In the vicinity of NEK, the results obtained with the Spray model are more trustworthy, which is why the results of RODOS models are not given for this area. Spray evidences good results for validation in the meteorologically similar case of Šoštanj surroundings, which is described in the sections **Validation of the models used** and **Linking the EIA calculations with the validated placements of the model.**

By using two different ways of calculating doses, three different dispersion models and meteorological data for two different years, it was shown that the expected differences in calculated doses do not change the conclusion that the doses are acceptably low for the distances studied.

[38] The comparison serves merely as an illustration and compares 30 days of exposure to the accident and 30 days of natural background.

As expected, for distances greater than 100 km, the RODOS models showed smaller dose values than for 100 km.

The radiological impact of an accident at NEK on the environment in the extended operation period would be no different than the impact of an accident during present operation (in 2021).

It should be noted that calculations made with Spray - the realistic model, realistic meteorological data were used to determine diffusion coefficients (X/Q), which are lower in comparison to calculations in the NEK Updated Safety Analyses Report (USAR). This is why doses for design basis accidents calculated in /196/ are smaller than the doses specified in the USAR, Chapter 15 /3/, where the diffusion coefficients used were calculated on the basis of a simple one-dimensional model.

Monitoring in the event of accidents with atmospheric releases

The **monitoring** consists of emission and environmental monitoring.

Emission monitoring consists of automatic monitoring and periodic manual monitoring. Automatic monitoring is used to monitor the activity of radionuclides in effluent from NEK.

The monitors are connected through the process information system (PIS) into NEK's Ecological Information System base (EIS NEK), and this base is fully automatically connected to the DOZE programme for population dose assessment during accidental releases and normal operation /213/.

Environmental monitoring consists of automatic monitoring and periodic manual monitoring which follows an implementation plan.

Automatic monitoring comprises:

- **automatic monitoring of radioactivity in the environment**,
- **automatic monitoring of meteorological variables** of the atmosphere as a basis for modelling radionuclide dispersion in the atmosphere,
- **designated 7-day forecast** of weather in half-hour increments and, on its basis, automatic prediction of radionuclide dispersion in the atmosphere.

Automatic monitoring of radioactivity in the environment comprises:

- NEK automatic monitoring of radioactivity in the environment:
    - A circle of independent gamma dose rate meters in the Krško basin,
    - 4 gamma dose rate meters at meteorological stations around NEK,
    - Gamma dose rate meters on the NEK perimeter fence,
    - A spectrometer on a NEK mobile unit.
- URSJV automatic gamma dose rate monitoring across Slovenia and
- URSJV automatic spectrometers in NEK and across Slovenia.

From URSJV, URSJV and NEK data are automatically displayed on their website and transmitted to the European EURDEP system and also displayed for the public on their website.

Automatic monitoring of meteorological variables of the atmosphere as a basis for modelling radionuclide dispersion in the atmosphere comprises:

- 4 ground automatic meteorological stations
- RASS (vertical wind profile and temperatures to a maximum of 500 m)

All meters are part of EIS NEK. The EIS NEK base is fully automatically connected with the DOZE programme for population dose assessment during accidental releases or normal operation.

Designated 7-day forecast of weather and dispersion in half-hour increments for radionuclide emissions into the atmosphere:

Prediction of weather and dispersion is automatically carried out by MEIS, which transmits the data to NEK once a day; each packet contains data for the current day and the next 6 days for each half an hour at 2 km spatial resolution. The prediction of atmospheric dispersion feeds directly into the DOZE software system for population dose assessment.

DOZE automatic data preparation and population dose prediction system

Automatic monitoring of emission variables, automatic monitoring of meteorological variables and designated 7-day weather prediction are brought together in a comprehensive system for predicting doses to the population in the event of an accidental release of radionuclides from NEK into the atmosphere /213/.

The system runs automatically to the point of preparing relative concentrations. At all times, NEK and URSJV experts have access to relative concentrations for the past and present (calculated from diagnostic measurements) and prognostic relative concentrations for the current day and for 6 days in advance in half-hour increments.

The **DOZE software package** uses all of the automatically collected data, and it also enables manual entry of data, so as to allow the user to assess an accident involving releases into the atmosphere on the basis of measurements or pre-prepared scenarios, and calculate the resulting doses to the population /213/. The DOSE software package is used by NEK, URSJV and the Civil Protection Service.

The whole system - the methodology, measurements and modelling system which together enable the diagnosis and prediction of population doses by using dispersion models - is described in detail in the article /200/.

The system is also used to assess regular releases.

OSART described the system in its 2003 report as an example of good practice /209/:

"**Good practice**: A special tool for the assessment of radiological consequences in the environment has been developed. It utilizes a more realistic dispersion model, Lagrangian particle model instead of the simple Gaussian, to calculate dispersion. This accurate modelling is very important in areas with a complicated meteorological modelling environment, such as Krsko." *(**Slovenian translation:** Dobra praksa: Razvito je bilo posebno orodje za oceno radioloških posledic v okolju. Za izračun disperzije uporablja bolj realističen model disperzije, Lagrangeev model delcev, namesto preprostega Gaussovega. To natančno modeliranje je zelo pomembno na območjih z zapletenim meteorološkim modeliranjem, kot je Krško.)*

In 2017, when the system was upgraded with dispersion prognosis, it was assessed by OSART as good performance /210/:

"It was also noted that the plant organization has enhanced the capability for off-site radiological monitoring by using plant-specific dose assessment software, which is fed on-line with meteorological data and uses the Lagrangian Particle Model to calculate accurate dispersion factors for site specific characteristics, and having available a mobile laboratory for quick sample analysis. The plant considers that this enhanced capability, which includes a prognosis application, allows a more accurate and prompt estimation of off-site radiological consequences, in support of the issuance of protective action recommendations for the public. The team considered this as a **good performance**." (International Atomic Energy Agency, 2017). *(**Slovenian translation:** Ugotovljeno je bilo tudi, da je organizacija elektrarne povečala zmogljivost za radiološko spremljanje v okolici elektrarne z uporabo programske opreme za oceno doz, specifične za to elektrarno, ki uporablja sprotne meteorološke podatke in Lagrangeev model delcev za izračun natančnih razredčitvenih faktorjev, karakterističnih za to lokacijo. Na voljo ima tudi mobilni laboratorij za hitro analizo vzorcev. Elektrarna meni, da ta izboljšana zmogljivost, ki vključuje uporabo navodil, omogoča natančnejšo in takojšnjo oceno radioloških posledic v okolici v podporo izdaji priporočil o zaščitnih ukrepih za javnost. Ekipa je to ocenila kot **dobro izvajanje**.)*

Concluding findings of the EIA Report author

The study "Calculation of Doses at Certain Distances for Design Basis (DB) and Beyond Design Basis (BDB) accidents at NPP Krško, FER-MEIS, 2021" /196/ dealt with:

- Large break loss of coolant accident (LB LOCA)
- Design extension conditions (DEC-B).

As evident from the results of the study, the effective 30-day dose at a distance of 10 km from the power plant is 1.16 mSv and more than two times lower than the annual natural background dose, which is about 2.5 mSv in Slovenia. The thyroid gland dose (13.5 mSv) at 3 km from NEK is under the limit (50 mSv for 7 days) prescribed by law for iodine prophylaxis /224/.

The distance of NEK from the closest borders of neighbouring countries is:

- 10 km from the border with Croatia;
- more than 75 km from the border with Austria;
- more than 129 km from the border with Italy;
- More than 100 km from the border with Hungary.

Considering the results of the study we can conclude that in the event of a large-break loss of coolant accident (LB LOCA) and design extension conditions (DEC-B), which also represent the worst possible accident scenarios, there **will not** be a **significant** transboundary impact on the environment and people's health and possessions.

On the basis of these results we can conclude that checking a **1,000 km** radius is **meaningless**, as it is clear from the study that the effective 30-day dose at a distance of 10 km from the power plant is 1.16 mSv and therefore two times lower than the annual natural background dose, which is 2.5 mSv in Slovenia. The thyroid gland dose (13.5 mSv) at 3 km from NEK is under the limit (50 mSv for 7 days)[39] prescribed by law for iodine prophylaxis /224/.

6.5 ANSWERS TO QUESTIONS AND COMMENTS RECEIVED IN THE COURSE OF TRANSBOUNDARY CONSULTATION – NOTIFICATIONS

6.5.1 Introductory notes

By 31 August 2021, the Ministry of the Environment and Spatial Planning of the Republic of Slovenia received notification from Austria, Croatia and Hungary requesting to participate in the process of transboundary assessment of potential significant impacts on the environment.

The aim of this chapter is to give answers to the questions received in the process of transboundary environmental impact assessment.

6.5.2 Description of documents in the introductory notes

The table below lists the documents received in the process of transboundary assessment.

Table 142: Documents received in the transboundary assessment process

Country	Document
Austria	Federal Ministry of the Republic of Austria for Climate Action, Environment, Energy, Mobility, Innovation and Technology, REF. no. 2021-0.410.044, Vienna, 9 June 2021
Croatia	Republic of Croatia, Ministry of Economy and Sustainable Development, KL.: 351-03/21-08/02, URBR.: 517-05-1-2-21-2, Zagreb, 28 May 2021

[39] Decree on dose limits, reference levels and radioactive contamination (Official Gazette of RS, No.18/18)

Country	Document
Hungary	Ministry of Agriculture, Department of Environmental Conservation, REF.no. KmF/122-5/2021, Budapest, 23 July 2021.

6.5.3 Republic of Austria

The following issues were highlighted by the Republic of Austria:

- nuclear safety,
- seismic safety,
- flood safety,
- power plant aging and
- long-term waste disposal.

Detailed information and descriptions regarding nuclear safety, seismic safety, flood safety, aging and long-term waste disposal are given in the preceding chapters of this report (see Sections 2.7 and 2.8). The key points related to these topics are given below.

Nuclear safety
See Sections 2.7 and 2.8 for a detailed description of nuclear safety. The key points which are vital to nuclear safety are discussed below.

The safety systems at NEK **prevent** the uncontrolled release of radioactive material into the environment. A high level of attention is paid to nuclear safety already in the phase when the reactor and power plant are 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:

1. effective reactivity control (reactor power control),
2. cooling of the fuel in the reactor and the spent fuel pool,
3. confinement of radioactive material (prevented release of radioactive material into the environment).

The release of radioactive material into the environment is **prevented by four successive** safety barriers:

1. The **first** barrier is the fuel (fuel pellets), which confines the radioactive material within itself.
2. The **second** barrier is a waterproof cladding that encloses fuel pellets and prevents leakage of radioactive gases from fuel.
3. The **third** barrier is the primary system boundary (pipe walls, reactor vessels and other primary components) that confines the radioactive water for reactor cooling.
4. 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 material from passing to the next barrier, whereas the fourth barrier prevents radioactive material from being released directly into NEK's surroundings.

As the operation of safety systems in the event of a defect and failure or even an unlikely accident at a nuclear power plant is paramount, all safety systems are doubled (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.

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 pool and/or spent fuel storage),
- heat removal from the core and spent fuel pool and
- the confinement of radioactive material and the prevention of its 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/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.

Seismic safety

Slovenia is a country with a medium seismic hazard. While earthquakes in Slovenia do not reach high orders of magnitude, their effects can be quite serious because of the relatively shallow epicentres. A belt of greater seismic hazard runs across the central part of Slovenia in a contiguous zone from the far northwest to the far southeast of the country. Moving away from this belt towards the northeast and southwest, the seismic hazard decreases.

The seismic intensity of the studied NEK area is grade 8 according to the EMS scale (European Macroseismic Scale). Seismic accelerations of up to 0.2 g PGA for a 475-year return period earthquake, and 0.45 g PGA for a 10,000-year return period earthquake can be expected in this area. These figures are based on the maps of macroseismic intensities in Slovenia for 475- and 10,000-year return periods /60/.

Detailed geomechanical, hydrological, geophysical, and seismological investigations were carried out at the NEK site in several stages. The first stage was carried out between 1972–1973 and included boring to a depth of 12–13 m and measurements of P and S wave velocities. These investigations were carried out in the wider surroundings of NEK and used to determine its final location.

The second stage took place in the second half of 1973. It covered seismic measurements of P and S wave velocities and microseismic ground noise measurements at the NEK site. These investigations were used to create a geotechnical model and define the seismic loading parameters.

The third stage was carried out in the middle of 1974. It included 30 geomechanical borings between 30 and 90 m in depth, laboratory material tests, and measurements of P and S wave velocities up to a depth of 45 m.

The fourth stage was carried out in 1974. It included 24 new geomechanical borings up to a depth of 100 m, measurements of P and S wave velocities, additional laboratory tests, gamma-gamma measurements of material density, and geoelectrical sounding of the terrain. The second, third and fourth stage of the investigations were carried out at the NEK site and refer to structures of category I.

Further investigations at the site were carried out as part of a seismic probabilistic safety analysis to assess the power plant's vulnerability to seismic events. Between 1994 and 1996, geological, seismological, and geophysical investigations were completed. Based on the preliminary results and IAEA recommendations, additional geological, seismological, and geophysical investigations were conducted as part of a revised "Programme for Additional Site Investigations". The studies focused on the NEK area and the surrounding region (radius 25 km) and included:

- update of the seismic event database;
- detailed geological mapping of the Krško basin and adjacent regions in the vicinity of the site at a scale of 1: 5,000;
- geophysical investigations;
- detailed investigations of Quaternary deposits, soils, and geomorphic surfaces that can be used to assess neotectonic deformation;
- acquisition and analysis of geodesic levelling and GPS survey data.

The results of geological, seismological, and geophysical investigations are presented in the first Periodic Safety Review (PSR), which provides an updated seismotectonic model of the Krško basin. This report provides a basis for reassessing and revising the Probabilistic Seismic Hazard Analysis (PSHA, 2002–2004).

Power plants are designed for return period earthquakes, which significantly exceed the return periods of earthquakes applied in designing ordinary structures. The earthquake in Petrinja on 29 December 2020, which was also felt in the Krško area, posed no danger to NEK and caused no damage whatsoever.

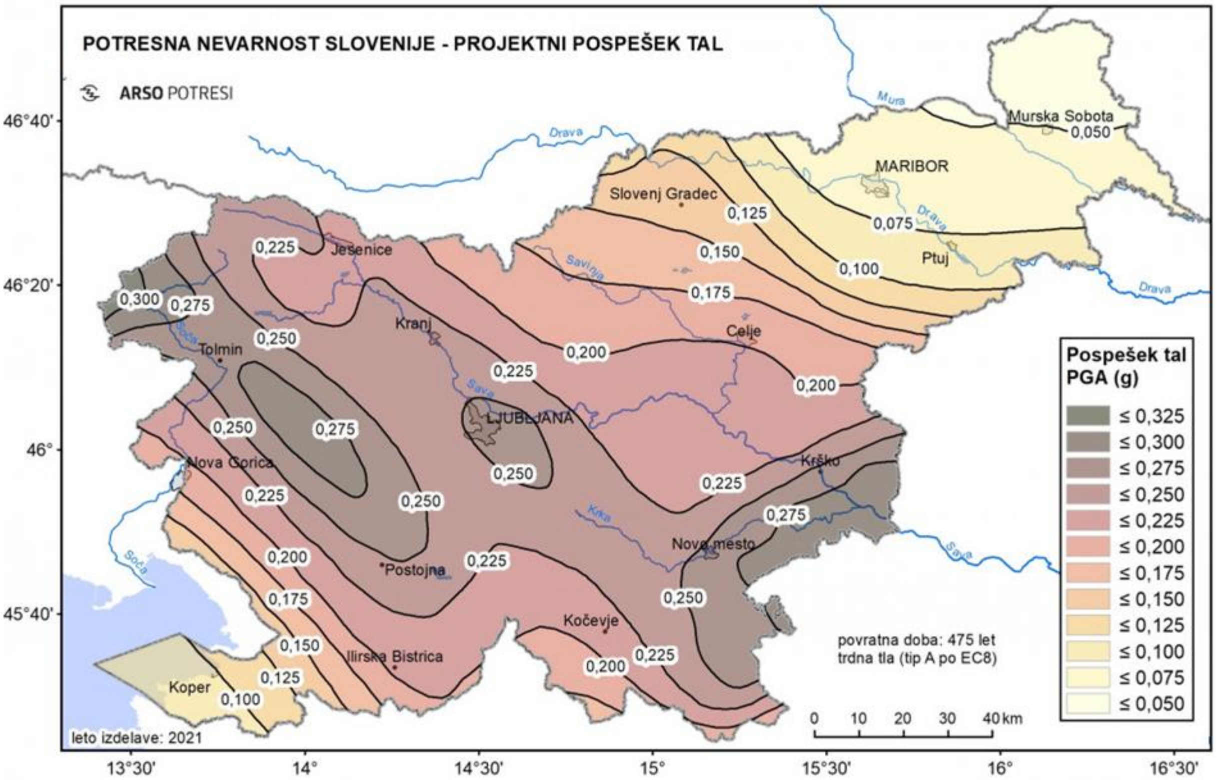

Figure 140: PGA for a 475-year return period (source: /60/)

POTRESNA NEVARNOST SLOVENIJE – PROJEKTNI POSPEŠEK TAL	SEISMIC HAZARD IN SLOVENIA – DESIGN-BASIS GROUND ACCELERATION
ARSO POTRESI	**ARSO** EARTHQUAKES

Pospešek tal PGA (g)	**Ground acceleration PGA (g)**
leto izdelave: 2021	made in: 2021
Povratna doba: 475 let trdna tla (tip A po EC8)	Return period: 475 years firm ground (EC8 type A)

The Reactor Site Criteria 10 CFR 100 App. A, which were applied in the design and construction of NEK, demand that buildings, components and systems of importance for nuclear safety be designed and constructed as earthquake-resistant structures, which is also in accordance with Slovenian legislation (Rules on radiation and nuclear safety factors (Official Gazette of RS Nos. 74/16, 76/17 - ZVISJV-1)). 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 course of the probabilistic safety analysis for earthquakes /225/.

After the end of the extensive probabilistic safety analysis for earthquakes /225/, which also involved 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), to better understand 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 since 2008 /274/,/275/, 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 /271/, which was produced in the years 2002-2004 after 10 years of previous research.

The stress tests at NEK /26/ 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 programme. All new buildings and systems constructed as part of the power plant safety upgrade programme 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 /274/ 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 (PGA). Ground accelerations at which large and early releases could occur should be higher than 1 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 /26/. Seismic analyses have shown that seismic shocks 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. /26/.

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, 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.

Flood safety

As it is situated on a former floodplain of the Sava, NEK was protected from flooding by embankments along the Sava and Potočnica during the construction. The Sava embankment extends approximately 2 km upstream and 1 km downstream from NEK, while the Potočnica embankment is 750 m long and runs from the mouth of the Potočnica flowing into the Sava to the railway line. During the construction of NEK, the right bank of the Sava was preserved in its natural state, thus ensuring an extreme flood would spill over onto the right-side floodplain along the Sava. At the time of the construction of NEK, the applicable Q10,000 flood was estimated at 4,272 m^3/s.

In 2011, flood safety of NEK was re-evaluated, and a new relevant flow of Q10,000 = 4,790 m^3/s was determined as part of the expanded analysis. Based on this analysis, a modification of flood embankments was completed in February 2012 (project NEKPMF-B056/186-2). The crown of the embankment along the Sava was raised up to 1 m at a length of 1,430 m, while the crown of the embankment along the Potočnica was raised up to 1.8 m, and a protective concrete wall was added in the far upstream section.

In March 2018, a second, minor modification of the embankments along the Sava and Potočnica was completed as a result of the construction of the Brežice HPP (project NEKPOT-A201/019). The project investors were INFRA, HESS, the Slovenian Infrastructure Agency (DRSI), and the Municipality of Krško. The crown of the embankment along the Sava was minimally corrected at a length of 100 m (up to 10 cm), while flood protection along the Potočnica was raised by an additional 0.5 m by building a parapet wall and raising the height of the existing flood wall.

As a result of the modifications of flood embankments along the Sava and Potočnica in 2011 and 2018, NEK is protected up to a flow of 11,130 m^3/s /3/.

The spent fuel dry storage building is designed to protect against floods with flood embankments. In the event of a probable maximum flood (PMF) following an earthquake above 0.3 g, additional protection is provided by a system of water barriers, i.e. sealing to an elevation of 157.53 m a.s.l. Flood sealing is ensured by the exterior RC walls, and the intrusion of water through the door is prevented by removable flood barriers.

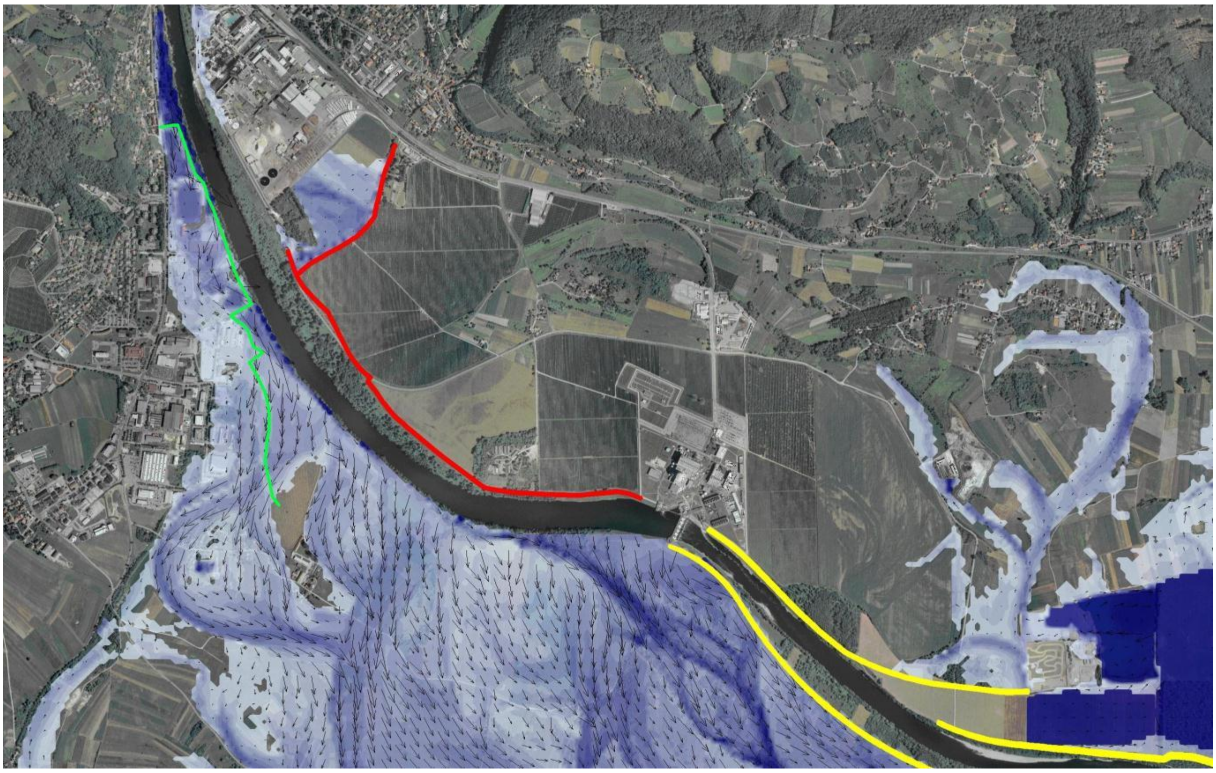

Figure 141: Areas of flooding around NEK and local water velocity vectors at QPMF = 7,081 m^3/s (unsteady flow) for conditions after the construction of the Brežice HPP (source: /151/)

The red line shows NEK embankments along the Sava and Potočnica, the green line shows flood embankments within the Brežice HPP project, and the yellow line shows the Brežice HPP dykes. From: Hydraulic analysis of high water flows in the Sava in the area of NEK under conditions of probable maximum flood (PMF) for conditions following the construction of Brežice HPP /151/.

Table 143: Highest flows of the Sava recorded at Radeče, which served as a reference water gauging station for NEK until 1994 (source: /3/)

Year	Flow	Year	Flow	Year	Flow	Year	Flow
1990	**2991**	*1909*	1863	*1916*	1466	*1952*	1302
1998	2940	*1991*	1862	*1960*	1458	*1928*	1294
1933	2809	*1987*	1857	*1939*	1458	*1944*	1264
1964	2699	*1969*	1839	*1918*	1458	*1997*	1250
1923	2676	*1985*	1831	*1983*	1450	*1994*	1217
1979	2498	*1949*	1820	*1959*	1420	*1978*	1216
1973	2460	*1962*	1789	*1956*	1420	*1999*	1133
1980	2391	*1940*	1772	*1921*	1420	*1911*	1131
1966	2350	*1915*	1754	*1984*	1416	*1910*	1119
1982	2313	*1993*	1735	*1947*	1412	*1912*	1104
1936	2228	*1967*	1712	*1919*	1400	*1955*	1068
1974	2213	*1968*	1708	*1989*	1391	*1953*	1018
1992	2153	*1948*	1693	*1995*	1390	*1913*	1007
1927	2134	*1963*	1661	*1976*	1380	*1957*	1000
1926	2109	*1931*	1661	*1937*	1380	*1924*	997
1930	2087	*1925*	1576	*1977*	1370	*1971*	973
2000	2080	*1922*	1576	*1970*	1346	*1981*	942
1961	2024	*1951*	1552	*1943*	1341	*1950*	929
1934	1998	*1954*	1536	*1988*	1331	*1941*	849
1965	1957	*1935*	1536	*1932*	1325	*1920*	832
1975	1930	*1917*	1513	*1914*	1321	*1945*	815
1972	1913	*1986*	1492	*1908*	1317	*1942*	805
1996	1865	*1938*	1482	*1958*	1309	*1929*	805
						1946	582

Table 144: Six highest flows of the Sava recorded in the Krško HPP profile (source: /246/)

Year	Date	Flow
1933	23.9.	*2940*
1964	25.10.	*2733*
1973	25.9.	*2549*
1979	29.1.	*2630*
1990	1.11.	*3050*
1998	4.11.	*3001*

As part of its maintenance processes, NEK regularly inspects the condition of flood protection and ensures regular implementation of training to review knowledge about implementing active flood protection.

On the basis of the protection measures described above and the historical flood records, it is concluded that NEK will be adequately protected against floods until 2043, even taking into account the effects of climate change.

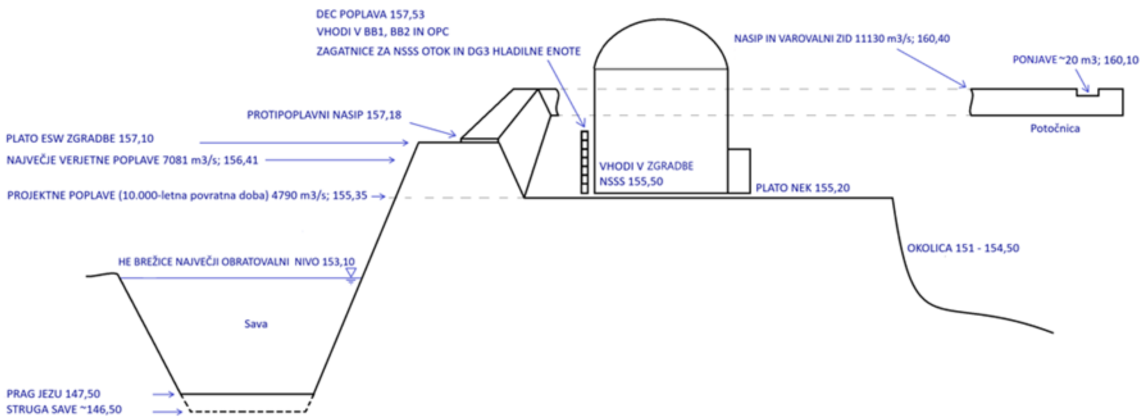

Figure 142: Flood protection at NEK

DEC POPLAVA 157,53	DEC FLOOD 157.53
VHODI V BB1, BB2 IN OPC	ENTRANCES TO BB1, BB2 and OPC
ZAGATNICE ZA NSSS OTOK IN DG3 HLADILNE ENOTE	WATER BARRIERS FOR THE NSSS ISLAND AND THE DG3 COOLING UNITS
NASIP IN VAROVALNI ZID 11130 m^3/s; 160,40	EMBANKMENT AND PROTECTIVE WALL 11,130 m^3/s; 160.40
PONJAVE ~20 m^3; 160,10	TARPAULINS ~20 m^3; 160.10
Potočnica	Potočnica
PROTIPOPLAVNI NASIP 157,18	FLOOD EMBANKMENT 157.18
PLATO ESW ZGRADBE 157,10	PLATEAU OF THE ESW BUILDING 157.10
NAJVEČJE VERJETNE POPLAVE 7081 m^3/s; 156,41	PROBABLE MAXIMUM FLOOD 7,081 m^3/s; 156.41
VHODI V ZGRADBE NSSS 155,50	ENTRANCES TO THE NSSS STRUCTURES 155.50
PLATO NEK 155,20	NEK PLATEAU 155.20
PROJEKTNE POPLAVE (10.000-letna povratna doba) 4790 m^3/s; 155,35	DESIGN BASIS FLOODS (a 10,000-year return period) 4,790 m^3/s; 155.35
OKOLICA 151-154,50	SURROUNDINGS 151-154.50
HE BREŽICE NAJVEČJI OBRATOVALNI NIVO 153,10	HPP BREŽICE MAXIMUM OPERATING LEVEL 153.10
Sava	Sava
PRAG JEZU 147,50	RIVER DAM SPILLWAY CREST 147.50
STRUGA SAVE ~ 146,50	SAVA RIVERBED ~ 146.50

Power plant aging and supervision

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

The AMP consists of various NEK programmes, 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 thus provides comprehensive control over plant aging, including mechanical, electrical and construction SSC, with which it systematically recognizes 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 set out in the procedures, are carried out by way of the work order system and the preventive maintenance programme.

The NEK aging management programme is thus based on 10 CFR 54 - "Requirements for Renewal of Operating Licences for Nuclear Power Plants". Other activities are controlled through the monitoring of maintenance efficiency – the so-called Maintenance Rule (10 CFR 50.56), Reliability Centred Maintenance (INPO API 913) and Environmental Qualification Programmes (10 CFR 50.49). The activities related to equipment replacement are included in the long-term investment plan and maintenance activities.

On the basis of a series of studies and analyses, the Slovenian Nuclear Safety Administration (URSJV) 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 the 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; and
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;
5. NEK has a comprehensive Aging Management Programme (AMP) in place to monitor aging of all passive structures and components (reactor vessel, concrete, underground piping, steel structures, electrical cables etc.). An effective preventive maintenance programme also monitors the aging of active components.

The above actions have already established the technical preconditions necessary for the extension of the operational lifetime.

Long-term radioactive waste disposal
In accordance with the Treaty /11/, the first removal of radioactive waste from NEK's LILW storage facility will take place in the 2023–2025 period. Further removal will be carried out in accordance with the RAW Disposal Programme, which is revised every five years /11/. As the contracting parties failed to reach a common solution, and in accordance with the third revision of the RAW Disposal Programme, 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 annual quantity of stored operating LILW, which was approximately 100 m^3 during the initial period of NEK operation, has been continuously reduced on account of active measures to reduce the quantities of LILW generated and appropriate procedures to process LILW and prepare it for storage, so that it currently amounts to less than 35 m^3, which is also NEK's long-term operational target.[40] Operating waste is stored in the storage facility, which was originally designed to take 5,000 drums or five years of LILW production. The capacity was subsequently increased to 11,200 drums or 3,000 tube type containers (TTCs), which is a form of LILW packaging. At the end of 2019, the volume of LILW at the storage facility was 2,274 m^3. As the radioactive waste storage facility was 95% full by 2012, NEK began to plan the construction of a waste manipulation building (WMB) in 2013. The new facility relieves the problems associated with delays in the construction of the LILW repository. Construction work was completed on the facility in 2018. The new structure has enabled measuring equipment and the supercompactor to be withdrawn from the handling area of the storage facility. This has freed up reserve storage capacity at the facility (5%) for emergency events. In NEK's assessment, this reorganisation of the storage facility will ensure that there is enough space for the storage of radioactive waste only until 2022. If NEK is to operate normally after 2022, activities to construct the LILW repository must be stepped up and the facility made ready to receive LILW in 2023.[41] Construction of the LILW repository

[40] Resolution on the National Programme for Radioactive Waste and Spent Fuel Management (ReNPRRO16–25), point 3.1.1.3.
[41] 2019 Report on Ionising Radiation Protection and Nuclear Safety in the Republic of Slovenia, URSJV, 2020.

is an independent project and entirely separate from the project of NEK operational lifetime extension. A dedicated environmental impact report was prepared for the project, and Environmental Protection Consent for it was received in 2021.

The quantities of operating LILW at the NEK storage facility are shown in the following chart (Figure 143).

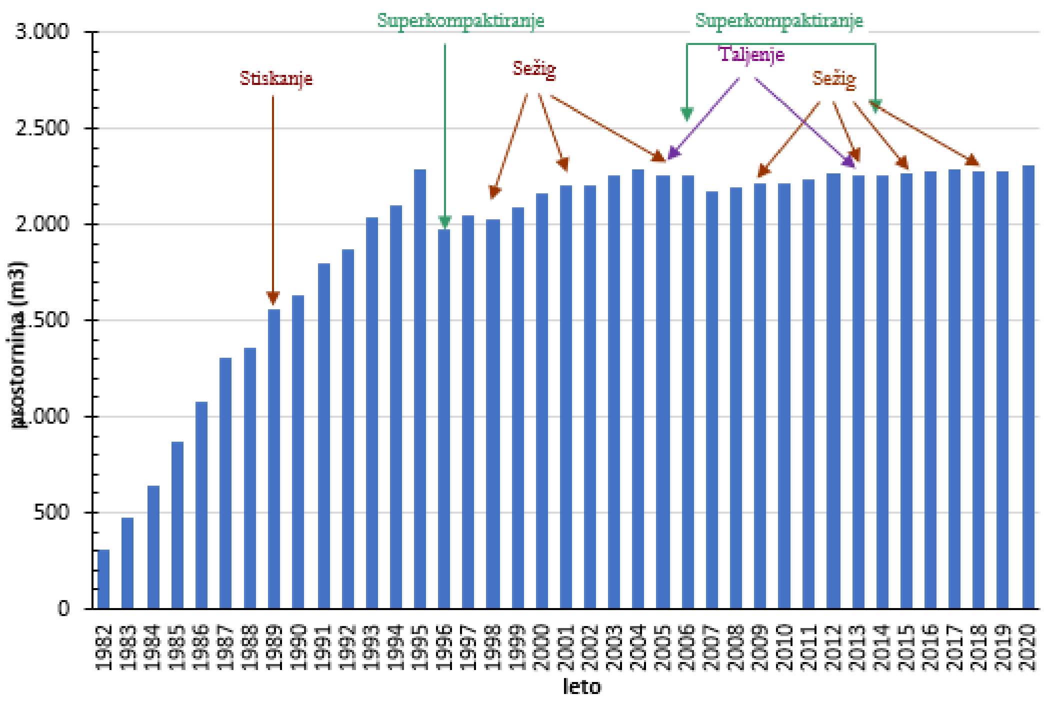

Figure 143: Quantities of LILW at the LILW storage facility at NEK (as at the end of 2020) /227/

Superkompaktiranje	Supercompacting
Stiskanje	Compacting
Sežig	Incineration
Taljenje	Melting
prostornina (m^3)	volume (m^3)
leto	year

It should be emphasised that the radioactive waste is very safely stored until there is a permanent disposal solution.

6.5.4 Republic of Croatia

In letter no. KL.: 351-03/21-08/02, URBR.: 517-05-1-2-21-2, Zagreb, 28 May 2021, the Republic of Croatia notified its participation in the process of transboundary environmental impact, but it did not put forward any preliminary questions.

6.5.5 Republic of Hungary

Within the notification process, the Republic of Hungary addressed the issues below at the Slovenian Ministry of the Environment and Spatial Planning.

1. With reference to seismic safety, it is stated that the Krško power plant is designed to withstand an earthquake that causes 0.3 g peak ground acceleration (PGA), and later on, that safety improvement measures were implemented to improve seismic safety (including the addition of a third diesel generator safety system). It is furthermore stated that according to analyses conducted in the course of stress testing, damage to the most critical structures and components in terms of safety

(reactor core, containment, spent fuel pool) would occur in the range of PGA between 0.8 - 1.0 g. At the same time, information is missing about the current actual seismic characteristics of the area, which are applied to the present design basis (PGA value for an actual safe shutdown (SSE) earthquake, and its recurrence frequency).

Answer from the EIA report author:

The Reactor Site Criteria 10 CFR 100 App. A, which were applied in the design and construction of NEK, demand that buildings, components and systems of importance for nuclear safety be designed and constructed as earthquake-resistant structures, which is also in accordance with Slovenian legislation (Rules on radiation and nuclear safety factors (Official Gazette of RS Nos. 74/16, 76/17 - ZVISJV-1)). 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. The response spectra which were determined/calculated in this way and used as a basis to qualify all equipment, are comparable to the response spectra calculated for a peak acceleration of 0.6 g at open surface. This is one of the key assumptions which gives NEK its high level of earthquake safety and which was already proven in the course of the probabilistic safety analysis for earthquakes.

After the end of the probabilistic safety analysis for earthquakes, which also involved 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), to better understand the seismic-tectonic structure of the Krško basin and reduce uncertainties in input data for determining the seismic hazard of the location and to set 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, 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. The stress tests at NEK 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 programme. All new buildings and systems constructed as part of the power plant safety upgrade programme 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, the return period of earthquakes in which the acceleration (PGA) would be 0.56, is 10,000 years, which today corresponds to an SSE design basis earthquake for the construction of new nuclear facilities (and which is what the new NEK systems were designed for).

The stress test report provides an estimate of peak ground accelerations at which damage to the core, the containment and the cliff edge effect could occur. Peak ground accelerations (PGAs) at which damage to the reactor core could occur were estimated in the range of 0.8 g. Peak ground accelerations at which large early releases could occur should be higher than 1 g PGA. Any subsequent filtered releases could occur in the range of PGA between 0.8 and 0.9 g. The integrity of the spent fuel pool would not be compromised up to the point of PGAs exceeding 0.9 g. Based on seismic analyses, it is estimated that earthquakes involving peak ground acceleration greater than 0.8 g at the location of the power plant are very rare and their expected return period is estimated at more than 50,000 years.
The seismic safety of NEK is described in Section 2.7.2.

2. In the scope of information that should be given about the effects of floods on safety, minimum possible water levels on the Sava (including their effects on cooling) and other extreme meteorological conditions, and furthermore in connection with the heat load on the river's temperature, it is necessary to evaluate and additionally illustrate the expected effects of climate change in the period of long-term operation (2023-2043).

Answer from the EIA Report author:

EIA assesses the impact of climate change on the safety aspects of the power plant and its normal operation. Expected changes of climate factors are analysed for the period until 2043. These include the effects of flooding and high water, the effects of reduced flow on cooling and safety, increased temperature of Sava water and air, extreme winds, extreme precipitation, hail and ice, natural fires and other extreme events. A systematic approach, the application of European Commission guidelines and other guidance applicable in Slovenia are the basis in assessing exposure, sensitivity and vulnerability, in making a risk assessment and in assessing the power plant's resistance to climate factors.

In addition to design basis floods (DBF, 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. The PMF, which was defined in 2010, 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. In 2018, additional reconstruction of the flood embankments of NEK was carried out. Hybrid mathematical and physical models had proved that the reconstructed embankments would ensure flood safety at NEK up to a Sava flow rate of 11,130 m^3/s, which is 2.78 times the rate of the greatest flood ever recorded. The scenarios defining PMF along with the proven limit flood safety amount to satisfactory resistance of NEK to the consequences of climate change in the long-term operation period.

The lowest level of the Sava required for essential service water (ESW) system operation is 147.85 m a.s.l., which corresponds to a flow rate of 32 m^3/s, which is extremely low and may occur with a 620-year return period (USAR). The mentioned lowest required level at a flow rate of 32 m^3/s is ensured with a concrete river dam spillway crest at 147.50 elevation. At this flow rate, the ESW system, which ensures ultimate heat sink (UHS), still operates without lowering the sluice gates of the dam on the Sava. If the flow is smaller or nonexistent, UHS operates through ESW via the circulation and cooling of water in the pool/lake formed behind the lowered gates. All climate change scenarios for Slovenia only indicate minor changes in the lowest flow rates of the Sava in the range of ± 5%, therefore no impact is expected on NEK operation from this perspective. Reservoirs built for HPPs on the Sava in the last 15 years represent additional water supplies, increasing the resistance of NEK against low Sava flows. In dry periods, the decrease in flow is predictable and changes take place gradually. The maximum temperature of the Sava that still ensures UHS in the case of normal operation is 29.2°C, and 28.3°C in the case of a state of emergency. Although the temperature of the Sava is gradually increasing due to a number of factors in its basin, these increases are not such as to threaten the reliability of NEK's operation. New HPP reservoirs have also been proven to have a positive effect on the temperature of Sava, most markedly in situations with high air temperatures and low Sava flows.

The above is discussed in the following sections of the EIA Report: 2.7 Ensuring NEK's safe operation, 4.1.2 Meteorological characteristics of the area, climate data, 4.1.9 Flood and erosion risk, 5.6 Impact of climate change on the activity, 5.3.2 Impacts on the thermal pollution of the Sava.

3. The results of atmospheric releases in case of the analysed severe accident scenarios should be presented by numerical values, as the minimum for the concentrations of isotope activities in the vicinity of the Hungarian border and moving forth, and for the estimated resulting doses (all of these taking into account the most adverse winds and other meteorological conditions).

Answer from the EIA Report author:

The report "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) gives a detailed analysis of relevant scenarios for the most severe accidents in conjunction with realistic meteorological data. The results are processed both in terms of relative concentrations X/Q and population doses. An analysis of isotope concentrations was also included for the nearby regions of all neighbouring countries, including Hungary. The methodology and key results were presented in the extended chapter of the EIA Report on transboundary impacts in the event of a radiological accident (Section 6.4 TRANSBOUNDARY IMPACTS IN THE EVENT OF AN EMERGENCY – ACCIDENT).

The relative concentrations X/Q, effective 30-day dose and 30-day thyroid dose, resulting from releases due to the analysed design basis accident and design extension conditions, are presented in the form of tables and charts and in correlation with distance from NEK (from 5 km to 100 km in 5 km increments, and between 100 km and 200 km in 10 km increments).

This is where doses can be identified for the Hungarian border or any other desired distance in the range described. Integrated concentrations of isotopic activity are given in charts for representative isotopes (Cs-134, I-131 and Xe-133) in correlation with distance (for distances from 10 km to 200 km).

The numerical results can be read from the charts. The isotopes were selected with regard to their relevance for dispersion, radiological impact, with regard to their half-life and with regard to their share of a release. The released activities for characteristic isotopes of iodine, caesium, krypton and xenon are presented in tabular form for intervals from the onset to day 1, from day 1 to day 3 and from day 3 to day 30 after the beginning of the accident.

4. As regards radioactive waste, it is not only necessary to present their quantities but also to define the storage capacity available. In consideration of these facts, it should be estimated how long the available capacities are adequate and when the need arises for the implementation of additional measures (e.g. to expand capacity or remove the Croatian share of waste from NEK for processing).

Answer from the EIA Report author:

The design capacity of the storage racks in the radioactive waste storage building (RWSB) is 11,200 drums or 3,000 tube type containers (TTCs), which is the most frequent form of packaging for LILW at NEK. In the given situation, the storage holds 2,217 TTCs and 1,521 drums (Table 21). The RWSB capacity suffices until such a time (2023 to 2025) when, pursuant to the agreement between the Republic of Slovenia and the Republic of Croatia, the public utility services of both countries each take over half of the radioactive waste (Ref.: 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 (BHRNEK)). Information about LILW handling by NEK owners is given in Section 2.19.4.1.

5. In addition to presenting the projected quantity of stored spent fuel, the available storage capacity should be included (including the dry storage capacity under construction). This information should be used as a basis to prove that the available capacity suffices for the quantity of spent fuel generated by the operation of NEK (taking into account the originally planned 40-year operation as well as 20 years of additional long-term operation). If from the beginning of a certain time the available capacity is smaller than the capacity required, information about possible additional measures should also be provided.

Answer from the EIA Report author:

All spent fuel at NEK is currently stored in the spent fuel pool, where 1,694 cells are available in storage racks (Section 4.4.11).

A total of 1,323 fuel elements was stored in the spent fuel pool at the end of 2020, including two special containers with fuel rods and a fission chamber from 2017. Besides that, one hundred and twenty-one (121) fuel elements are located in the reactor (Section 4.4.11). The spent fuel pool enables the safe storage of fuel elements in compliance with the terms and restrictions of operation (requirements in NEK's Technical Specifications). Storage capacities are sufficient even in the case of emergency core unloading (ECU). If NEK operated until the end of 2023, a projected 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; see Section 4.4.11. The spent fuel dry storage facility is under construction and is expected to be completed in the first half of 2023. The spent fuel dry storage facility will provide storage for spent fuel in 70 containers. Each of the containers can contain 37 fuel elements. Sixty-two (62) containers are planned for the storage of SF generated by the operation of NEK until 2043, and the remaining eight (8) containers serve as reserve storage capacities. The first phase of dry storage loading will be carried out in 2023, when the initial 592 spent fuel elements are to be transferred (Sections 2.7.11 and 4.4.11). The available dry storage capacity suffices for the storage of spent fuel generated by the operation of the Krško NPP, including the extension of its operational lifetime from 40 to 60 years until 2043.

6. As regards the measures implemented to improve safety, it should be clearly indicated which of these measures were adopted before stress test analyses (e.g. based on the first and second periodical safety review - PSR) and which of them resulted from analyses and stress test assessments. Furthermore, information should be given about the timely implementation or the estimated delay of safety improvement measures planned until the 2021 deadline, and about the construction of additional SF dry storage with the planned date of operation in 2023.

Answer from the EIA Report author:

The key safety updates and upgrades in the last few decades at NEK are included in Section 2.8. The safety upgrade projects, which were carried out as part of the Safety Upgrade Programme (PNV) on the basis of the national post-Fukushima action plan after the EU stress tests, are set out in Section 2.8.5. All the safety updates in this context have been completed, except for the spent fuel dry storage facility. The spent fuel dry storage, which has been granted a building permit and also assessed for environmental impacts within the transboundary assessment, is under construction and will be finished in the first half of 2023.

NEK safety upgrade projects comprise:

- Installation of passive autocatalytic hydrogen recombiners in the containment (completed in 2013);
- Construction of the system for filtered venting of the containment (completed in 2013);
- Flood safety of NEK facilities (completed in 2017);
- Construction of the emergency control room (completed in 2019);
- Upgrade of the technical and operating support centres (Completed in 2021);
- Alternative cooling of the spent fuel pool (completed in 2020);
- Installation of bypass motor-operated relief valves of the primary system (completed in 2018);
- Alternative cooling of the reactor cooling system and the containment (completed in 2021);
- Construction of the reinforced bunkered building (BB2) with additional water tanks for removal of residual heat from reactor (completed in 2021);
- Alternative auxiliary feedwater - AAF (completed in 2021);
- Alternative safety injection - ASI (completed in 2021);
- Spent fuel dry storage (SFDS) - the estimated time limit for project completion is the first half of 2023;
- Installation of high-temperature seals in the reactor coolant pump (completed in 2021).

In accordance with the applicable legislation and operating licence requirements, NEK performs a Periodic Safety Review (PSR) every 10 years, which is then approved by the authorised administrative body, i.e. the Slovenian Nuclear Safety Administration (URSJV). The first Periodic safety Review (PSR1) was performed in 2003 and involved a comprehensive examination of the level of NEK's nuclear safety. The examination confirmed that NEK was able to operate safely in the following 10 years. The key outcomes/improvements, which stem from the PSR1 action plan and were implemented before the stress tests and post-Fukushima action plan (Section 2.8) are:

- renovation/upgrade of flood protection for the case of a probable maximum flood (PMF) - raising the embankments;
- installation of an additional safety diesel generator - DG3.

The second Periodic Safety Review (PSR2) was performed in 2013. The second Periodic Safety Review re-confirmed that the power plant met the level of safety planned in its design and that it is able to operate safely for at least the next ten (10) years. The PSR2 action plan did not include any significant structural upgrades to the facility, because NEK was already implementing actions B.5.b (related to the WTC attack on 11 September 2001) and had formulated a draft of the Safety Upgrade Programme.

7. A more detailed demarcation of zones of radiological impact (depicted with a map) is necessary, taking into consideration the most severe accident.

Answer from the EIA Report author:

All the key analyses of transboundary radiological impact in the case of accidents are depicted numerically as well as graphically on an appropriate map. The main results are shown in the EIA Report (Section 6.4 TRANSBOUNDARY IMPACT IN THE EVENT OF AN EMERGENCY – ACCIDENT), and all the details in the report "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). The methodology of statistical processing is also described in detail.

2D maps of 95th percentiles of relative concentrations X/Q, effective 30-day doses and 30-day thyroid doses and integrated concentrations of isotope activities are given for distances up to 200 km from the power plant. The spatial resolution of results is in the range between 1 km x 1 km and 8 km x 8 km. The values are depicted using a colour scale, and the borders between countries are added. The maps and distance-based charts can be used to determine the values at a chosen distance. Results are given for the selected design basis accident and design extension conditions.

As evident from the maps, the closest point of the border between Slovenia and Hungary is at a distance slightly more than 100 km from NEK. The value of the 95th percentile of the effective 30-day dose at this distance is, depending on the model used, between 1.26e-2 mSv (RADTRAD + SPRAY X/Q) and 3.66e-2 (LASAT for 2020). In the case of using DIPCOT distribution of 95th percentiles for the effective 30-day dose for 2020, the value in the area of the border with Hungary is approximately 1.1e-2 mSv. That is approximately 1% of the permitted annual dose for the general population and lower than the monthly dose limit (assuming an even exposure throughout the year, the latter is equal to 1mSv/12=8.3e-2 mSv). The 95th percentile of the 30-day thyroid dose at this distance ranges between 7.4e-2 mSv (RADTRAD + SPRAY X/Q) and 6.34e-2 mSv (DIPCOT for 2020). In the case of using DIPCOT distribution of 95th percentiles for the 30-day thyroid dose for 2020, the value at the closest point of the border between Slovenia and Hungary is approximately 6.e-2 mSv. No harmful effects on health are foreseen for such a thyroid dose.

The integrated concentrations of isotope activities in the air (95th percentiles spatially) at a distance of 100 km are approximately 1.4e5 Bq-s/m^3 (or 1e5 in DIPCOT 2D distribution of the 95th percentile of all weather situations for 2020 at the point on the Slovenian-Hungarian border closest to NEK) for Cs-134, approximately 4.6e5 Bq-s/m^3 (4e5 in DIPCOT 2D distribution of the 95th percentile of all weather situations for 2020 at the point on the Slovenian-Hungarian border closest to NEK) for I-131, and approximately 6.3e9 Bq-s/m^3 (4e9 in DIPCOT 2D distribution of the 95th percentile of all weather situations for 2020 at the point on the Slovenian-Hungarian border closest to NEK) for Xe-133. The 95th percentile spatially at 100 km for integrated concentrations of isotope activities is always greater than the value at the point on the border between Slovenia and Hungary which is closest to NEK.

8. The values of activity concentrations and the expected values of doses on the Hungarian border are to be presented for the event of disrupted operation with the maximum expected release of radioactive material. The expected environmental, radiological and health effects and consequences of the event should be assessed, and the characteristics of the event, its trigger factors and processes, radioactive releases and the methodology used in the analyses should be described.

Answer from the EIA Report author:

As stated before, the relative concentrations X/Q, effective 30-day dose and 30-day thyroid dose and integrated isotope activity concentrations for distances up to 200 km from NEK are given for a limited design basis accident (large break loss of coolant accident – LB LOCA) and a severe accident resulting in core melting and melt relocation to the containment sump (SBO with no action taken in the first 24 hours). In the context of both design basis accidents and design extension conditions, it is these two accidents which constitute the greatest expected releases. A detailed and realistic model for atmospheric dispersion was used for distances up to 100 km and two simplified models from RODOS were used for distances up to 200 km. Likewise, all information was provided which is necessary to understand the methodology used and the assumptions for calculations.

The expected radiological consequences of a DEC-B accident at NEK for the location of the closest point on the border between Slovenia and Hungary are given above. The doses from LB LOCA are lower by an order of magnitude. The 95th percentiles of the effective 30-day dose at this distance are, depending on the dispersion model used, between 4.e-4 mSv (RADTRAD + SPRAY X/Q) and 9.e-4 (LASAT for 2016). However, if the 95th percentile of the 2D distribution of the effective 30-day dose calculated with DIPCOT for 2020 is applied, the value at the border between Slovenia and Hungary is approximately 4.1e-4 mSv (and the corresponding 95th percentile value is 5.1e-4 mSv). That is negligible in comparison with the natural background, which amounts to ca. 2.5 mSv a year.

The 95th percentile of the 30-day thyroid dose at this distance ranges between 5.8e-3 mSv (RADTRAD + SPRAY X/Q) and 4.8e-3 mSv (DIPCOT for 2020). However, if the 95th percentile of the 2D distribution of the 30-day thyroid dose calculated with DIPCOT for 2020 is applied, the value at the point on the border between Slovenia and Hungary closest to NEK is approximately 3.6e-3 mSv. No harmful effects on health are foreseen for such a thyroid dose. As above in the case of SBO, the values for the point on Slovenian-Hungarian border closest to NEK are lower than the corresponding spatial 95th percentile at a distance of 100 km.

The integrated concentrations of isotope activities in the air (95th percentile spatially) at 100 km distance are approximately 1.1e4 Bq-s/m^3 for Cs-134, approximately 4.e4 Bq-s/m^3 for I-131 and approximately 3.e7 Bq-s/m^3 for Xe-133. As shown earlier, the 95th percentile spatially at 100 km is always greater than the value at the point of the border between Slovenia and Hungary which is closest to NEK.

9. The testing methodology used and the baseline and reference data used in performing the above calculations and analyses should also be examined in order to ensure that the partial results are in compliance with international requirements and practices.

Answer from the EIA Report author:

The models used in the modelling system were originally designed to simulate weather conditions of the atmosphere and the dispersion of light pollutants in the atmosphere over challenging, complex terrain. They were validated (compared with measurements in the natural environment) by the manufacturers on various sets of data /222/, /223/.

In addition, before being used for NEK EIA, we abundantly validated the models on an area of Slovenia positioned in a challenging part of the target 200 km x 200 km domain.

The WRF model was tested in the areas of Zasavje, Šoštanj and Krško. The terrain in all these areas is very complex. We compared forecasts with measurements at ground meteorological stations on hills and in basins and wind measurements with SODAR in Šoštanj (vertical wind profile up to 1,000 m above terrain). WRF was likewise extensively tested in the area of NEK. We compared forecasts and measurements at ground meteorological stations in the broader area, measurements on a 70-metre tower near NEK and measurements made with SODAR and RASS (vertical wind profile and temperatures up to 500 m above terrain).

The WRF model proved to be a very good model for forecasting weather in this area /213/, /214/, /215/. The ARIA Industry model system (SURFPro, Minerve, Spray) was also abundantly tested in the area of Šoštanj and partly in the area of Zasavje. For the Šoštanj area, we have a scientifically recognised set of data at our disposal for testing dispersion models over the very complex terrain of Velenje basin surroundings with weak winds and temperature inversions. This data set is from the Šoštanj-91 measurement campaign, where SO2 from the Šoštanj Thermal Power Plant was used as a tracer in model testing. The emission and environmental concentrations, and meteorological measurements are available in half hour increments /216/. The model system was tested on Šoštanj-91 data also in combination with re-analyses of meteorological fields conducted with the WRF model. The model system was used with success to illustrate concentrations of pollutants, and good congruence was determined for location and time. We carried out the validations in the framework of Slovenian research projects and within the task of testing models for modelling dispersion into the surroundings of nuclear power plants. This task was directed by MEIS in the MODARIA I and MODARIA II programmes at IAEA /218/, /219/. We also calculated relative concentrations using data from the Šoštanj-91 measurement campaign. The values are in the same range as the data calculated for NEK's surroundings.

Linking the EIA calculations with the validated placements of the model

The ARIA Industry models (SURFPro, Minerve, Spray) used together showed a satisfactory congruence of the measured and calculated concentrations on the Šoštanj-91 set of validation data /216/, /217/, /218/, /219/. The calculations were performed using measured meteorological data from 6 ground meteorological stations located in the basin and in the hills and SODAR measurements for a 15 km x 15 km area.

We call such a local layout of the modelling system a reference modelling system. We did not carry out tracking tests at the NEK site. As the complexity of the terrain and the meteorology are a little less demanding than in Šoštanj, we can reasonably assume that the model used in a similar way will give similarly good results. That is why we also made calculations for the 25 km x 25 km area using meteorological measurements (RASS and ground stations) taken around NEK. We call this use the NEK reference modelling system /211/. Then in two further steps we added expansions which illustrate by how much the results of the dispersion change statistically if we use forecast meteorology /211/, /212/, /215/, /216/ from WRF and/or if we expand the area to 200 km x 200 km. All the details about the NEK reference modelling system are gathered in article /211/.
We used meteorological data from 4 ground stations and data on the vertical wind and temperature profiles (SODAR, RASS) up to a maximum of 500 m above the level of the basin.

By using this measured meteorological data from the 200 km x 200 km area as an intermediate result, we have checked the congruence in the vicinity of NEK between the results of the NEK reference modelling system and the 200 km x 200 km system. We found that the congruence is satisfactory.

10. The solutions and functioning of power plant systems for the monitoring of emissions and the environment should be described in detail (e.g. sampling frequency, sample preparation, measurement methods, measuring instruments and their capacity and efficacy, detection limits, how measurement results should be evaluated, reporting of data and reporting responsibilities).

<u>Answer from the EIA Report author:</u>

Monitoring during accidents with atmospheric releases

The monitoring consists of emission and environmental monitoring.

Emission monitoring consists of automatic monitoring and periodic manual monitoring. Automatic monitoring is carried out to monitor the activities of radionuclides in releases from NEK.

The monitors are connected into the database of NEK's ecological information system (EIS NEK), and this base is fully automatically connected with the DOZE programme for population dose assessment during accidental releases or normal operation.

Environmental monitoring consists of automatic monitoring and periodic manual monitoring which follows an implementation plan.

Automatic monitoring comprises:

- automatic monitoring of radioactivity in the environment,
- automatic monitoring of meteorological variables of the atmosphere as a basis for modelling radionuclide dispersion in the atmosphere,
- dedicated 7-day forecast of weather in half-hour increments and, on its basis, automatic prediction of radionuclide dispersion in the atmosphere.

Automatic monitoring of radioactivity in the environment comprises:

- NEK automatic monitoring of radioactivity in the environment:
  - → a circle of independent gamma dose rate meters in the Krško basin,
  - → 4 gamma dose rate meters at meteorological stations around NEK,
  - → gamma dose rate meters on the NEK perimeter fence,
  - → a spectrometer on a NEK mobile unit.

- URSJV automatic gamma dose rate monitoring across Slovenia, and
- URSJV automatic spectrometers in NEK and across Slovenia.

From URSJV, URSJV and NEK data are automatically displayed on their websites and transmitted to the European EURDEP system and also displayed for the public on their website.

Automatic monitoring of meteorological variables of the atmosphere as a basis for modelling radionuclide dispersion in the atmosphere comprises:

- 4 ground automatic meteorological stations,
- RASS (vertical wind profile and temperatures to a maximum of 500 m).

All meters are part of EIS NEK. The EIS NEK base is fully automatically connected with the DOZE programme for population dose assessment during accidental releases or normal operation.
Dedicated 7-day forecast of weather and dispersion in half-hour increments for radionuclide emissions into the atmosphere:
Prediction of weather and dispersion is automatically carried out by MEIS, which transmits the data to NEK once a day; each packet contains data for the current day and the next 6 days for each half an hour at 2 km spatial resolution. The prediction of atmospheric dispersion feeds directly into the DOZE software system for population dose assessment.

DOZE automatic data preparation and population dose prediction system

Automatic monitoring of emission variables, automatic monitoring of meteorological variables of the atmosphere and dedicated 7-day weather prediction are combined in a comprehensive system for predicting doses to the population in the event of an accidental release of radionuclides from NEK into the atmosphere.

The system runs automatically to the point of preparing relative concentrations X/Q. At all times, NEK and URSJV experts have access to relative concentrations X/Q for the past and present (calculated from diagnostic measurements) and prognostic relative concentrations X/Q for the current day and for 6 days in advance in half-hour increments.

The DOZE software package uses all of the automatically collected data, and it also enables manual entry of data, so as to allow the user to assess an accident involving releases into the atmosphere on the basis of measurements or pre-prepared scenarios, and calculate the resulting doses to the population. The DOSE software package is used by NEK, URSJV and the Civil Protection Service.

The whole system – the methodology, measurements and modelling system which together enable the diagnosis and prediction of population doses by using dispersion models - is described in detail in a research article (Mlakar 2019).

The system is also used to assess regular releases.

In its 2003 report, OSART (International Atomic Energy Agency, 2003) described the system as a case of good practice:
"Good practice: A special tool for the assessment of radiological consequences in the environment has been developed. It utilizes a more realistic dispersion model, Lagrangian particle model instead of the simple Gaussian, to calculate dispersion. This accurate modelling is very important in areas with a complicated meteorological modelling environment, such as Krsko." (**Slovenian translation:** "Dobra praksa: Razvito je bilo posebno orodje za oceno radioloških posledic v okolju. Za izračun disperzije uporablja bolj realističen model disperzije, Lagrangeev model delcev, namesto preprostega Gaussovega. To natančno modeliranje je zelo pomembno na območjih z zapletenim meteorološkim modeliranjem, kot je Krško.").

In 2017, when the system was upgraded with dispersion prognosis, it was assessed by OSART as good performance:
"It was also noted that the plant organization has enhanced the capability for off-site radiological monitoring by using plant-specific dose assessment software, which is fed on-line with meteorological data and uses the Lagrangian Particle Model to calculate accurate dispersion factors for site specific characteristics, and having available a mobile laboratory for quick sample analysis. The plant considers that this enhanced capability, which includes a prognosis application, allows a more accurate and prompt estimation of off-site radiological consequences, in support of the issuance of protective action recommendations for the public. The team considered this as a **good performance**." (International Atomic Energy Agency, 2017).

11. A description should be given about special technological and organisational measures designed to prevent, avoid, eliminate and mitigate events which are not usual (abnormal radioactive releases), minimise environmental damage and control releases in case of the failure of systems for environment and emission control.

<u>Answer from the EIA Report author:</u>

A high level of attention was paid to nuclear safety in the phase of planning the reactor and designing the power plant. Section 2.7 describes all safety systems that ensure the safe operation of NEK. These safety systems prevent the uncontrolled release of radioactive material into the environment. They are designed to provide safety functions in all operational states, even in the event of specific equipment failure. Section 2.8 describes the key safety characteristics of the power plant, including a list of safety updates and upgrades to NEK, which were implemented to improve the safety and efficiency of its operation. Further on, Section 2.12 gives a description of the systems and devices for preventing and mitigating accidents, which serve to detect deviations from the normal operating states of the power plant, to alert operators and activate all other safety systems if the deviations of the power plant's safety parameters exceed the set limit values. The power plant possesses the instrumentation and systems for operational state assessment, nuclear safety assessment and emergency management, as well as operative procedures for normal operation and for the management of abnormal states (AOP), emergencies (EOP) and severe accident states of the power plant (SAMG). The common task of all these safety systems is to prevent an uncontrolled release of radioactive substances into NEK's surroundings in all operating conditions and types of accident. Continuous radiological monitoring in all states of the power plant is carried out on-site and off-site within the radiological monitoring of technological process and effluents, the radiological monitoring of technological facilities and the system for radiological monitoring upon the onset of an emergency. In the event of a radiological monitoring system failure, an additional autonomous, mobile system for radiological monitoring is used, which has its own power supply and wireless data transmission, enabling continuous mobile measurements and radiological monitoring during normal operation or during a major release of radioactive material in emergency conditions.

7. MEASURES TO PREVENT, REDUCE, AND OFFSET THE IDENTIFIED SIGNIFICANT HARMFUL IMPACTS ON THE ENVIRONMENT

7.1 ENVISIONED SOLUTIONS AND MEASURES

This section sets forth the prescribed measures and solutions that should be highlighted in particular (not all of the measures stipulated by regulations are listed – regulations that must be observed in the activity (LTE) are given in section 2.20), the measures and solutions envisaged in the scope of the project, which the developer is implementing and will continue to implement after the changes (operational lifetime extension).

7.1.1 Operation

7.1.1.1 Waters, including thermal pollution

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime

- **Measures stemming from regulations**

➢ Ordinance on NEK's development plan (Official Gazette of the SRS, No. 48/87, Official Gazette of RS, Nos. 59/97 and 21/20)

- Article 15; The quality of treated water and the treatment plant must comply with the requirements set out in the issued water management opinion.
- Article 18; When monitoring the thermal pollution of the Sava, the discharge (intake) rate of the Sava into the groundwater, the temperature of which cannot rise above 15 degrees Celsius, shall also be monitored. The conditions for the abstraction and discharge of cooling water from or into the Sava are laid down in the water management consent. Due to the cooling water's impact on the Sava’s temperature, regular controls need to be carried out of the Sava’s impact on the temperature of groundwater.
- Article 21; An independent meteorological station is mandatory throughout the operation of NEK. The programme of measurements must be aligned with the programme of measurements and the methodology that applies to the global meteorological network to which the station must be telemetrically linked. The programme of measurements shall be defined by way of a decision by the Slovenian Nuclear Safety Administration (URSJV).

- **Measures stemming from the environmental permit**

➢ Compliance with the provisions set out in the environmental permit regarding emissions into waters, the permitted quantities of water abstracted from the Sava, and on-site pumping of water from wells:

  - use of technology that consumes as little water as possible, recirculates water and uses other water-saving methods and techniques, use of raw materials less harmful and dangerous to the environment and employees in the maintenance of water drainage systems and treatment plants in the technological process wherever possible,
  - priority treatment of partial flows of industrial wastewater and the separation of waste substances at the location of their production,
  - safe and environmentally acceptable removal of sludge,
  - recycling of waste substances, heat recovery and efficient use of raw materials and energy,
  - prioritised use of membrane processes such as microfiltration, reverse osmosis and electrodialysis,

- preventing the discharge of waste chemicals used in water preparation into the sewage system or directly into a watercourse,
- use of chlorine-free cleaning and disinfection agents,
- for the preparation of water, the use of chemicals in relation to which the safety data sheet states that more than 80% of the chemicals (measured using SIST ISO 7827 test methods) are broken down by micro-organisms within 14 days,
- avoidance of the use of ethylenediaminetetraacetic acid, its homologs and salts, and other aminopolycarboxylic acids and their homologs and salts,
- avoidance of the use of organometallic compounds, chromates and nitrites,
- use of a circulation cooling process with the lowest possible losses of water circulating in the cooling system or with the lowest possible condensation coefficient,
- repeated use of cooling water by means of successive positioning of flow cooling systems,
- consistent separation of cooling systems from other wastewater systems,
- priority use of surface condensers and discontinuation of the use of mixed condensers,
- use of corrosion-resistant materials or combinations of materials, the use of passive or active measures to protect against corrosion of cooling systems, and the adjustment of measures for the conditioning of circulating water to the properties of the materials of the cooling system,
- avoidance of the use of chromates, nitrites, mercaptobenzothiazoles and other imidazoles as anti-corrosion agents,
- avoidance of the use of zinc compounds as anti-corrosion agents in the main cooling circuits of power plants,
- prevention of the growth of microbes in cooling systems by employing measures such as excluding empty spaces in pipes, discontinuing the use of organic polymers with a high proportion of monomers or occasionally using biocides to prevent the growth of micro-organisms,
- avoidance of the continuous use of biocides, with the exception of hydrogen peroxide, ozone or UV rays,
- avoidance of the use of organic mercury, organostannic or other organometallic compounds (bindings of metal and hydrogen),
- avoidance of the use of quaternary ammonium compounds,
- when using dispersal agents, the use of non-toxic substances in relation to which the safety data sheet states that more than 80% of the chemicals (measured using SIST ISO 7827 test methods) are broken down by micro-organisms within 14 days,
- consideration of eco-toxicological data on safety data sheets for the chemicals used,
- avoidance of the use of ethylenediaminetetraacetic acid (EDTA) and diethylenetriaminepentaacetic acid (DTPA), and their homologs and salts,
- avoidance of the use of other aminopolycarboxylic acids, their homologs and salts as dispersal agents or hardness stabilisers,
- use of chlorine, bromine or bromine-releasing biocides in pulse treatment only.

➢ The limit emission value of transmitted heat in the 24-hour average for the removal of wastewater into the Sava via discharges V1 and V7 is equal to 1. The client must ensure that the synergetic action of the discussed discharge of industrial cooling waters and other discharged wastewaters does not cause the Sava to exceed its natural temperature by more than 3 K at any time of the year. The client must activate the cooling water recirculation system in a timely manner via the cooling towers so that the temperature of the Sava does not exceed the natural temperature by more than 3 K. If the combined cooling system is insufficient to fulfil this condition, the client must reduce the power of the power plant accordingly.

→ *Compliance with the limit values specified in the environmental permit.*

→ *Prevention of surface water and groundwater pollution.*

- **<u>Additional measures that the developer has implemented or is carrying out</u>**

➢ Expansion of the cooling tower system, which reduces the quantity of water abstracted from the Sava, reduces the heat load, and increases resilience to climate change. Four new cooling cells (a new cooling tower – CT3) were installed, and all the electrical equipment of the cooling tower system was replaced. The expansion was carried out in 2008 and it increased the power of the cooling towers by 36%. The emission value of transmitted heat in the 24-hour average is maintained below 1.

7.1.1.2 <u>Climate change</u>

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime

- **<u>Measures stemming from regulations</u>**

In addition to the measures set forth in Section 7.1.1.1, NEK implements the measures below that stem from legislation.

Article 7 of the Decree on the use of fluorinated greenhouse gases and ozone-depleting substances (Official Gazette of RS, No. 60/16) stipulates:

➢ the obligation of the operator to report stationary equipment, and the obligation of the operator, maintenance provider and authorised company to report the use, capture, and delivery of waste fluorinated greenhouse gases and waste ozone-depleting substances to the waste collector. NEK reports the presence of stationary equipment containing fluorinated greenhouse gases (F-gases) and SF6 gas to ARSO (Slovenian Environment Agency). F-gases are present in the equipment for cooling, air-conditioning and the heat pumps, and the fire-extinguishing equipment, while SF6 gas is present in the circuit breakers and switchgear.

- **<u>Measures stemming from the environmental permit</u>**

➢ the structures, systems and components of the power plant are dimensioned to withstand extreme weather events and meteorological parameters with highly conservative margins, in view of nuclear legal framework requirements, global practices and Best Available Techniques (BAT);

➢ the periodic safety review, which is performed every 10 years, includes a deep analysis of the impact of extreme weather events on the safety of the power plant. Two reviews will be performed in the period to come (2021-2023 and 2031-2033);

➢ measures from the environmental permit related to limitation of the heat load and water collection through the use of a combined cooling system (flow system and cooling towers). In all river flow conditions of the Sava, the power plant maintains a temperature difference of no more than ΔT 3°C, which will not change in the power plant's future operation. In 2008, NEK supplemented its cooling facilities with the construction of a third block of cooling towers.

➢ NEK has preparation procedures in place for the event of hydrological conditions that may affect the plant's operation: activation of cooling towers at high water levels due to the risk of inflow of debris (branches, plastic etc.);

➢ NEK has procedures in place for cooperation with other energy facilities on the Sava – the Agreement on measures and obligations to ensure unchanged, safe and uninterrupted operation of NEK during the operation of HPP on the lower Sava with additional monitoring activities on the Sava;

➢ on-site measurements of meteorological parameters are carried out at the automatic station with the 70-metre-tall meteorological tower and the use of SODAR for high-altitude atmospheric measurements. The measurements are reported on a yearly basis.

→ *Compliance with the limit values specified in the environmental permit.*

→ *Prevention of surface water and groundwater pollution, and resilience to climate change.*

7.1.1.3 Waste

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime.

- **Measures stemming from regulations**

Rules on Radioactive Waste and Spent Fuel Management (Official Gazette of RS, No. 125/21):

- Management of radioactive waste and spent fuel is carried out in accordance with written procedures.
- It is ensured that radioactive waste or spent fuel is managed in accordance with the radioactive waste or spent fuel management programme.
- Radioactive waste is sorted with regard to its aggregate state and by category and type.
- The packaging used for packing radioactive waste and spent fuel, in combination with the inserted radioactive waste or spent fuel, must ensure safety for the planned manner and time period of handling the containers.
- NEK conducts periodic checks to make sure the packaging meets the requirements for temporary or long-term storage.
- All containers containing radioactive waste or spent fuel containers must be labelled with the warning symbol for radiation hazard as specified in the regulation governing the use of radiation sources and radiation practice, and a label that identifies each container and its contents;
- NEK holds radioactive waste in temporary storage until it is handed over to the storage facility, public service provider or until it is cleared for release from control.
- Radioactive waste is stored in the radioactive waste storage facility, and spent fuel in the spent fuel storage facility.
- NEK ensures storage for all radioactive waste and all spent fuel which is not subject to processing, relocation or temporary storage.
- The storage facility may provide storage for radioactive waste or spent fuel which meets the criteria for acceptance into storage under Article 20 of these rules.
- Radioactive waste or spent fuel may be stored only in packaging approved for storage.
- NEK implements the storage of spent fuel and HLW in such a way as to prevent criticality and ensure the removal of residual heat.
- NEK, which is bound by international commitments relating to nuclear material security and record-keeping, stores radioactive waste and spent fuel in a way that allows the implementation of these commitments.
- Radiation activities must be carried out in such a manner that the releases of liquid or gaseous radioactive waste into the environment do not exceed the approved limit values.
- NEK keeps records of radioactive waste or spent fuel as regards:
  - their storage,
  - their processing in the technological process,
  - their storage or release,
  - clearance, recycling or reuse,
  - their delivery to the public service provider and
  - temporary or permanent export or shipment abroad.

- If the collected wastewater exceeds the clearance levels for the release of radioactive material from radiological control, it is treated as secondary radioactive waste that is processed at NEK.
- If the collected wastewater does not exceed the clearance levels for release of radioactive material from radiological control and if it meets the criteria for municipal wastewater, it is discharged into the internal water treatment plant.
- If the collected wastewater exceeds the criteria for discharge to the sewage system, it is dispatched for treatment to an authorised collector or processor of such waste.

→ *Prevention of soil, surface water and groundwater pollution, and prevention of uncontrolled releases of ionising radiation into the environment.*

- **Measures planned within the SF dry storage project**

- The work platform in front of the dry storage building (DSB) and the loading/unloading area in DSB are equipped with drainage pits. Any water collected will be removed using mobile devices. Sampling will be carried out before the pits are emptied. In the event that the limit values for discharge are exceeded (Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system, Official Gazette of RS, Nos. 64/12, 64/14 and 98/15), a special container will be used to transport the wastewater to the technological section of NEK for processing.

  → *Prevention of soil, surface water and groundwater pollution.*

- Before pumping water from the CTF (in the event of leakage from a HI–TRAC VW transfer overpack), radiological and chemical monitoring of the collected water is performed.
- If the collected wastewater exceeds the clearance levels for the release of radioactive material from radiological control, it is treated as secondary radioactive waste that is processed at NEK.
- If the collected wastewater does not exceed the clearance levels for release of radioactive material from radiological control and if it meets the criteria for municipal wastewater, it is discharged into the internal water treatment plant.
- If the collected wastewater exceeds the criteria for discharge to the sewage system, it is dispatched for treatment to an authorised collector or processor of such waste.

  → *Prevention of soil, surface water and groundwater pollution.*

7.1.1.4 Nature

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime.

- **Measures stemming from regulations**

Article 8 of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14 and 98/15) stipulates the limit emission value of transmitted heat in the discharge of industrial wastewater, which is:

- 0.8 for discharges into a watercourse section which is classified as cyprinid water by the regulation governing the designation of surface water sections important for freshwater fish species,
- 0.6 for discharges into a watercourse section which is classified as salmonid water by the regulation in the previous indent,
- 1 for discharges into a watercourse section which is not a section of a watercourse referred to in the first or second indent of this paragraph.

- **Measures stemming from the environmental permit**

- The limit emission value of transmitted heat in the 24-hour average for the removal of wastewater into the Sava via discharges V1 and V7 is equal to 1. The client must ensure that the synergetic action of the discussed discharge of industrial cooling waters and other discharged wastewaters does not cause the Sava to exceed its natural temperature by more than 3 K at any time of the year. The client must activate the cooling water recirculation system in a timely manner via the cooling towers so that the temperature of the Sava does not exceed the natural temperature by more than 3 K. If the combined cooling system is insufficient to fulfil this condition, the client must reduce the power of the power plant accordingly.

  → *Prevention of excessive thermal pollution of the Sava.*

  → *Preventing the deterioration of temperature conditions for organisms in the Sava.*

- **Additional measures that the developer is already carrying out**

- If the flow rate of the Sava is less than 100 m^3/s, NEK activates the cooling towers, which employ circulation to cool a portion of condenser water.
- Expansion of the cooling tower system – four new cooling cells (a new cooling tower – CT3) were installed, and all the electrical equipment of the cooling tower system was replaced. The expansion was carried out in 2008 and it increased the power of the cooling towers by 36%.
  - → *Prevention of excessive thermal pollution of the Sava.*
  - → *Preventing the deterioration of temperature conditions for organisms in the Sava.*

7.1.1.5 Ionising radiation

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime

- **Measures stemming from the operating licence**

The valid NEK 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) sets out the following restrictions:

- The maximum permissible annual effective dose from emission of radioactive material at 500 m from the reactor centre: 50 µSv;
- Limit on the annual activity of fission and activation products in liquid discharges: 100 GBq;
- Limit on the quarterly activity of fission and activation products in liquid discharges: 40 GBq;
- Limit on the annual activity of H-3 in airborne discharges: 45 TBq;
- Limit on the annual activity of iodine in gaseous discharges: 18.5 GBq;
- Limit on the annual activity in dust particles: 18.5 GBq;
- Limit on the annual effective dose of external radiation on the NEK perimeter fence: 200 µSv.
  - → *The implementation of these measures will ensure compliance with all radiation conditions and limits set out in the valid NEK operating licence.*
  - → *Population health protection.*

The restrictions for SF dry storage facility operation are as follows:

- Permissible dose rate on the exterior of the dry storage facility: 3 µSv/h (Rules on radiation protection measures in controlled and monitored areas, Official Gazette of RS, No. 47/18, Article 4)
- After the SF is placed in storage in the dry storage facility, the annual effective dose of external radiation at the NEK perimeter fence shall not exceed the limit of 200 µSv (valid operating licence).
- The effective dose limit for exposed workers is 20 mSv per year (Article 35 of the ZVISJV-1).
  - → *The implementation of these measures will ensure compliance with all radiation conditions and limits set out in the valid NEK operating licence and in the Ionising Radiation Protection and Nuclear Safety Act (Official Gazette of RS, Nos. 76/17 and 26/19).*
  - → *Population health protection.*

- **Measures planned within the SF dry storage project**

To ensure that the above limits for dry storage are not exceeded, the following measures are planned within the project:

- Adequate structural protection (the thickness of the concrete walls of the dry storage facility is adequate to ensure protection against gamma radiation, and the walls are lined with neutron radiation protection material
- In order to monitor the impact of the dry storage facility on radiation parameters at the NEK perimeter fence, radiation will be measured using dosimeters:
- dosimeters for measuring gamma radiation and neutron radiation are to be installed in a spot which is closest to the spent fuel dry storage building, while an additional 3 dosimeters on each side will follow each other at a distance of 10 metres. The proposal is to install 7 gamma radiation dosimeters and 7 neutron radiation dosimeters.

Once the SF dry storage facility has been built, passive dosimeters will also be installed in the storage area of the spent fuel dry storage facility;

- Dosimeters will be installed in the northwest and southwest corners of the storage area; the upper dosimeter will be placed just below the roof structure, the lower dosimeter above the height of the partition wall, and the middle dosimeter halfway in height between the upper and lower dosimeter. Three dosimeters are thus planned for each of the two corners, or a total of six dosimeters in the DSB.
- Dosimeters will be read and replaced at least once every 6 months.
- During the transport of spent fuel from the fuel handling building to the SF dry storage facility, a controlled area will be established along the transport routes, that is, the area will be cordoned off, marked, and unauthorised access will be prevented.

- **Additional measures that the developer is already carrying out**

- Filtration of liquid emissions;
- Filtration of gaseous emissions;
- Confinement of radioactive releases in order to minimise radioactivity through radioactive decay;
- Measures to ensure fuel integrity;
- Design and implementation of structural protection (adequate wall thickness, labyrinth design of the rooms);
- Installation of temporary shields for short term activities that result in locally increased levels of external radiation;
- Storage of radioactive waste and spent fuel at dedicated facilities intended for this purpose.
  - → *The implementation of these measures will ensure compliance with all radiation conditions and limits set out in the valid NEK operating licence.*
  - → *Population health protection.*

7.1.1.6 Material assets

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime

- **Measures stemming from regulations**

There are no special legislative measures covering material assets during operation. The measures taken into account are those set out for individual relevant factors (see Sections 7.1.1.1, 7.1.1.3, 7.1.1.5 and 7.1.1.7).

- **Additional measures that the developer is already carrying out**

All the measures that the developer is carrying out and are listed in the previous sections (see Section 7.1.1.5).

7.1.1.7 Risks of environmental and other accidents

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime

- **Measures stemming from regulations**

  - Ordinance on NEK's development plan (Official Gazette of the SRS, No. 48/87, Official Gazette of RS, Nos. 59/97 and 21/20), Article 10, Paragraph 10:

10. Solutions and measures applying to defence and to protection against natural and other disasters, including protection against fire.

The dry storage facility shall be constructed taking into account:
- 0.78 g design-basis ground acceleration,
- the effects of strong winds,
- heavy rainfall. For this purpose, a water holding tank is built under the access platform to prevent the overloading of the existing sewerage system. Furthermore, overflows are planned on the roof to enable the overflow of rainwater in the event of exceptional rainfall.
- safety from extreme flooding (PMF) to the elevation of 157.53 m a.s.l. The facility is sealed against floods with exterior RC walls, and water intrusion through the door is prevented with removable flood barriers,
- snow load,
- lightning strikes; the facility is made of steel and reinforced concrete. The facility earthing is designed for lightning strikes,
- extreme outdoor temperatures,
- potential explosion. The dry storage facility is built using solid reinforced concrete walls and a steel framework, which would, e.g. in the case of an airplane collision, considerably decrease the kinetic energy of the airplane. In addition, the high mechanical strength and large mass of the facility's steel and concrete shell protects the multi-purpose canister (MPC) containing spent fuel against any final impact and potential explosion.
- The external and internal effects of combined earthquake & flood and earthquake & fire events are also taken into account in the construction. The dry storage system is designed for high seismic stress, as well as flood.

Fire safety measures:
- the potential spread of fire to adjacent structures and land is restricted by the use of fire-resistant materials,
- evacuation exits from the facility are provided on the northwest and southwest side of the building,
- water for fire suppression is provided through the existing hydrant network and the NEK pumping station,
- the existing emergency access routes within the Krško NPP complex provide access for firefighting vehicles from the eastern and southern side of the facility; A work area is provided for firefighters on the driveway to the east of the facility.
- The use of hazardous substances on the construction site (fuel for diesel motors, lubricants, paints, etc.) is restricted to areas equipped with oil traps to prevent spillage into the environment.

Further measures taken into account are those set out for individual relevant factors (see Sections 7.1.1.1, 7.1.1.3, 7.1.1.5).

- **Measures planned within the SF dry storage project**

➢ All the measures listed in the previous sections (see Sections 7.1.1.3 and 7.1.1.5).

- **Additional measures that the developer is already carrying out**

- All the measures that the developer is carrying out and are listed in the previous sections (see Sections 7.1.1.5 and 7.1.1.4).

7.1.1.8 Population and human health

Measures that the developer is already implementing and must continue to implement during the extended operational lifetime

- **Measures stemming from regulations**

There are no special legislative measures covering material assets during operation. The measures taken into account are those set out for individual relevant factors (see Sections 7.1.1.1, 7.1.1.3, 7.1.1.5, 7.1.1.7).

- **Additional measures that the developer is already carrying out**

All the measures that the developer is carrying out and are listed in the previous sections (see Section 7.1.1.5).

7.1.2 Termination of activity

7.1.2.1 Radioactive waste and ionising radiation

- **Measures stemming from regulations**

- The decommissioned area will still have limited access, be marked out and considered a radiologically monitored area.
- All activities associated with the cessation of operation will be carried out in accordance with the requirements of regulations, the management system and written work procedures and instructions.
  - → *The implementation of these measures will prevent uncontrolled emission of ionising radiation into the environment.*

7.2 ADDITIONAL MEASURES IN VIEW OF THE ESTIMATED TOTAL OR NET ENVIRONMENTAL BURDEN

NEK is already implementing measures that prevent an excessive environmental burden. No additional measures are required given the estimated total environmental burden.

7.3 POSSIBLE ALTERNATIVE MEASURES

No alternative measures were studied prior to adopting the measures described above, since no feasible and more effective alternatives were identified. The ongoing activity represents the current operation of the developer, who, in addition to meeting the prescribed obligations, plans and implements additional measures in several areas, both technical and organisational, in order to minimise environmental impacts, while regularly monitoring the effectiveness of these measures. The environmental burdens are within the permitted limits, and the planned change, which does not increase production capacity, but extends the operational lifetime of NEK (under the same environmental and radiation conditions as set out in the existing operating licence), will have a negligible effect on increasing the existing environmental burdens resulting from the operation of NEK.

8. MONITORING THE STATUS OF IMPACT MITIGATION FACTORS AND MEASURES

8.1 OPERATION

8.1.1 Waters

Sampling and analysis of wastewater, collected in the CTF drain sump, must be ensured in the event of leakage from the HI-TRAC VW transfer overpack (which also contains glycol in winter). In any HI-STORM leakage event, sampling and analysis of collected water in the drain sump should be performed, taking into consideration the Rules on initial measurements and operational monitoring of wastewater (Official Gazette of RS, Nos. 94/14, 98/15) and the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14, 98/15).

8.1.1.1 Use of water for technological purposes

Mode: measurements of the amount of water intake*

Methods: in accordance with legislation and water permits

Location: sampling locations specified in water permits

Timetable: continuous

* 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, Decision No. 35536-26/2011-9 of 23 May 2013, Decision No. 35530-7/2018-2 of 22 June 2018, Water Permit No. 35530-100/2020-4 of 14 November 2020, and Water Permit No. 35530-48/2020-3 of 9 September 2021.

8.1.1.2 Wastewater

Mode: measurements of pollution parameters and wastewater amounts, performed by an authorised contractor

Methods: in accordance with the Rules*, the Decree**, and the Environmental permit ***

Locations: measuring points in accordance with the Environmental permit***

Timetable: operational monitoring in accordance with the Decree** and the Environmental permit***

* Rules on initial measurements and operational monitoring of wastewater (Official Gazette of RS, Nos. 94/14, 98/15)

** Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system (Official Gazette of RS, Nos. 64/12, 64/14, 98/15, 203/20)

*** Environmental permit concerning emissions to water (Slovenian Environment Agency, No. 35441-103/2006-24 of 30 June 2010), which was amended in three points of the operational part (points 1.1, 1.4 and 1.8 of the Environmental permit). Decision No. 35441-103/2006-33 of 4 June 2012 reaffirmed the Environmental permit, which was amended (point 1.5, Table 3) under decision No. 35444-11/2013-3 of 10 October 2013.

In order to determine whether the concentrations of sedimentary matter and undissolved substances are due to the power plant or to elevated concentrations in the Sava, measurements of parameters at the entrance to the system should be carried out, if the conditions in the Sava at the time of sampling clearly indicate elevated concentrations of sedimentary matter and undissolved substances. The measurements at the inflow must be carried out at the same time as the measurements at outlets V1-1, V7-7 and V-7-10, at the inflow with coordinates y=540294, x=88198.

8.1.2 Air

Due to the possibility that the auxiliary boilerhouse may operate more than 300 hours per year, which falls under the regime of monitoring emissions set out in the Decree on the emission of substances into the atmosphere from medium-sized combustion plants, gas turbines and stationary engines (Official Gazette of RS, Nos. 17/18 and 59/18), it is recommended that a one-off measurement of emissions is performed by an authorised laboratory (dust, smoke number, CO, NOx, SO_2).

8.1.3 Noise

Mode: measurements performed by an authorised contractor

Methods: in accordance with the Rules*

Locations: determined by the authorised contractor in accordance with the Rules*

Timetable: once every three years in accordance with the Rules*

* Rules on initial assessment and operational monitoring of sources of noise and conditions for the implementation of monitoring (Official Gazette of RS, No. 105/08)

8.1.4 Electromagnetic radiation

Mode: measurements performed by an authorised contractor

Methods: in accordance with the Rules*

Locations: determined by the authorised contractor in accordance with the Rules*

Timetable: once every three years in accordance with the Rules*

* Rules on initial measurements and operational monitoring of sources of electromagnetic radiation and conditions for the implementation of monitoring (Official Gazette of RS, Nos. 70/96, 41/04 – ZVO-1, 17/11 – ZTZPUS-1).

8.1.5 Ionising radiation

NEK is carrying out extensive monitoring of radioactive emissions and immissions, which is defined in the Radiological Effluent Technical Specification (RETS) /7/. The document describes the systems for monitoring liquid and airborne emissions, locations, and frequency of monitoring. NEK monitors radioactive emissions in all systems where radioactivity might occur during operation. Sampling points, monitoring frequency, and type of analysis for liquid and gaseous emissions are described in Tables 3.11-1 and 3.11.-2, respectively. Both tables are given below (Table 145, Table 146).

Table 145: Programme of measurements of liquid emissions (source: /7/)

Type of discharge	Sampling frequency	Minimum analysis frequency	Type of analysis	LLD(1) (Bq/m^3)
1. Occasional one-off discharge(2) Waste monitor tank (WMT) no. 1	P Each individual tank	P Single discharge	Main gamma emitters(3), I-131, H-3	1.9 x 10^4 3.7 x 10^4 3.7 x 10^5
Waste monitor tank (WMT) no. 2	P Each individual tank	M	Dissolved and captured gases (gamma emitters)	3.7 x 10^5
Condensate transfer tank (CTT)	P Each individual tank	M Composite(4)	H-3 Total alpha activity	3.7 x 10^5 3.7 x 10^3
Drain tank in the component-cooling building	P Each individual tank	Q Composite(4)	Sr-89, Sr-90 Fe-55 C-14	1.9 x 10^3 3.7 x 10^4 1.9 x 10^3
2. Continuous discharges(5)	Continuously(6) for ESW P, S – SGBD Sampling	W composite(5) ESW W composite(4) SGBD	Main gamma emitters(3), H-3	1.9 x 10^4 3.7 x 10^5
Steam generator blowdown (SGBD) system discharges	P – SGBD Sampling	P composite(4) SGBD	Dissolved and captured gases	3.7 x 10^5
Essential service water (ESW) discharges	P, S – SGBD Sampling	M – composite(4) SGBD	H-3 Total alpha activity	3.7 x 10^5 3.7 x 10^3
	P, S – SGBD Sampling	M – composite(4) SGBD	Sr-89, Sr-90 Fe-55	1.9 x 10^3 3.7 x 10^4

Note: sampling frequencies: S–at least once every 12 hours, P–prior to each discharge, M–monthly, Q–quarterly.
Note: for 1.c, 1.d, and 2b only major gamma emitters and H-3 (for H-3 in ESW composite samples the minimum analysis frequency is monthly).

(1) LLD – Lower limit of detection.
(2) A one-off discharge is a discharge of liquid waste in a limited quantity. Prior to sampling for analysis, the discharge must be isolated and the contents mixed to ensure a representative sample.
(3) The main gamma emitters to which LLD refers are: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141. Ce-144 must also be measured; the LLD is 1.85x10^5 Bq/m^3. There are other radionuclides that may occur in addition to the ones listed above, and they must also be identified and reported. Such radionuclides are e.g. Cr-51, Zr-95, Ag-110m, Sb-124, I-131, I-133, I-135 and Ba-140.
(4) A composite sample is a sample that is proportional in quantity to discharged liquid and is obtained using a sampling method that ensures it is representative.
(5) Continuous discharges are discharges of liquid waste that do not have a predetermined volume and flow continuously, e.g. from a system during discharge.
(6) In order for the samples to be representative of the quantities and concentrations in the discharge, they must be collected continuously in proportion to steam flow. Prior to analysis, all samples must be mixed to ensure that the composite sample is representative of the discharge.

Table 146: Programme of measurements of gaseous emissions (source: /7/)

Type of discharge	Sampling frequency	Minimum analysis frequency	Type of analysis	LLD(1) (Bq/m^3)
1. Gas decay tank	P Individual tank One-off sampling	P Individual tank	Main gamma emitters(2)	3.7 x 10^6
2. Containment	P; W One-off sampling each discharge and venting(3)	P; W(3) One-off sampling each discharge and venting(3)	Noble gases Main gamma emitters(2)	3.7 x 10^6
3.a Discharge from the ventilation channel(6) (including FHB and AB)	W(3)(4)	W(3)	Main gamma emitters(2)	3.7 x 10^6
	Continuously(3) or at a minimum W	W(3) Noble gas spectrometry	Main gamma emitters(2)	3.7 x 10^4
	Continuously Continuously	M M	H-3 (oxide) C-14	3.7 x 10^3 3.7 x 10^1
3.b Discharge from the fuel handling building (FHB) ventilation channel	M(5)	M	Main gamma emitters(2)	3.7 x 10^6
3.c Discharge from the condensate ejector(6)	W One-off sampling	W	Main gamma emitters(2)	3.7 x 10^6
4.a Main ventilation channel (plant vent)(6) 4.b Fuel handling building (FHB) 4.c Auxiliary building (AB) 4.d. RAW storage 4.e Decontamination building(6)	Continuously	W(7) Sampling of charcoal filters	I-131	0.037
	Continuously	W(7) Sampling of particulates	Main gamma emitters(2)	0.37
5.a Main ventilation channel (plant vent)(6) 5.b Decontamination building(6)	Continuously	M Composite, sampling of particulates	Total alpha activity	0.37
	Continuously	Q Composite, sampling of particulates	Sr-89, Sr-90	0.37
Containment	Continuously	P, W Charcoal filter	I-131	0.037
		P each discharge W, sampling of particulates	Main gamma emitters(2)	0.37

Note: sampling frequencies: S–at least once every 12 hours, P–prior to each discharge, W-weekly, M–monthly, Q–quarterly.

(1) LLD – Lower limit of detection.
(2) The main gamma emitters to which LLD refers are: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135 and Xe-138 in discharges of noble gases, and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141 and Ce-144 in discharges of iodine and particulates. There are other radionuclides that may occur in addition to the ones listed above, and they must also be identified and reported.
(3) Sampling and analysis must also be carried out after a forced shutdown, start-up, or a change in thermal power if the change exceeds 15% of the rated thermal power in one hour.
(4) Single H-3 samples from the ventilation system must be taken at least once every 24 hours when the refuelling channel is filled with water or during the purge of the containment.
(5) Single samples must be taken from the spent fuel pool exhaust at least once every 7 days when spent fuel is in the pool.
(6) The relationship between the flow of air that is being sampled and the flow of air already sampled must be known for all periods when doses or dose rates are calculated.

Samples should be changed at least once every 7 days and analysed no later than 48 hours after replacement or removal from the sampler. Sampling must also be carried out at least once every 24 hours for at least 7 days after each shutdown, start-up, or a change in thermal power if the change exceeds 15% of the rated thermal power in one hour. Samples should be analysed no later than 48 hours after sampling. If samples are collected for 24 hours and then analysed, the LLD may be greater by a factor of 10. This requirement does not apply if: (1) analyses show that the equivalent dose concentration of I-131 in the reactor coolant did not increase by more than a factor of 3; and (2) noble gas monitors show that the activity in the effluents did not increase by more than a factor of 3.

At the same time, extensive monitoring of radioactivity in immissions is carried out in the vicinity of NEK. The monitoring includes all transmission routes by which a person can receive a dose:

- the Sava (water, sediments, and aquatic biota);
- water supply network and boreholes;
- pumping stations and catchments;
- precipitation and depositions;
- air;
- external radiation;
- soil;
- food – milk, fruit, garden crops and field crops.

A detailed programme with sampling locations, sampling frequency, and required types of analyses is described in Table 3.12.-1 in RETS. The table (Table 147) specifies a programme of measurements from the existing table in RETS and additional measurements which will be included in the new revised RETS (request for alteration 21-2, rev. 02, RETS Change package: Modernisation of RETS with valid legislation and harmonisation with the actual sampling state as of 31 August 2021).

Table 147: Programme of monitoring radioactivity in the vicinity of NEK (immissions)

1. WATER, THE SAVA

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Krško – 4 km upstream from NEK	- water and suspended solids - filter residue	composite sample collected over 31 consecutive days	once every 92 days	4
				once every 92 days	4
	2. above the dam of the Brežice HPP, 7.2 km downstream from NEK*			once every 31 days	12
				once every 31 days	12
	3. Brežice – 7.8 km downstream from NEK			once every 31 days	12
				once every 31 days	12
	4. Jesenice na Dol. – 17.5 km downstream from NEK			once every 31 days	12
				once every 31 days	12
Tritium (H-3), specific analysis with a scintillation counter	1. Krško	aqueous distillate	composite sample collected over 31 consecutive days	once every 31 days	12
	2. above the dam of the Brežice HPP*			once every 31 days	12
	3. Brežice			once every 31 days	12
	4. Jesenice na Dol.			once every 31 days	12
Strontium Sr-90/Sr-89, specific analysis (radiochemical isolation of Sr-90/Sr-89, detection with proportional counter)	1. Krško	- water and suspended solids - filter residue	composite sample collected over 31 consecutive days	once every 92 days	4
				once every 92 days	4
	2. above the dam of the Brežice HPP*			once every 31 days	12
				once every 92 days	4
	3. Brežice			once every 31 days	12
				once every 92 days	4
	4. Jesenice na Dolenjskem			once every 31 days	12
				once every 92 days	4

* Measurements from the programme of Operational radioactivity monitoring in the vicinity of NEK started in July 2017 to account for the construction of the Brežice HPP.

2. THE RIVER SAVA – WATER, SEDIMENTS, AND AQUATIC BIOTA

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Left bank, 0.5 km upstream from NEK	one-off sampling: - water and suspended solids - sediments, - fish	once every 92 days	once every 92 days	12
	2. Left bank at Brežice, 4-7.8 km downstream from NEK	one-off sampling: - water and suspended solids - sediments, - fish	once every 92 days	once every 92 days	12
	3. above the dam of the Brežice HPP, 7.2 km downstream from NEK	one-off sampling: - water and suspended solids - sediments, - fish	once every 92 days	once every 92 days	12
	4. Right bank at Jesenice, 17.5 km downstream from NEK	one-off sampling: - water and suspended solids - sediments, - fish	once every 92 days	once every 92 days	12
	5. 2 samples on both banks of the reservoir between the river profiles 120 and 121	one-off sampling: water	once every 31 days	once every 31 days	24
		one-off sampling: sediments	once every 31 days	once every 31 days	24
	6. Replacement habitat NH1	one-off sampling: water	once every 92 days	once every 92 days	4
	7. The Brežice HPP reservoir	fish	once every 182 days	once every 182 days	2
	8. Podsused	one-off sampling: sediments fish (two samples)	once every 92 days once every 182 days	once every 92 days once every 182 days	4 2
Strontium Sr-90/Sr-89, specific analysis	1. Left bank, 0.5 km upstream from NEK	one-off sampling: - water and suspended solids - sediments, - fish	once every 92 days	once every 92 days	12
	2. Left bank at Brežice, 4-7.8 km downstream from NEK				12
	3. above the dam of the Brežice HPP, 7.2 km downstream from NEK				12

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
	4. Right bank at Jesenice, 17.5 km downstream from NEK				12

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Strontium Sr-90/Sr-89, specific analysis	5. 2 samples on both banks of the reservoir between the river profiles 120 and 121	one-off sampling: water	once every 31 days	once every 31 days	24
		one-off sampling: sediments	once every 31 days	once every 31 days	24
	6. Replacement habitat NH1	one-off sampling: water	once every 92 days	once every 92 days	4
	7. The Brežice HPP reservoir	fish	once every 182 days	once every 182 days	2
	8. Podsused	one-off sampling: sediments	once every 92 days	once every 92 days	4
Tritium (H-3), specific analysis with a scintillation counter	1. Left bank, 0.5 km upstream from NEK	aqueous distillate	once every 92 days	once every 92 days	4
	2. Left bank at Brežice, 4-7.8 km downstream from NEK		once every 92 days	once every 92 days	4
	3. above the dam of the Brežice HPP, 7.2 km downstream from NEK		once every 92 days	once every 92 days	4
	4. Right bank at Jesenice, 17.5 km downstream from NEK		once every 92 days	once every 92 days	4
	5. 2 samples on both banks of the reservoir between the river profiles 120 and 121		once every 31 days	once every 31 days	24
	6. Replacement habitat NH1		once every 92 days	once every 92 days	4
	7. Podsused [42]		once every 182 days	once every 182 days	2
C-14	5. 2 samples on both banks of the reservoir between the river profiles 120 and 121	one-off sampling: water and suspended solids	once every 92 days	once every 92 days	8
	7. The Brežice HPP reservoir	one-off sampling: fish	once every 182 days	once every 182 days	2

Note: Gamma spectrometry and strontium analysis in water and in solid samples.
Podsused is a location in Croatia where H-3 in the water is also analysed.

* Measurements from the Operational radioactivity monitoring programme to account for the construction of the Brežice HPP, started in July 2017 in the vicinity of NEK.

3. WATER SUPPLY, BOREHOLES

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Krško (water supply network)	individual sample	once every 92 days	once every 92 days	4
	2. Brežice (water supply network)				4
	3. Inside the NEK perimeter fence, borehole 0071				4
	4. Medsave borehole (Croatia)[42]	One-off water sampling	once every 31 days	once every 31 days	12
	5. Šibice borehole (Croatia)[42]		once every 31 days	once every 31 days	12
Strontium Sr-90/Sr-89, specific analysis	1. Krško (water supply network)	individual sample	once every 92 days	once every 92 days	4
	2. Brežice (water supply network)				4
	3. Inside the NEK perimeter fence, borehole 0071				4
	4. Medsave borehole (Croatia)[42]	One-off water sampling	once every 31 days	once every 31 days	12
	5. Šibice borehole (Croatia)[42]		once every 31 days	once every 31 days	12
Tritium (H-3), specific analysis with scintillation counter	1. Krško (water supply network)	individual sample	once every 92 days	once every 92 days	4
	2. Brežice (water supply network)		once every 92 days	once every 92 days	4
	3. Inside the NEK perimeter fence, borehole 0071		once every 92 days	once every 92 days	4
	4. Groundwater near NEK on the left bank of the Sava (VOP-4)		once every 31 days	once every 31 days	12
	5. borehole VOP-1/06 (ARAO)		once every 31 days	once every 31 days	12
	6. borehole V-7/77 (NEK)		once every 31 days	once every 31 days	12
	7. borehole V-12/77 (NEK)		once every 31 days	once every 31 days	12
	8. Medsave borehole (Croatia)[42]	One-off water sampling	once every 31 days	once every 31 days	12
	9. Šibice borehole (Croatia)[42]		once every 31 days	once every 31 days	12

4. PUMPING STATIONS AND CATCHMENTS

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Pumping station Krško - Rore 2. Pumping station Krško–Brege 3. Catchment Dolenja vas 4. Pumping station Brežice VT1 5. Pumping station Brežice 481 6. Petruševac pumping station (Croatia) [42]	composite water samples	once per day	once every 31 days	6 × 12
Tritium (H-3), specific analysis with scintillation counter			once per day	once every 31 days	6 × 12
Strontium Sr-90/Sr-89, specific analysis			once per day	once every 31 days	6 × 12
			once per day	once every 31 days	6 × 12

Note: In Brežice, sampling is only performed at active pumping stations that supply the water supply network.

5. PRECIPITATION AND DEPOSITIONS

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Stara vas 2. Brege 3. Dobova	composite sample collected over 31 consecutive days	once every 31 days	once every 31 days	3 × 12
Tritium (H-3), specific analysis with scintillation counter					3 × 12
Strontium Sr-90/Sr-89, specific analysis					3 × 12

SLD = Straight-line distance

6. DEPOSITIONS – VASELINE SLIDES

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	7 sampling points at iodine pumps and the orchard next to NEK, 3 groups of locations	monthly composite sample from 3 groups of locations, i.e. a month-long sample from an individual location at elevated values	continuous sampling 31 days	once every 31 days	3 × 12

7. AIR

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Measurement of I-131 (gamma spectrometry)	1. Sp. Stari Grad *SLD* = 1.8 km, 4C1 2. Stara vas *SLD* = 1.8 km, 16C 3. Leskovec *SLD* = 3 km, 13D 4. Brege *SLD* = 2.3 km, 10C 5. Vihre *SLD* = 2 km, 8D 6. Gornji Lenart *SLD* = 5.9 km, 6E 7. Spodnja Libna *SLD* = 1.3 km, 2B	continuous pumping through a glass fibre filter and a charcoal filter (15 days)	once every 15 days	once every 15 days	7 × 24
Strontium Sr-90/Sr-89, specific analysis	1. Libna or Stara vas *SLD = 1.4 km* or *1.8 km*	filter residue continuous pumping through an aerosol filter	once every 92 days	once every 92 days	4
Isotope analysis of particulates and aerosols using gamma-ray spectrometry	1. Sp. Stari Grad *SLD* = 1.8 km, 4C1 2. Stara vas *SLD* = 1.8 km, 16C 3. Leskovec *SLD* = 3 km, 13D 4. Brege *SLD* = 2.3 km, 10C 5. Vihre *SLD* = 2 km, 8D 6. Gornji Lenart *SLD* = 5.9 km, 6E 7. Spodnja Libna *SLD* = 1.3 km, 2B 8. Dobova *SLD* = 12.0 km, 6F	continuous pumping through an aerosol filter (filter is changed every 31 days or when clogged)	once every 31 days	once every 31 days	8 × 12
airborne C-14 in CO_2	2 locations inside the NEK perimeter fence	CO_2 absorbed on NaOH as Na_2CO_3	once every 2 months	once every 2 months	2 × 6

8. EXTERNAL RADIATION DOSE AND DOSE RATE

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Dose measured with environmental passive dosimeters in a ring around NEK	67 measuring points in Slovenia, of which 57 are arranged in circles at distances of 1.5 to 10 km from NEK, and 9 measuring points on the NEK fence – a total of 66 measuring points in the vicinity of NEK and 1 measuring point in Ljubljana; 10 in Croatia[42]	TL dosimeter, at least 2 per measuring point	once every 182 days	once every 182 days	134 in Slovenia 20 in Croatia
Measurement of gamma radiation dose rate	at least 10 measuring points surrounding NEK	network with automatic operation		constant measurement	constant monitoring

Note: NEK performs dose measurements with OSL dosimeters at six points on the site fence. At the same locations neutron dosimeters are used to also measure the neutron dose.

9. SOIL

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Amerika, *SLD* = 3.2 km, floodplain, brown alluvial deposits 2. Trnje (Kusova Vrbina), *SLD* = 8.5 km, floodplain, grey alluvial soil 3. Gmajnice (Vihre) *SLD* = 2.6 km, floodplain, brown alluvial deposits	one-off sampling of soil from 4 depths 0–5 cm, 5–10 cm, 10–15 cm, 15–30 cm one-off sampling: alluvial deposits, pasture or arable land	once every 6 months	once every 6 months	2 × (3 × 4)
Strontium Sr-90/Sr-89, specific analysis (radiochemical isolation of Sr-90/Sr-89, detection with proportional counter)					2 × (3 × 4)

[42] The measuring points are in the Republic of Croatia.

10. FOOD – MILK

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	1. Pesje 2. Drnovo 3. Skopice	one-off sampling every 31 days	once every 31 days	once every 31 days	3 × 12
Strontium Sr-90/Sr-89, specific analysis		one-off sampling every 31 days			3 × 12
I-131, specific analysis		one-off sampling every 31 days during the grazing period – 8 months			3 × 8

11. FOOD – FRUIT

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	selected locations on the Krško Polje/Brežiško Polje: the orchard near NEK, Sremič, Leskovec	one-off sampling of various seasonal fruits: apples, pears, currants, strawberries, wine	once every 365 days	once every 365 days	10
Strontium Sr-90/Sr-89, specific analysis					10

12. FOOD – GARDEN AND FIELD CROPS

TYPE AND DESCRIPTION OF MEASUREMENT	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	selected locations on the Krško Polje/Brežiško Polje: Brege, Žadovinek, Vrbina, Sp. Stari Grad, Trnje	one-off sampling of seasonal broad-leaved garden and field crops: lettuce, cabbage, carrots, potatoes, tomatoes, parsley, beans, onions, wheat, barley, corn, hops	once every 365 days	once every 365 days	20
Strontium Sr-90/Sr-89, specific analysis					20

13. FOOD – MEAT, POULTRY AND EGGS

TYPE AND DESCRIPTION OF MEASUREMENTS	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Isotope analysis using gamma-ray spectrometry	selected locations on the Krško Polje/Brežiško Polje: Žadovinek, Vrbina, Sp. Stari Grad, Pesje	one-off sampling of various meat and eggs	once every 365 days	once every 365 days	6
Strontium Sr-90/Sr-89, specific analysis					6

14. FOOD – C-14 MEASUREMENTS

TYPE AND DESCRIPTION OF MEASUREMENTS	SAMPLING POINT	SAMPLE TYPE	SAMPLING FREQUENCY	MEASUREMENT FREQUENCY	NO. OF ANNUAL MEASUREMENTS
Carbon C-14	selected locations on the Krško Polje/Brežiško Polje: the orchard next to NEK, Vrbina, Žadovinek, Brege, Spodnji Stari Grad, Dobova* (up to 17 locations)	Samples of seasonal garden crops, field crops and various fruit	twice every 365 days	twice every 365 days	35

* Dobova is a reference sampling point.

Immission measurements are performed by authorised environmental monitoring contractors in accordance with the Rules on the monitoring of radioactivity (Official Gazette of RS, No. 27/18). A report on radioactivity monitoring in the vicinity of NEK, which includes dose estimations for reference population groups, is compiled every year. In 2020, the conservatively estimated annual effective dose for the most exposed individuals was less than 0.071 µSv.

For several years, C-14 has been the largest contributor to the dose, yet the monitoring programme in the Rules on the monitoring of radioactivity (Official Gazette of RS, No. 27/18) only requires 5 measurements of C-14 in cereal samples. In previous years, most recently in 2019 /144/, NEK commissioned measurements of 34 plant samples (vegetables, fruits), on the basis of which dose estimations are possible. We believe that a programme of these measurements should be included in the regular monitoring programme, that is, added to RETS. Since H-3 is also an isotope whose emissions into the environment are measurable and contribute to the dose, it makes sense to determine H-3 (organically bound tritium) in the same samples used to determine C-14.

The one-off evaluation of the possible impact on the environment or persons based on organically bound H-3 (OBT) measurements is an integral part of reporting to administrative bodies and is also foreseen by NEK in 2021. Various expert works have already been published in connection with this, for example: Report on OBT intercomparison from IRB, Ruđer Bošković Institute, I. Krajcar Bronić workshops on the subject of OBT in Romania 2019; and Interlaboratory comparison and OBT measurements in biota in the environment of NPP Krško, a conference about radiation measurements in 2019 in the Czech Republic, R. Krištof, J. Kožar Logar, A. Sironić, I. Krajcar Bronić.

In the Republic of Croatia, measurements of the Sava are performed at a location in Podsused, while measurements of external radiation are performed at 10 locations. In 2018 and 2019, NEK also financed measurements of H-3 in continuous samples from the Petruševec pumping station, which is the largest potable water pumping station for the city of Zagreb. An article (J. Barešić, J. Parlov, Z. Kovač, A. Sironić: Use of nuclear power plant released tritium as a groundwater tracer, The Mining-Geology-Petroleum Engineering Bulletin, 2020) notes that H-3 values at Petruševec have increased, which is to be expected. Since this is the largest pumping station for the city of Zagreb, we propose it is added to the radioactivity monitoring programme, that is, RETS. In addition to H-3, measurements of Sr-89/90 and gamma emitters should also be performed at the site using high-resolution gamma-ray spectrometry.

As follows from the report /71/ Monitoring of radioactivity in the vicinity of NEK, Report for 2019, Jožef Stefan Institute, IJS-DP-12784, March 2020, measurements of fish samples using high-resolution gamma-ray spectrometry are performed at Podsused and Otok sites (4 samples at each site) in the Republic of Croatia. Measurements of groundwater are also performed in the Republic of Croatia at the Medsave and Šibice sites (high-resolution gamma-ray spectrometry, Sr, H-3). In addition, sediment (gamma emitters and Sr-90) is measured at the Podsused site. These measurements are not listed in RETS, although they have been carried out for a number of years. We therefore propose that the monitoring of sediments and fish at the Podsused site be included in the regular monitoring programme.

Monitoring of radioactive emissions follows the water transport path of the Sava. All sampling points are located under the NEK dam, except for the point near the VIPAP VIDEM KRŠKO cellulose plant. Sporadic measurements of OBT (organically bound H-3) in vegetation on the right bank of the Sava near the NEK dam (above the spillways) indicate increased OBT activity concentrations. It is not clear whether this is caused by airborne or liquid discharges from NEK. It is possible that released radioactivity does not fully drain through the spillways, and that stagnation and even counterflow of surface water occur on the right bank of the river. The study Tritium in organic matter around Krško Nuclear Power Plant /145/ showed that OBT activity concentrations in vegetation along the southwestern fence of NEK are higher than at other points along the NEK fence, which is caused by airborne transport from NEK, where H-3 predominates in the form of the HTO molecule, which is part of the water cycle. The increased values were observed after an outage. These observations could be grounds for a change in radioactivity monitoring. Since the model of radioactivity dispersion along the Sava will be defined in the terms of reference for the "Impact of the Brežice HPP on NEK and the Environmental Impact Assessment Report for the extension of NEK's operational lifetime" (public invitation to tender published on the Public Procurement Portal of Slovenia on 16 February 2021, public contract no. JN000870//2021-E01), we propose that the findings of the study be included in the radioactivity monitoring programme. Following construction of the Mokrice HPP, it will be necessary to review the radioactivity monitoring programme for the Sava.

8.1.5.1 Spent fuel dry storage

The construction of the spent fuel dry storage building (DSB) will require additional external radiation monitoring. Currently, NEK is measuring the dose rate of ionising radiation with six passive optically stimulated luminescence (OSL) dosimeters at measuring points on NEK fence. After the construction of the DSB, passive dosimeters will also be installed in the northwestern and southwestern corners of the storage area in the DSB; the upper dosimeter will be placed just below the roof, the lower dosimeter above the height of the partition wall, and the middle dosimeter halfway in height between the upper and lower dosimeter. Three dosimeters will thus be installed in each of the two corners, or a total of six dosimeters in the DSB. Additional passive dosimeters will be installed on the NEK fence; one at a spot nearest to the DSB, and three more on each side of the first dosimeter at a distance of 10 m from each other. The dosimeters will measure neutron and gamma radiation doses and will be read or changed at least once every 6 months. Even before the construction starts, baseline monitoring will be conducted using the existing OSL dosimeter closest to the DSB. The proposed scope of monitoring may be changed after a certain period of measurements.

According to calculations, the total annual effective external radiation dose (due to the operation of the dry storage and other NEK activities) on the fence will not exceed the limit value of 200 µSv.

During the transfer of spent fuel from the FHB to the DSB, a temporary controlled area will be established along the transfer route and measurements of radiation parameters will be carried out.

8.1.5.2 Radioactivity monitoring following the construction of the Brežice HPP

Since July 2017, NEK has been conducting additional radioactivity monitoring of the Sava to account for the impacts of the construction and operation of the Brežice HPP. In addition to the usual sampling locations, radioactivity is measured on both sides of the reservoir, at the Brežice HPP dam, in the replacement habitat, and in additional boreholes. With the damming of the Sava, the flow and dispersion of radioactivity in the river have changed, as additional monitoring has shown. There was no increase in liquid radioactive discharges from NEK. The model currently in use is based on the study Exposure of the reference population group to radiation due to liquid discharges of NEK into the Sava /146/. As mentioned above, the study: "Impact of the Brežice HPP on NEK and the Environmental Impact Assessment Report for the extension of NEK's operational lifetime", is being carried out. The results of this project will show whether it is necessary to change the radioactivity monitoring programme for the Sava.

9. THE AREA IN WHICH THE ACTIVITY WILL CAUSE AN ENVIRONMENTAL BURDEN THAT COULD AFFECT HUMAN HEALTH OR PROPERTY

9.1 BASES AND METHOD FOR DEFINING THE AREA

In accordance with Article 15 of 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), the section relating to the definition of the area in which the activity will cause an environmental burden that may affect human health or property must define the area in such a way to take into account expected environmental burdens as a consequence of the impacts of activities affecting the environment, in particular due to:

- the emission of substances into the atmosphere, including odours;
- emission of substances into water;
- waste generation and waste management;
- the use of hazardous substances and associated risks;
- burdening the environment with noise or vibrations;
- burdening the environment with electromagnetic or ionising radiation; or
- light pollution.

The decree also stipulates that the area referred to in the preceding paragraph shall be defined under the rules of the profession governing environmental impact assessments.

9.2 AREA DURING OPERATION

The area in which the activity causes environmental burdens that could affect human health or property during operation is defined for the ongoing activity after the change, as this involves two spatially-connected activities. When defining this area, we proceeded from the findings of this report regarding the expected burdens of the ongoing activity after the change (overall impact), taking into account all the factors discussed in the report.

The area during operation is defined as the area inside NEK's fence, which covers land referenced with lot no.

1197/44, cadastral municipality (1321) Leskovec.

The graphical illustration of the area during operation is given in **Appendix 3**.

The decree provides that the areas that impact all environmental factors must be graphically illustrated, and a cumulative graphical presentation of all impacts must be drawn up, including the display, numbering and explanation of the measures to reduce environmental impacts. To that end, we also clarify that the graphical presentation has been drafted as a cumulative presentation of all impacts, as it relates to an energy facility area with technological processes that require adequate skills from employees. Hardware, electrical and other equipment is located in all the facilities within NEK's complex, which places people's health at risk during the improper use or maintenance of this equipment. Additional measures that are defined in this report for the period of operation cannot be graphically illustrated and as such are not included in the presentation.

9.3 AREA IN THE EVENT OF ACTIVITY TERMINATION

If the activity is terminated, the area in which the activity is causing an environmental burden that could affect human health or property is not defined or is identical to the area during operation, taking into account all the measures determined by regulations and the measures additionally prescribed in this report.

9.4 SIGNIFICANT IMPACT ON NEIGHBOURING COUNTRIES

The area in which the activity is causing environmental burdens that could affect human health or property during NEK's operation is **restricted to** the land referenced with lot no. 1197/44, cadastral municipality (1321) Leskovec. The area impacted by the activity is defined on the basis of the consequences of the activity's environmental impacts, which are discussed in sections 5.2 to 5.19.

Based on the above, we can conclude that the envisaged activity under **normal operation** will have no transboundary effects on factors discussed in this report that would stem from individual impacts or their mutual effects, as the **closest** national border to the activity is the border with the Republic of Croatia, which is more than 10 kms away.

10. NON-TECHNICAL SUMMARY OF THE REPORT

Developer information:

The developer, Nuklearna elektrarna Krško, d.o.o., operates on the basis of the operating licence, which relates directly to the NEK Updated Safety Analyses Report (USAR;/3/), and contains the conditions and limitations for the power plant's safe operation. NEK has a valid open-ended operating licence (/4/) and is technically capable of operating until 2043, provided that, in accordance with the applicable legislation, it performs a Periodic Safety Review (PSR) every 10 years. NEK is obliged to ensure all aspects of the power plant's safe operation.

NEK is equipped with Westinghouse's pressurised light-water reactor with thermal power of 1994 MW. Its net electrical output is 696 MW. The power plant is connected to the 400 kV network that supplies electricity to consumers in Slovenia and Croatia. It annually produces over 5 billion kWh of electrical energy, which is approximately 38% of the total electricity produced in Slovenia, half of which is exported to Croatia /40/.

Type and main characteristics of the activity:

The operator intends to extend NEK's operational lifetime from 40 to 60 years, i.e. from 2023 to 2043.

The extension of NEK's operational lifetime means that the facility's operational lifetime is extended by 20 years, from 40 to 60 years. This:

- **does not change** the position or location of NEK;
- **does not change** the dimensions and technical design of NEK;
- **does not change** the production capacity of NEK and its operation mode.

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.

No new activities are required for the extension of NEK's operational lifetime. The spent fuel dry storage (functional connection), which has a building permit, and for which an environmental impact assessment has also been carried out, is under construction and will be completed in the first half of 2023. The dry storage building will already be in operation at the beginning of NEK's extended operational lifetime in 2023, while the environmental impacts of dry storage are discussed in this report, as an impact of the activity (see Section 5.1).

No other activities were carried out to extend the plant's operational lifetime. Safety upgrades, which are not covered by the assessment, were carried out irrespective of the extension of NEK's operational lifetime on the basis of Slovenia's Post-Fukushima Action Plan following EU stress testing.

NEK has in the past already performed all the necessary analyses and safety updates, and acquired all the permits necessary for them and the agreement of the Slovenian Nuclear Safety Administration. NEK has thus replaced all key equipment to ensure further uninterrupted, safe, reliable and environmentally compliant production of electricity. The above actions have already established the technical preconditions necessary for the extension of the operational lifetime.

By the end of the operational lifetime that will be extended from 40 to 60 years until 2043, NEK will have operated as to date, i.e. safely and in keeping with the limits on emissions into the environment. Safety culture and the proficiency of employees and their responsibility are a core element of the organisational and business structure of NEK, and will continue to be the guiding principle and assurance of 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.

All risks connected with NEK's operation have been significantly mitigated through a comprehensive upgrade of safety systems 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 /49/. NEK's existing water permits will also not require changes /50/, /163/, /276/.

The crucial document for the operation of NEK is the operating licence, which relates directly to the NEK Updated Safety Analyses Report (USAR), and contains the conditions and limitations for the power plant's safe operation.

NEK operates in accordance with the following: Approval to Commence NEK Operation, 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 (referred to as: URSJV) No. 3570-8/2012/5 of 22 April 2013, and NEK Updated Safety Analyses Report (USAR).

NEK – as it is now and after its operational lifetime is extended – is not classified as an activity or installation that can cause large-scale environmental pollution as defined in the Decree on the types of activity and installation that could cause large-scale environmental pollution (Official Gazette of RS, No. 57/15).

NEK – as it is now and after its operational lifetime is extended – is not classified as an installation with a high or low risk for the environment as defined in the Decree on the prevention of major accidents and mitigation of their consequences (Official Gazette of RS, No. 22/16).

Alternative solutions and reasons to choose the proposed solution:

Energy, system, environment protection 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 will have matured for commercial use by 2023.

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 produces minimal CO_2 emissions, whereas other technologies that use fossil fuels would put Slovenia far off from fulfilling the demands of the Kyoto Protocol;
- land use, as it does not require any new spatial developments; 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, July 2021 /243/.

The existing state of the environment where the activity will be carried out:

The site of the activity is in the Municipality of Krško, in the southern part of the Vrbina settlement, at the address Vrbina 12, Krško. This is an area of long-term energy use on the left bank of the Sava. It is located south-west of the town of Krško. According to the valid spatial planning document the site is located in an area of building land intended for **E** – energy infrastructure, in spatial planning unit (EUP) **KRŠ 025**.

The nearest residential areas are located northeast (buildings in Spodnji Stari Grad), at a distance of approximately 500 m, north (buildings in Spodnja Libna) at a distance of approximately 550 m and approximately 1.4 km west (Žadovinek) from the site of the planned activity.
An industrial road leads up to the power plant and connects to the regional road R1 Krško – Spodnja Pohanca. The plant also has an industrial railway track, which connects it to Krško railway station.

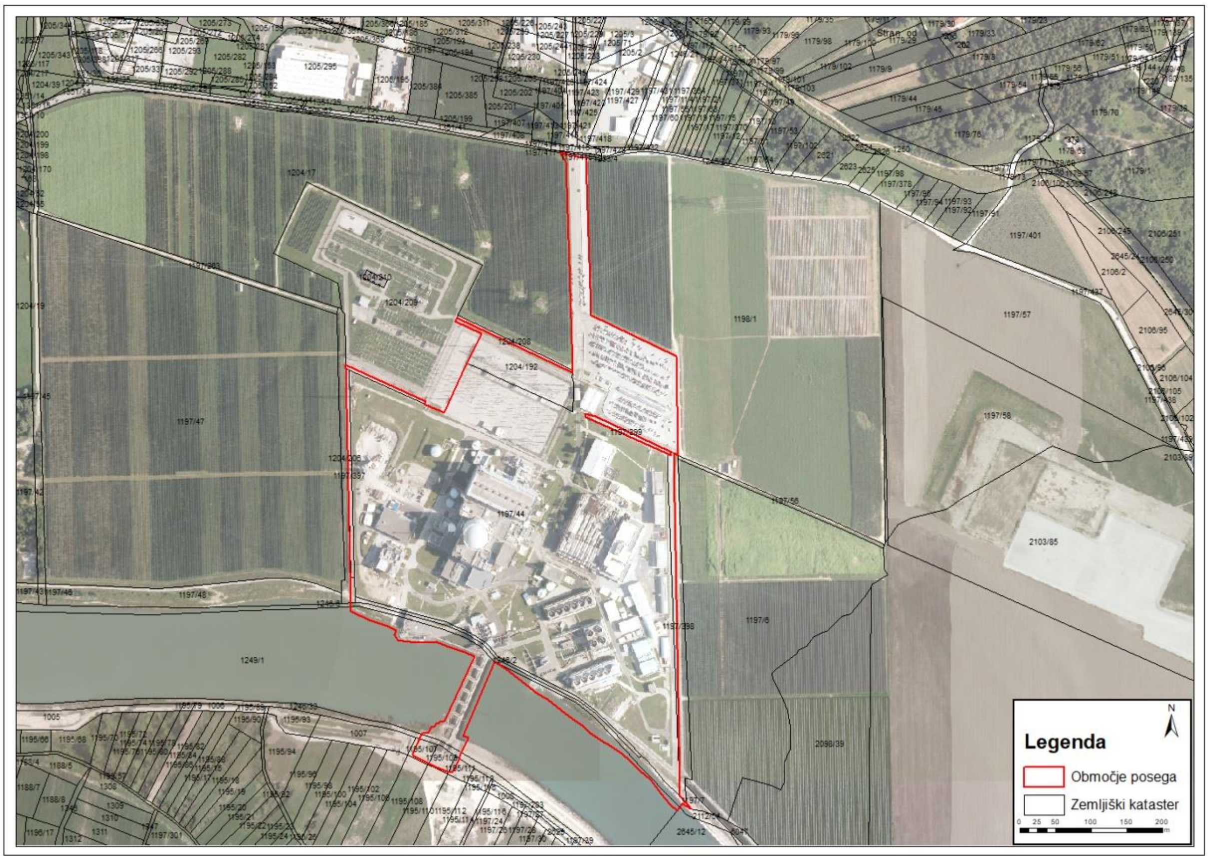

Figure 144: Aerial photograph showing the spatial characteristics of the activity and its location in the environment (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
Zemljiški kataster	Cadastral register

The site is located away from areas that are at risk from flooding and erosion, and away from areas protected by regulations governing nature preservation and the conservation of cultural heritage, and areas where it could affect them. The far southern part encroaches on the second water protection zone on the right bank.

The quality of groundwater and surface water in the broader area is good.

For the Vrbina industrial zone, the spatial planning document determines level IV noise protection, while the nearby residential areas have level III noise protection. Noise measurements in 2020 showed that NEK does not cause excessive noise for the nearby residential estate.

For the industrial zone, the spatial planning document determines level II protection from electromagnetic radiation, while the nearby residential areas have level I protection from electromagnetic radiation, which requires additional protection from radiation. The last measurements taken in 2021 showed that due to the presence of low frequency sources of electromagnetic radiation from NEK's operations, the area is not overloaded with radiation and due to its distance there is also no effect on the nearby residential areas.

When operating, the emissions from NEK's ventilation system release radioactive materials into the air. The dose resulting from the total annual activity of emitted noble gases for 2020 amounts to approximately 0.012% of the annual limit, which is similar to 2019 and to previous years.

The chemical state of the Sava at the WB Sava Krško–Vrbina measuring point was evaluated as good in the 2014–2019 period, while the level of confidence was also high. Analyses of the chemical status parameter in biota were also carried out at this measuring point. The status was assessed as poor. The reason for the poor chemical status was the increased presence of mercury.

NEK does not overburden the environment with the discharge of industrial wastewater because annual quantities of adsorbable organic halogens (AOX) are not exceeded and because the plant as a whole does not exceed thermal emission limits.

The average concentrations of active strontium in other Slovenian rivers are similar or higher than those measured in the Sava near NEK.

The natural radionuclides of uranium (U-238, Ra-226 and Pb-210) and thorium (Ra-228 and Th-228) that decay were regularly detected in all water samples. The values were similar to those measured in other Slovenian rivers.

In 2020 all the radioactive effects of NEK on the NEK fence (the estimate is approximately valid also at a distance of 500 m from the middle of the reactor) and 350 m downstream from the NEK dam were estimated to be less than 0.071 µSv annually on the nearby population.

The estimated value is small in comparison with the authorised dose limit for the population in the vicinity of NEK (the effective dose of 50 µSv annually at a distance of 500 m and more for contributions via all pathways).

The estimated value of the radioactive impacts from NEK along the NEK perimeter fence is approximately 0.0029% of the typical, unavoidable natural background. The estimate also approximately applies at a distance of 500 m from the reactor shaft.

Possible effects of the activity on the environment and burdens on the environment:

The planned activity at the foreseen site will not affect the odours and cultural heritage in the broader surroundings, so the effects on these factors are not dealt with in more detail in the report.

The following is a summary of possible effects of the activity on the environment and the health of people, as found in the report based on an analysis of possible direct and indirect effects during the extended operational lifetime, bearing in mind the sensitivity of the environment where the activity is being carried out.

- **Soil**

The dry storage building will have already been built by the beginning of the extended operational lifetime in 2023. There will be no construction work, so there will also be no activities in or on the soil. The way wastewater is discharged will not change with the extension of NEK's operational lifetime. There will be no emission of pollutants into the soil during operation, as all wastewater is already being disposed of properly.

All waste, including radioactive waste, on the NEK site is appropriately stored and does not present a danger for soil contamination.

- **Waters**

The source of the greatest potential effect on the Sava are the cooling waters that are discharged in large quantities. While their composition occasionally exceeds the permitted concentrations of suspended solids and sediments, the power plant itself does not pollute the water, as the substances enter into the system with the water from the Sava. The fact that these effluents depend on the composition of the river water is shown by the monitoring of COD (chemical oxygen demand) and BOD5 (biochemical oxygen demand) values at three locations in and around the NEK site, where it is evident that the water contains certain components of these parameters before it enters the power plant.

Dry storage of the spent fuel does not emit anything into the water and is designed to be flood-proof with water-proof canisters for the waste and also containers that are resistant to breaking, water and other possible threats. In comparison with the current state, the extension of NEK's operational lifetime will not cause changes in wastewater effluents, even if there is a probability that the quantity of cooling water released through the cooling towers will increase. Considering that the state of the water body into which NEK wastewater is discharged is presently good, it is estimated that the effect will be insignificant and that the good state of waters in this area will not deteriorate.

NEK does not release harmful materials or polluted water directly into the ground, thereby potentially polluting the groundwater. The only way is indirect pollution via discharges into the Sava and by means of infiltration into the groundwater. The discharge of materials by NEK into the Sava is within prescribed limits and will remain so in the power plant's extended operation.

Extending NEK's operational lifetime will not have any effect on the flood safety of the buildings either. Protection against floods was already implemented during the planning of the power plant and through the construction of embankments 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 the protective embankment.

- **Air**

The emissions of NEK into the air are negligible, the only emissions come from the auxiliary boiler room and the emergency diesel generator (three generators). These sources operate for short periods of time during outages and equipment testing. During the extended operation of the power plant there will be no new emissions of SO_2, NOx and PM_{10} or others, and the current level of emissions will not increase. The impact on air quality is negligible, which was verified by the modelling of dispersion in the atmosphere. The power plant has an indirect positive effect on air quality because its production of electricity means it did not have to be produced in fossil-fuel burning power plants. EU Member States have agreed to reduce air pollution emissions in their territories (LRTAP convention and NEC Directive), and NEK is contributing to this goal.

The operation of the cooling towers releases heat into the air, together with droplets and damp air, which in certain conditions forms a visible plume of steam. The effect of the cooling towers depends to a large extent on the weather conditions around the tower and the effect is local in nature. Due to climate change, the power plant will in future probably use the cooling towers even more to keep the thermal load on the Sava within ΔT 3°C. The magnitude of the effect will remain within the existing limits, the only difference could be that the impact may last longer.

- **Impact on the climate and resilience to climate change**

The increased concentration of greenhouse gases in the atmosphere is bringing about warming. In Slovenia in 2019 the electricity producing sector contributed 27% to the emission of greenhouse gases. The nuclear power plant emits no greenhouse gases and together with renewable energy sources is considered to be a low-carbon technology for electricity production. Thanks to the electricity produced by NEK, Slovenia contributes to the common goal of the EU, to reduce the emission of greenhouse gases and the goals of the Paris Agreement where the goal is to limit the rise in global temperature to a maximum of 2.0°C, if possible only to 1.5°C. If the Slovenian share (50%) of electricity produced at NEK was produced by thermoelectric plants, the electricity producing sector would have 1.5 times greater greenhouse gas emissions annually, which would amount to around 2,500,000 tCO_2-eq/year.

In 2019 the average global temperature was 1.1 ± 0.1 ° C higher than the preindustrial level. The year 2019 was likely the second warmest year since measurements started, while the previous decade 2010–2019 was the warmest decade on record. Each decade from the 1980s has been warmer than the decades that came before. The growth in average annual air temperatures in the period between 1961 and 2020 in Slovenia shows a rapid growth in temperatures at the end of the 20th and the beginning of the 21st century. In the years between 1961 and 2011 the average air temperature rose by 1.7°C. The amount of precipitation on an annual basis has fallen by around 15% in the western half of the country, and somewhat less (10%) in the eastern half of the country where the changes are not statistically significant. The water temperature grew by 0.2°C per decade for surface waters (1953–2015) and 0.3°C per decade for groundwater (1969–2015).

When planning investments in infrastructure and energy generation facilities, it is essential to analyse the resistance of the projects to climate change, whether they have sufficient integrated adjustment measures for the expected changes in climate variables (temperature, wind, storms, floods, hail and sleet, etc.). During the evaluation of impact it was found that NEK's production of electricity is sensitive to three climatic variables: access to water from the Sava, the temperature of the Sava and the extreme outdoor temperature. The power plant takes water from the Sava for the cooling of its condensers, the turbine cycle and the safety components. In periods of reduced flow of the Sava, the power plant uses its cooling towers to discharge some of its heat through the recirculation cycle. In this way the power plant maintains a temperature difference of no more than ΔT 3°C regardless of the state of the Sava, and this remains unchanged also in the power plant's future operation. In 2008, the nuclear power plant supplemented its cooling facilities with the construction of a third block of cooling towers. This has strengthened the plant's resistance to changes that could in the future be connected with a reduction in the river's flow and a rise in air and water temperatures. The construction of a system of hydroelectric power plants on the lower reaches of the Sava has moderated variations in the river's flow and temperature which favourably affects the stability of production.

An analysis of the impact of climate change on safety are analysed in accordance with legislation and the regulations governing nuclear safety and protection against ionising radiation. Extreme weather conditions in combination with other natural and other occurrences are an integral part of the safety analysis of power plants. The Periodic Safety Review (PSR), which is compulsory every ten years, includes an analysis of the effect of climate change and the Updated Safety Analyses Report (USAR) is constantly updated regarding all important safety aspects.

- **Noise**

No new noise sources are foreseen due to the extension of NEK's operational lifetime. NEK's production capacity also remains unchanged, and the power plant will continue to operate 24 hours a day, every day of the year, even after the extension of the operational lifetime. In the context of climate change, there could be an increase in the operation of cooling towers, but given the trend of climate variables, we estimate that the number of days that the cooling towers operate will not change significantly. The measured equivalent noise levels indicate that even if the cooling towers were to operate 365 days a year, the area of NEK and its immediate surroundings (the area of measuring points) would not be subject to excessive noise pollution.

Measurements and analyses of environmental noise in 2015 and 2020 (the results are described in report no. LFIZ – 201500001 – JJ/M and LOM – 20200588 – KR/M) have found that the sources in question did not exceed the limit values for environmental noise defined in the Decree on limit values for environmental noise indicators (Official Gazette of RS, Nos. 43/18 and 59/19) at any assessment point (in front of the most exposed buildings with safety premises) during the power plant's operation.

- **Electromagnetic radiation**

No new sources of electromagnetic radiation (EMR) (e.g. new transformer stations) are foreseen as a result of NEK's operational lifetime extension. Likewise, there are no plans to fit the existing transformer stations with new transformers or replace them with greater capacity transformers. On the basis of the above, we estimate that the burden from EMR will remain unchanged, i.e. as shown by the last EMR measurements in 2021.

The entire NEK site is classified as a Level II electromagnetic radiation protection area, while the nearby residential areas and other nearby radiation-sensitive areas constitute Level I electromagnetic radiation protection areas. The main sources of low frequency EMR on the NEK site are transformers and power lines. The developer operates several transformer stations. The 2020 report on measurements of low frequency electromagnetic fields /53/ shows that the limit values for Level II radiation protection were not exceeded on the NEK site and on the site's boundaries. All transformer stations are regularly checked and serviced, with appropriate records kept.

- **Vibrations**

The site of the activity covered by this report is at least 500 m away from the nearest residential building or other buildings that are sensitive to vibrations (e.g. cultural heritage structures, kindergartens, schools, etc.). Road transport in the scope of the activity flows along public regional and state roads, while local roads in densely populated areas are not used for the delivery of raw materials and ancillary materials, and the transport of products. The scope of road transport for operational needs is and will continue to be small, and will also flow along public regional roads outside densely populated areas. The production process inside NEK does not include machines, devices or activities that could be a significant source of vibrations in the environment.

- **Waste**

The types and annual quantities of waste (including radioactive) generated by NEK will not change substantially due to its extended operational lifetime. The rate at which waste is generated will remain the same.

The introduction of dry storage will change the technology of storing spent fuel from wet to dry. 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. An environmental impact assessment was carried out for the dry storage of spent fuel and a building permit was acquired (building permit no. 35105-25/2020/57 of 23 December 2020).

Due to the extension of the operational lifetime from 2023 to 2043, there will be an extra 547 m^3 or 884 t of low- and intermediate-level radioactive waste.

The burden on the environment due to this extra spent fuel will be equal in size and form to the existing burden, i.e. the burden in the years before the operating period was extended.

If NEK operated until the end of 2023, a total of 1,553 elements of spent fuel would be produced. If NEK operates until the end of 2043, 2,281 spent fuel elements will be produced.

Due to the extension of the operational lifetime from 2023 to 2043, an extra 728 spent fuel elements will be generated.

There are around 36 existing types of waste (2020) that are generated in all production and support processes, of which 19 are hazardous types of waste (description in section 2.19.4.1). The total volume of waste generated in 2020 was around 2,302 tonnes, including 2,192 tonnes of construction waste from works performed in 2019. The hazardous waste amounted to approximately 12.3 tonnes. The extended operational lifetime will not change the rate at which waste is created.

All waste, except for radioactive waste, is handed over for treatment to a contractor. NEK does not treat the other waste.

- **Ionising radiation**

During NEK's operating period the emission of radioactive material into the environment will be equal to the existing rate. NEK is continuously upgrading and improving its safety and process systems, which means that the environmental burden is constantly decreasing. The estimated annual effective dose for an inhabitant most affected by NEK's impacts in 2020 was 0.071 µSv. Compared to the annual effective dose from natural background radiation, which amounts to 2500 µSv in Slovenia, the contribution of NEK is negligible.

All calculations of radiation levels show that the dose rates and doses of ionising radiation resulting from the dry storage of spent fuel will be within the very strict limits, which were set out in the technical specifications of the project for the construction of dry cask storage, and are lower than the permitted levels.

Likewise, the annual effective external radiation dose on the NEK perimeter fence from all contributors, including the dry storage of spent fuel, will not exceed, during operation, the radiation load that currently applies to the NEK perimeter fence, which is 200 µSv.

- **Light pollution**

As NEK's external lighting is an integral part of the technical systems for ensuring physical protection, NEK is not bound by the Decree on limit values for light pollution (Official Gazette of RS, Nos. 81/07, 109/07, 62/10, 46/13), but by the Rules on the physical protection of nuclear facilities and nuclear and radioactive materials, and the transport of nuclear materials (Official Gazette of RS, Nos. 17/13, 76/17 [ZVISJV-1]).

Nevertheless, NEK continuously strives to comply with requirements for reducing light pollution by, for example:
- using the appropriate, horizontally mounted lights with level glass;
- not turning lights upwards more than is foreseen in the project to achieve appropriate illumination levels; and
- upgrading lights with modern, energy efficient solutions such as LEDs, etc.

The extended operational lifetime **does not foresee** the installation of additional lights on the NEK site, so the illumination of the area and the light emitted to the surroundings will be **equal** to the existing state.

- **Landscape**

The appearance of the power plant will not change during the extended operating period. At the beginning of the extended operational lifetime, dry cask storage for spent fuel will have already been built, while no other construction works are foreseen. Due to the increasingly common occurrence of either high or low levels of the Sava, it is expected that the cooling towers will operate more often, accompanied by steam emissions that will be visible from larger distances. The occasional appearance of steam will not have a significant effect on NEK's visibility in the surroundings. The planting of a forest belt alongside the low- and intermediate-level radioactive waste depository will further reduce the power plant's visibility from the east and south-east.

- **Nature**

During its operation, NEK does not emit ionised radiation into the environment which could have a marked effect on the flora and fauna surrounding the power plant. NEK uses water from the Sava for cooling the condensers and turbines and for cooling the safety components. The environmental permit stipulates that NEK must ensure that at no time of year, the synergetic action of the discharge of industrial cooling waters and other discharged wastewaters may cause the Sava to exceed its natural temperature by more than 3 K. NEK fulfils this condition. The ecological state of the Sava downstream from NEK is evaluated as being good. A sustained impact on the vegetation and types of habitat in the vicinity of NEK could occur in the event of a serious accident resulting in the discharge of radioactive substances into the environment. Numerous safety upgrades have been implemented at NEK. For this reason, the possibility of core damage is very small.

- **Land**

The site of the planned activity is located in an area of building land on which mainly industrial buildings classified E – energy infrastructure have been built (the intended use is presented in section 1.8.1). The planned change (expansion) does not reach outside the area presently occupied by NEK, and is in accordance with valid spatial planning documents, while the planned and actual land use do not change with the planned extension of NEK's operational lifetime.

In terms of wooded land, an opinion has been given by the Ministry of Agriculture, Forestry and Food (no. 3401-43/2020/4). On the basis of a review of materials, the aforementioned ministry finds that there is no wooded land on the NEK site. There will thus be no direct impact on wooded land. There will also be no indirect or remote impacts on the forest, as the wooded land is more than 450 m away from the site of the planned activity. No additional negative impact on wildlife is expected either.

In terms of agricultural land, an opinion has also been given by the Agriculture Directorate of the Ministry of Agriculture, Forestry and Food (no. 351-77/2020/5). The competent ministry believes that the planned extension of NEK's operational lifetime from 40 to 60 years will not have any particular impact on agricultural land.

- **Natural assets**

The direct use of natural resources in production encompasses the use of water from the public water network for sanitary needs and fire safety, and river water and groundwater, which is taken from wells and the Sava for technological needs on the basis of water permits. River water and groundwater is not used as a raw material (it is not incorporated into products), but is used in supportive cooling processes. Following use and appropriate treatment, all the water is returned into the environment, i.e. into the Sava. The water pumped from the three temporary wells returns directly into the Sava via the rainwater drainage system.

During the extended operational lifetime, the use of river water and groundwater will not change significantly and will remain similar to the current state.

- **Material assets**

The extension of NEK's operational lifetime will not have a significant impact in terms of increasing existing burdens on the environment. The state will remain unchanged. All activities that enable the extension of the operational lifetime will have been carried out before it begins. The annual effective external radiation dose on the NEK perimeter fence from all contributors, including the dry storage of spent fuel, will not exceed, during operation, the radiation load that currently applies to the NEK perimeter fence, which is 200 μSv.

In the period of NEK's extended operational lifetime, there will be no effect on material assets (land, buildings and cultural heritage) around the site of the activity.

- **Risks of environmental and other accidents**

Extending NEK's operational lifetime means prolonging its operation by 20 years (2023–2043) under the same environmental and radiation conditions as prescribed in the existing operating licence.

Although NEK was designed for a minimal operating period of 40 years, the power plant has carried out all the necessary analyses and upgrades from which it follows that it can operate for another 20 years. 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 the operational lifetime is based above all on the following facts:

- the power plant has built-in materials and equipment that provide sufficient safety reserves;
- all equipment that affects the reliability of operation has been replaced;
- the operation of the power plant is stable;
- a safety upgrade has been implemented in accordance with the demand of ZVISJV-1 and the lessons learnt from all past major nuclear accidents which is reflected in ENSREG (the national post-Fukushima plan);
- NEK has a comprehensive aging management programme (AMP) in place to monitor the aging of all passive structures and components (reactor pressure vessel, concrete, underground pipelines, steel structures, electrical cables, etc.).

Safe and reliable operation in all conditions is NEK's top priority. Since it began operating, NEK has carried out a series of modernisations which have increased the site's safety and efficiency.

Extending the operational lifetime will not represent a risk for the environment or other possible accident, considering the foreseen solutions and safety functions are ensured.

- **Population and health protection**

As follows from the findings in previous chapters of this report, which deal with the impacts of lifetime expansion (LTE) on all relevant environmental factors it might affect, NEK's current level of production does not exceed the limit values for substance emissions and radiation into the environment. It is not expected that the limit values will be surpassed during the planned extension of operational lifetime of NEK either. The limit value is the prescribed level whose aim is to avoid, prevent or reduce harmful effects on human health or the environment as a whole. NEK implements, and will continue to implement after the changes, all the measures to reduce burdens and prevent pollution of the environment and the impact on human health, which stem from regulations. Regular monitoring is also carried out in keeping with applicable prescriptions and permits.

The change in the current activity (extension of the operational lifetime) will not cause changes to natural and other conditions of life and habitation near the site of the activity and further afield.

During the extended operational lifetime, there will be regular monitoring throughout NEK, which is already being carried out now - measurements of river water pumping for technological purposes, measurements and analyses of wastewater discharged into the sewage system, and measurements of radiation.

- **Transboundary impacts during normal operation**

NEK's current level of production does not surpass the limit values of substance emissions and radiation into the environment. It is not expected that the limit values will be surpassed during the planned extension of operational lifetime of NEK either. The area in which the activity causes an environmental burden, that can affect human health or property, will be limited to the narrower NEK site. Under normal operation, the foreseen activity will have no transboundary effects on factors dealt with in this report that would stem from individual influences or their mutual effects.

- **Transboundary impacts in the event of an emergency – accident**

The study "Calculation of doses at certain distances for Design Basis (DB) and Beyond Design Basis (BDB) accidents at NEK", FER-MEIS, 2021, dealt with the design basis Large-break Loss of Coolant Accident (LB LOCA) and the Design Extension Conditions (DEC-B). As evident from the results of the study, the effective 30-day dose at a distance of 10 km from the power plant is 1.16 mSv and therefore more than two times lower than the annual natural background dose, which is about 2.5 mSv in Slovenia. The thyroid gland dose (13.5 mSv) at a distance of 3 km from NEK is below the limit (50 mSv for 7 days) prescribed by law (Decree on dose limits, reference levels and radioactive contamination, Official Gazette of RS, No. 18/18) for iodine prophylaxis.

The distance of NEK from the closest borders of neighbouring countries is:
- 10 km from the border with Croatia;
- more than 75 km from the border with Austria;
- more than 129 km from the border with Italy;
- More than 100 km from the border with Hungary.

The results of the study show that in the event of a Large-break Loss of Coolant Accident (LB LOCA) and Design Extension Conditions (DEC-B), which also represent the worst possible accident scenarios, there will not be a significant transboundary impact on the environment and people's health and possessions.

Measures to prevent, reduce, and offset the identified significant adverse impacts on the environment – Operation

Described below are the mitigation measures required to prevent significant impacts on individual environmental components. These include mitigation measures that the developer is already implementing and will continue to implement during the extended operational lifetime. They are divided into measures prescribed by law, measures set out in the environmental permit, measures defined by the project, and additional measures.

Waters, including thermal pollution

- Compliance with the provisions of the Ordinance on NEK's development plan:
    - adequate quality of the water treated in the treatment plant;
    - monitoring the influence of NEK cooling water on the inflow of the Sava water into groundwater, the temperature of which must not exceed 15°C;
    - an independent meteorological station at NEK. The programme of measurements is defined by the Slovenian Nuclear Safety Administration.
- Compliance with the measures set out in the environmental permit regarding emissions into waters, the permitted quantities of water abstracted from the Sava, and on-site pumping of water from wells.
    - The limit emission value of transmitted heat in the 24-hour average for the removal of wastewater into the Sava – at any time during the year, the discharge of industrial cooling waters and other discharged wastewaters must not cause the Sava to exceed its natural temperature by more than 3 K. NEK must activate the cooling water recirculation system in a timely manner via the cooling towers so that the temperature of the Sava does not exceed its natural temperature by more than 3 K. If the combined cooling system is insufficient to fulfil this condition, the power of the power plant must be reduced accordingly.
- Compliance with the additional measures that the developer has implemented or is carrying out:
    - Expansion of the cooling tower system, which reduces the quantity of water abstracted from the Sava, reduces the heat load, and increases resilience to climate change. Four new cooling cells were installed, and all the electrical equipment of the cooling tower system was replaced. The power of the cooling towers has increased by 36%. The emission value of transmitted heat in the 24-hour average is maintained below 1.

→ *Compliance with the limit values specified in the environmental permit, prevention of surface water and groundwater pollution.*

Climate change

- Compliance with the provisions of the Decree on the use of fluorinated greenhouse gases and ozone-depleting substances:
    - Obligation of the operator to report stationary equipment, and the obligation of the operator, maintenance provider and authorised company to report the use, capture, and delivery of waste fluorinated greenhouse gases and waste ozone-depleting substances to the waste collector.
- Compliance with the measures set out in the environmental permit:
    - The structures, systems and components of the power plant are dimensioned to withstand extreme weather events and meteorological parameters by ensuring highly conservative margins, and by following best practices and technology development;
    - The periodic safety review (performed every 10 years) includes analysis of the impact of extreme weather events on the safety of the power plant;
    - Limitation of the heat load on the Sava through the use of the combined cooling system (flow system and cooling towers). The power plant maintains a temperature difference of no more than ΔT 3°C regardless of the state of the Sava;
    - Procedures in the event of hydrological conditions that may affect the operation of the power plant: activation of cooling towers at high water levels due to the risk of inflow of debris (branches, plastic, etc.);
    - Cooperation with other energy facilities on the Sava – agreement on measures and obligations to ensure unchanged, safe and uninterrupted operation of NEK during the operation of the hydroelectric power plants on the lower Sava by implementing additional monitoring on the Sava;
    - Measurement of meteorological parameters at the automatic station with an on-site meteorological tower and the use of SODAR for high-altitude atmospheric measurements. Annual reporting of the measurements.

→ *Compliance with the limit values specified in the environmental permit, prevention of surface water and groundwater pollution, and resilience to climate change.*

Waste

- Compliance with the provisions of the Rules on radioactive waste and spent fuel management:
    - Management of radioactive waste and spent fuel is carried out in accordance with written procedures – the radioactive waste and spent fuel management programme;
    - Sorting of radioactive waste with regard to its aggregate state and by category and type;
    - The packaging of radioactive waste and spent fuel must ensure that the intended manner of handling the containers is safe at all times. The suitability of packaging for confinement and storage conditions is verified;
    - The radioactive waste and spent fuel containers are marked with a radiation hazard symbol and a container label identifying their contents;
    - Radioactive waste is stored in the radioactive waste storage facility, and spent fuel in the spent fuel storage facility. Spent fuel and high-level radioactive waste are stored in such a way as to prevent criticality and ensure the removal of residual heat;
    - Radiation activities are carried out in such a manner that the releases of liquid or gaseous radioactive waste into the environment do not exceed the approved limit values;
    - NEK keeps up-to-date records on the confinement of radioactive waste and spent fuel, as well as on its processing in the technological process, storage or release, clearance, recycling or reuse, delivery to a public service provider, and temporary or permanent export or shipment abroad;
    - If the collected wastewater exceeds the clearance criteria, it is treated as secondary radioactive waste that is processed at NEK. If it does not exceed the clearance criteria, and if it meets the criteria for municipal wastewater, it is discharged into the internal water treatment plant. If the collected wastewater exceeds the criteria for discharge to

the sewage system, it is dispatched for treatment to an authorised collector or processor of such waste.

- Compliance with the measures defined by the dry storage project:
    - The work platform in front of the dry storage and the transfer facility in the storage area are equipped with drainage sumps. Any water collected will be removed using mobile devices. Sampling will be carried out before the pits are emptied. In the event that the limits for discharging this water are exceeded, a special container will be used to transport the wastewater to the technological section of the power plant, where it will be processed.
    - In the event of leakage from a transfer overpack, radiological and chemical monitoring of the collected water is performed before the water is pumped from the pit. If the collected wastewater exceeds the clearance criteria, it is treated as secondary radioactive waste that is processed at NEK. If the collected wastewater does not exceed the clearance criteria, and if it meets the criteria for municipal wastewater, it is discharged into the internal water treatment plant. If the collected wastewater exceeds the criteria for discharge to the sewage system, it is dispatched for treatment to an authorised collector or processor of such waste.

→ *Prevention of soil, surface water and groundwater pollution, and prevention of uncontrolled releases of ionising radiation into the environment.*

Nature

- Compliance with the provisions of the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system with regard to the limit emission value of transmitted heat in the discharge of industrial wastewater.
- Compliance with the measures set out in the environmental permit:
    - The limit emission value of transmitted heat in the 24-hour average for the removal of wastewater into the Sava – at any time during the year, the discharge of industrial cooling waters and other discharged wastewaters must not cause the Sava to exceed its natural temperature by more than 3 K. NEK must activate the cooling water recirculation system in a timely manner via the cooling towers so that the temperature of the Sava does not exceed its natural temperature by more than 3 K. If the combined cooling system is insufficient to fulfil this condition, the power of the power plant must be reduced accordingly.
- Compliance with the additional measures that the developer has implemented or is carrying out:
    - If the flow rate of the Sava is lower than 100 m^3/s, NEK activates the cooling towers, through which a portion of the condenser water is cooled via recirculation. Expansion of the cooling tower system – four new cooling cells (a new cooling tower – CT3) were installed, and all the electrical equipment of the cooling tower system was replaced.

→ *Prevention of excessive thermal pollution of the Sava, prevention of adverse temperature conditions for organisms in the Sava.*

Ionising radiation

- Compliance with the restrictions set out in NEK's operating licence:
    - The maximum permissible annual effective dose from emission of radioactive material at 500 m from the reactor centre : 50 µSv;
    - Limit on the annual activity of fission and activation products in liquid discharges: 100 GBq;
    - Limit on the quarterly activity of fission and activation products in liquid discharges: 40 GBq;
    - Limit on the annual activity of H-3 in airborne discharges: 45 TBq;
    - Limit on the annual activity of iodine in gaseous discharges: 18.5 GBq;
    - Limit on the annual activity in dust particles: 18.5 GBq;
    - Limit on the annual dose of external radiation on the NEK perimeter fence: 200 µSv.
- Compliance with the restrictions for the operation of the SF dry storage facility:
    - Permissible dose rate on the outside of the dry storage facility: 3 µSv/h;

  - Following the storing of SF in the dry storage facility, the annual effective external radiation dose at the NEK perimeter fence will not exceed the limit of 200 μSv;
  - The effective dose limit for exposed workers is 20 mSv per year.
- Compliance with the measures defined by the SF dry storage project:
  - The thickness of the concrete walls of the dry storage facility is adequate to ensure protection against gamma radiation, and the walls are lined with neutron radiation protection material;
  - In order to monitor the impact of the dry storage facility on the radiation parameters at the NEK perimeter fence, radiation will be measured using dosimeters (7 dosimeters for gamma radiation and 7 dosimeters for neutron radiation). Passive dosimeters will also be installed in the storage area of the spent fuel dry storage building;
  - Dosimeters will be read and replaced at least once every 6 months;
  - During the transport of spent nuclear fuel from the fuel handling building to the dry storage building, a controlled area will be established along the transport routes, that is, the area will be cordoned off, marked, and unauthorised access will be prevented.
- Compliance with the additional measures that the developer is already carrying out:
  - Filtration of liquid emissions;
  - Filtration of gaseous emissions;
  - Confinement of radioactive effluents in order to minimise radioactivity through radioactive decay;
  - Measures to ensure fuel integrity;
  - Design and implementation of structural protection (adequate wall thickness, labyrinth design of the rooms);
  - Installation of temporary shields for short term activities that result in locally increased levels of external radiation;
  - Storage of radioactive waste and spent fuel at the facilities intended for this purpose.

→ *The implementation of these measures will ensure compliance with all radiological conditions and limits set out in the valid NEK operating licence and in the Ionising Radiation Protection and Nuclear Safety Act.*

→ *Population health protection.*

Material assets

- There are no special legislative measures covering material assets during operation. The measures taken into account are those listed for individual relevant factors (waters, waste, ionising radiation, risks of environmental and other accidents).
- All measures that the developer is already carrying out are listed in the previous sections (ionising radiation).

Risks of environmental and other accidents

- Compliance with the provisions of the Ordinance on NEK's development plan:
  - Compliance with the provisions for the SF dry storage;
  - Implementation of solutions and measures applying to defence and to protection against natural and other disasters, including protection against fire;
  - The potential spread of fire to adjacent structures and land is restricted by the use of fire-resistant materials;
  - Emergency exits from the facilities;
  - Water for fire suppression is provided through the existing hydrant network and the NEK pumping station;
  - Emergency access routes within the NEK complex provide access for firefighting vehicles;
  - The use of hazardous substances (fuel for diesel motors, lubricants, paints, etc.) is restricted to areas equipped with oil traps to prevent spillage into the environment.
- Compliance with the measures set out for other environmental components (waters, climate change, waste, ionising radiation).

Population and health protection

- There are no special legislative measures covering material assets during operation. The measures taken into account are those listed for individual relevant factors (waters, climate change, waste, ionising radiation).
- All additional measures implemented by the operator are those previously listed for environmental components (waters, waste, ionising radiation, risks of environmental and other accidents).

Measures to prevent, reduce, and offset the identified significant adverse impacts on the environment – Termination of activity

Radioactive waste and ionising radiation

- Compliance with the measures that stem from regulations:
    - The decommissioned area will still have limited access, be marked out and dealt with as an area of radiation monitoring.
    - All activities associated with the termination of operation will be carried out in accordance with the requirements of regulations, the management system and written work procedures and instructions.

→ *The implementation of these measures will prevent uncontrolled emission of ionising radiation into the environment.*

Monitoring the status of impact mitigation factors and measures – Operation

Waters

In the event of leakage from the HI-TRAC transfer overpack (which also contains glycol in winter), sampling and analysis of wastewater collected in the CTF drain sump is performed in accordance with the Rules on initial measurements and operational monitoring of wastewater and the Decree on the emission of substances and heat in the discharge of wastewater into waters and the public sewage system.

Measurements of the quantities of water abstracted for process purposes are carried out at abstraction locations in accordance with the environmental permit. Measurements of pollution parameters and wastewater quantities are carried out at measuring points in accordance with the environmental permit.

It is recommended that the measurements of parameters are performed at the entrance to the system, if the conditions in the Sava at the time of sampling clearly indicate elevated concentrations of sedimentary matter and undissolved substances.

Air

Due to the possibility that the auxiliary boilerhouse may operate more than 300 hours per year, it is recommended that a one-off measurement of emissions is performed by an authorised laboratory (dust, smoke number, CO, NOx, SO_2) in accordance with the Decree on the emission of substances into the atmosphere from medium-sized combustion plants, gas turbines and stationary engines.

Noise

In accordance with the Rules on initial assessment and operational monitoring of sources of noise and conditions for the implementation of monitoring, an authorised contractor will carry out noise measurements once every three years.

Electromagnetic radiation

In accordance with the Rules on initial measurements and operational monitoring of sources of electromagnetic radiation and conditions for the implementation of monitoring, an authorised contractor will carry out EMR measurements once every three years.

Ionising radiation

NEK is carrying out extensive monitoring of radioactive emissions and immissions, which is defined in the Radiological Effluent Technical Specification (RETS). The document describes the systems for monitoring liquid and airborne emissions, locations, and frequency of monitoring. NEK monitors radioactive emissions in all systems where radioactivity might occur during operation.

Emission monitoring includes:

- measurements of liquid emissions in periodic and continuous discharges,
- measurements of gaseous emissions: periodic and continuous.

At the same time, extensive monitoring of radioactivity in immissions is carried out in the vicinity of NEK. The monitoring includes all transmission routes by which a person can receive a dose:

- the Sava (water, sediments, and aquatic biota);
- water supply network and boreholes;
- pumping stations and catchments;
- precipitation and depositions;
- air;
- external radiation;
- soil;
- food – milk, fruit, garden crops and field crops.

Immission measurements are performed by authorised environmental monitoring contractors in accordance with the Rules on the monitoring of radioactivity. A report on radioactivity monitoring in the vicinity of NEK, which includes dose estimations for reference population groups, is compiled every year.

The construction of the spent fuel dry storage building will require additional external radiation monitoring. Currently, NEK is measuring the dose rate of ionising radiation with six passive optically stimulated luminescence (OSL) dosimeters at measuring points on NEK fence. After the construction of the dry storage building, a total of six passive dosimeters will also be installed in the storage area. Additional passive dosimeters will be installed on the NEK perimeter fence.

During the transfer of spent fuel from the FHB to the DSB, a temporary controlled area will be established along the transfer route and measurements of radiation parameters will be carried out.

Since July 2017, NEK has been conducting additional radioactivity monitoring of the Sava to account for the impacts of the construction and operation of the Brežice HPP. In addition to the usual sampling locations, radioactivity is measured on both sides of the reservoir, at the Brežice HPP dam, in the replacement habitat, and in additional boreholes.

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/268/ Strategic framework of adapting to climate change, December 2016 https://www.preventionweb.net/files/61770_sozp.pdf

/269/ JASPERS Guidance Note, The Basics of Climate Change Adaptation Vulnerability and Risk Assessment, Version 1, JASPERS, June 2017

/270/ Krško nuclear power plant, Annual report on NEK operation for 2019, February 2020

/271/ 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

/272/ Minutes of the 10th meeting of the Intergovernmental Commission for Monitoring the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations regarding Investment, Exploitation and Decommissioning of NEK, dated 20 July 2015

/273/ COM(2021) 551 final 2021/0211 (COD) Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757

/274/ 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

/275/ 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

/276/ MOP, DRSV (2021): NEK Water Permit, No. 35530-48/2020-3, 9 September 2021, Ljubljana

/277/ 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

/278/ Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, last amended by Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, which entered into force on 16 June 2017

/279/ Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people, COM (2020) 562 final, 2020

/280/ Report on the quality of potable water in the public water supply system, and on the discharge and treatment of wastewater in the municipalities of Krško and Kostanjevica na Krki in 2019, Kostak, March 2020

/281/ Act Ratifying the United Nations Framework Convention on Climate Change (Official Gazette of RS – International Treaties, No. 13/95)

/282/ Act ratifying the Paris Agreement (Official Gazette of RS – International Treaties, Nos. 16/16 and 6/17 – corr.)

/283/ Ministry of the Environment and Spatial Planning (2021): Draft Water Management Plan for the Danube River Basin 2022–2027. Material for public consultation, December 2021, https://www.gov.si/assets/ministrstva/MOP/Javne-objave/Javne-obravnave/NUV_III/nuvIII_osnutek_Donava.pdf

/284/ Attia, S. The influence of condenser cooling water temperature on the thermal efficiency of a nuclear power plant. Amsterdam: Elsevier., 2015

/285/ Precipitation, relative humidity and soil moisture for March 2020, https://climate.copernicus.eu/precipitation-relative-humidity-and-soil-moisture-march-2020

/286/ IPCC (TAR5) Long-term Climate Change: Projections, Commitments and Irreversibility, fig 12.21

/287/ Ali Ayoub, at al.: Cooling towers performance in a changing climate: Techno-economic modeling and design optimization, Energy 160 (2018), 1133-1143

11.1.2 Availability, quality, punctuality and completeness of data

The report made use of the latest public data about the state of the environment in the relevant area by the Slovenian Environment Agency, mainly for 2020 and 2019, which do not reflect the current state (2021) for certain factors, but we estimate that they are still up-to-date and of a good enough quality to evaluate the existing state of the environment in the area of the activity. The availability, quality, punctuality and completeness of data about the existing burdens on the environment - reports on monitoring and other data provided by the developer, was very high.

11.1.3 Warnings

The decommissioning of the facility is **not the subject** of this assessment and will be subject to other administrative procedures relating to construction, nuclear safety and environmental protection, and as such the decommissioning of the facility, in the parts relating to impacts resulting from this activity's termination, is **not addressed** by this report.

Environmental impacts due to the extension of NEK's operational lifetime are therefore described and evaluated for the period of operation and if the activity is terminated, emphasising once again that the activity termination **disregards** the decommissioning programme for the reasons described in the beginning of Section 2.18.

The report makes use of data for 2020 and partly for 2019 and the representative data from previous years. In connection with this we must explain that the maximum capacity of electricity production by NEK did not change during this period, just as the operating period did not change (24 hour production, every day of the year).

While drawing up the report we did not come across technical or other difficulties which could affect the assessment of the activity on the environment so there are no other particular warnings.

11.2 GRAPHIC REPRESENTATIONS

For greater clarity, the existing state of the environment and the spatial characteristics of the activity are presented in a series of aerial photographs which enable an appropriate presentation of the activity and the environment in which the activity will take place. The area in which the lifetime extension causes an environmental burden that can affect human health or property is presented in **Attachment 3**.

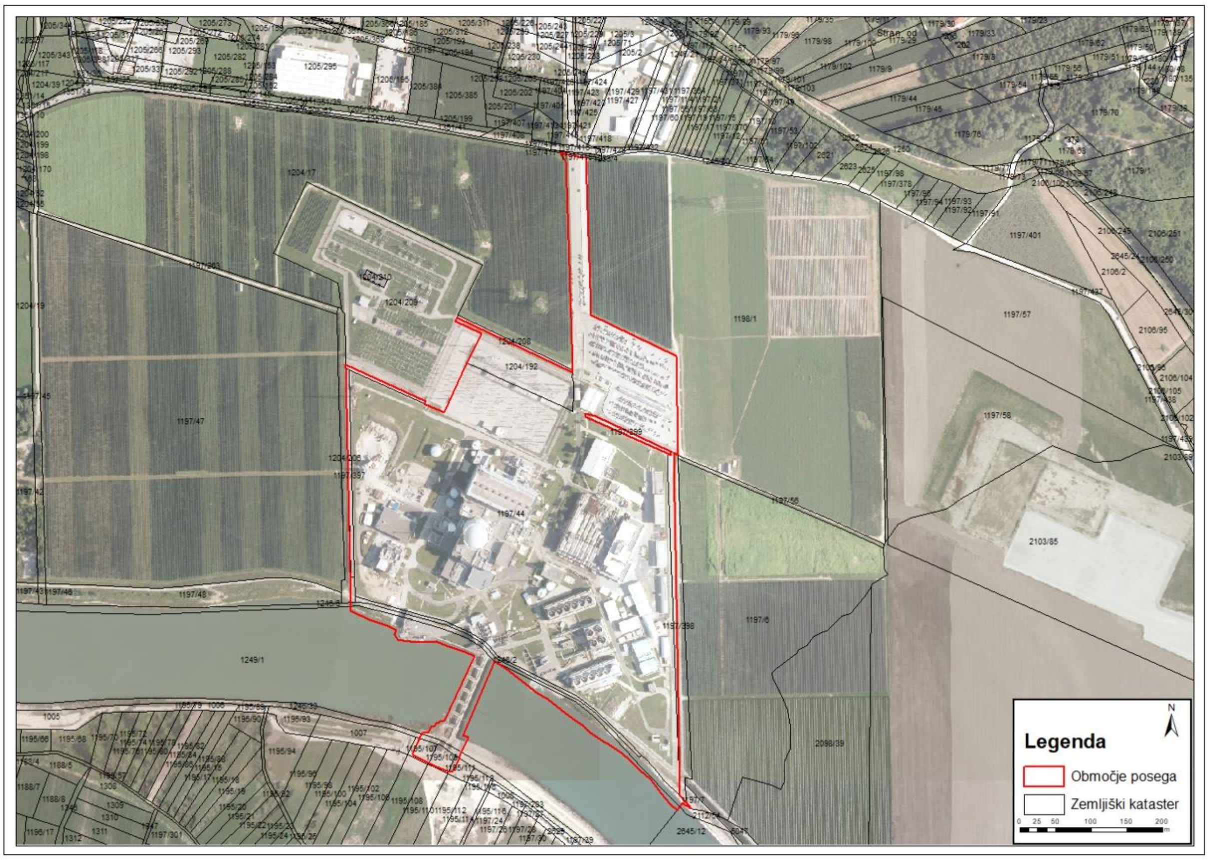


Figure 145: Spatial characteristics of the activity (source: /1/, /60/)

Legenda	Key
Območje posega	Area of the activity
Zemljiški kataster	Cadastral register

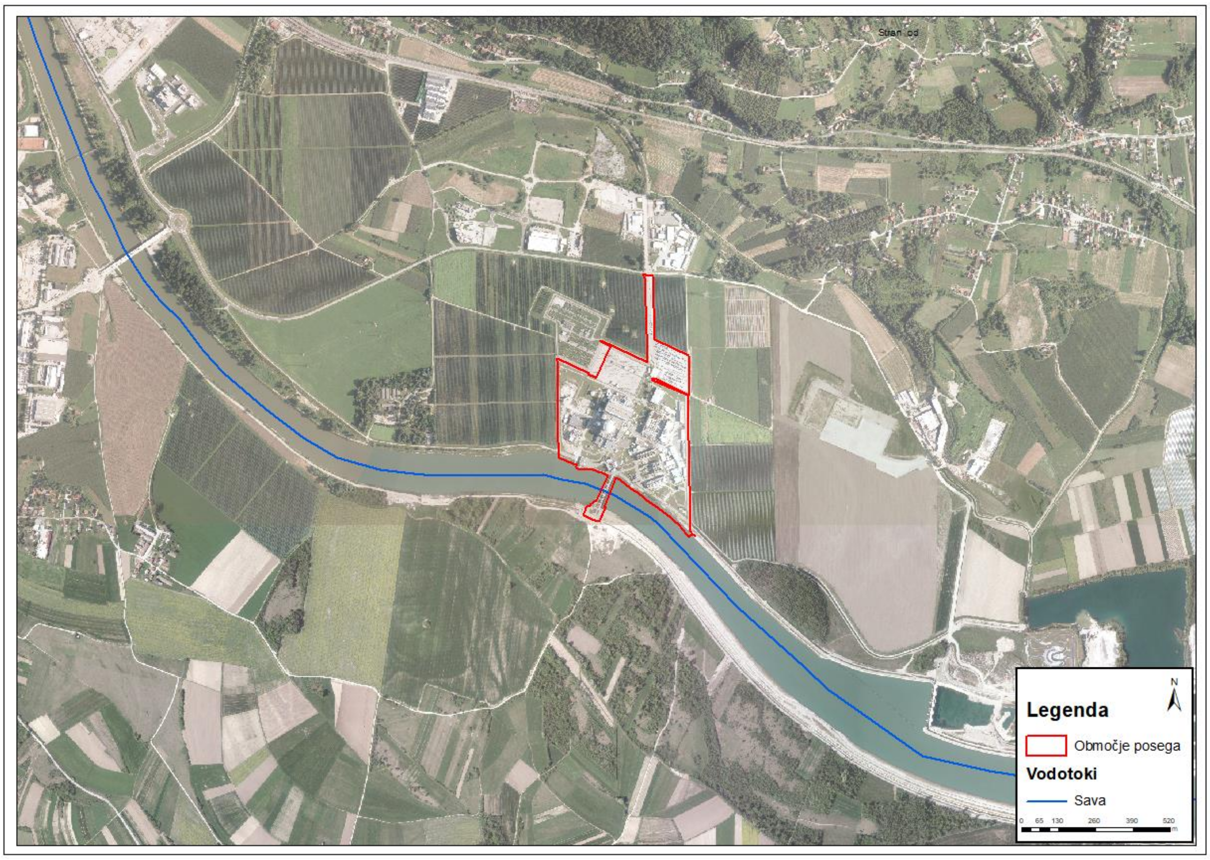


Figure 146: Surface waters in the broader surroundings of the activity on a scale of 1:10,000 (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
Vodotoki	**Watercourses**
Sava	Sava

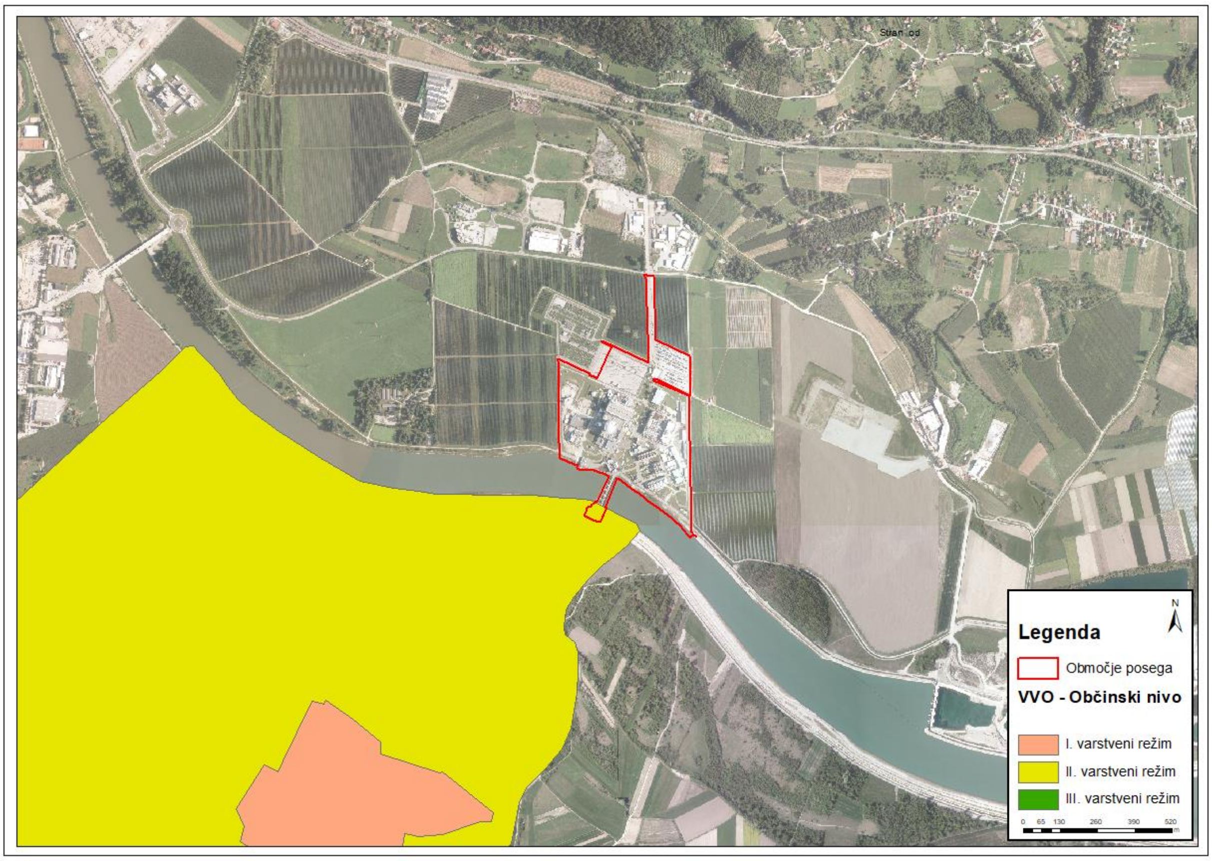


Figure 147: Water protection and catchment areas (municipal level) in the broader surroundings of the activity on a scale of 1:10,000 (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
VVO – Občinski nivo	**Water protection areas - Municipal level**
I. varstveni režim	Protection regime I
II. varstveni režim	Protection regime II
III. varstveni režim	Protection regime III

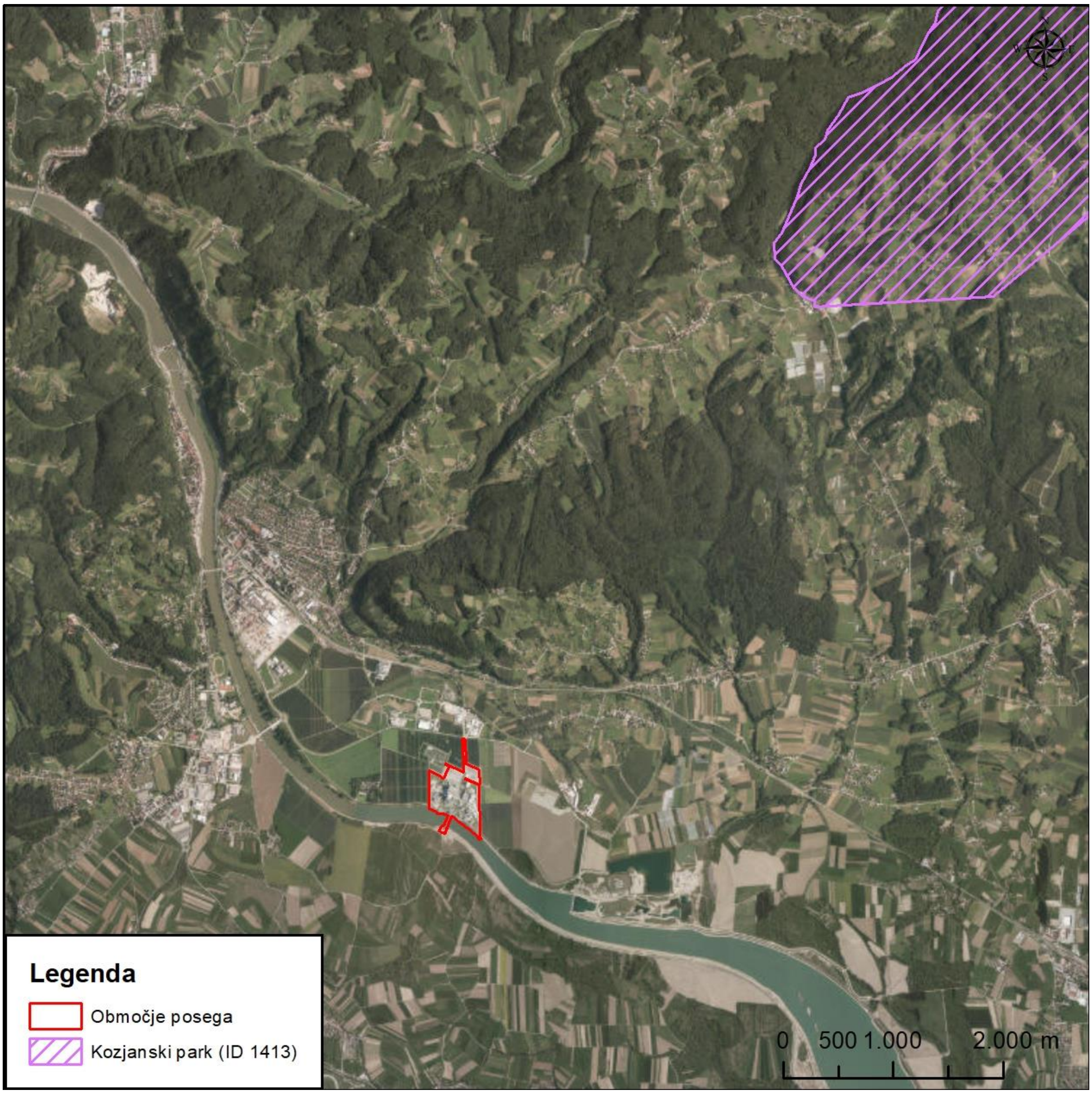


Figure 148: Protected areas of local importance in the broader surroundings of the activity (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
Kozjanski park (ID 1413)	Kozjanski park (ID 1413)

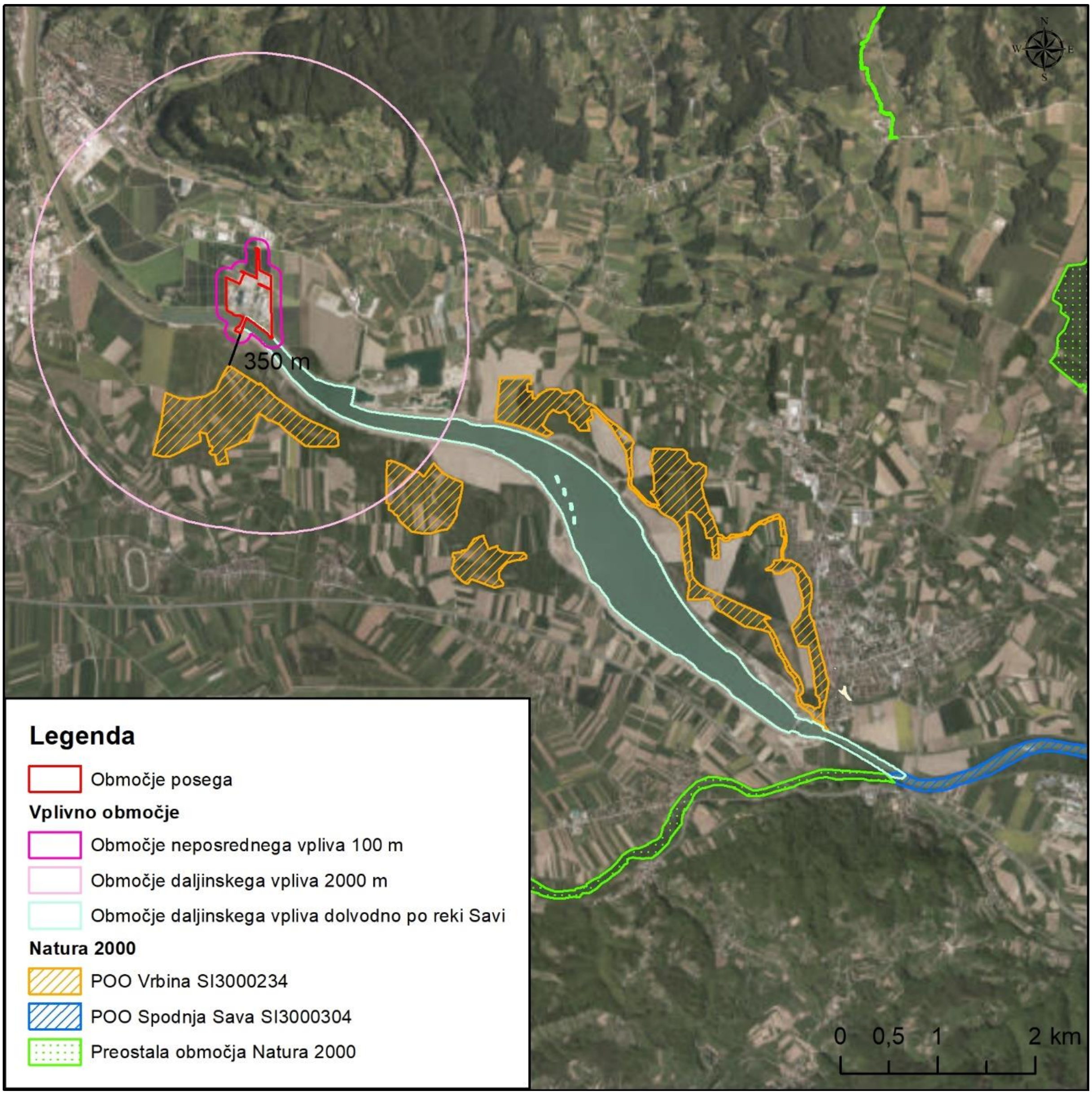


Figure 149: Natura 2000 areas in the broader surroundings of the activity (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
Vplivno območje	**Impact area**
Območje neposrednega vpliva 100 m	Area of direct impact 100 m
Območje daljinskega vpliva 2000 m	Area of remote impact 2,000 m
Območje daljinskega vpliva dolvodno po reki Savi	Area of remote impact along the Sava downstream
Natura 2000	**Natura 2000**
POO Vrbina SI3000234	Vrbina SAC SI3000234
POO Spodnja Sava SI3000304	Lower Sava SAC SI3000304
Preostala območja Natura 2000	Other Natura 2000 areas

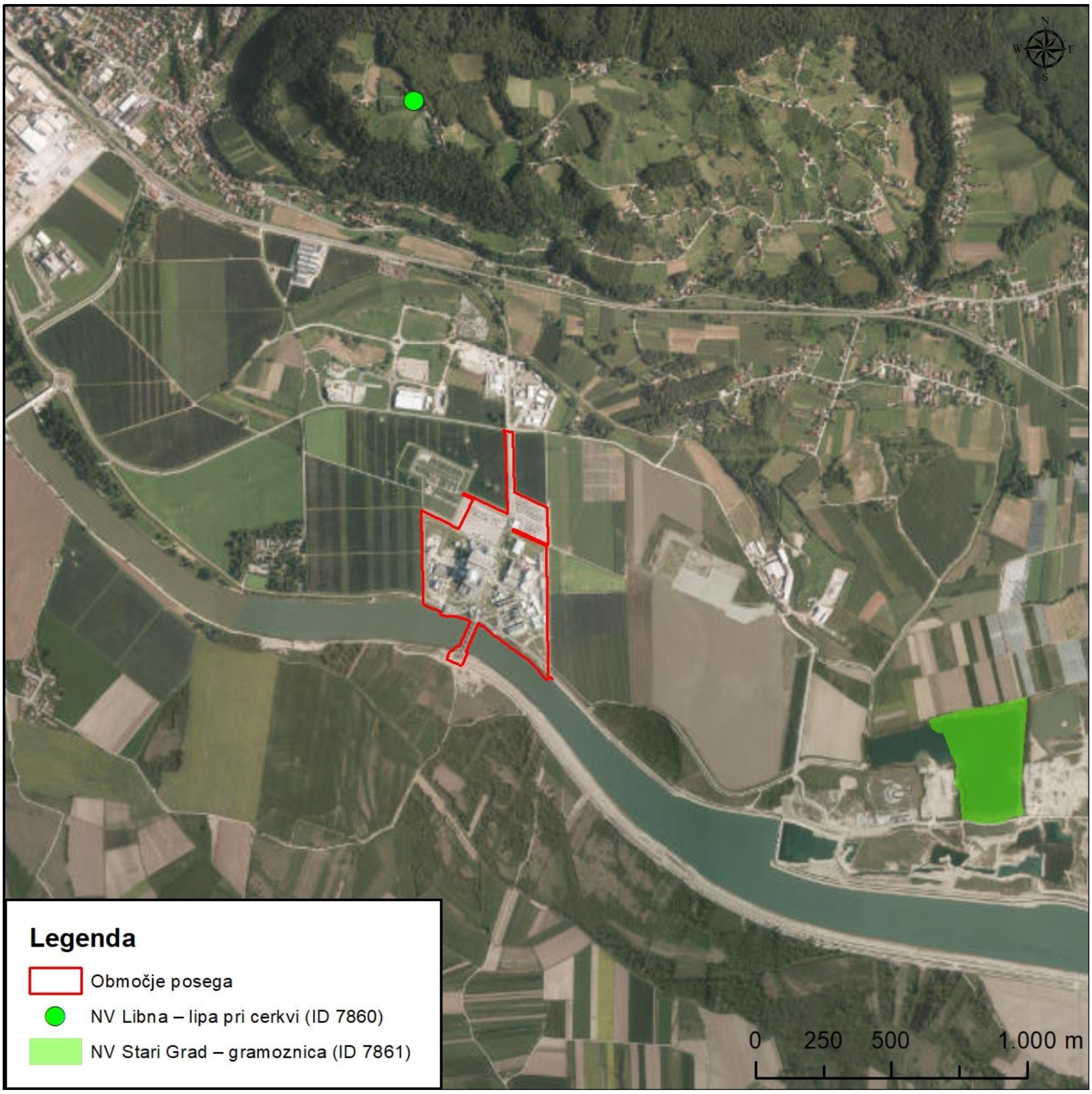


Figure 150: Natural assets in the broader surroundings of the activity (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
NV Libna – lipa pri cervi (ID 7860)	VNF in Libna – linden tree next to church (ID 7860)
NV Stari Grad – gramoznica (ID 7861)	VNF in Stari Grad – gravel pit (ID 7861)

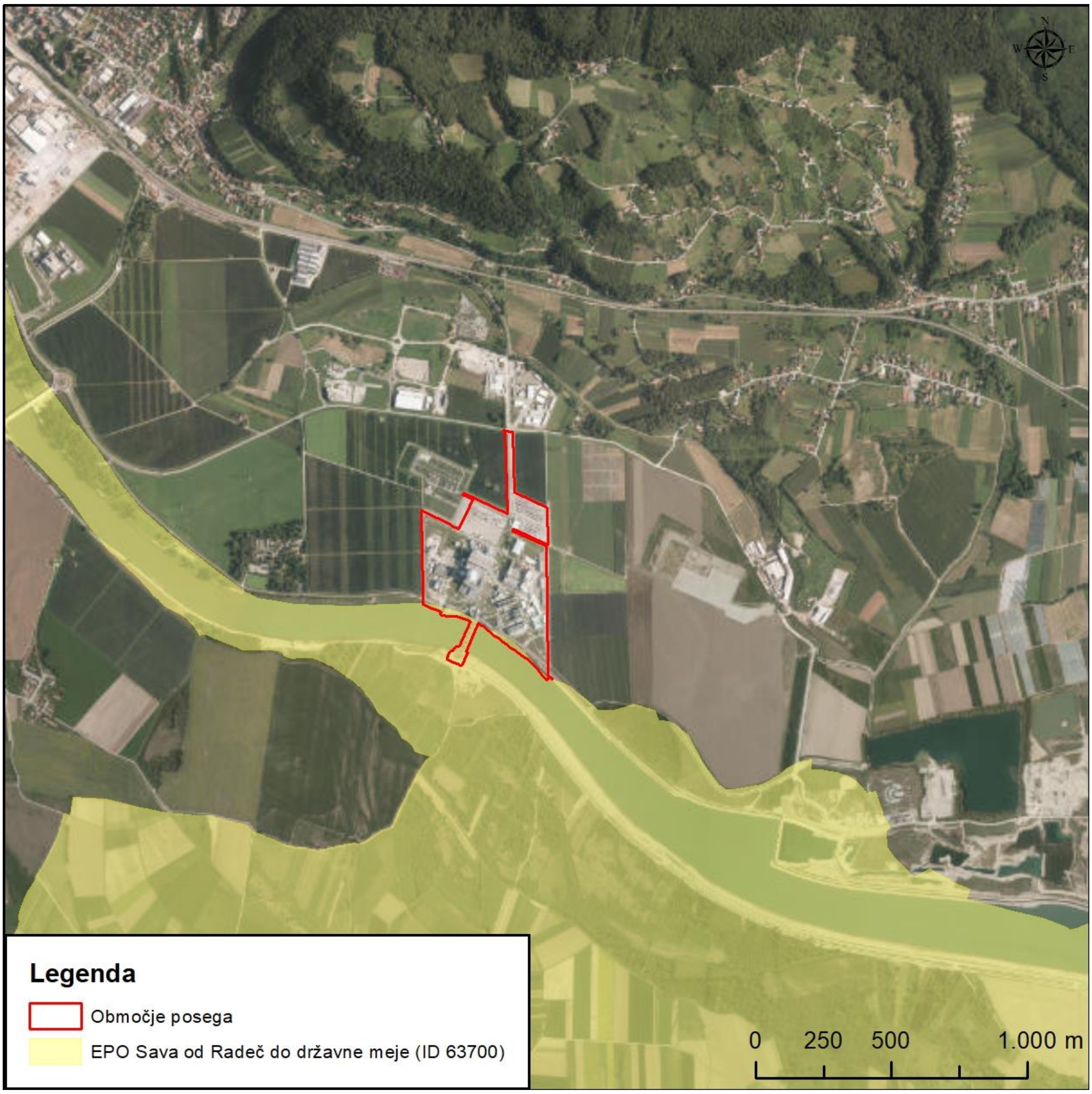


Figure 151: Important ecological areas in the broader surroundings of the activity (source: /1/, /60/)

Legenda	Key
Območje posega	Area of the activity
EPO Sava od Radeč do državne meje (ID 63700)	IEA Sava from Radeče to national border (ID 63700)

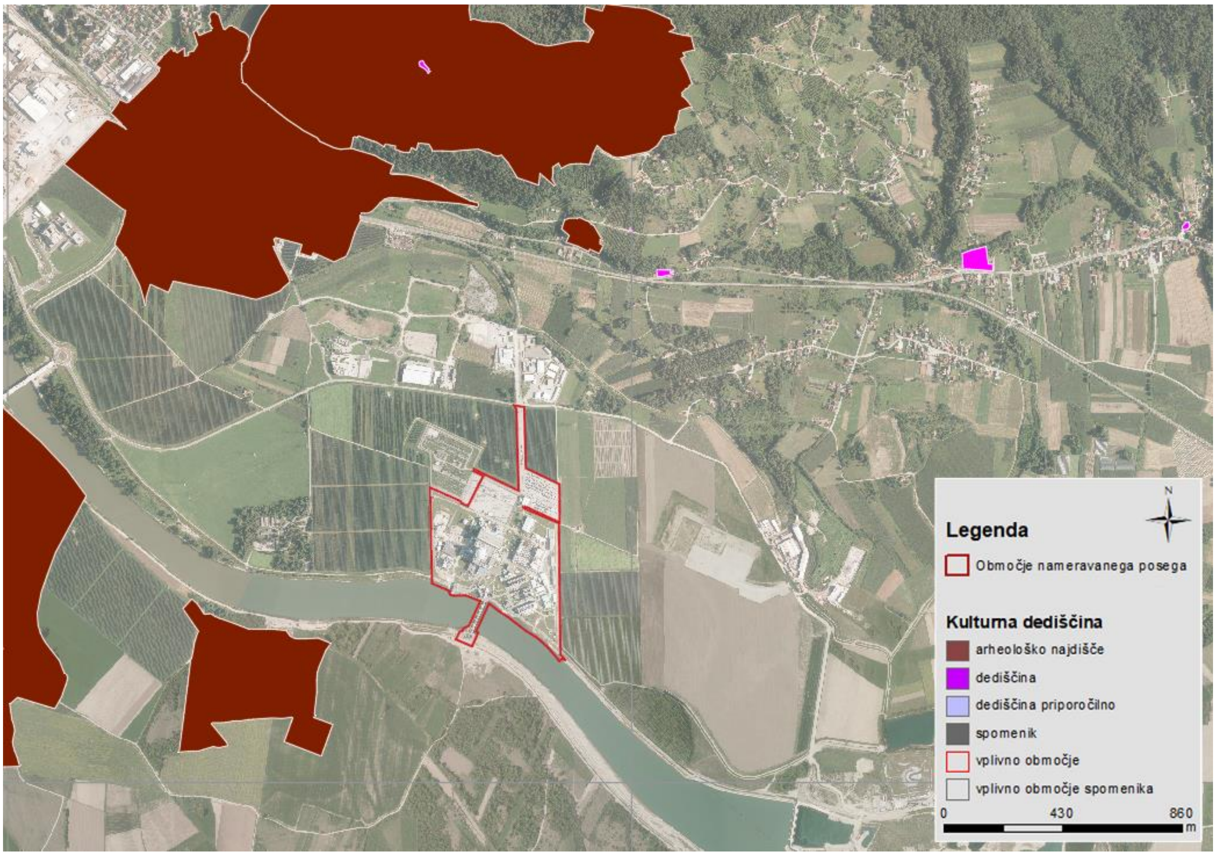


Figure 152: Cultural heritage in the broader surroundings of the activity (source: /1/, /64/)

Legenda	**Key**
Območje nameravanega posega	Area of the planned activity
Kulturna dediščina	**Cultural heritage**
arheološko najdišče	archaeological site
dediščina	heritage
dediščina priporočilno	heritage recommended
spomenik	monument
vplivno območje	impact area
vplivno območje spomenika	monument impact area

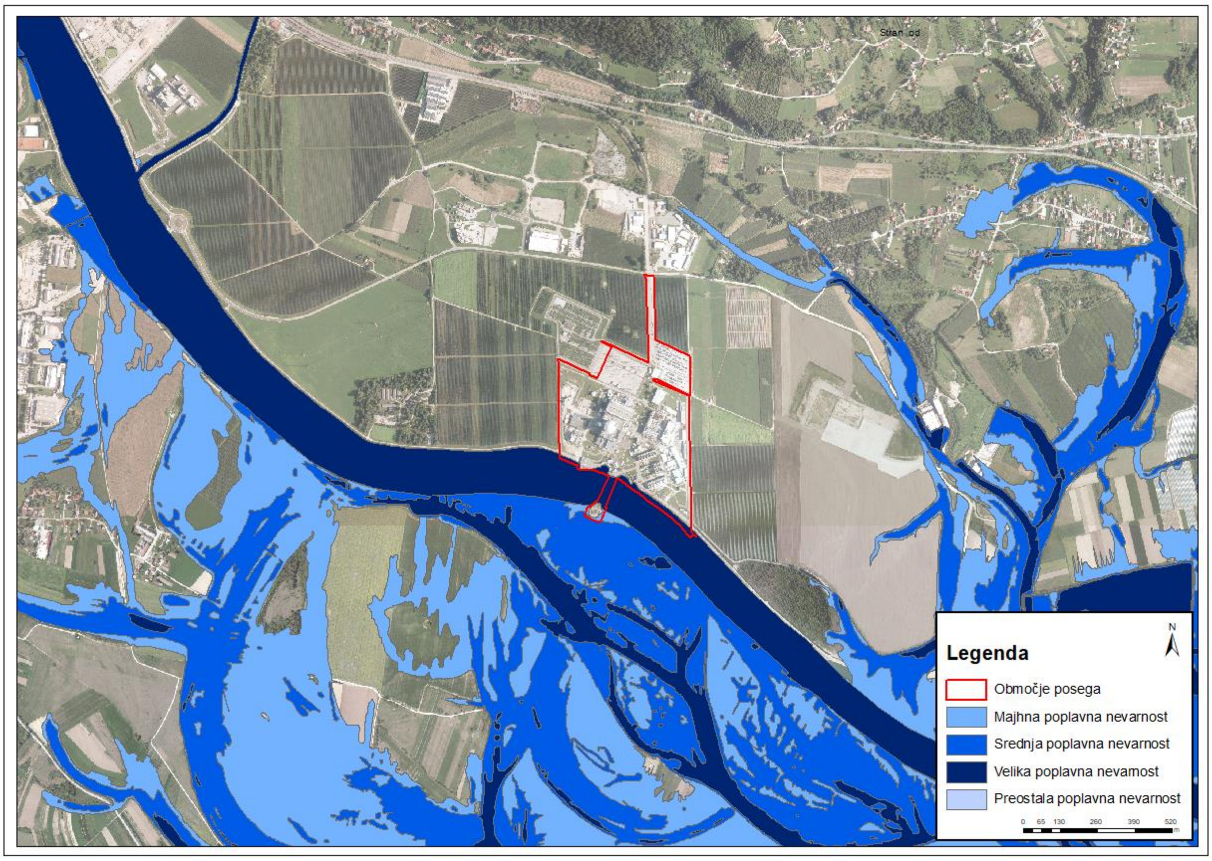


Figure 153: Flood hazard map (source: /1/, /60/)

Legenda	**Key**
Območje posega	Area of the activity
Majhna poplavna nevarnost	Small flood hazard
Srednja poplavna nevarnost	Medium flood hazard
Velika poplavna nevarnost	Large flood hazard
Preostala poplavna nevarnost	Other flood hazards

12. APPENDICES

Appendix 1: References relating to the assessment of environmental impacts by the head of report drafting (2010 - 2021)

First name and surname, title: **Dr Domen Novak**

Head of report drafting:

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE R15/1 LENDAVA – LJUTOMER (E-NET OKOLJE d.o.o., No. 101016-dn, 30 September 2020)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M1A/1 ROGATEC INTERCONNECTION (E-NET OKOLJE d.o.o., No. 100619-dn, 16 June 2020)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR UPGRADING THE SPENT FUEL STORAGE TECHNOLOGY BY INTRODUCING DRY STORAGE – NEK (E-NET OKOLJE d.o.o., No. 101118-dn, March 2020)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE UPGRADING OF THE REGIONAL CENTRE FOR WASTE MANAGEMENT GAJKE (E-NET OKOLJE d.o.o., No. 100220-dn, December 2019)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT, RENOVATION OF LJUBLJANA ATHLETICS CENTRE (E-NET OKOLJE d.o.o., No. 100819-dn, December 2019)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR ŠIŠKA REZIDENCE - NEWBUILD, FOUR MULTI-APARTMENT BUILDINGS (E-NET OKOLJE d.o.o., No. 100419-dn, August 2019)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE INDUSTRIAL FACILITY PRECISION RESOURCE D.O.O. (E-NET OKOLJE d.o.o., No. 100219-dn, June 2019)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE INCREASED PRODUCTION OF THE FOUNDRY – KOVIS LIVARNA D.O.O. (E-NET OKOLJE d.o.o., No. 100918-dn, October 2020)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M3/1 AJDOVŠČINA – ŠEMPETER PRI GORICI (E-NET OKOLJE d.o.o., No. 100918-dn, 2 April 2018)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR RESIDENTIAL AREA RAKOVA JELŠA II (E-NET OKOLJE d.o.o., No. 101013-dn, 12 December 2017)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR WASTE TREATMENT AT THE TERMIT D.D. SITE (E-NET OKOLJE d.o.o., No. 100516-dn, 26 October 2016)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR TREATMENT OF WASTE AND THE EXPLOITATION OF MINERAL RESOURCES IN THE ANDRAŽ NAD POLZELO QUARRY EXTRACTION SITE ANDRAŽ 2 (E-NET OKOLJE d.o.o., No. 100315-dn, 25 May 2015)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR TREATMENT OF SLAG FROM STEEL PRODUCTION (E-NET OKOLJE d.o.o., No. 100412-dn, 1 June 2012)

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE CONSTRUCTION OF PHASE III OF THE CENTRAL WASTEWATER TREATMENT PLANT LJUBLJANA (E-NET OKOLJE d.o.o., No. 100112-dn, 17 February 2012)

Participant in the drafting of the report:

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE INTENDED ACTIVITY: NEW STORAGE FACILITY TEDI SEŽANA AND CONSTRUCTION OF A

PORTION OF THE UTILITIES INFRASTRUCTURE OF THE MUNICIPAL LOCATION PLAN FOR THE SOUTH-WEST SEŽANA COMMERCIAL ZONE (E-NET OKOLJE d.o.o., No. 100121-jh/mm, July 2021)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE INTENDED ACTIVITY: TERRAIN LEVELLING IN THE SOUTH-WEST SEŽANA COMMERCIAL ZONE IN AN AREA OF 19.7 ha (E-NET OKOLJE d.o.o., No. 101020-mm/mz, March 2021)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT TO INCREASE THE CAPACITY OF THE FACILITY FOR WASTE DISPOSAL – RETAL d.o.o. (E-NET OKOLJE d.o.o., No. 100920-ppm/nz, 31 December 2020)

(air) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THREE RESIDENTIAL BUILDINGS IN DRAVLJE (E-NET OKOLJE d.o.o., No. 100519-jh/nz, 19 May 2020)

(air, noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE KROMBERK–NOVA GORICA COMMERCIAL ECONOMIC ZONE (ROAD LINKS AND CONNECTIONS AND UTILITIES INFRASTRUCTURE) (E-NET OKOLJE d.o.o., No. 100320-jh/nz, 13 March 2020)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE BEŽIGRAD SPORTS PARK (E-NET OKOLJE d.o.o., No. 101318-jh/nz, 6 May 2019)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE EXPANSION OF PRODUCTION AT MAGNA, PHASE 2 OF MAGNA STEYR d.o.o. (E-NET OKOLJE d.o.o., No. 100318-jh/mm, 31 May 2018)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR IM BRNIK – PRODUCTION-STORAGE AND COMMERCIAL BUILDING ISKRA MEHANIZMI, d.o.o. (E-NET OKOLJE d.o.o., No. 100418-jh/nz, 30 May 2018)

(air, noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE CONSTRUCTION OF TWO PRODUCTION FACILITIES "IV. POLJE POLIZDELKI" AND "IV. POLJE KONFEKCIJA (ADDITION)", GOODYEAR DUNLOP SAVA TIRES d.o.o. (E-NET OKOLJE d.o.o., No. 100218-jh/nz, 13 April 2018)

(air, noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE LOGISTICS CENTRE AND FOR THE EXPANSION OF CURRENT PRODUCTION OCEAN ORCHIDS d.o.o. (E-NET OKOLJE d.o.o., No. 100118-jh/nz, 22 February 2018)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE MAGNA NUKLEUS INDUSTRIAL PLANT OF MAGNA STEYR (E-NET OKOLJE d.o.o., No. 100917-ppm, 17 July 2017)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE COMMERCIAL AND RESIDENTIAL BUILDING ŠUMI IN LJUBLJANA (E-NET OKOLJE d.o.o., No. 100617-jh/nz, 30 June 2017)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR INCREASED PRODUCTION CAPACITIES AT TAB d.d., SPE IB ŽERJAV (E-NET OKOLJE d.o.o., No. 100316-ppm, 16 May 2017)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE VELIKI POTOK DETENTION BASIN (E-NET OKOLJE d.o.o., No. 100717-mz, 15 June 2017)

(air) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE RESIDENTIAL/COMMERCIAL BUILDINGS, SCHELLENBURG VILLA AND PALACE (E-NET OKOLJE d.o.o., no. 100217-jh/nz, 20 February 2017)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE ARJA VAS LOGISTICAL CENTRE (E-NET OKOLJE d.o.o., No. 100117-mz, 15 February 2017)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE RECONSTRUCTION OF THE TURNIŠČE WASTEWATER TREATMENT PLANT (E-NET OKOLJE d.o.o., No. 100716-ppm, 1 December 2016)

(noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE CONSTRUCTION OF THE WAREHOUSE/PRODUCTION FACILITY/BUSINESS AND TRADE BUILDING

FOR MDM INVEST d.o.o. (E-NET OKOLJE d.o.o., No. 100516-jh/nz, 11 October 2016)

(air, noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE IKEA COMMERCIAL BUILDING IN LJUBLJANA (E-NET OKOLJE d.o.o., No. 100116-jh/nz, 15 April 2016)

(noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE PRODUCTION OF EXHAUST SYSTEMS FOR MOTOR VEHICLES, AKRAPOVIČ d.d. IN ČRNOMELJ (E-NET OKOLJE d.o.o., No. 100315-jh/nz, 3 December 2015)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M3/1 KALCE - AJDOVŠČINA (E-NET OKOLJE d.o.o., No. 100913-mz, 24 August 2015)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M3/1 VODICE - KALCE (E-NET OKOLJE d.o.o., No. 100813-mz, 27 March 2015)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE CHEMICAL PROCESSING OF DANGEROUS WASTE ACCORDING TO THE D9 PROCEDURE AT THE CENTRAL WASTEWATER TREATMENT PLANT DOMŽALE - KAMNIK (E-NET OKOLJE d.o.o., No. 100414-jh/nz, 4 August 2014)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE UPGRADING OF THE REGIONAL CENTRE FOR WASTE MANAGEMENT GAJKE (E-NET OKOLJE d.o.o., No. 100213-ppm, 14 February 2014)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE MECHANICAL PROCESSING OF MIXED MUNICIPAL WASTE AND BULKY WASTE AND FOR THE TRANSHIPMENT OF SEPARATELY COLLECTED BIOLOGICAL WASTE IN MARIBOR (E-NET OKOLJE d.o.o., No. 100616-ppm, 7 February 2014)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M9 LENDAVA - KIDRIČEVO (E-NET OKOLJE d.o.o., No. 100313-mz, 1 November 2013)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M6 AJDOVŠČINA-LUCIJA SECTION AJDOVŠČINA-OSP (E-NET OKOLJE d.o.o., No. 100513-mz, 9 August 2013)

(water) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE UPGRADING OF THE REGIONAL CENTRE FOR WASTE MANAGEMENT (RCERO) LJUBLJANA AND THE BUILDINGS FOR WASTE PROCESSING (MBO) (E-NET OKOLJE d.o.o., No. 100113-jh/nz, 21 June 2013)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE ENLARGEMENT OF THE GLOBOKO NON-HAZARDOUS WASTE LANDFILL (E-NET OKOLJE d.o.o., No. 100712-ppm, 30 April 2013)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR GAS TRANSMISSION PIPELINE M6 AJDOVŠČINA-LUCIJA SECTION OSP-KOPER (E-NET OKOLJE d.o.o., No. 100511-mz, 12 December 2012)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE CONSTRUCTION OF THE COMMERCIAL AND RESIDENTIAL ESTATE TOBAČNA MESTO (E-NET OKOLJE d.o.o., No. 100312-mz, 3 July 2012)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE RESTRUCTURING AND EXPANSION OF THE SUHOR PRI VINICI QUARRY (E-NET OKOLJE d.o.o., No. 100810-dn, 30 November 2011)

(noise) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE ŠIŠKA CENTER LJUBLJANA (E-NET OKOLJE d.o.o., No. 100310-jh/nz, 25 May 2010)

(all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR INCREASED PRODUCTION CAPACITIES AT TAB d.d., ŽERJAV SPE IB ŽERJAV (E-NET OKOLJE d.o.o., No. 100109-ppm, 31 March 2010) (all factors) ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE CHANGE OF USE AND INCREASED PRODUCTION CAPACITIES AT TAB d.d., SPE TOPLA ČRNA NA KOROŠKEM (E-NET OKOLJE d.o.o., No. 100709-ppm, 10 March 2010)

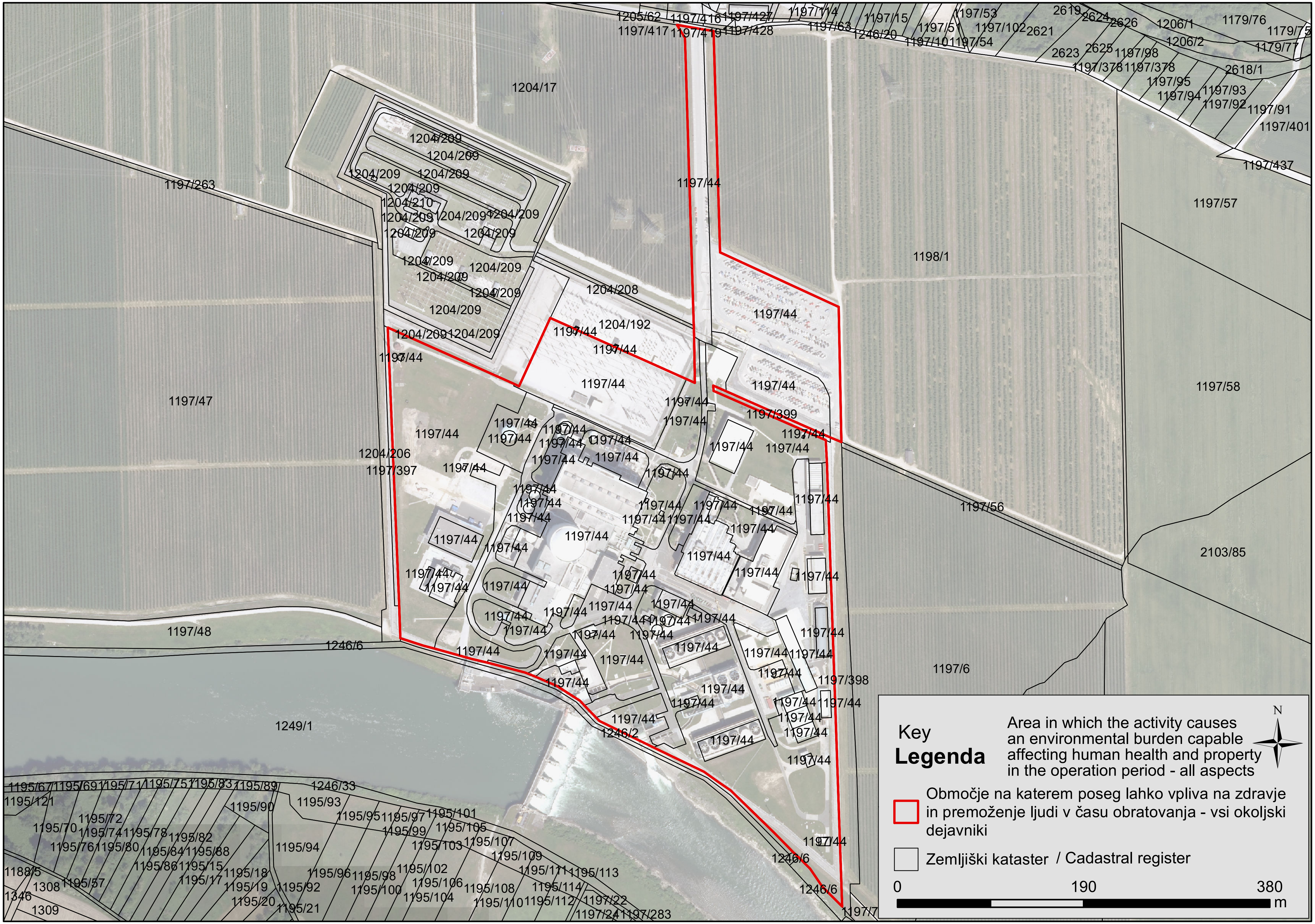
Appendix 2:

Overview status - site of the lifetime extension

Key
Legenda
Area of the activity
Območje posega
Cadastral register
Zemljiški kataster
N
0 20 40 80 120 160
m

Appendix 3:

The area in which the activity causes burdens on the environment, that can affect human health or property during the operating period


Key
Legenda
Area in which the activity causes an environmental burden capable affecting human health and property in the operation period - all aspects
Območje na katerem poseg lahko vpliva na zdravje in premoženje ljudi v času obratovanja - vsi okoljski dejavniki
Zemljiški kataster / Cadastral register
0
190
380
m
N
1197/44
1197/47
1197/48
1197/56
1197/57
1197/58
1197/6
1198/1
2103/85
1204/17
1204/208
1204/209
1204/192
1204/206
1197/397
1197/398
1197/399
1197/263
1246/6
1246/2
1249/1

Appendix 4:

Map of monitoring points

KRŠKO
LESKOVEC
BREŽICE
DOBOVA
ČATEŽ
CERKLJE
DRNOVO
VIHRE
SAVA
KRKA
Nuklearna elektrarna
Continuous dose rate monitors /
Kontinuirni merilniki hitrosti doze zunanjega sevanja
Ribe / Fish
Sedimenti / Sediments
Črpališče / Pumping st.
Vzorec iz pipe /
Tap water sample
Aerosolne črpalke /
Aerosol pumps
Lovilne plošče / Fallout plates
Padavine / Percipitation
Črpalke za jod / Iodine pumps
Hrana / Food
Mleko / Milk
Zemlja / Soil
Mesečni vz. vode / Monthly water samples
Enkratni vz. vode / Singular water samples
1 km

Appendix 5:

NEK illumination plan

LEGENDA

	Svetilka CN 116–1250 (HQL 250 MFB–U), montirana na konzole na fasadah objektov
	L01–Street LED luminaries DITO, TYPE DSL–24XMD–P2, 96W
	Svetilka tip HOFFMEISTER KUBUS (HQL 250 MFB–U), steber CRS 2B–900–2, H=9m, lok L1–150–2 (60° ali 180°)
	2x svetilka M/SNF210/250 v vsaki: (SNF 210 250 IC lamps SON–T plus 250W steber KORS 2B–1200–2, H=12m,
*	Svetilka tip M/SNF210/250 (NaVT250W).
	Reflektorski steber H=14m, tip KORS4–1400–2
	Reflektorski steber H=18m, tip KORS5–1800–2
	Reflektorski steber H=25m, tip RSn 25–12–2
	Reflektorska svetilka TechnoSpot S.3538.14 CDM–T 150W NDL
B3	Reflektorji tip SUPER 400–532 (številka pomeni število reflektorjev) NaVT400W
C3	Reflektorji tip SUPER 400–533 NaVT 400W
	Reflektorji tip IR 2000s
	Razsvetljava platoja NaVT 150W
	Razsvetljava pred vhodom v SB (6x21W varčne)
	Svetilka tip E40 HME Hoffmeister 2x250W VTNa
****	Svetilke montirane na stebrih RKS na višini 16m
***	Svetilke montirane na stebrih RSn na višini 9m
**	Svetilke montirane na stebrih RSn na višini 12m
*	Svetilni stolp z dvojnim lokom (180°) svetilke za osvetlitev poti v stikališču (glej projekt razsvetljava stikališča IBE 5463/209)
20a	Svetilka tip MIG–SM–400W–HPS VTNa 400W (številka pomeni oznako kabla)
20a	Svetilka tip MIG–AS–400W–HPS VTNa 400W (številka pomeni oznako kabla)
	Svetilka tip MIG–SM–250W–HPS VTNa 250W
	Svetilka tip MIG–AS–250W–HPS VTNa 250W
	Svetilka Ex tip ELLK 92036/36 2 x 36W

OPOMBA

Kabli se položijo v zelenicah direktno v zemljo in v cevi
pod asfaltnimi površinami

Original Design Firm: IBE
Replaced Manual Drawing: 1667/2/33/62
Last Revision And Date: E, 22.06.2000

THIS IS A CAD DRAWING AND SHOULD NOT BE REVISED OR MODIFIED MANUALLY

NO.	DATE	BY	REVISION	CKD. BY	LE APPR.
J	08.11.04	K.K.	REV'D PER CAP 2004-2318	A.B.	D.V.
I	22.11.02	B.L.	REV'D PER MOD. 327-TZ-L-DMP13	A.B.	B.Š.
M	03.09.20	K.K.	REV'D PER CAP 2020-1384	G.J.	B.P.
L	14.01.16	M.I.	REV'D PER CAP 2014-1394	I.L.	B.P.
K	02.04.15	M.L.	REV'D PER MOD 519-PG-L & CAP 2015-982	S.J.	B.P.

NUKLEARNA ELEKTRARNA KRSKO
NUCLEAR POWER PLANT KRSKO

DISPOZICIJA SVETILK ZA ZUNANJO
RAZSVETLJAVO
SITUACIJA

DESIGN ENGINEERING
NUCLEAR POWER PLANT KRSKO — KRSKO, SLOVENIA

MADE	CHECKED	LE APPROVAL
1. M. KODRIČ	2. A. BROD	3. D. VEHOVAR

REFERENCE DRAWINGS:

SCALE	DRAWING NUMBER	SYSTEM	SH.NO.	REV
1:600	1667/2/33/62			IA

FILE: 1667233362 DWG, SPREJEL:

LEGENDA / KEY

Svetilka CN 116–1250 (HQL 250 MFB–U), montirana na konzole na fasadah objektov
Lamp CN 116-1250 (HQL 250 MFB-U), mounted on cantilevers on facades

LD1–Street LED luminaries DITO, TYPE DSL–24XMD–P2, 96W
LD1 - Street LED luminaries DITO, TYPE DSL-24XMD-P2, 96W

Svetilka tip HOFFMEISTER KUBUS (HQL 250 MFB–U),
steber CRS 2B–900–2, H=9m, lok L1–150–2 (60° ali 180°)
Lamp type HOFFMEISTER KUBUS (HQL 250 MFB-U)
pole CRS 2B-900-2, H=9m, arc L1-150-2 (60 degrees or 180 degrees)

2x svetilka M/SNF210/250 v vsaki: (SNF 210 250 IC lamps SON–T plus 250W
steber KORS 2B–1200–2, H=12m,
2x lamp M/SNF210/250, in each: (SNF 210 250 IC lamps SON T plus 250W)
pole KORS 2B-1200-2, H=12 m

Svetilka tip M/SNF210/250 (NaVT250W).
Lamp type M/SNF210/250 (NaVT250W)

Reflektorski steber H=14m, tip KORS4–1400–2
Reflector pole H=14 m, type KORS4-1400-2

Reflektorski steber H=18m, tip KORS5–1800–2
Reflector pole H=18 m, type KORS5-1800-2

Reflektorski steber H=25m, tip RSn 25–12–2
Reflector pole H=25 m, type RSN 25-12-2

Reflektorska svetilka TechnoSpot S.3538.14 CDM–T 150W NDL
Reflector lamp TechnoSpot S.3538.14 CDM-T 150W NDL

B3 Reflektorji tip SUPER 400–532 (stevilka pomeni stevilo reflektorjev) NaVT400W
Reflectors type SUPER 400-532 (no. represents the no. of reflectors) NaVT400W

C3 Reflektorji tip SUPER 400–533 NaVT 400W
Reflectors type SUPER 400-533 NaVT 400W

Reflektorji tip IR 2000s
Reflectors type IR 2000s

Razsvetljava platoja NaVT 150W
Plateau illumination NaVT 150W

Razsvetljava pred vhodom v SB (6x21W varcne)
Entrance illumination in SB (6x21W energy-saving)

Svetilka tip E40 HME Hoffmeister 2x250W VTNa
Lamp type E40 HME Hoffmeister 2x250W VTna

Skupni potek kablov
Common cable route

✱✱✱✱ Svetilke montirane na stebrih RKS na visini 16m
Lamps mounted on poles RKS, at 16 m height

✱✱✱ Svetilke montirane na stebrih RSn na visini 9m
Lamps mounted on poles RSn, at 9 m height

✱✱ Svetilke montirane na stebrih RSn na visini 12m
Lamps mounted on poles RSn, at 12 m height

✱ Svetilni stolp z dvojnim lokom (180°) svetilke za osvetlitev
poti v stikaliscu (glej projekt razsvetljava stikalisca IBE 5463/209)
Lighting tower with double arc (180 degrees) lamps for illumination of the path in the switchyard

20a Svetilka tip MIG–SM–400W–HPS VTNa 400W (stevilka pomeni oznako kabla)
Lamp type MIG-SM-400W-HPS VTNa 400 W (no. represents cable ID)

20a Svetilka tip MIG–AS–400W–HPS VTNa 400W (stevilka pomeni oznako kabla)
Lamp type MIG-AS-400W-HPS VTNa 400 W (n. represents cable ID)

Svetilka tip MIG–SM–250W–HPS VTNa 250W
Lamp type MIG-SM-250W-HPS VTNa 250W

Svetilka tip MIG–AS–250W–HPS VTNa 250W
Lamp type MIG-AS-250W-HPS VTNa 250W

Svetilka (Ex) tip ELLK 92036/36 2 x 36W
Lamp Ex type ELLK 92036/36 2 x 36W

Ograja
Fence

Appendix 6:

Temperature of the Sava when mixed with cooling water from NEK 2018–2020

The Sava river temperature after mixing with NEK cooling water [°C], 2020

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6,26	9,94	9,90	11,72	18,98	18,60	23,27	24,48	19,73	13,94	12,77	8,91
2	6,44	10,05	8,58	12,47	18,84	18,76	23,83	24,71	18,11	14,48	12,76	8,84
3	6,68	10,09	8,82	12,31	18,44	19,45	22,24	23,95	18,01	14,52	12,98	8,48
4	6,63	10,64	8,78	12,09	18,74	19,24	22,50	21,11	17,68	14,23	13,38	8,22
5	6,64	10,65	8,79	12,30	18,61	18,34	23,03	18,67	18,57	14,02	13,59	7,60
6	6,72	10,51	8,89	12,80	18,33	16,09	22,56	18,78	19,22	13,05	13,46	5,93
7	6,86	10,66	9,02	13,37	18,42	13,89	21,04	18,70	19,03	12,63	13,11	6,65
8	6,48	9,97	8,88	13,93	18,68	14,37	20,82	19,54	19,62	12,82	13,44	7,66
9	6,28	9,14	9,49	14,35	19,19	14,14	21,32	21,36	20,54	12,97	12,17	7,54
10	6,31	8,97	9,70	14,77	18,89	13,03	21,44	22,32	20,36	13,07	12,10	7,25
11	6,70	8,91	10,13	15,39	19,00	13,28	22,37	22,84	20,16	13,15	11,88	7,60
12	6,84	9,02	11,03	15,74	18,19	14,41	21,78	23,44	20,53	11,41	11,63	7,96
13	6,95	9,18	11,00	16,15	17,93	15,58	21,80	23,95	20,90	11,34	11,65	8,14
14	7,17	10,15	11,48	15,92	17,27	16,70	21,45	24,02	21,18	11,47	12,04	8,14
15	7,75	10,71	11,90	16,45	16,06	17,49	22,02	23,52	21,44	11,54	12,02	8,34
16	7,78	10,79	11,57	16,79	15,54	17,62	21,92	23,53	21,66	11,06	11,53	8,04
17	7,67	10,73	11,80	17,17	14,70	17,92	21,44	23,99	21,70	11,28	10,15	8,11
18	7,70	10,87	12,16	16,72	15,12	17,89	21,25	23,51	21,59	11,50	10,56	8,05
19	8,28	10,96	11,75	16,33	15,00	18,96	22,09	23,54	21,38	11,72	10,47	8,42
20	8,26	10,68	12,40	16,67	15,11	18,72	22,36	23,70	21,11	11,80	10,66	8,73
21	8,39	10,75	13,59	16,89	15,93	19,55	22,55	23,80	21,00	12,02	10,61	8,54
22	8,40	11,07	13,10	17,37	16,38	19,48	22,61	23,76	20,68	12,22	10,07	8,86
23	8,31	11,37	12,72	17,82	17,71	19,79	23,34	23,79	20,55	12,49	9,64	9,14
24	8,18	11,27	12,40	17,75	17,71	20,11	22,98	23,94	20,44	12,87	9,41	9,55
25	7,98	10,84	12,05	17,73	17,56	20,93	22,06	24,25	19,53	12,90	8,57	8,90
26	7,81	10,40	10,36	17,57	18,60	20,50	21,91	24,50	16,41	13,05	9,10	8,17
27	7,83	9,87	10,11	17,69	19,56	20,61	21,74	24,44	13,97	12,93	9,16	7,60
28	7,97	10,93	10,27	17,91	18,81	21,21	22,12	23,89	13,20	12,54	9,07	7,03
29	8,18	10,92	10,33	18,02	18,93	22,32	22,89	23,79	13,33	12,35	9,09	6,41
30	8,88		10,30	18,26	18,87	22,86	22,13	23,73	13,54	12,38	8,96	6,33
31	9,64		11,11		18,68		24,04	22,16		12,54		7,20
Average	**7,48**	**10,35**	**10,72**	**15,68**	**17,73**	**18,06**	**22,22**	**22,96**	**19,17**	**12,59**	**11,20**	**7,95**

The Sava river temperature after mixing with NEK cooling water [°C], 2019

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7,6	7,5	10,1	13,2	13,0	12,9	25,6	23,4	24,4	16,3	15,0	9,9
2	7,4	6,3	10,5	13,9	13,5	13,9	25,5	23,5	24,4	16,1	14,7	9,9
3	7,4	6,6	10,9	14,3	14,2	15,1	24,1	23,0	22,9	16,2	14,6	8,5
4	7,4	7,4	11,1	14,8	14,7	16,2	23,6	23,0	23,0	15,2	12,4	8,4
5	7,4	7,3	10,8	14,6	13,5	17,0	23,6	22,7	22,4	14,4	11,8	7,9
6	7,5	7,0	11,8	13,4	12,2	17,8	24,0	23,2	21,9	13,7	11,3	7,6
7	7,1	6,8	12,2	12,8	11,9	18,5	23,0	23,5	21,5	13,4	11,1	7,6
8	6,5	6,7	12,1	13,1	12,3	19,2	23,0	23,7	19,8	13,1	11,0	7,8
9	6,5	6,8	12,3	12,7	12,7	19,5	22,5	24,0	17,5	13,3	10,8	8,2
10	6,6	7,1	12,7	12,7	13,2	19,8	21,6	24,8	16,4	13,1	10,7	8,2
11	6,6	7,3	12,7	11,9	13,4	20,6	21,9	25,1	17,0	13,0	10,5	8,4
12	6,7	7,1	12,6	11,2	13,9	20,7	22,2	24,8	17,8	13,0	10,7	7,9
13	6,8	7,4	12,4	10,7	13,1	21,1	22,1	24,8	18,2	13,4	10,1	7,4
14	7,2	7,4	12,3	11,1	11,8	21,2	22,1	24,8	18,6	13,8	9,9	7,3
15	7,3	7,7	11,8	11,4	11,4	21,7	22,7	24,9	19,1	14,0	10,0	7,3
16	7,3	7,9	11,8	12,1	10,7	22,2	23,0	24,7	19,9	14,0	10,0	7,4
17	7,3	8,0	12,1	12,6	11,3	21,9	22,9	24,6	20,6	13,9	10,3	8,1
18	6,9	8,2	12,1	13,5	12,4	21,8	23,3	24,4	20,5	14,1	10,5	9,1
19	6,9	8,4	11,0	14,2	13,4	22,4	23,7	24,1	20,5	14,2	10,1	9,4
20	8,4	8,5	12,5	15,0	14,1	22,6	24,2	24,2	20,4	14,3	10,2	9,8
21	8,5	8,9	12,3	15,5	14,4	22,6	24,7	24,6	20,1	14,6	10,3	9,7
22	7,7	9,2	11,7	16,1	13,9	22,1	24,9	24,4	20,1	14,4	10,5	9,1
23	7,5	9,0	12,0	16,5	13,7	19,5	25,1	24,2	19,4	14,3	10,5	8,8
24	7,3	9,0	12,4	15,5	14,7	18,6	25,4	24,5	17,8	14,6	10,5	8,8
25	7,4	9,1	12,6	15,4	16,1	20,6	25,9	22,9	17,5	14,6	10,6	8,3
26	7,1	8,8	12,0	14,6	16,7	20,9	26,3	22,9	17,7	14,5	10,6	8,0
27	6,9	8,8	12,6	15,1	16,8	22,4	26,7	23,2	18,4	14,3	10,4	8,0
28	6,2	9,4	12,8	14,8	16,0	23,6	25,7	23,3	18,8	14,2	10,3	7,9
29	5,7		12,6	13,7	13,4	24,4	24,3	23,4	18,3	14,5	10,5	7,6
30	6,0		12,8	13,2	11,7	24,8	24,1	23,6	18,6	15,2	11,0	7,0
31	6,7		12,7		11,9		23,2	23,8		15,4		6,5
Average	**7,1**	**7,8**	**12,0**	**13,6**	**13,4**	**20,2**	**23,9**	**23,9**	**19,8**	**14,3**	**11,0**	**8,2**

The Sava river temperature after mixing with NEK cooling water [°C], 2018

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6,8	8,6	4,4	8,4	14,0	18,6	21,3	25,8	18,9	16,5	11,0	8,0
2	7,1	7,9	4,6	8,6	14,7	18,8	21,2	26,1	17,9	16,7	11,1	8,2
3	7,0	6,8	4,9	8,8	15,2	19,7	21,8	26,3	17,1	16,7	11,4	8,4
4	7,1	5,9	5,2	9,5	15,5	19,7	22,3	26,6	16,6	16,7	12,0	8,8
5	7,1	6,5	5,9	9,7	15,1	20,2	22,4	26,9	16,8	16,2	12,3	9,5
6	7,7	7,0	6,2	9,8	15,2	20,8	22,1	27,4	17,8	15,7	12,4	10,1
7	8,3	7,1	7,1	10,2	15,5	21,1	22,9	27,3	18,3	16,1	12,6	10,3
8	8,7	6,9	7,1	10,3	16,2	20,9	23,0	27,3	19,3	15,6	12,7	10,2
9	8,6	6,8	7,2	10,5	16,5	20,8	23,3	27,0	19,6	16,9	12,7	9,4
10	8,2	7,4	7,2	11,0	16,7	20,6	23,1	27,1	20,2	17,4	12,7	9,6
11	8,2	7,9	7,1	11,1	16,9	20,8	22,2	26,7	20,8	17,6	12,6	9,5
12	8,1	7,4	7,1	11,1	17,1	21,6	20,0	26,5	21,2	17,8	12,9	9,2
13	8,0	7,1	7,4	10,9	17,1	21,8	19,1	26,9	21,5	17,6	13,2	8,8
14	8,1	7,2	8,0	10,2	16,8	21,4	19,8	26,5	21,7	17,6	13,6	8,9
15	7,5	7,1	8,4	10,6	15,9	20,9	20,2	26,7	21,7	17,4	13,2	8,3
16	7,4	7,4	8,4	11,1	14,7	20,5	21,2	26,3	21,8	17,4	12,8	8,0
17	7,4	7,6	8,2	11,4	14,7	20,9	21,2	25,9	21,8	17,3	12,8	7,8
18	7,8	7,0	7,6	11,8	15,3	21,2	21,8	25,7	21,7	17,3	11,9	8,1
19	7,5	7,0	6,9	11,8	15,7	21,9	22,6	25,7	21,8	17,2	11,3	8,0
20	7,1	7,5	6,4	12,2	16,2	22,1	23,0	25,4	21,7	16,9	10,4	7,9
21	7,6	7,1	6,5	12,5	16,8	22,7	23,5	25,4	22,0	16,6	10,1	8,0
22	7,2	6,7	6,9	13,0	17,0	21,7	23,7	25,5	21,4	16,4	10,7	8,1
23	7,3	6,9	7,2	13,3	17,0	21,1	23,7	25,8	21,3	16,3	10,0	8,3
24	7,2	6,8	7,3	13,5	17,3	20,9	23,6	25,9	19,8	16,6	9,8	8,7
25	7,1	6,5	7,7	13,7	17,3	20,5	23,3	25,2	16,8	16,5	9,1	8,9
26	7,1	6,2	8,1	13,7	17,8	19,6	23,3	22,5	17,1	15,8	9,3	9,1
27	7,6	5,8	8,5	13,8	18,6	21,0	23,1	17,7	17,4	15,7	9,6	9,0
28	8,4	5,0	9,1	13,6	19,2	20,6	23,7	17,6	17,1	14,1	9,4	8,9
29	8,5		9,7	13,7	19,6	20,4	24,1	18,6	16,9	13,3	9,0	8,5
30	9,1		9,2	14,0	19,3	20,9	25,0	19,5	16,4	12,4	8,4	8,0
31	8,6		8,7		18,7		25,2	19,3		11,5		7,6
Average	**7,7**	**7,0**	**7,2**	**11,5**	**16,6**	**20,8**	**22,5**	**24,9**	**19,5**	**16,2**	**11,4**	**8,7**