Environmental Impact Assessment for the Project
"Refurbishment of Cernavoda NPP U1 and Extension of Intermediate Dry Spent Fuel Storage with MACSTOR - 400 Modules"

Project owner:

National Society NUCLEARELECTRICA S.A. – CERNAVODA NPP BRANCH

Elaborator:

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The original version of this Report is in Romanian language. To avoid misunderstanding, any interpretation of the English version shall be confirmed by the Authors addressing the original document issued in Romanian

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List of abbreviations

Acronym	Romanian	English
ABADL	Administrația Bazinală de Apă Dobrogea Litoral	Agency for Dobrogea Litoral Water Basin
AECL	-	Atomic Energy of Canada Limited
AIE/IEA	Agenția Internațională de Energie	International Energy Agency
AIEA/IAEA	Agenția Internațională pentru Energie Atomică	International Atomic Energy Agency
AGA	Autorizația de Gospodărire a Apelor	Water Management Authorization
AGOA	Adunarea Generală Ordinară a Acționarilor	Ordinary General Meeting of Shareholders
ALARA	Principiul ”cât mai scăzut posibil, în mod rezonabil”	As Low As Reasonably Achievable
ANAR	Administrația Națională ”Apele Române”	The National Administration “Romanian Waters”
ANDR	Agenția Nucleară pentru Deșeuri Radioactive	Nuclear and Radioactive Waste Agency
ANM	Administrația Națională de Meteorologie	National Meterology Administration
ANPM/NEPA	Agenția Națională pentru Protectia Mediului	National Agency for Environmental Protection
ANRE	Autoritatea Națională de Reglementare în domeniul Energiei	National Energy Regulatory Authority
APM/EPA	Agenția pentru Protectia Mediului	Agency for Environmental Protection
ASHRAE	Societatea Americană a Inginerilor de Încălzire, Refrigerare și Aer condiționat	American Society of Heating Refrigerating and Air-conditioning Engineers
BCU	Bazinul de combustibil uzat	Spent Fuel Storage Bay
CANDU	CANadian Deuterium Uranium	CANadian Deuterium Uranium
CapEx	Cheltuieli de capital	Capital expenditures
CCUA	Clădirea Control al Urgenței pe Amplasament	Site Emergency Control Building
CDMN	Canalul Dunăre - Marea Neagra	Danube – Black Sea Canal
CFSU	Clădirea Facilităţilor pentru Situaţii de Urgenţă	Building for Emergency Situations Facilities
CLU/LLF	Combustibil lichid ușor	Light liquid fuel
CMD	Concentrație minimă detectabilă	Minimum detectable concentration
CNCAN	Comisia Națională pentru Controlul Activităților Nucleare	National Comision for Control of Nuclear Activities
CNE Cernavodă/ Cernavodă NPP	Centrala Nuclearo-Electrică Cernavodă	Cernavodă Nuclear Power Plant
CNU	Combustibil nuclear uzat	Spent nuclear fuel
COG	Grupul deținătorilor de CANDU	CANDU Owners Group
COV/VOC	Compușii organici volatili	Volatile organic compounds
CPPON	Centru de pregatire personal	Training Personnel Center
CTP	Centrala Termică de Pornire	Thermal Start-up Power Plant
CTRF	Instalaţie de detritiere CNE Cernavodă	Cernavodă Tritium Removal Facility
CSAN	Clădirea Servicii Auxiliare Nucleare	Nuclear Auxiliary Services Building

Acronym	Romanian	English
DEEE	Deșeuri de echipamente electrice și electronice	Waste electrical and electronic equipment
DEI	Decizia etapei de încadrare	The decision of the scoping stage
DFDSMA	Depozitul Final pentru Deşeuri de Slabă şi Medie Activitate	Final Repository for Low and Intermediate Radioactive Waste
DGR	epozitului geologic de mare adâncime	Deep Geological Repository
DICA/ IDSFS	Depozitului Intermediar de Combustibil Ars	Interimediate Dry Spent Fuel Storage Facility
DIDR-U5	Depozit intermediar pentru deșeuri radioactive, amenajat în Clădirea Reactorului Unității 5	Intermediate storage facility for radioactive wastes, set up in Unit 5 Reactor Building
DIDSR	Depozitul Intermediar de Deșeuri Solide Radioactive	Solid Radioactive Waste Interim Storage Facility
DJ/DN	Drum județean/Drum național	County Road/National Road
DNGS	Centrala Nucleaoelectrică Darlington	*Darlington* Nuclear Generating Station
D2O	Apă grea	Heavy water
DOP test	Testarea filtrului pentru particule de ulei dispersat	Dispersed oil particulate filter testing
EA	Evaluare adecvată	Adequate assessment
EGCA	Evaluarea şi gestionarea calităţii aerului	Air quality assessment and management
EGZA	Evaluarea și gestionarea zgomotului ambiant	Ambient noise assessment and management
EPS	Alimentare cu energie la avarie	Emergency Power Supply
FE	Factor de emisie	Emission factor
GDM/MDG	Grup Diesel mobil	Mobile Diesel Group
GE	Grup Electrogen	Electrogen Group
GES/GHG	Gaze cu efect de seră	Greenhouse Gases
GIS	Sistem de informații geografice	Geographic Information System
GSN	Ghid de securitate Nucleară	Nuclear Safety Guidline
H.C.L	Hotărârea Consiliului Local	Decision of the Local Council
HEPA - filtru	Filtru de înaltă eficiență pentru particule din aer.	high-efficiency particulate air filter
HG	Hotărâre de Guvern	Governmental Decision
ICRP	Comisia Internațională pentru Radioprotecție	International Commission on Radiological Protection
IGSU	Inspectoratul General pentru Situații de Urgență	The Romanian General Inspectorate for Emergency Situations
INCDDD Tulcea	Institutul Național de Cercetare-Dezvoltare Delta Dunării	Danube Delta National Institute for R&D - Tulcea
INHGA	Institutul Național de Hidrologie și Gospodărire a Apelor	The National Institute for Hydrology and Water Management
INSP/NIPH	Institutul Național de Sanatate Publică	National Institute of Public Health
IPCC	Grupul Interguvernamental al Națiunilor Unite pentru Schimbările Climatice	Intergovernmental Panel on Climate Change
INPO	-	Institute of Nuclear Power Operations

Acronym	Romanian	English
ISCIR	Inspecția de Stat pentru Controlul Cazanelor, Recipientelor sub Presiune și Instalațiilor	State Inspection for the Control of Boilers, Pressure Vessels and Installations
K-Box	Container de depozitare intermediara ecranat	Shielded interim storage container
KHNP	-	Korea Hydro & Nuclear Power Co.
LAR	riscul atribuibil pe durata vieții	Lifetime Attributable Risk
LCM	Laboratorul Control Mediu al CNE Cernavodă	Cernavodă NPP Environmental Control Laboratory
LDE/DEL	Limită derivată de evacuare	Derived Emission Limit
LILW-LL	Deşeuri de activitate joasă și medie de viaţă lungă	Low and Intermediate Level Radioactive Waste, Long Lived
LILW-SL	Deşeuri de activitate joasă și medie de viaţă scurtă	Low and Intermediate Level Radioactive Waste, Short Lived
LTO	Operare pe termen lung	Long Term Operation
MACSTOR	Depozit Modular cu Ventilație Naturală	Modular Air-Cooled STORage
MB	Monitorizarea biodiversităţii	Monitoring of biodiversity
MDA	Activitate minimă detectabilă	Minimum Detectable Activity
MEG/GEM	Monitor de Efluenți Gazoși	Gaseous Effluent Monitor
MEL /LEM	Monitor de efluenți lichizi	Liquid Effluent Monitor
MID	Mașina de Incărcat Descărcat	Loading- Unloading Machine
MMAP/MEWF	Ministerul Mediului, Apelor și Pădurilor	The Ministry of Environment, Waters and Forests
MS	Ministerul Sănătății	Ministry of Health
N/A	Neaplicabil	Not applicable
NBS	Biroul Naţional de Standarde	National Bureau of Standards
NMC	Norme de managementul calității în domeniul nuclear	Quality management norms in the nuclear field
NSN	Normă de securitate Nucleară	Nuclear Safety Norm
OBT	Tritiu legat organic	Organicaly Bound Tritium
OCPI	Oficiul de Cadastru și Publicitate Imobiliara	Cadastre and Real Estate Advertising Office
OM/MO	Ordin de Ministru	Minister's order
OPEX	Experiența de exploatare	Operating experience
OG/GO	Ordonanță de Guvern	Government Ordinance
OUG/GEO	Ordonanță de Urgență	Emergency Ordinance
PAEC	Planul National de actiune pentru Economia circulară	National Action Plan for Circular Economy
PCA	Punct de Control Acces	Access Control Point
PCB	Bifenili policlorurați	*Polychlorinated* biphenyls
PHWR	Reactor cu Apa Grea sub Presiune	Pressurized Heavy Water Reactor
PIT	Panouri de Izolare Termică	Thermal Insulation Panels
PLGS	Centrala Nucleaoelectrică Point Lepreau	Point Lepreau Generating Station
PM10/2.5	Particule în suspensie – fracțiunile 10/2.5	Particule matters 10/2.5
PNIESC	Planul Național Integrat în domeniul Energiei și Schimbărilor Climatice	National Integrated Plan for Energy and Climate Change

Acronym	Romanian	English
RFS	Raport Final de Securitate	Final Safety Report
RIM/EIA	Raportul privind Impactul asupra Mediului	Environmental Impact Assessment Report
RNSRM	Reţeaua naţională de supraveghere a radioactivităţii mediului	The national network for monitoring environmental radioactivity
RT-U1 şi DICA	Retehnologizarea Unității 1 a CNE Cernavodă și extinderea Depozitului Intermediar de Combustibil Ars cu module tip MACSTOR 400	Refurbishment of Unit 1 of Cernavodă NPP and extension of the Intermediate dry spent Fuel Storage with MACSTOR - 400 modules
SCADA	Monitorizare, Control și Achiziții de Date	Supervisory Control and Data Acquisition
SCI	*sit* de importanță comunitară	Site of Community Importance
SDG	Generatoare Diesel de rezervă	Stand-by Diesel Generator
SDS	Sistem de oprire rapidă a reactorului	Reactor Shutdown System
SEN	Sistemul Energetic Național	National Energy System
SF	Studiu de fezabilitate	Feasability Study
SLD/BLD	Sub limita de detecție	Below detection limit
SNEC	Strategia Națională pentru Economie Circulară	National Strategy for Circular Economy
SPA	Arii de Protectie Specială Avifaunistică	Special Protection Areas
SPAI	Sistemul de apă de stins incendiu	Fire extinguishing water system
SPTC/PHTS	Sistem primar de transport al căldurii	Primary Heat Transport System
SNN SA	Societatea Națională Nuclearelectrica SA	National Nuclearelectrica SA Company
SSCE	Sisteme, structuri, componente, echipamente	Systems, structures, components, equipment
STA	Staţia de Tratare Chimică a Apei	Water Chemical Treatment Plant
SWC/LWC	Container mic pentru deșeuri/ Container mare pentru deșeuri	Small Waste Container/ Large Waste Container
SWTF/LWTF	Container mic ecranat pentru transferul deșeurilor/Container mare ecranat pentru transferul deșeurilor	Small Waste Transfer Flask/Large Waste Transfer Flask
THP	Hidrocarburi totale din petrol	Total hydrocarbons from petroleum
TLD/DTL	Dozimetre termoluminiscente	Thermoluminescent dosimeter
TSP	Particule totale în suspensie	Total Suspended Particles
U1, U2	Unitățile nuclearoelectrice 1 și 2 de la CNE Cernavodă	Nuclear-electric Units 1 and 2 at Cernavodă NPP
UNSCEAR	Comisia Științifică a Națiunilor Unite pentru Efectele Radiațiilor Atomice	United Nations Scientific Committee on the Effects of Atomic Radiation
WANO	Asociația Mondială a Operatorilor Nucleari	World Association of Nuclear Operators

1. PROJECT DESCRIPTION

1.1 Introduction

S. N. Nuclearelectrica S.A. - Cernavodă NPP branch has 2 nuclear power units in operation, Unit 1 in commercial operation since December 1996 and Unit 2 since November 2007. Each unit has one turbogenerator providing an electrical power of 706.5 MWe, for U1, 704.8 MWe respectively for U2, using the steam produced by one CANDU-PHWR-600 type nuclear reactor. The nuclear energy production technology at Cernavodă Nuclear Power Plant is based on CANDU (CANadian Deuterium Uranium) nuclear reactor concept, which works with natural uranium and uses heavy water (D2O) as a moderator and cooling agent.[1]

The operation of the two reactors at Cernavodă currently provides approximately 20% of Romania's energy needs. At the same time, the two units provide heating for more than 75% of the population of Cernavodă town.

The operation of Units 1 and 2 at Cernavodă Power Plant is carried out within a well-defined regulatory system under the strict control of the regulatory authority ***in the nuclear field, the National Commission for the Control of Nuclear Activities (CNCAN).*** The operation of the two units is done according to the national standards of radioprotection and nuclear security that take into account the control of radioactive emissions in order to ensure the protection of workers on site, the population and the environment against the effects of ionizing radiation. hese national standards are in full agreement with the international recommendations established in the safety standards of the IAEA - International Atomic Energy Agency. The IAEA's nuclear safety standards are based on the conclusions of the United Nations Scientific Commission on the Effects of Atomic Radiation - UNSCEAR and on the recommendations of the International Commission on Radiological Protection - ICRP regarding the principles, criteria and methodologies of radioprotection of the public and the environmen.

The aspects specific to the nuclear field, relevant for the assessment of the environmental impact on Cernavodă NPP platfrome, take into account the conditions imposed by the Ministry of Environment, Waters and Forests, CNCAN, and other regulatory authorities in specific fields (MS[2], ANAR[3], IGSU[4] etc.), through the regulatory acts issued for Cernavoda NPP.

At present, the activity of the nuclear facilities U1, U2 and DICA on Cernavodă NPP site is regulated by the Environmental Authorization published by "GD no. 84/2019 *regarding the issuance of the environmental authorization for the National Company "NUCLEARELECTRICA" - S.A. - “Cernavodă NPP Branch - Unit no. 1 and Unit no. 2 of Cernavodă Nuclear Power Plant*”.

The activity of the Cernavodă NPP is also subject to CNCAN rules requiring compliance with dose limits (dose constraints) - established both for operating personnel and for the population and the environment - for operation on the Cernavodă NPP site, i.e. compliance with the following authorizations issued by CNCAN:

- Authorization for carrying out activities in the nuclear field No. SNN Cernavodă NPP U1 – 01/2023 rev. 0 for the operation of the Cernavodă NPP, Unit 1 through the Cernavodă NPP Branch, valid until 04/30/2061,
- Authorization for carrying out activities in the nuclear field No. SNN Cernavodă NPP U2 – 01/2020 for the operation of the Cernavodă Nuclear Power Plant, Unit 2 through the Cernavodă NPP Branch, valid until 07.12.2030,

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[1] Refurbishment of Unit 1 of the Cernavodă Nuclear Power Plant, Stage 2 - Feasibility Study, version v1, 2022
[2] *Ministry of Health*
[3] *National Administration "Romanian Waters"*
[4] *General Inspectorate for Emergency Situations*

- Authorization for carrying out activities in the nuclear field No. SNN DICA -11/2024 for the operation of Modules 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 of the Intermediate Spent Fuel Storage Facility (DICA) through Cernavodă NPP branch, valid until 15.07.2053,
- Authorization for carrying out activities in the nuclear field No. SNN CERNAVODĂ NPP DIDSR -01/2023 for the operation of the Intermediate Solid Radioactive Waste Storage Facility (DIDSR) through the Cernavodă NPP Branch, valid until 30.04.2033.

CANDU reactors have an initial lifetime of 30 years. **Following a refurbishing process, this lifespan can be extended by another 30 years**.

Unit 1 of Cernavodă NPP has been in commercial operation starting on December 2, 1996.

SNN SA's strategy regarding the long-term operation of Unit 1 considers two operating cycles for this objective, which are supported by management of aging activities and **by refurbishing the nuclear installation**, in accordance with the Operating Licences issued by CNCAN.

Within the National Energy Strategy, **nuclear energy production is one of the priorities for Romania's energy security and for the reduction of greenhouse gas (GHG) emissions in the energy production sector.**

At the same time, Romania's National Energy and Climate Plan specifically emphasizes the prospect of refurbishing Unit 1 of Cernavodă Nuclear Power Plant, thus ensuring a sustainable transition towards production of electricity with low carbon emissions and covering between 5% and 10% of Romania's electricity demand in the next three decades.

The DICA development envisages the transition to the construction of MACSTOR 400 type modules in accordance with the "Long-term strategy of SNN SA for the development of the intermediate dry spent fuel storage and licensing with a view to extending the lifetime of Units 1 and 2 harmonized with the observations of CNCAN and the Ministry of Environment", approved by the shareholders of SNN SA by AGOA Decision no. 8/28.09.2017. The Cernavodă NPP spent nuclear fuel management policy and the provisions of the long-term strategic document for the development of the DICA at Cernavodă NPP are in line with the provisions of the National Medium and Long-Term Strategy for the Safe Management of Spent Nuclear Fuel and Radioactive Waste. This national strategy was developed by the Nuclear Agency for Radioactive Waste (ANDR) in consultation with the main generators of radioactive waste in Romania and approved by GD 102/2022.

MACSTOR 400 represents the more compact module version developed by AECL (Atomic Energy of Canada Limited în colaborare cu KHNP - Korea Hydro & Nuclear Power Co.), starting from the MACSTOR 200 storage module project designed by AECL. The DICA extension process involves increasing the intermediate storage capacity by introducing modules with double storage capacity compared to those currently in use and by increasing the current storage area. This will increase the number of MACSTOR modules from a total of 27 modules to 37 modules, of which 17 are MACSTOR 200 modules and 20 will be MACSTOR 400 modules.

The operation of the DICA involves the construction of the intermediate storage modules at a pace in line with the operation of the U1 and U2 nuclear power units.

The Cernavodă NPP spent fuel management policy consists of:

- wet storage in the reactor spent fuel pool for a minimum of 6 years;
- **long-term interim storage in dry storage facility for spent fuel until the availability of the deep geological repository (DGR) to be commissioned by ANDR.**

The extension of the DICA will provide for the long-term interim storage of spent fuel resulting from the operation of units 1 and 2 of the Cernavodă NPP, with two operating cycles each.

Through the refurbishment project SN Nuclearelectrica S.A. aims ***to extend the lifetime of Unit 1 so as to ensure the long-term safe operation of the plant with a second operating cycle***. This is ***the main objective of the project***. The investment is in line with Romania's electricity needs, given that the demand for electricity is expected to grow in the medium and long term, requiring significant investment to reduce the gap between generation and demand. Nuclear power can prove to be a cost-effective solution in the long term, capable of meeting growing electricity needs while decarbonising the energy sector. Nuclear power is considered a ”climate-neutral energy” source.

In addition to the main objective, ***the secondary objective of the refurbishment project includes the equipments upgrade and improvement*** of Cernavodă Nuclear Power Plant, thus aiming to increase operational safety beyond the current minimum requirements. Combined, the two objectives contribute to:

- **the development of radioactive waste handling and interim storage facilities that will be used for the long-term operation of the Cernavodă Nuclear Power Plant** (Units 1 and 2) and for a possible expansion (Units 3 and 4;
- increase the stability of the network by ensuring a reliable coverage of the basic load; meeting the increase in electricity demand;
- affordability of electricity prices for the population and businesses;
- reducing electricity imports.

The Project: „REFURBISHMENT OF CERNAVODĂ NPP U1 AND EXTENSION OF INTERMEDIATE DRY SPENT FUEL STORAGE WITH MACSTOR - 400 MODULES” consists of two sub-projects:

➢ Sub-project Refurbishment of Unit 1 of Cernavoda NPP (RT-U1) - which will consist in the replacement of the components of the reactor assembly, in the rehabilitation and upgrading of the systems in the nuclear part and in the classical part of the unit and the accomplishment of the infrastructure necessary for the implementation of the subproject;

➢ Sub-project Extension of the Intermediate Storage of Spent Fuel with MACSTOR 400 type modules (DICA-MACSTOR 400) - which will consist in the construction and putting into service of modules with double the storage capacity than those currently used and in increasing the current storage area, in order to ensure the intermediate storage of the cooled spent fuel that will result from the operation of the U1 and U2 nuclear power units at the Cernavodă NPP and in their second operating cycle. Thus, the DICA-MACSTOR 400 sub-project is a support for the long-term operation of the nuclear power units.

According to Law no. 292/2018 regarding the assessment of the impact of certain public and private projects on the environment, for the purpose of approving the development of the project ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”,* proposed to be located in Constanța county , Cernavodă city, Medgidiei str. no. 2. (Cernavodă NPP site), owner Societatea Națională Nuclearelectrica SA., the classification stage was completed, and the Ministry of Environment, Waters and Forests - representing the central environmental protection authority with attributions in the regulation of this project - published the **Decision of the scoping stage no. 1/23.02.2022 by which it is proposed to start the environmental impact assessment procedures**, *without the need for adequate assessment and assessment of the impact on water bodies*. (Annex 3)

The project ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”,* ***is under the scope of the Convention on environmental impact assessment in a cross-border context, adopted in Espoo on February 25, 1991, ratified by Law no. 22/ 2001, with subsequent additions***.

SN Nuclearelectrica SA submitted to MMAP the necessary documentation to start the consultation process within the EIA procedure with potentially affected parties, in accordance with the provisions of art. 3 of the Espoo Convention, on 24.02.2022. MMAP sent the project notification to the responsible authorities in Bulgaria, Hungary, Serbia, Ukraine and the Republic of Moldova. Austria subsequently indicated its intention to participate in the environmental impact assessment procedure.

This document represents **the Environmental Impact Assesment Report** (EIA Report) for the ***project "Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules",*** developed according to the recommendations of Order no. 269/2020 *on the approval of the general guide applicable to the stages of the environmental impact assessment procedure, the guide for environmental impact assessment in a cross-border context and other specific guidelines for different fields and categories of projects, Annex 1 - General guide applicable to the stages of the assessment procedure of the impact on the environment.*

When developing the EIA, there were taken into consideration the provisions of Law no. 292/2018, Annex no. 4 *Information requested from the project owner for projects subject to environmental impact assessment, and of the Guidance on the content of the Environmental Impact Report for the project "Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules"* - annex to the address DGEICPSC/R/14305/19.07.2023 issued by MEWF.

1.2 General information regarding the project

1.2.1 Name of the project

”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*”

1.2.2 Components of the project

The project subject of the present EIA consists of two sub-projects:

- ***Sub-project Refurbishment of Unit 1 of Cernavoda NPP (RT-U1);***
- ***Sub-project Extension of the Intermediate Storage of Spent Fuel with MACSTOR 400 type modules (DICA-MACSTOR 400).***

1.2.3 Information on the project holder

Company name: National Nuclearelectrica SA (SNN SA) -
Cernavodă Nuclear Power Plant Branch (Cernavoda NPP)

Postal address:

- SNN-SA: Bucharest, Crystal Tower building, Bd. Iancu de Hunedoara, No. 48, Code 011745;
- Cernavoda NPP Branch: str. Medgidiei no. 2, Cernavodă town, cod 905200, Constanța county.

Phone number, fax and e-mail address, website address:

- SNN – SA: phone +40 21 2038200; fax: 021 3169400,
  email: office@nuclearelectrica.ro; http://www.nuclearelectrica.ro;
- Cernavoda NPP Branch: phone 0241 801001; fax: 0241 239266;
  e-mail: Corespondenta.UNKNOWN@nuclearelectrica.ro ; http://www.nuclearelectrica.ro/cne.

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1.2.4 Information about the certified author of the impact assessment study

In accordance with the provisions of Law no. 292/2018, Art 12, this RIM is developed by experts whose competence is recognized according to the specific legislation in force, certified by the commission in charge of attestation that operates within the professional association in the field of environmental protection, recognized at national level as well as by the authorities with responsibilities in the field of control of nuclear activities.

The association consists of the following members:

- SC CEPSTRA GRUP SRL
- RATEN NUCLEAR RESEARCH INSTITUTE PITEȘTI
- SC SUPPORT UNIT FOR INTEGRATION SRL
- SC OCON ECORISC SRL
- CP MED LABORATORY SRL.

The attestations/certifications held by experts – *individual and legal persons*, in accordance with the specifics and nature of the investment project under the environmental impact assessment procedure, are the following:

- **SC CEPSTRA GRUP SRL:**

− Certificate of attestation Series RGX no.027/07.10.2021. Type of studies and attestation fields: **RIM-4**, **EGCA**; **EGZA**.

− The organization owns an environmental laboratory - Accreditation Certificate No. LI 1239 for NOISE tests.

− Certificate of Acceptance for carrying out activities in the controlled area of the operating companies No. CA 03/2023.

- **RATEN Nuclear Research Institute Pitești**

− The organization owns the Laboratory for Radioprotection, Environmental Protection and Civil Protection - LRMPPC - Designation Certificate No. LI03_LRPMPC/2021 1136 for TESTS.

− Certificate of Acceptance for the extension of authorized activities in the controlled area of an operating company No. CA 04/2024.

− Licence to practise No DCCN 10/2024 in the nuclear field: ON, SD LEVEL 3 - Expert in radiological protection - Alexandru Toma.

− Licence to practise No DCCN 11/2024 in the nuclear field: SD LEVEL 3 - Expert in radiological protection - Dulamă Cristian Nicolae.

- **SC SUPPORT UNIT FOR INTEGRATION SRL**

− Certificate of attestation Series RGX no. 398/06.10.2022. Type of studies: **EA** și **MB**

- **OCON ECORISC SRL**

− Certificate of attestation Series RGX no. 240/31.05.2022. Type of studies and attestation fields: **RS-4**

- **CP Med Laboratory SRL**

− The organization owns a testing laboratory - Accreditation Certificate No. LI 1136 for TESTS/SAMPLING (water, eluate, soil, acoustic field, fixed source emissions, immissions, sampling for subsequent tests)

− Certificate of attestation Series RGX no. 251/07.06.2022. Principal level expert - individual. Type of studies: **EGSC**.

1.3 Importance of project implementation

The refurbishing project of Unit U1 at Cernavodă NPP is of national importance and is considered a priority investment project as an intervention by the Romanian state, being included in:

- **Romania's energy strategy 2025-2035, with the perspective of 2050**. *(https://energie.gov.ro/strategia-energetica-nationala/)*
- **The National Integrated Plan in the field of Energy and Climate Change 2021-2030 (PNIESC) April 2020** - published in the Official Gazette, Part I no. 963bis from October 8, 2021.
- **The medium- and long-term national strategy regarding the safe management of spent nuclear fuel and radioactive waste** – approved by GD no. 102/2022 - published in the Official Gazette, Part I no. 89bis of January 28, 2022.
- **Nuclear Safety Guide on the preparation of the refurbishment of nuclear installations - GSN 07**, approved by Order of the President of CNCAN no. 341/09.01.2019 and published in the Official Gazette, Part I, no. 22 of 09 January 2019.

Romania's energy strategy 2025-2035, with the perspective of 2050, provides that *Romania needs pragmatic development benchmarks, and the Energy Strategy vision is to grow the Romanian energy sector. The development of the energy sector requires, on the one hand, coherent and clear energy policies, and on the other hand - investments in low-carbon energy production, by substituting the use of coal with natural gas and renewable energy sources or* ***investments in increasing nuclear energy capacities****, investments in the refurbishment, expansion and modernization of energy networks by introducing digitalization and smart grids or the realization and completion, where appropriate, of cross-border interconnections with neighboring countries and investments in storage capacities.*

According to Romania's Energy Strategy, *the refurbishment of existing nuclear units and the construction of new large nuclear units* - are considered priority investments, which lead to the achievement of the fundamental objectives of the strategy.

Nuclear energy, an energy source with low carbon emissions, has a significant share in the total national electricity production - about 18% and represents a basic component of the energy mix in Romania. Nuclear energy in Romania is supported by internal resources and infrastructure that cover the entire cycle opened by nuclear fuel; practically, Romania has a high degree of independence in the production of nuclear energy.

The Integrated National Plan in the field of Energy and Climate Change 2021-2030 (PNIESC) April 2020 includes the refurbishing project mentioning the following:

*"****Extending the operating life of Units 1 and 2 from Cernavodă NPP is an efficient solution****, given that the extension by one more life cycle is done at costs around 40% of the value of a new objective of the same capacity,* ***through which it is possible to ensure the supply of electricity without greenhouse gas emissions, with minimal impact on the environment****, at competitive costs,* ***thus contributing sustainably to the decarbonization of the energy sector and the achievement of Romania's energy and environment targets for the year 2030, in line with the objectives expected at the European and even global level (the Paris Agreement).****"*

The medium and long-term national strategy regarding the safe management of spent nuclear fuel and radioactive waste, from 19.01.2022, applies to:

- ***„activities for the safe management of spent nuclear fuel from the operation of nuclear installations for the production of electricity*** and research reactors;
- ***safe management activities of radioactive waste from the operation, refurbishing and decommissioning of nuclear power generation facilities,*** research reactors and from industrial, medical and research activities that use radioactive sources."

The content of the National Program for the responsible and safe management of spent nuclear fuel and radioactive waste is established in accordance with the provisions of Directive 2011/70/EURATOM, as well as with those of the applicable national legislation.

According to this legislation, ***SNN SA as nuclear licensee is responsible for the pre-disposal of radioactive waste and spent nuclear fuel generated by Cernavoda NPP, while the Nuclear and Radioactive Waste Agency is responsible for the final disposal of radioactive waste and spent nuclear fuel***.

The extension of the intermediate storage capacity of spent fuel in the existing DICA MACSTOR 200 Facility, in operation at Cernavodă NPP site, **by introducing MACSTOR 400 modules, is a planned measure for <u>improving the efficiency of the intermediate storage of spent fuel</u>, per surface unit, in order to accommodate the spent fuel produced by the refurbished units U1 and U2, over the period of two operating cycles.**

According to the medium and long-term National Strategy on the safe management of spent nuclear fuel and radioactive waste, the **pre-disposal of radioactive waste represents** - "***any of the activities performed before final storage, such as sorting, characterization, collection, treatment, conditioning, <u>intermediate storage</u>, including the preparation of final storage packages***".

As part of the planned measures to improve pre-disposal activities, the medium- and long-term national strategy for the safe management of spent nuclear fuel and radioactive waste envisages **the extension of the intermediate storage capacity for radioactive waste resulting from the refurbishment activities at Cernavodă NPP. Thus, the provision of the intermediate storage capacity for the radioactive waste resulting from the refurbishing will be done by fitting the Reactor Building of Unit 5 as the new DIDR-U5**.

In line with the objectives of the ***National Medium and Long Term Strategy for the Safe Management of Radioactive Waste and Spent Nuclear Fuel***, approved by GD 102/2022, the National Agency for Radioactive Waste (ANDR) is responsible for the construction of a surface repository for low and intermediate level radioactive waste - *Final Repository for Low and Intermediate Radioactive Waste* (DFDSMA).

The National Program integrated into the National Strategy provides the following on concepts, plans and technical solutions for the safe management of spent nuclear fuel and radioactive waste from generation to final disposal:

"*a) Low and intermediate level short-lived radioactive waste - LILW-SL, generated from the operation, refurbishment and decommissioning of the nuclear units at the Cernavodă NPP will be permanently stored in a surface repository, DFDSMA. Activities for the siting and construction of this repository will be planned so that the facility will become operational in 2028. Until the commissioning of the DFDSMA, LILW-SL radioactive waste will be intermediately stored in dedicated facilities at the Cernavodă NPP site;*

b) Spent nuclear fuel is currently considered as waste and will be disposed of in a deep geological repository, together with low and intermediate level long-lived radioactive waste - LILW-LL. The siting and construction of this repository will be planned so that the facility will become operational in 2055. Until the deep geological repository is operational, both spent nuclear fuel and LILW-LL radioactive waste will be stored in interim storage in dedicated facilities.”

According to the legislation, SNN SA as nuclear licence holder is responsible for the pre-disposal of radioactive waste and spent nuclear fuel generated by the Cernavodă NPP.

The operation of the two nuclear units at the Cernavodă NPP results in quantities of radioactive waste (*low and intermediate level radioactive waste with short-lived radionuclides*) which are intermediately stored on the Cernavodă NPP site in an interim storage facility, and which must be finally and safely disposed of in the DFDSMA repository.

The DFSMA will be designed and built to ensure the safety of occupationally exposed personnel, the public and the environment, with a margin large enough to cover possible uncertainties in the input data and modelling. DFSMA will be designed to have a maximum storage capacity of 122000 m^3 of treated and conditioned low and intermediate level short-lived waste. DFSMA will contain a maximum of 64 storage cells, to be constructed in 8 stages, with 8 cells/stage commissioning.

At present, Romania decided to use nuclear fuel in an open cycle, considering spent nuclear fuel as high-level radioactive waste to be disposed of in a deep geological repository (DGR).

Spent nuclear fuel and radioactive waste (LILW-LL) generated from the operation of the ***Cernavodă NPP*** will be intermediately stored in dedicated facilities on the plant site, **until the Deep Geological Repository (DGR) is commissioned**, ***according to the National Medium and Long Term Strategy for the Safe Management of Radioactive Waste and Nuclear Fuel***.

It is the Government's policy that geological disposal should be carried out as soon as reasonably practicable, taking into account economic and social factors, so as not to impose undesirable burdens on future generations. [5]

The Extraordinary General Meeting of Shareholders of SNN SA approved by Decision no.27/23.12.2013, the strategy and plan for the refurbishment of Unit 1 of the Cernavodă NPP, in order to extend its lifetime.

Also, the Extraordinary General Meeting of SNN Shareholders on 25.10.2019 approved Decision no. 10 regarding the modification of the DICA investment project, the transition from MACSTOR 200 type modules to MACSTOR 400 type modules respectively.

[5] National medium and long-term strategy for the safe management of radioactive waste and spent nuclear fuel, approved by GD 102/2022

1.4 The necessity of the project

We present below the general information regarding the two subprojects and the importance of their implementation.

Subproject RT-U1

Nuclear power plants, like other industrial installations, have a limited lifetime. In the case of CANDU plants, this time is given by the lifetime of the pressure tubes, the most physically strained components of the reactor structure.

In the case of CANDU-type power plants, the life time is given by the time analyzed for the fuel channels, Calandria tubes and feeders. When designing these specific equipments, it was taken into account that they would work for 30 years, at a capacity factor of 80%, which leads to 210000 "Effective Full Power Hours" (EFPH). Considering that the current capacity factor of nuclear power plants is higher than 90% (compared to that of the '70s/80s'), current studies and experiments have demonstrated that it is possible to operate up to 245000 EFPH, which will allow the operation of CANDU-type power plants for up to 30 years.

At the beginning of the 2000s, as the first CANDU plants were approaching the end of their first 30-year operating cycle, the CANDU project licensee developed a refurbishing technology that would allow them to operate for another operating cycle. **The main element of this technology is the changing of CANDU reactor components (*fuel channels, calender tubes, feeders, etc.)*, for which the life span ends at the end of the first operating cycle.**

From the operating experience so far, it appears that **the refurbishing of the CANDU reactors is technically and economically feasible**, allowing the extension of their operating life by one more operating cycle, **under appropriate conditions of safety and economic efficiency.**

Until now, the following CANDU nuclear power plants have been refurbished and are operating in their second life cycle: Point Lepreau, Embalse, Bruce Power 1, 2 & 6 și Darlington 2 & 3, and the refurbishment of the other units at Bruce and Darlington continues.

The main advantages for the refurbishment of a nuclear unit after the end of the first life cycle are the following:

- **<u>the refurbished nuclear unit is able to operate at the project parameters for one more operating cycle</u> for an investment of about half of the investment for building a similar nuclear objectiv;**
- **the refurbishment of a nuclear unit is more advantageous than the construction of a new capacity, in that it does not require the authorization of a new location for this unit;**
- **the estimated duration for the refurbishment of a nuclear unit is significantly shorter than the duration of the construction of a similar new unit, based on the experience of other CANDU nuclear unit operators.**

In terms of policies and strategies, the Integrated National Plan for Energy and Climate Change 2021-2030 (PNIESC) specifically highlights the prospect of refurbishing of Unit 1 of Cernavodă NPP, in addition to building at least one new nuclear unit by 2030 (ensuring thus a sustainable transition towards electricity production with low carbon emissions), while the National Energy Strategy 2025-2035, with the perspective of 2050, underlines the strategic option of nuclear energy generation for Romania including by the refurbishment of existing nuclear units.

Considering all these, by Decision no. 27/23.12.2013 of the Extraordinary General Meeting of SNN Shareholders, the **Strategy and plan for the refurbishment of Unit 1 Cernavodă NPP** was approved, in order to extend its life, and by Decision no. 9/28.09.2017 the Extraordinary General Meeting of SNN Shareholders approved the start of Phase I of the Strategy for the Refurbishment Project of Unit 1 Cernavodă NPP.[6]

Subproject DICA-MACSTOR 400

In order to support the specific needs for the operation of the nuclear power units at Cernavodă NPP, the most important aspect is related to the management of spent nuclear fuel, for which the phased construction works of the Interim Spent Fuel Storage Facility (DICA) are underway.

The DICA project, as approved by Environmental Agreement no. 2058/22.04.2002 issued by Environmental Protection Inspectorate of Constanta, relies on the construction of MACSTOR 200 type modules and stipulates the storage of spent fuel that meets the thermal storage conditions in 27 monolithic concrete modules, arranged in 3 rows, which represents the storage capacity of spent fuel from the operation of two nuclear units, with a single operating cycle. The current, approved and allocated site of DICA, on which **17 MACSTOR 200 modules** will be built out of the 27 modules originally envisaged and approved, does not provide the necessary intermediate storage space for the spent fuel resulting from the operation of 2 nuclear units with 2 cycles of operation, thus **being necessary to extend the intermediate storage capacity of the spent fuel**.

SNN SA's long-term strategy for the development of the Intermediate Burnt Fuel Storage Facility (DICA) and authorization in the perspective of extending the life of Units 1 and 2, revised and consistent with the requirements and recommendations of CNCAN and of the Ministry of Environment, was approved by the shareholders SNN by AGOA Decision no. 8/28.09.2017 and later amended by AGOA Decision no. 10/25.10.2019.

The development of DICA takes into account the transition to the construction of MACSTOR 400-type modules in accordance with the revised long-term SNN SA Strategy. MACSTOR 400 represents the more compact module version developed by AECL (Atomic Energy of Canada Limited in collaboration with KHNP - Korea Hydro & Nuclear Power Co.), starting from the MACSTOR 200 storage module project designed by AECL.

[6] Notice on the endorsement/approval of the start of Phase 1 of the Strategy for the Unit 1 Refurbishment Project

According to the development plan for the DICA objective, it is intended to build, starting with Module 18, a number of 20 MACSTOR 400 type modules. The construction of the 17th MACSTOR 200 type module is planned to be completed at the end of semester I 2024, the construction of Module 18 - the first of the MACSTOR 400 type - to begin with the second semester of 2025 and to last for 1.5 years.

Nuclear energy, an energy source with low carbon emissions, has a significant share in the total national electricity production - 20% in 2022 - and represents a basic component of the energy mix in Romania.[7]

From this perspective, the projects initiated on the Cernavodă NPP platform, aimed at the refurbishment of Unit U1 and the completion of Units 3 and 4 respectively, priority investments for the energy sector in Romania, will contribute to ensuring the achievement of environmental and energy security objectives and targets, security of supply and diversification of sources for a balanced energy mix, to ensure the transition to an energy sector with low greenhouse gas emissions and an affordable energy price for consumers.

1.5 Description of the location of the project

1.5.1 General description of the project location

The Cernavoda NPP site is located in Constanta county, approx. 2 km SE from the town of Cernavoda and approx. 1.5 km NE of the first watergate of the Danube-Black Sea Canal (CDMN), being bordered to the northeast by Valea Cismelei, and to the southwest by DJ 223 and the secondary railway line, access to the industrial area and the port of Cernavoda. The Cernavoda NPP platform resulted from the excavations from the former Ilie Barza limestone quarry, with a current elevation of + 16.00 mdMB compared to the level of the Baltic Sea.

The nuclear site was authorized by *Site Authorization no. I/665 of September 30, 1978 issued by the State Committee for Nuclear Energy (CSEN)*, and the land related to the construction of the plant was defined following the State Council decree no. 15 of 10.01.1979 and represents the property of SNN SA, according to the Certificate of Attestation of Land Ownership Series M03 no. 5415/25.04.2000 issued by the Ministry of Industry and Commerce.

Both subprojects, RT-U1 and DICA-MACSTOR 400, will be carried out on the current site of Cernavoda NPP.[8]

1.5.2 The land use regime in the area of the project location

In accordance with the legislation in force in the nuclear field, the lands related to the location of the Cernavoda NPP will be used only with the approval of the National Commission for the Control of Nuclear Activities (CNCAN) and the Cernavoda NPP, only constructions related to the operation of the nuclear power plant, construction works for roads, railways, technical-building networks, derivation channels, facilities and technical equipment of the area being allowed.

The legal status of the land on which the RT-U1 and DICA-MACSTOR 400 project is located, was established by State Council Decree no. 31/27.01.1986 (for the construction of Cernavoda NPP Units 1-5), the land being expropriated.

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[7] Electricity production and consumption in Romania, by types of producers, http://www.sistemulenergetic.ro/

[8] Presentation Memoir - "*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*", November 2021

The land related to the Project consists of plots inside the Cernavoda NPP premises, which is the property of SNN-SA, according to the Land Deed Extract for information no. 41832/28.07.2022 issued by OCPI Constanta and the Certificate of Attestation of Land Ownership, series M03, no. 5415, issued by the Ministry of Industries and Resources, at 25.04.2000.

According to the Urbanism Certificate no. 37 din 03.04.2024, the land related to the location of the RT-U1 and DICA-MACSTOR 400 project:

- it is located in the inner city of Cernavoda, Constanta county, according to P.U.G. approved by H.C.L. no. 242/2014,
- it is found in the Territorial Reference Unit U.T.R. A3 - sub-area of production units related to NPP.
- category of use: yards, constructions.

The area of the land on which the RT-U1 and DICA-MACSTOR 400 project will be carried out is approximately 325000 square meters.

1.5.3 The objectives located in the vicinity of the project site, in premises of the NPP

On the Cernavoda NPP site there are the following objectives [9]:

- ***Unit 1***, nuclear facility in operation since December 2, 1996;
- ***Unit 2***, nuclear installation which is in the exploitation stage since November 1, 2007;
- ***The buildings and installations of Units 3 and 4***, under conservation;
- ***Unit 5***, for which the destination has changed, from construction of a nuclear power plant, to a useful support objective for the lifetime of Units 1 and 2 in operation and of the future Units 3 and 4, according to DEI 6983RP of 08.11.2016 with the Annex of 11.05.2020 issued by APM Constanta;
- ***The Intermediate Spent Fuel Storage Facility (DICA),*** used for dry intermediate storage of CANDU-6 (natural Uranium) spent fuel bundles, resulting from the operation of Units 1 and 2;
- ***The Intermediate Radioactive Solid Waste Storage Facility (DIDSR),*** in which the radioactive solid waste generated from the operation of Units 1 and 2 of the nuclear power plant is temporarily stored.
- ***Office buildings, thermal start-up plant, etc***. - necessary for the activity.

The activities related to the implementation of the two subprojects will be carried out on the Cernavoda NPP platform, as follows:

- The actual refurbishment activities, consisting of replacement, repair and modernization works, will take place inside Unit 1
- The set-up of the support spaces for refurbishment, respectively the construction works for permanent, temporary and temporary spaces/buildings, will be done in the perimeter of Unit 1 - located in the SE part of the NPP platform, in the area of Unit 5 - in the N part of the Cernavoda NPP platform, as well as in the area located south of DICA – in the W part of the NPP platform
- DICA extension - in the extension of the current DICA site, towards the area of Unit 5.

[9] Final Nuclear Security Report Unit 1 - Summary, February 2023

The layout of the surfaces related to the two sub-projects compared to other objectives on the Cernavoda NPP site and the area related to the construction site are shown in the following figure:

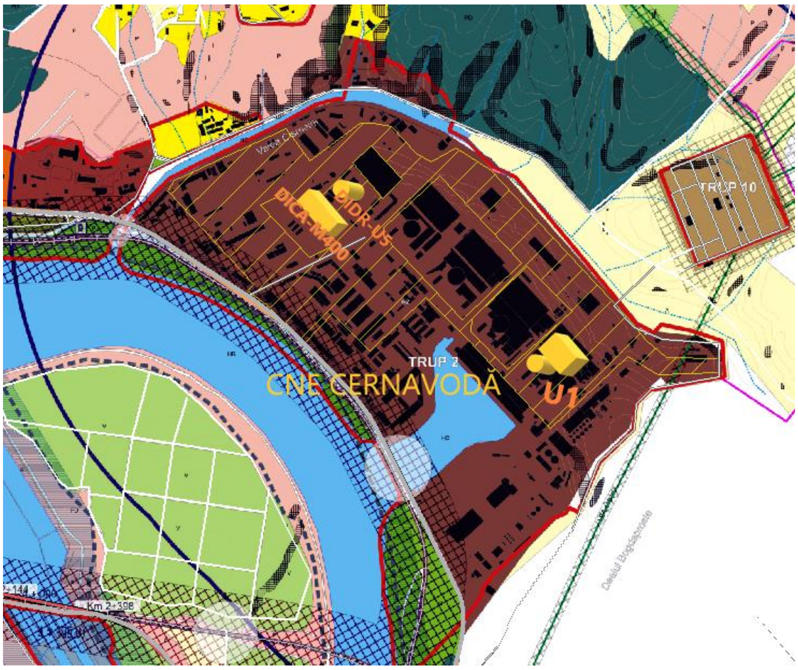


Fig. 1 Illustration of the area allocated to the RT-U1 and DICA-MACSTOR 400 project within the Cernavoda NPP platform *(edited on the basis of public data*[10] *and plans provided by the owner)*

1.5.4 Distances between the location of the project works and the objectives of interest outside the project area

1.5.4.1 Distances from the location of the project works to the nearest localities

The nearest towns to the area of influence of Cernavoda NPP as a whole are:

- the town of Cernavoda - located approx. 1.6 km NW of the Cernavoda NPP platform,
- the village of Stefan cel Mare located approx. 2 km SE of Cernavoda NPP,
- the village of Seimeni located approx. 2.4 km NE,
- the village of Dunarea located approx. 8.5 km NE,
- the village of Capidava located approx. 15 km NE,
- the village of Topalu located approx. 22 km N.

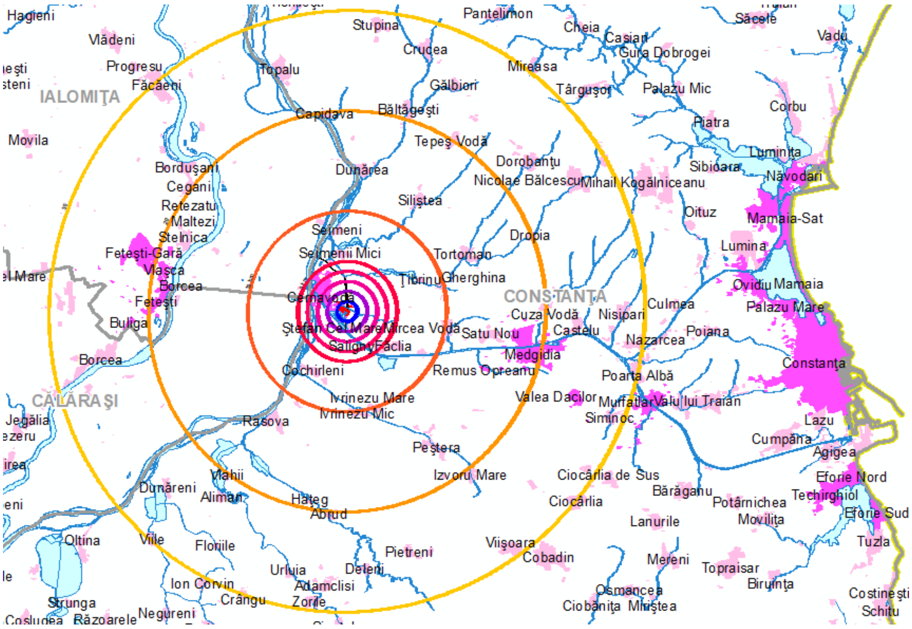
Based on the nuclear security analyzes proposed by the activity owner - SNN SA and approved by CNCAN, exclusion zones and low population areas were defined.

As a result, the following areas were established around Cernavoda NPP:

- ***an exclusion zone within a radius of 1 km around the reactors in operation*** - an area in which there are taken measures to exclude the location of permanent residences for the population and the development of social and economic activities that are not directly related to the operation of Cernavoda's NPP nuclear facilities;
- ***a low populated area with a radius of 3 km around the reactors in operation*** - in which measures are taken to restrict the location of permanent residences for the population and the performance of social and economic activities.[11]

[10] Cernavoda City Hall, Cernavoda PUG - Functional zoning, https://primaria-cernavoda.ro/administratie/directii-si-servicii/compartiment-urbanism/pug-plan-urbanistic-general/

[11] Final Nuclear Security Report Unit 1 - Summary, February 2023



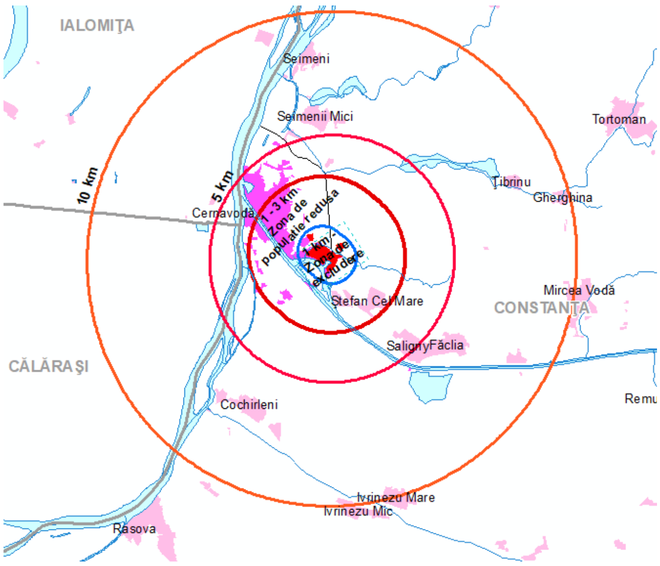


Fig. 2 Urban and rural settlements within the 30 km radius of Cernavoda NPP and detail for the exclusion and low populated area [12]

1.5.4.2 Distances from the location of the project works to the nearest historical monuments with cultural value of national interest

According to the List of historical monuments 2015 - Constanta county, an integral part of the Annex to MO no. 2314/2004, with subsequent amendments, and the National Archaeological Repertoire provided by Government Ordinance no. 43/2000 regarding the protection of the archaeological heritage and the declaration of some archaeological sites as areas of national interest, republished, with subsequent amendments and additions, respectively according to the Map Server for the National Cultural Heritage, the Cernavoda NPP platform is located in an area with a concentration in the territory of built heritage with cultural value of national interest - Cernavoda town, Mircea Voda and Topalu communes.

The relief and climate conditions were favorable for habitation, the monuments dating from various eras (Byzantine era, Hellenistic era, Hellenistic/Roman era, Roman era, prehistory).

[12] *ANCPI "Contains public information based on the Open Government License v1.0", www.geoportal.gov.ro*

The closest archaeological sites of national interest are the Necropolis of Axiopolis (RAN Code 60785.02, LMI Code CT-I-m-A-02620.02 – approx. 2.5 km WSW and Valul de piatra from Cernavoda (RAN Code 60785.04, LMI Code CT-I-m-A-02559.01) – about 2.5 km SW.

The "Axiopolis" Museum, which belongs to the Constanta National History and Archeology Museum, presents prehistoric, Daco-Roman, Roman-Byzantine archaeology, treasure from the feudal period and illustrates modern and contemporary achievements[13]. The museum is in Cernavoda, approx. 2.3 km NNW of the NPP platform.

Among the closest representative historical monuments in the city of Cernavoda is Geamia (LMI Code CT-II-m-A-02874) ~2 km NNW, the Church “St. Emperors Constantine and Elena" (LMI Code https://ro.wikipedia.org/wiki/Cod:LMI:CT-II-m-A-02873) ~ 2.5 km NNW and the Charles I Bridge (designed and executed under the direction of engineer Anghel Saligny) with the "Dorobants" statues (LMI Code LMI Code: CT-II-m-A-02872) ~3 km NW.

No monuments of historical and cultural interest were identified in the Cernavoda NPP perimeter.

1.5.4.3 Distances from protected natural areas

This sub-chapter presents the location of the project in relation to the Natura 2000 sites:

- located within a radius of 15 km from the project: ROSPA0039 Dunăre - Ostroave, ROSCI0022 Canaralele Dunării (which includes 2.534 Cernavodă Fossil Site and 2.355 Seimenii Mari Fossil Site), ROSPA0012 Brațul Borcea, RAMSAR RORMS0014 - Brațul Borcea, ROSPA0002 Allah Bair - Capidava (which includes Nature Reserve 2.367 Allah Bair Hill), ROSPA0001 Aliman - Adamclisi, ROSCI0353 Peştera - Deleni, ROSCI 0412 Ivrinezu.
- located up to 30 km from the project: ROSCI0053 Allah Bair Hill, ROSCI0071 Dumbrăveni - Valea Urluia - Lacul Vederoasa (also includes 2.351 Aliman Fossiliferous Site and IV.30 Vederoasa Lake), ROSCI0172 Padurea and Valea Canaraua Fetii - Iortmac, ROSCI0278 Bordușani - Borcea, ROSCI0319 Mlastina de la Fetești, ROSPA0007 Balta Vederoasa, ROSPA0012 Brațul Borcea, ROSPA0054 Lacul Dunăreni), to which are added the natural reserves of national interest IV.26 - Bratca Forest (included in ROSCI0022 Canaralele Dunării) and 2.352 Neo-Jurassic Reef from Topalu (included in ROSCI0022 Canaralele Dunării).
- The areas located at distances greater than 30 km from the project are also graphically represented, respectively 2.350 Limestone walls from Petroșani - Deleni Commune (approximately 34 km in a straight line), 2.361 Dumbrăveni Forest (approximately 33 km in a straight line), 2.369 Canaralele from Port Hârșova (approx. 39 km in a straight line), IV.24 Celea Mare - Valea lui Ene (approx. 36 km in a straight line), IV.19 Ostrovul Șoimul (approx. 47 km in a straight line), IV. 25 Padurea Cetate (approximately 39 km in a straight line).

[13] https://www.minac.ro/muzeul-axiopolis-cernavoda.html

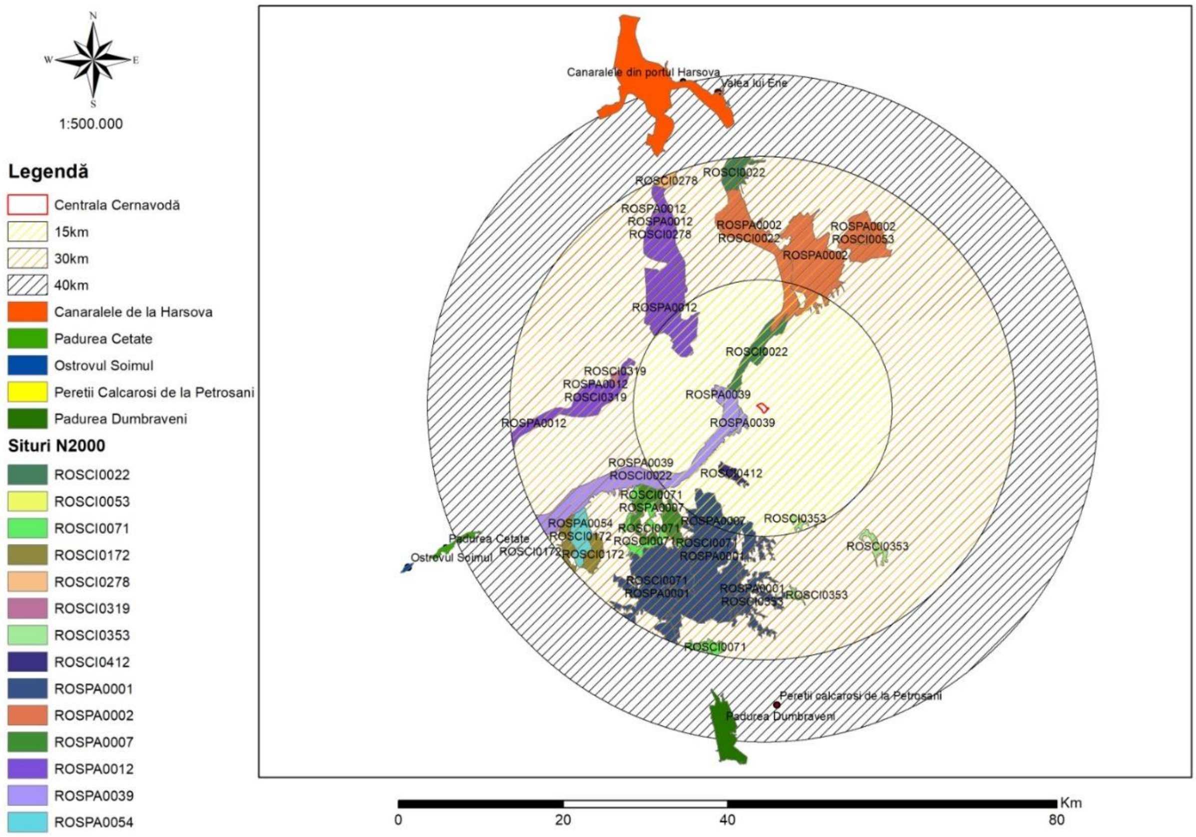


Fig. 3 Protected natural areas located up to 15 km, 30 km and over 30 km around the project site [14]

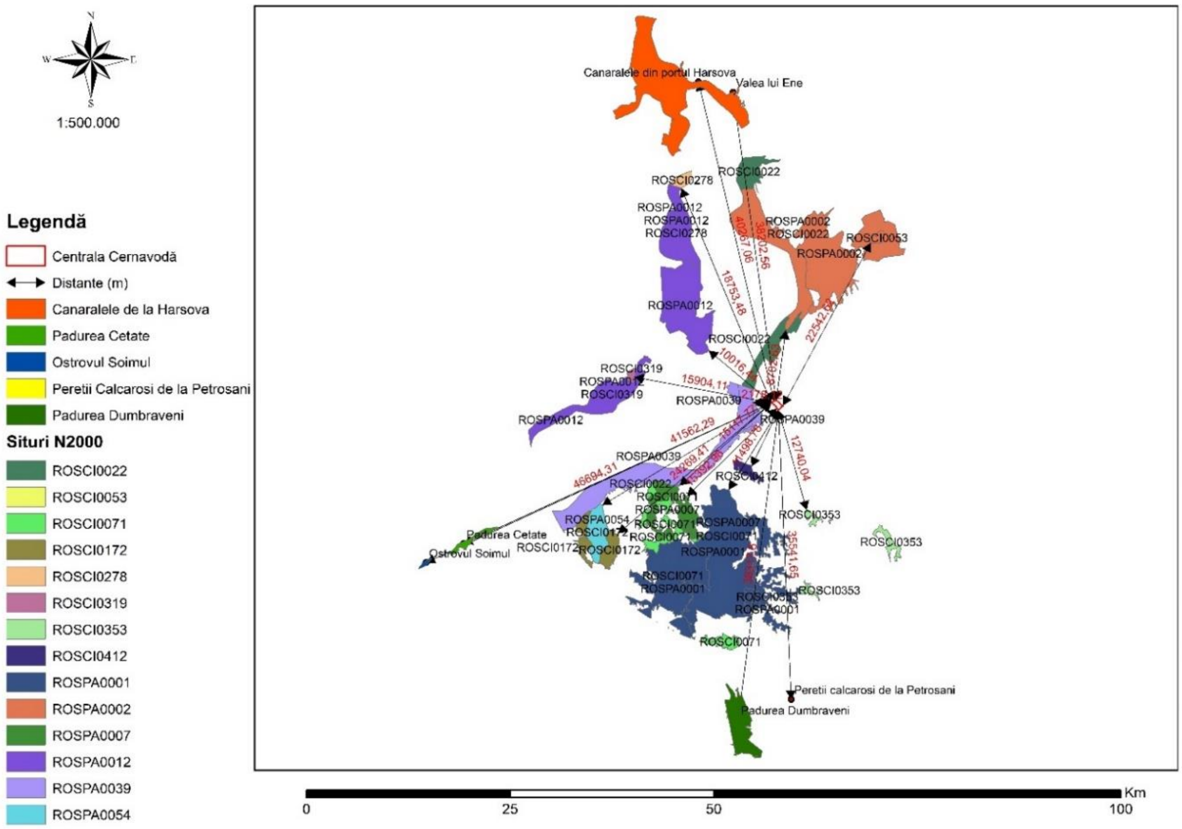


Fig. 4 Illustration of distances between the project site and protected natural areas located within a radius of 40 km

[14] Ministry of Environment, Waters and Forests, https://www.mmediu.ro/categorie/date-gis/205

Tab. 1 Minimum distances from the project site to protected natural areas within 40 km and spatial orientation

No.	Site N2000	Site name	Distance (m)	Cardinal point
1	ROSCI0022	Canaralele Dunării	2178.12	NW
2	ROSCI0053	Dealul Alah Bair	22542.62	N
3	ROSCI0071	Dumbraveni - Valea Urluia - Lacul Vederoasa	15117.77	SW
4	ROSCI0172	Padurea și Valea Canaraua Fetii - Iortmac	24269.41	SW
5	ROSCI0278	Bordușani - Borcea	18753.48	NW
6	ROSCI0319	Mlaștina de la Fetești	15904.11	W
7	ROSCI0353	Peștera - Deleni	12740.04	SE
8	ROSCI0412	Ivrinezu	7563.02	S
9	ROSPA0001	Aliman - Adamclisi	11498.78	S
10	ROSPA0002	Allah Bair - Capidava	8702.63	N
11	ROSPA0007	Balta Vederoasa	15392.96	SW
12	ROSPA0012	Brațul Borcea	10016.44	NW-W
13	ROSPA0039	Dunăre - Ostroave	1684.23	W
14	ROSPA0054	Lacul Dunăreni	24269.41	SW
15		Pereii calcaroși de la Petroșani	35541.66	S
16		Padurea Dumbrăveni	38317.50	S
17		Padurea Cetate	41562.29	SW
18		Ostrovul Șoimul	46694.31	SW
19		Valea lui Ene	38202.56	N
20		Canararele din portul Hârșova	40267.06	N

Distances to protected natural areas located on the territory of Bulgaria: SCI BG0000106 Harsovska Reka and SPA BG0002039 Harsovska Reka – 61 km from the project, SCI BG000017 Suha Reka and SPA BG0002048 Suha Reka – 37 km from the project.

1.5.5 Distances from the location of the project works to the borders with Bulgaria, Ukraine, the Republic of Moldova, Serbia, Hungary and Austria

The proposed project, intended for the Cernavoda nuclear power plant, falls under the scope of the Convention on environmental impact assessment in a cross-border context, adopted in Espoo on February 25, 1991, ratified by Law no. 22/2001, with subsequent additions.

As part of the regulatory procedure, the Ministry of the Environment requested neighboring states to participate in the environmental impact assessment procedure and the following states expressed their interest: Bulgaria, Ukraine, Republic of Moldova, Serbia, Hungary and Austria.

The distances from the Cernavoda NPP site to the borders of these states are:

- approx. 36 km from Bulgaria,
- approx. 112 km from Ukraine,
- approx. 128 km from the Republic of Moldova,
- approx. 421 km from Serbia,
- approx. 575 km from Hungary,
- approx. 926 km from Austria.

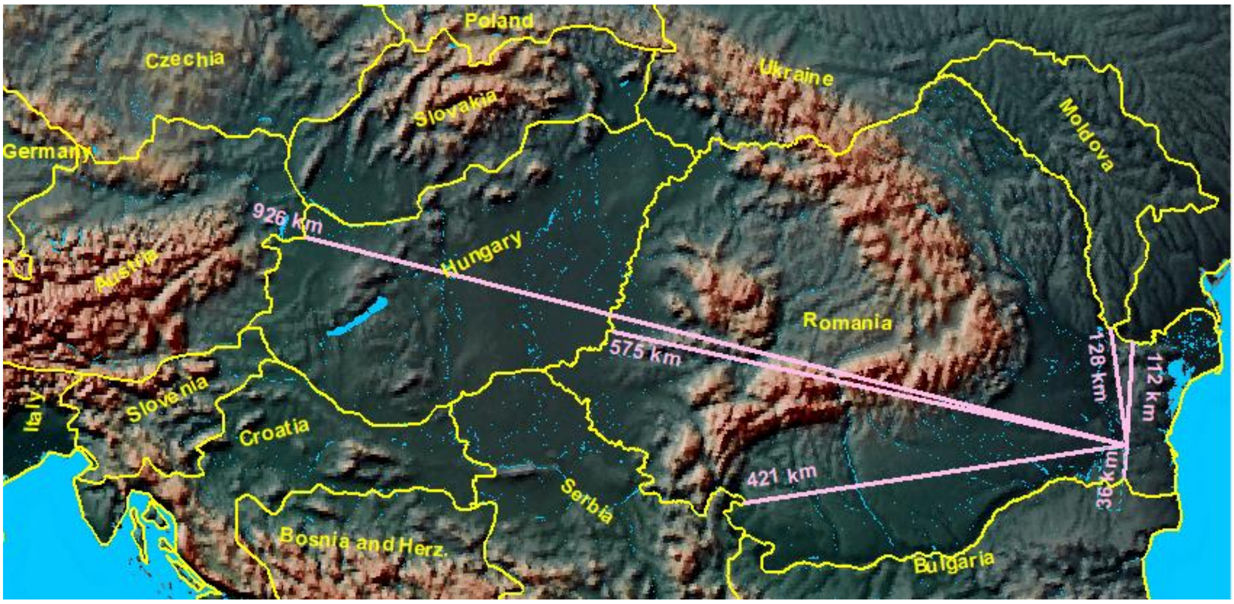


Fig. 5 Distances from the Cernavoda NPP site to the borders of the interested states
(edited based on public sources[15] [16] [17] and plans provided by the owner)

1.6 The physical characteristics of the entire project, including, if applicable, the necessary demolition works, as well as land use requirements during the construction and operation phases

1.6.1 The program for the implementation of the project

1.6.1.1 Project phases and durations

Subproject RT-U1

The sub-project RT-U1 is structured in three phases:

○ **Phase 1 –** *Defining the object of the Unit 1 refurbishment project*, the start of which was approved by Decision no. 9/28.09.2017 of the Extraordinary General Meeting of Shareholders of Societatea Nationala Nuclearelectrica S.A.

The activities in this phase consist in contracting the necessary technical studies to identify the activities to be carried out within the Refurbishment Project and are initiated the activities required for the preparation of the documentation for obtaining the approvals and agreements in order to start the project activities, as well as the documentation necessary for the execution of the project's infrastructure.

According to the Note regarding the approval/acceptance of the start of Phase 1 of the Strategy for the project of refurbishment Unit 1 approved by Decision no. 9/28.09.2017 of the Extraordinary General Meeting of Shareholders of Societatea Naționala Nuclearelectrica S.A., phase 1 started at the beginning of 2018.[18]

Phase 1 have been finalized with the approval of the feasibility study, by Decision no.4 from 23.02.2022, of the Extraordinary General Meeting of the Shareholders of the Nuclearelectrica National Company.

The duration of the phase *November 2017 – February 2022*

[15] *Natural Earth - Made with Natural Earth. Free vector and raster map data @ naturalearthdata.com*
[16] *ANCPI – Administrative-territorial units - Data produced by ANCPI,, www.geoportal.gov.ro*
[17] *EEA– CLC_2018 DOI (vector): https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0*
[18] Presentation Memoir - ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”*, November 2021

○ **<u>Phase 2</u>** – *<u>Preparing the implementation of the Project</u>*, in which it is completed the process of obtaining of the approvals, agreements and authorizations necessary for the start of the works on the refurbishment Project. After obtaining these authorizations, or in parallel, all the design and execution works for phase 3 (the actual refurbishment) will be contracted and works will be carried out to create the related infrastructure - organization/refurbishing/building the necessary spaces (workshops, changing rooms, offices, concrete platforms), as well as spaces specially arranged for the storage of radioactive waste resulting from the project.

- Notification to the European Commission (EC) in accordance with Article 41 of the Euratom Treaty;
- Obtaining construction permits from the National Commission for the Control of Nuclear Activities (CNCAN) for the radioactive waste intermediate storage resulting from the refurbishment period, as well as for the construction of the auxiliary buildings;
- Obtaining other approvals, agreements and authorizations necessary to start the refurbishment project;
- Obtaining the environmental agreement for the refurbishment project;
- Drafting financial packages and obtaining financing;
- Purchase of equipment and components with a long manufacturing cycle;
- Awarding engineering, procurement, and construction (IPC) contracts;
- Construction/arrangement of radioactive waste storage structures resulting from refurbishment;
- Set-up of the facilities for the storage of heavy water;
- Separating access and ensuring physical protection for Unit 2;
- Special arrangements to ensure physical protection during the refurbishment project;
- Organizing the construction site (including the construction of buildings for staff training on simulators, offices).[19]

At the end of phase 2, the infrastructure will be completed and ready for the start of Unit 1 refurbishment activities.

The estimated duration of phase 2 of the Unit 1 Refurbishment Project: ***March 2022 – December 2026***.

○ **<u>Phase 3</u>** – *<u>The implementation of the project</u>* - consists in shutting down Unit 1 for a period of at least 2 years, during which the replacement of components with a limited lifespan will be carried out, as well as other rehabilitation and modernization works, to operate Unit 1 for another operating cycle.[19]

The main activities of this phase are:

- Shutting down the unit and unloading the nuclear fuel;
- Drainage and storage of heavy water, drying and decontamination of the sistems from the nuclear side where works are about to be carried out;
- Conditioning for conservation of the system during the shut-down period;
- Preparing the reactor building and the reactor assembly,
- Dismantling feeders, fuel channels, calandria tubes and preparing them for storage as radioactive waste;
- Installation of calandria tubes, fuel channels and new feeders;
- Managing radioactive waste;
- Carrying out other planned works, identified in the process of defining the purpose of the project;

[19] Presentation Memoir - ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”*, November 2021

- Reinstalling the physical protection and access control systems as for an operational nuclear unit;
- Restoring the configuration of the systems, filling with heavy water and performing pressure tests;
- Putting the equipment and systems back into operation and demonstrating the fulfillment of the project requirements, where they have been modified;
- Loading the fuel and reaching the criticality of the reactor;
- Carrying out all unit commissioning tests, including the performance test;
- Project closure – acceptance and decommissioning or preservation of the temporary facilities used in the refurbishment process.

The estimated duration of phase 3 is at least 2 years: ***2027 – 2029***.

Subproject DICA-MACSTOR 400

The works on the DICA - MACSTOR 400 subproject will be carried out in stages, module by module, the pace of completion of the DICA - MACSTOR 400 Subproject being staggered in such a way as to ensure the necessary storage space for the spent fuel at Cernavoda NPP and which meets the transfer conditions according to CNCAN regulations and applicable CNCAN authorizations.

The execution of the first MACSTOR 400 module (module 18) is expected to start in the second half of 2025, after obtaining all the approvals and agreements required by the Urban Planning Certificate and the Site/Nuclear Safety and Construction Authorizations from CNCAN. The execution time of a MACSTOR 400 module is approx. 1.5 years.

1.6.1.2 The main stages of the project

The implementation of the Project involves the following main stages:

Subproject RT-U1

- preparing the necessary infrastructure, setting up the appropriate space in U5 Reactor Building (the new DIDR-U5) for the intermediate storage of radioactive waste, setting up facilities (light structures) for the temporary storage of recoverable/recyclable waste, setting up spaces for the temporary storage of materials, equipment used in the refurbishment activities,
- Unit 1 shutdown and unloading the nuclear fuel, preparation of the reactor building and the reactor assembly, isolation, decontamination, drainage, drying, retubing the reactor, management and storage of radioactive waste, technological tests and commissioning, closure of the project - reception and decommissioning or preservation of the temporary facilities used for refurbishment.

Subproject DICA-MACSTOR 400

- extension of the DICA site from an area of about 24000 m^2 to approx. 40000 m^2 (the area included between the limits of the external fence of the objective),
- land preparation, construction of MACSTOR 400 modules with dimensions of 12.95 m x 21.94 m x 7.60 m and a double storage capacity compared to MACSTOR 200 modules, with phased execution, module by module, staggered so as to ensure the necessary intermediate storage space for the spent fuel from the refurbished U1 and U2 nuclear power units, which are in operation,
- Performing other planned works, identified in the process of defining the scope of the project (e.g. relocation of the power line poles from DICA site).

1.6.2 The main activities for project implementation

Subproject RT-U1

All the spaces necessary to carry out the preparatory and support activities of the refurbishment will be located inside the Cernavoda NPP site.

The specific, refurbishment activities will be carried out inside the existing buildings, related to Unit 1 and in the support spaces that will be specially built and arranged.

- ***Setting up the spaces and supporting infrastructure for refurbishment, outside the Unit 1***

The preparation for the refurbishment of Unit 1 involves the following main developments on the Cernavoda NPP:

a) ***construction of new buildings and temporary constructions***:

- Buildings that will not contain radioactive material:
  - Office building for refurbishment staff and archive building.
  - The command center of retubing activities - ***temporary***, container-type construction.
  - Building for the specific training of the personnel involved in the retubing activity of U1 reactor. The sub-project will be carried out by teams with experience in refurbishment CANDU-6 type reactors, the on-the-job training aiming at the optimized approach, adapted to the structural characteristics of Unit 1 at Cernavoda NPP.
  - Reactor components building, clean room - for receiving, storing, inspecting, preparing, cleaning and packaging the new components that are installed in the reactor building and where the sensitive equipment used in the retubing activity will be calibrated and stored. Components and equipment in this building are not radioactively contaminated.
  - Building where the EPS batteries, control panels, automation, signaling and cables will be located, to ensure the supply of electricity from batteries to vital consumers that must be functional after an event in the Design Extension Conditions category.
  - Metallic structure to support the cooling equipment belonging to the new Stand-by Diesel Generators – SDG U1.
  - Emergency Diesel Generator - in the parking area on the WNW side of the Cernavoda NPP site.
  - Access Control Points (PCA) at different objectives/areas on the site – buildings for 3 permanent PCA (PCA12, 16 and 13A), modular containers for ***2 temporary PCA (PCA4 and 13B)***.

- Buildings that will contain radioactive material:
  - Extension of the changing rooms for the staff who will carry out activities in the radiologically controlled area of Unit 1.
  - Active Components Building - for the reception and preparation of the tools needed for retubing. The facility will be used to receive, host, process and register/label the tools used for retubing, for decontamination and to carry out their maintenance work.
  - Auxiliary building U5 - for unloading radioactive waste transport containers and loading storage containers.
  - Space for the temporary storage of equipment removed from the radiological area and which have fixed contamination - temporary light structure and with tight closures on the platform of the current DIDSR.

b) **alterations of some existing buildings**:

- Organization of the space inside the Unit 5 Reactor Building (the new DIDR-U5) for intermediary storage of the low and intermediate level waste resulting from the refurbishment of Unit 1 and the long term operation of the nuclear power units.
- Relocation of the overpass of the heating water/steam pipes and electrical cables, along approximately 120 meters.

The authorization requirements for the new intermediate repository of radioactive waste - DIDR (the new DIDR-U5) were established between CNCAN and SNN SA and recorded in the Minutes of the meeting of 21.12.2021, approved by the president of CNCAN, with no. 3822 from 01.08.2022.

The assessment of the availability of the building (storage capacity and structural integrity) was carried out in the framework of the *Feasibility Study on the Management of Radioactive Waste Generated during the Refurbishment of Unit 1 and during the Operation period of Units 1 and 2 from Cernavoda NPP after Refurbishment*, completed by The report drafted by KHNP in May 2021

The new DIDR-U5 will be installed inside the reactor containment of Unit 5, a building with a diameter of 43 m and a height of 42 m, located on the Cernavoda NPP site, ***60% completed*** and in a state of preservation. The construction made of massive reinforced concrete elements, with a thickness of over 1 m, will be intended for the intermediary storage of containers with radioactive waste (correlated with the types of waste to be stored - activated, contaminated, operational). The building will be equipped with ventilation, conditioning, and monitoring systems, specific for the storage of low and medium radioactive solid waste (T1, T2 and T3).

The new DIDR-U5 will be linked to the new building provided for the transfer of radioactive waste from transport containers to intermediate storage containers.

c) **organization of access ways used temporarily (for access of equipment/tools/materials) and permanently (for transporting radioactive waste), parking lots, other related works**:

For the activities of the RT-U1 subproject, the road, and pedestrian walkways currently existing inside the NPP premises will be used, where the road configuration allows, especially near the outdoor concrete platforms in the construction site area of U3-U5. These roads will be used during the execution works of the U1 refurbishment project, to move between the additional car parking area and Unit 1.

Roads for transport exististing in the Cernavoda NPP premises will be used, during the refurbishment works of U1, for the transport of heavy and oversized equipment on the route between the area of Unit 1 and the area of warehouses and workshops located on the platforms next to units U3-U5. Also, these roads will be used during the refurbishment works for Unit 1 for the transfer of low and intermediate level waste resulting from the refurbishment activity on the route from Unit 1 to the future intermediate storage facility for radioactive waste that will be located in the reactor building of Unit 5.

For _the transfer of equipment/tools/materials_, access will be through the following points:

- access control point, PCA#16, going forward the road in front of DICA, continuing between U4 and U5 and then behind U4, U3, U2 until entering U1 - Nuclear Auxiliary Services Building (CSAN -U1) or Integrated Building U1 - and returning on the same route.

- access control point, PCA#16, going forward the road behind DICA, continue behind U5 and then behind U4, U3, U2 until entering U1 Nuclear Auxiliary Services Building (CSAN -U1) or U1 Integrated Building and returning on the same route.

The transfer of radioactive waste from RT-U1 to the new DIDR-U5 takes place on the CSAN-U1 route, continuing behind U2, U3, U4, U5 buildings and entering the Auxiliary Building (unloading hall) next to the new DIDR-U5. The trailer returns to U1 on the same route. Note: Radioactive waste is transported exclusively on the Cernavoda NPP site.

Associated/auxiliary works supporting the project: The access and maneuvering roads as well as the platforms necessary for the rehabilitation and redevelopment of the Emergency Facilities Building - CFSU, approved by DEI 6983RP from 08.11.2016, will be used as support for the development of DIDR-U5 located in the vicinity.

As part of the project, the existing parking lot in the WNW part of the Cernavoda NPP site, in the access area from Medgidiei street, will be redeveloped.

d) ***concrete platform for construction site organization and the storage of containers***:

The space provided for the organization of the construction site and for the storage of containers will be set up in the NW part of the Cernavoda NPP site, to the W of DICA.

Situation Plan of the project, with the marking of the mentioned routes and roads, will be submitted to the Ministryof Environment, Waters and Forests by the project's owner.

- ***The implementation of refurbishment***

The actual refurbishment of Unit 1 involves the following activities:

- ***Unit shut-down and unloading nuclear fuel***

It is expected that Unit 1 will be shut down at the end of 2026. After shutting down the reactor, the fuel will be unloaded from the reactor into the spent fuel storage pool.

Fig. 6 The intermediate storage of dry spent fuel

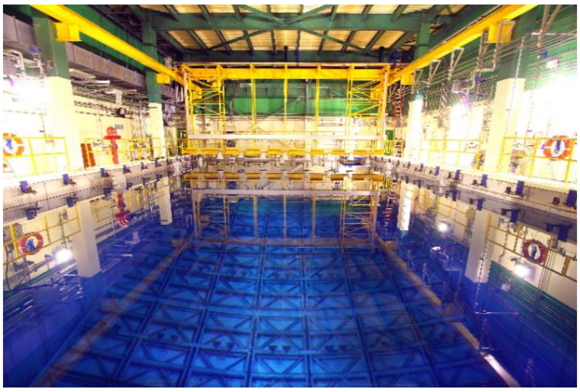


Fig. 7 The main discharge basin of the spent fuel

After unloading the spent fuel, the following activities will be performed:

- ***Preparing the reactor building and reactor assembly, isolation, draining, drying.***
  - ***Drainage and storage of heavy water.*** The heavy water discharged from the reactor systems will be stored in specially designed storage tanks for this purpose, at the Cernavoda NPP site.

    During the operation of the reactor, heavy water management involves the following operations, carried out based on Cernavoda NPP procedures, respectively: storage (supply), recovery, treatment, and enrichment of heavy water. The management of heavy water comprises four closed technological systems that manage the inventory of heavy water (D_2O) in the reactor circuits, namely:

- The D_2O storage system has the role of supplying with fresh D_2O, the systems belonging to the primary circuit and the moderator and storage of D_2O originating from the reactor circuits and from fresh/reconcentrated D_2O transports;
- The D_2O Vapor Recovery System has the role of reducing D_2O losses by recovering the D_2O vapors removed in the air of the technological rooms in the U1 Reactor Building and reducing the tritium fields in certain areas of the U1 Reactor Building;
- The D_2O Purification System has the role of purifying the recovered heavy water and the degraded water from the primary circuit and the moderator circuit;
- The D_2O Reconcentration System has the role of increasing the isotopic of the heavy water recovered from the primary agent and moderator systems to reintroduce it into the plant systems. [20]

During the reurbishment, the entire amount of heavy water discharged from the reactor systems – approx. 202.5 m^3 from the primary heat transport system and approx. 264 m^3 from the moderator – will be stored in storage tanks specially arranged for this purpose, at the Cernavoda NPP site.

- ***After draining the heavy water, the systems in the nuclear part to be worked on will be dried and decontaminated.***

  Decontamination of the primary heat transport system is part of the preparatory activities for retubing, aiming to reduce the levels of radiation fields in the work areas so that the objectives of the ALARA plan can be met.[21]

  Decontamination technologies applied to date at CANDU reactors include:

  - Complete or subsystem decontamination of the primary heat transport circuit using specific chemical processes;
  - Removal of antimony isotopes (Sb-122 and Sb-124) from the core using using specially dedicated technologies.

- ***Conditioning/preservation of systems during the shutdown period***. This activity takes place both in the nuclear part and in the secondary part. The conservation of the systems will be carried out according to the recommendations in the programme developed under the contract: "Elaboration of the conservation program of U1 systems/components during the refurbishment period and technical assistance in its implementation at Cernavoda NPP". The contract was awarded to the companies that developed such programs within CANDU units previously refurbished in Canada and Argentina.

  The conservation programme aims to maintain the integrity and performance of the nuclear power plant's systems and components throughout the refurbishment period and will complement existing reliability maintenance programmes for systems, structures, components and equipment (SSCE). Since the refurbishment activities involve drainage of most of the systems from the plant to facilitate activities for inspection, maintenance, implementation of project modifications, replacement of equipment/components etc, the ingress of air (oxygen) in the systems/components might facilitate onset of the surface corrosion phenomena in the absence of protective or compensatory measures. The

[20] Cernavoda NPP Level 1 Environmental Balance Report, 2018
[21] Technical Solution to Replace Nuclear Fuel Channels, Calandria Tubes, and Feeders (ICCTCF) of the Cernavoda NPP U1 Reactor, Doc. 79-01000-PLA-002 Rev. 0

application, monitoring and evaluation of such measures will contribute to the safe operation and will reduce the effects concerning equipment lifetime, respectively the time needed for recommissioning of these systems at the finalization of refurbishment

The documents of the program, especially the specific conservation reports for the systems (BSI)/components, contain information that describe the establishment, maintaining, verification and control of the conservation state. These include details concerning:

- Activities/actions needed to be implemented in operation of Unit 1, prior to the long term shutdown for refurbishment (including those specific for regular shutdowns)
- Requirements preliminary to the establishment of the conservation state
- Description of the conservaton state
- Maintaining of the conservation state
- Monitoring of the conservation state parameters
- Activities/actions for preparation for removing the conservation state
- Removing the conservation state (prior to the recommissioning).

Thus, for the control of the corrosion the following methods are used: [22]

- *Humidity removal*:
  - Maintaining low humidity (below 40%) prevents the formation of a continuous water layer, adsorbed on the surface of materials exposed to air. Without a conductive layer present, corrosion reactions cannot occur uncontrolled. For removind and control of humidity dryers, pumps, fans, etc. can be used.
  - The application of hydrophobic film-forming amines or other hydrophobic coatings also prevents the access of water to the metal surface.
    The application of hydrophobic film-forming amines or other hydrophobic coatings also prevents the access of water to the metal surface.
- *Oxygen removal:*
  - Oxygen dissolved in water causes corrosion. Hydrazine in solution creates a reducing environment, consuming oxygen and generating inert gas ($N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$).
  - For materials exposed to air in the presence of high humidity, oxygen can be replaced by an inert gas (e.g. nitrogen N_2).
- *Controlling the chemistry* of the filling fluid of a system has as its main purpose the control of corrosion with the aim to ensure the lifetime of the equipment. Exclusion of impurities such as salts, halogens and sulphur compounds helps to reduce the corrosion rate. Similarly, there are defined optimal pH ranges, respectively of concentrations of reducing agents (hydrazine), specific to the type of material (alloy) from which the equipment/systems are made. The conditions required to minimize corrosion are provided in the chemical specifications for each system. [22]

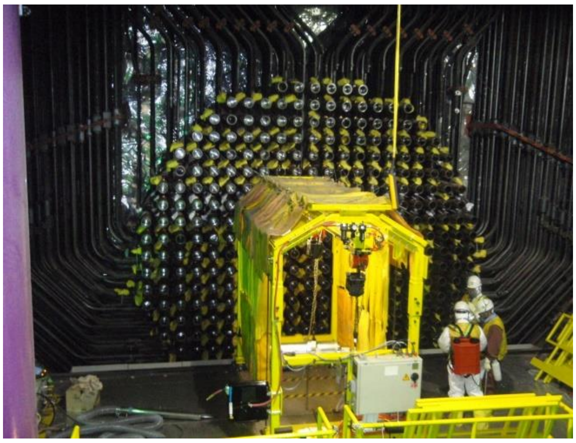
The conservation process is complex and aims to reduce general corrosion, the localized corrosion due to a potential difference between the surfaces, the microbiologically induced corrosion and corrosion due to biofouling, or appearing because of mechanical stress. Systems conservation involves checks – inspections and monitoring – of both systems that are in conservation state and of support equipment used for the installation and maintenance of the conservation.

[22] Technical Report On The Basics Of The Conservation Program, Doc. CNPSA-SNN82-REP-002, September 2021

- ***RT-U1 – retubing Unit 1 reactor***

  This activity involves several stages [23]:

  - ***Dismantling the feeders.*** At this stage, the 380 input feeders and the 380 output feeders are dismantled, i.e. all the pipes including the coupling assemblies, sampling tubing and temperature detectors. Thus, the entire length of the feeder tubes is removed, including the impulse tubes connected to the feeders related to the monitoring of delayed neutrons and the tubes of the temperature detectors related to each feeder. After removing the feeders, the inlet and outlet collectors are inspected. Feeders and the other resulting waste are collected in containers for radioactive waste and are transferred to the spaces specially arranged for the intermediate storage of low and intermediate level waste, inside the Unit 5 Reactor Building of Cernavoda NPP.



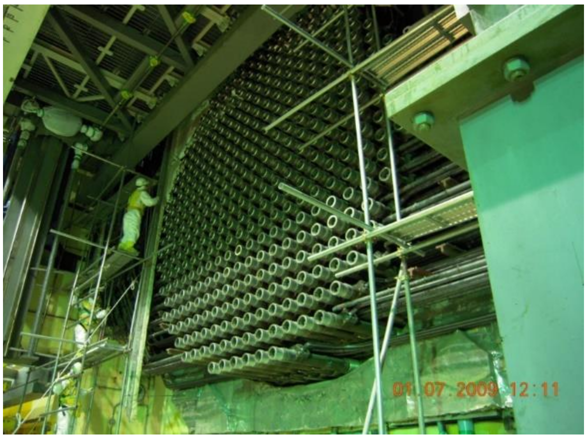


Fig. 8 Dismantling the feeders

  - ***Dismantling fuel channels, calandria tubes and preparing them for storage as radioactive waste***. After completing the activity of dismantling the feeders, the retubing cranes are installed, and then with their help, the platform for dismantling the pressure tubes and calandria tubes is also installed.

Fig. 9 The platform for dismantling the fuel channels

[23] Presentation Memoir - "*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules"*, November 2021

After the installation of the platform, the following activities are performed:

- cutting the compensator bellows;
- cutting the pressure tubes from the area of the swaged joint with the terminal fittings;
- removing the terminal fittings of the channels, which are placed in dedicated containers in order to store them in the spaces specially arranged for the intermediate storage of radioactive waste;
- removing of the calandria tube inserts which, in turn, will be placed in dedicated containers for their storage in the spaces specially arranged for the intermediate storage of radioactive waste;
- removing the pressure tubes, together with the calandria tubes and ring spacers. In order to reduce the volume resulting from cutting the tubes, on the front of the reactor, on the platform for dismantling the fuel channels, it is installed a volume reducing system the assembly composed of pressure tubes, calandria tubes and ring spacers. After cutting and reducing the volume, they are placed in dedicated containers for their storage in the spaces specially arranged for the intermediate storage of radioactive waste.

***Fig. 10* Equipment for the removal of pressure tubes and calandria mounted on the pressure tube and calandria platform removal**

- ***Installation of new fuel channels (pressure tube/calandria tube assembly) and feeders***. After dismantling the assembly composed of pressure tubes, calandria and ring spacers, the waste reduction equipment is removed from the platform and the equipment is installed for the inspection and cleaning of the area where the calandria tube will be fixed in the tubular plate of Calandria and the compensating bellows. Also, the inner area of Calandria will be inspected.

After the completion of the inspections, the activity of mounting the new feeders, calandria tubes, pressure tubes together with the related assemblies will be carried out.

Fig. 11 Installation of upper feeders

- ***Activities regarding radioactive waste management***

It should be noted that all the equipment related to the operation of Unit 1 - the collection, treatment and evacuation systems of liquid and gaseous effluents, in operation - will also serve during the refurbishment period of Unit 1. The systems are presented in detail in sub-chapter 1.7.4 *Installations for the retention, evacuation, and dispersion of liquid and gaseous pollutants (effluents) in the environment.*

Radioactive waste resulting from the dismantling activities of pressure tubes and calandria and their related assemblies, after volume reduction, is placed in Small Waste Container/Large Waste Container (SWC/LWC) type containers - as appropriate - and subsequently placed in authorised containers, which will be transferred for interim storage in the new DIDR-U5.

The authorization requirements for the new intermediate repository of radioactive waste - DIDR (the new DIDR-U5) were established between CNCAN and SNN SA and recorded in the Minutes of the meeting from 21.12.2021, approved by the president of CNCAN with no. 3822 from 01.08.2022.

The assessment of the availability of the building (storage capacity and structural integrity) was carried out in the framework of the *Feasibility Study on the Management of Radioactive Waste Generated during the Refurbishment of Unit 1 and during the Operation period of Units 1 and 2 from Cernavoda NPP after Refurbishment* developed by Korea Hydro&Nuclear Power Co. Ltd. in 2021.

In the process of Unit 1 refurbishment, the transfer and interim storage of the generated radioactive waste is an activity of major importance.

The transfer of radioactive waste from the core during the refurbishment process at the Cernavoda NPP to the intermediate radioactive waste storage facility (the new DIDR-U5) is carried out in accordance with the technical retubing solution proposed by Candu Energy Inc. Thus, Cernavoda NPP will build and provide interimediate storage facilities for medium radioactive waste, consequently, the design and supply of storage containers must ensure:

- compatibility with the new facility;
- shielding in accordance with radiological security regulations;
- complying with the acceptance criteria of Cernavoda NPP.

Two types of containers were used to handle the intermediate-level radioactive waste from the refurbishment of CANDU 6 reactors: large containers (Large Waste Containers - LWC) for end fittings, respectively small containers (Small Waste Containers – SWC) for pressure tubes, calandria tubes and calandria tube inserts. These containers only ensure waste containment and not radiation shielding. Therefore, for transport and transfer in storage structures, special containers are needed: Small Waste Transfer Flask (SWTF) for SWC and Large Waste Transfer Flask (LWTF) for LWC, which ensure shielding and transport under radiological security conditions within the controlled area from Cernavoda NPP.

- **Route of End Fittings**

The end fittings removed from the fuel channels, using retubing tools, are placed in unshielded containers (LWC) then loaded into a shielded transport container (LWTF). These full shielded containers are transported inside the controlled area (by industrial road) to the Hall for unloading containers with radioactive waste and storing containers with waste (hereinafter referred to as the Hall). The transport of these shielded containers from Unit 1 to the Hall is done behind U1-U5 area. During this transport, personnel access to this route is restricted.

After the shielded transport container has arrived in the Hall, it begins the transfer of the unshielded containers containing end fittings from the shielded transport container to the shielded intermediate storage container K-Box, which ensures both the reduction of the gamma dose rate outside and the containment of radioactivity inside.

The transfer activity is carried out in a shielded and ventilated room (ventilation which is provided with HEPA filters and which is connected to the active ventilation system in the Building where the radioactive waste will be stored (Reactor U5 Building). After filling a container K-box, it is sealed, decontaminated (if free contamination is identified on its exterior) and then transported to the intermediate storage area located in the U5 Reactor Building where it will be stored until the deep geological repository is commissioned.

- **The route of the pressure tubes, calandria tubes and calandria tube inserts**

The pressure tubes, the calandria tubes and the calandria tube inserts are removed using retubing tools. In order to reduce the volume, the pressure tubes and the calandria tubes are shredded directly after removing them from the core, using a special shredding system, system provided with HEPA filters for retaining small radioactive particles. This activity is carried out in Unit 1 Reactor Building. After this stage, the inserts of the calandria tubes, respectively the crushed pieces of the calandria tubes and pressure tubes, are placed in unshielded containers (SWC) and then loaded into a shielded transport container (SWTF). These full shielded-containers are transported to the Hall by the industrial NPP road. The transport of these shielded containers from U1 to the Hall is done behind U1-U5 area. During this transport, personnel access to this route is restricted.

After the shielded transport container has arrived in the Hall, it begins the transfer of the unshielded containers containing the shereded pressure tubes and the calandria tubes, as well as the calandria tube inserts, from the shielded transport container into the shielded intermediate storage container, K-Box.

The transfer activity is carried out in a shielded and ventilated room (ventilation which is provided with HEPA filters and which is connected to the active ventilation system in the Building where the radioactive waste will be stored (Reactor Building U5). After filling a K-box container, it is sealed, decontaminated (if free contamination is identified on its exterior) and then transported to the intermediate storage area located in the U5 Reactor Building where it will be stored until the deep geological repository is commissioned.

- ***Carrying out other planned works, identified in the project definition process***

Parallel with retubing of the reactor, during this long term shutdown period, other planned upgrading works of the Cernavoda NPP will be carried out.

The main upgrading works (apart from retubing the reactor) consist of:

- reengineering works of process computers (reengineering of power supplies, replacement of intracabinet cables, reengineering of reference sources);
- reengineering of the microcomputers of the reactor fast shutdown systems (SDS1 and SDS2);
- eddy current inspections on the tubular bundles of the nuclear heat exchangers, to determine their physical condition;
- replacing the manual valves V1-V10 on the moderator system to ensure the system's functionality for another 30-year operating cycle
- replacing the P005, P007, P008 pumps on the service water system and the associated valves;
- replacing the valves associated with the pumps on the condensate extraction system, to reduce dynamic loads during transients;
- replacing the heat exchangers of the Intermediate Cooling Water System to increase cooling capacity;
- internal inspections of tanks TK1-TK6 on the fast shutdown system of reactor no. 2 (SDS2) - which uses gadolinium nitrate-based poison injection;
- internal inspection of the helium tank related to the liquid poison injection system (SDS2);
- inspection of moderator pumps to determine the degraded components that must be replaced;
- radiographic inspections of the bellows related to the liquid poison injection system to determine the degree of aging and their replacement if necessary;
- overhaul of the turbine, rewinding of the electric generator;
- replacement of emergency diesel generators (EPS);
- replacement of stanby diesel generators (SDG);
- major overhaul of the motorized valves of the active zone cooling system (ECC);
- replacement of the main condenser tubes, etc.

The non-radioactive equipment that will be replaced will be stored in the plant's warehouses, after which a technical committee will carry out an evaluation regarding the possibility of reuse or recovery.

- ***Activities necessary in order to put Unit 1 back into operation***

After the completion of all the refurbishment activities, the necessary activities will be initiated to put Unit 1 back into operation. In this sense, the following activities will be started:

- reconfiguration of the physical protection and access control systems;
- restoring the system configuration, their filling and performing pressure tests;
- loading the fuel and reaching the criticality of the reactor;
- carrying out all unit commissioning tests, under the supervision of CNCAN;
- closing the refurbishment project – works acceptance and decommissioning or preserving the temporary facilities used for refurbishment.

Subproject DICA-MACSTOR 400

The increase in the storage capacity of the intermediate storage of spent fuel will be achieved both by extanding the surface of the existing facility - and consequently the number of modules - as well as by building modules with double the storage capacity compared to those currently used.

- ***Activities involved in the extension of the DICA site***

The surface of the DICA site will be extended with about 16000 m^2 towards the new DIDR-U5, respectively from 24000 m^2 to approx. 40000 m^2 (the area included between the limits of the external fence of the objective), to allow the placement of a total number of 37 modules compared to the 27 modules approved by the Environmental Agreement no. 2058/22.04.2002 for the existing storage.

The increase of storage surface involves:

- the delimitation of the extended area of the DICA, towards the new DIDR-U5, by extending the fence surrounding the site;
- reconfiguration of the physical protection system;
- expansion of the rain water sewer network system within the DICA premises;
- location of the site for the execution of new drillings for phreatic aquifer monitoring - 2 pcs. - according to the specifications of the hydrogeological expert report issued by INHGA.

- ***Activities involved in the construction of MACSTOR 400 type modules***

Ensuring the storage capacity of the dry spent fuel resulting from the operation of the two nuclear units 1 and 2 with two operating cycles, involves the construction - starting with Module no. 18 – 20 MACSTOR 400 modules that have double the storage capacity of the currently used MACSTOR 200 modules.

Land preparation and the construction of the modules will be carried out in stages, correlated with the rate of generation of the spent fuel from the operation of the two nuclear units.

Execution of modules type MACSTOR 400 involves the same activities as in the case of MACSTOR 200 modules and consists of the following works:

- excavations for the construction of foundations for modules, platforms, roads, gutters, carriage-ways, and rain water collection;
- works for the construction of modules, platforms, roads, gutters, carriage-ways and rainwater collection manholes;
- installation of the equipment/circuits that serve the DICA - MACSTOR 400 subproject;
- the installation of the gantry crane that serves each row of modules;
- technological tests and commissioning.

1.6.3 Demolition/decommissioning activities necessary for project implementation

The refurbishment of Unit 1 does not involve the demolition of some constructions, but there will be works to relocate some water/heating pipe overpasses and existing cable routes over a length of approx. 150 m.

To extend DICA with MACSTOR 400 modules, the following activities will be required:

- the demolition of a building with an area of 264 square meters and a height regime of one floor, on a reinforced concrete structure with external walls and partitions made of BCA masonry, which is currently used as an archive, located in the area where the DICA will be extended.

- the relocation of the medium voltage line LEA 20 kV which is located on the area where DICA will be extended, which involves the dismantling and relocation of 8 reinforced concrete poles. The medium voltage power line LEA 20kV is an aerial connection consisting of 37 poles linking ENEL network to the transformation posts PA1 and PA3 20/6/0,4 kV. From the 37 poles of the line, only 8 are on the extention area of DICA and their relocation will be needed. This activity will be required around the year 2035.

1.6.4 Land use requirements

The "RT-U1 and DICA -MACSTOR 400" project will be carried out exclusively on the authorized site of Cernavoda NPP, and the allocated area is approximately 325000 m^2, according to the plan attached to the Urban Planning Certificate no. 37/03.04.2024.

The Situation Plan of the project, annex to the Urban Planning Certificate, will be made available for the Ministry of Environment, Waters and Forests by the project holder.

Tab. 2 Projected territorial balance for the RT–U1 and DICA–MACSTOR 400 project

Category	Surface (m^2)	Occupancy percentage (%)
Total surface allocated to the project	325000	100
Surface estimated to be temporarily occupied	27300	8.4
Built-up surface, including roads and platforms	297700	91.6

Subproject RT-U1

Project implementation stage

The total area of Unit U1 - which includes the exploitation of specific nuclear equipment and its annexes for production and distribution of electrical power is of 208710 m^2 (GD no. 1008/2005 for issuing of the Environmental Authorization for operation of Cernavodă NPP Unit 1).

The permanent roads, existing on Cernavoda NPP site that will be allocated to the transport of equipment/machinery/materials during the implementation period of the project, according to the attached plan, have the following routes:

- Entrance through PCA#16, continue the road in front of DICA, continue between U4 and U5 and then behind U4, U3, U2 until entering U1 - Nuclear Auxiliary Services Building (CSAN -U1) or Integrated Building U1 - and return on the same route with the length L=1300 m.
- Entrance through PCA#16, continue the road behind DICA, continue behind U5 and then behind U4, U3, U2 until entering U1 CSAN -U1 or Integrated Building U1 and return on the same route with the length L= 1750 m.

The road allocated for the transfer of radioactive waste from RT-U1 to the new DIDR-U5 is on the route from CSAN-U1, continuing through the back of U2, U3, U4, U5 and entering the Auxiliary Building (unloading hall) next to the new DIDR-U5. The trailer returns to U1 on the same route with a length of L= 1200 m. **The road is permanent, being used both during the project implementation and during the operational stage of the refurbished of Unit 1.**

The access and maneuvering roads as well as the platforms required for the project include the roads approved by DEI 6983RP of 08.11.2016 for the rehabilitation and reengineering of the Emergency Situations Facilities Building - CFSU.

The area allocated to the development of the new DIDR-U5 will be surrounded with a fence with length L=350 m and will include:

- the reactor building of Unit 5- arranging the space inside, for storage of radioactive waste (the new DIDR-U5) with an area of 1492.25 m^2, diameter of 43.60 m, and height about 42 m,
- radioactive waste containers unloading and storage hall – with an area of 975 m^2 and height about 21 m,
- the DIDR-U5 Access Control Point building (PCA13A) with the surface of 140 m^2, surrounded by a fence on 3 sides L = 350m,
- the active components repairing and decontamination building, with the surface of 2860 m^2, with a height of about 9.2 m.

As part of the project, the existing parking lot with the surface of 12000 m^2 located in the WNW part of Cernavoda NPP site, in the access area from Medgidiei Street, will be redeveloped.

The project also provides for the arrangement of the following facilities:

- ***Permanent***:
  - an EPS battery building with a surface of 370 m^2, P+1;
  - clean room building (storage of new reactor components) with a surface of 1192 m^2;
  - a Mock-Up simulator building, with a surface of 2675 m^2 and a height of about 12.2 m;
  - office building, P+3, with a surface of 1550 m^2, and a height of about 15 m;
  - an archive building + offices for archive staff, P+1, with a surface of 1000 m^2, and a height of about 10 m;
  - coolers building SDG-U1, with a surface of 550 m^2 and a height of about 8 m**;**
  - Changing rooms for radiological area CSAN-U1 U1, at the level 105.41 m, with a surface of 70m^2 and a height of about 4.5 m (room suspended on pillars);
  - Access Control Point 12; P+1, S= 1300 m^2 and a height of about 10 m;
  - Access Control Point Building - PCA 16, with a surface of 660 m^2 and a height of about 10 m;
  - Emergency Diesel Generator – for PCA 16, sited close to the building, 30 m^2 and a height of about 5.5 m;
  - Fire Water Station and Fire Extinguishing System, S = 600 m^2 and a height of about 10 m;
  - Concrete platforms in a total area of 400m^2 for 3 transformers 6/04kW, 300 m^2 for one transformer 110/6kW and 25 m^2/ Emergency Diesel estimated at 8-8.5KW and one more transformer 6/04kV – 100 m^2. (located opposite the building 1)

- ***Temporary***:
  - Space for the temporary storage of contaminated equipment/components removed from Unit 1 (temporary light modular structure and with airtight closures on the platform of the current DIDSR) - 660 m^2;
  - Temporary Access Control Point Building - PCA13B - with modular Containers – 30 m^2 (2 pcs x 6 x 2.5, and a height of about 3.5 m);
  - Command Center Building (Retube Operation Center ROC) – 60 m^2;
  - Temporary Access Control Point Building - PCA4 - with modular containers 60 m^2 – 4 pcs. x 6 x 2.5m^2 and a height of about 3.5 m;
  - Isolation of the waste transfer route against U3-U4 , through a fence along the passageway behind U3 and U4, until U2;
  - U2 isolation by using two outdoor turnstiles and access gates at East and West on the passage way between U1 and U2.

The area provided for the concrete platform for storage of containers for tools and devices components, will occupy an area of 27300 m^2, on the north-west side of the Cernavodă NPP site, to the west of DICA.

Other spaces made available to contractors for site organization during the project period are:
- office spaces/locker rooms (barracks/office-type containers) for the contractor’s execution staff, with an area of 3100 m^2;
- workshop spaces, with an area of 15000 m^2.

At the closure of the sub-project, the ***temporary*** facilities used for the refurbishment will be decommissioned.

Project operation period

During the operation period of the refurbished Unit 1, the roads and permanent constructions shown above will be used. All roads and access roads executed in the new DIDR-U5 area will be used during the operation of U1 refurbished, U2, U3 and U4.

Subproject DICA-MACSTOR 400

Project implementation period

The area of the DICA location will increase by about 16000 m^2, respectively from about 24000 m^2 to approx. 40000 m^2 (the area between the boundaries of the objective's outer fence) [24].

The area allocated to the sub-project, of 16000 m^2, will be distributed as follows:

- Surface for MACSTOR 400-type modules: 320 m^2/module x 20 modules = approx. 6400 m^2
- Physical protection fence surface aprox. 3135 m^2
- Road surface: 415 m^2 + 470 m^2+ 147 m^2+ 1696 = approx. 2728 m^2
- Platform surface: approx. 3323 m^2.

Project operation period

As the operation of the DICA, both now and after the extension, involves the staged construction of the storage modules, platforms, roads, tracks, gutters and rainwater manholes will be constructed as the modules are built.

[24] Urban Planning Certificate no. nr. 37/03.04.2024 – issued by Cernavodă Municipality

During the operation period of DICA-MACSTOR 400 ¬ the transfer of the cooled spent nuclear fuel from the BCU to the MACSTOR 400 modules will be carried out on the same route currently allocated for this activity (road that is included in the radiologically survey area on the Cernavoda NPP platform, according to the attached situation plan).

1.6.5 Structural components

1.6.5.1 Construction details

The information is presented in subsections *1.6.2 Main activities for the implementation of the project* and *1.6.4 Land use requirements.*

1.6.5.2 Construction methods adopted

Authorization of nuclear specific constructions and state control is the responsibility of CNCAN, according to art. 35, letter o) of "Law no. 111/1996 on safe conduct, regulation, authorization and control of nuclear activities, republished, with subsequent amendments and additions".

The definition of nuclear-specific constructions, as well as the application of art. 35 of the law can be found in the Norms regarding the authorization of the execution of nuclear-specific constructions, approved by the CNCAN President's Order no. 407/2005 and published in the Official Gazette, Part I no. 193 of 01/03/2006, Cap. II - Scope.[25]

Also, the requirements regarding the quality of installations and technological equipment for production provided in the field-specific regulations will be respected, according to the following normative acts:

- CNCAN order no. 72/30.05.2003 for the approval of the Norms regarding the specific requirements for quality management systems applied to construction-assembly activities for nuclear facilities (NMC-08).
- Law no. 10/1995 regarding quality in construction.

Subproject RT-U1

In the case of the **RT-U1 Subproject**, the following types of work will be carried out:

- replacement, repair and upgrading works of the systems, structures and components inside Unit 1 that take into account the results of the assessment of their current state/condition, and here we mainly refer to the retubing activities and replacement/modernization activities of the equipment in the plant to ensure operation under nuclear and environmental safety conditions, for another operation cycle;
- construction works of the buildings/spaces necessary to carry out preparatory and support activities for refurbishment;
- construction works for the set-up of spaces within the Unit 5 Reactor Building for the interim storage of radioactive waste resulting from the refurbishment of Unit 1 and from the operation of the refurbished Unit 1 and Unit 2 (the new DIDR-U5).

SNN SA – Cernavoda NPP, as a member of the COG, participates in the Refurbishment Forum, a working group created to share knowledge, experience, lessons to be learned and good practices among CANDU plants, which were carried out or are carrying out refurbishment activities.

[25] http://www.cncan.ro/assets/NCN/ncn01.pdf

For the implementation of this project, Cernavoda NPP benefits from the support of the experts of the Canadian Nuclear Partners company, who participated in refurbishment projects for Candu power plants and who provided technical consultancy within the U1 Refurbishment Project.

SNN SA is affiliated to international profile organizations such as:

- ***CANDU Owners Group (COG)*** – whose members are the companies that have in operation or under construction CANDU-type power plants, as well as service providers and design organizations (AECL) that participate in certain programs. COG's mission is to provide a ***framework for cooperation, mutual assistance, and information exchange*** for the purpose of sustained development and progress in the operation and maintenance of CANDU power plants
- ***World Association of Nuclear Operators (WANO)*** - international non-profit organization of nuclear power plant operators, which promotes the highest standards of security and reliability in the operation of nuclear power plants. WANO programs take place in the field of information exchange, performance indicators, and technical support for members.
- ***Institute of Nuclear Power Operations (INPO)*** – non-profit organization whose vision is to establish a global standard in the field of nuclear security.

Subproject DICA-MACSTOR 400

MACSTOR 400 represents the more compact version of the module developed by AECL (Atomic Energy of Canada Limited in collaboration with KHNP - Korea Hydro & Nuclear Power Co.), starting from the MACSTOR 200 storage module project, developed by AECL.

For the **DICA - MACSTOR 400 Subproject** the following works are required [26]:

- the increase of the surfaces occupied by roads and internal platforms;
- the extension of the physical protection fence and the perimeter ditch on the sides from the U5 reactor building and from Cismelei Valley;
- the constrution of the carriage-ways for the rows of newly built modules.

The construction of the MACSTOR 400 module will be done in a similar way to that of a MACSTOR 200 module.

After the groundworks are completed, the actual construction continues with the following steps:

- The sub-base is poured, considering the rectangular shear studs that intersect in the middle of the structure. The sub-base is built directly on top of the fill concrete;
- The module's raft is poured over two polyethylene sheets placed above the sub-base, between which a lubricating material is applied. It is also poured to form the drainage within the module.
- The side walls and re-check columns are then poured.
- Ventilation ducts, drainage lines, and SEGM pipes are integrated into the longitudinal walls.
- The walls are poured up to the ventilation openings; the verifications columns are positioned at the upper level of the concrete;

[26] Presentation Memoir - ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”*, November 2021

- Thermal Insulation Panels (PIT) are installed on the upper part of the inner face of the 4 walls;
- The PITs are installed at the soffit of the upper plate and the storage cylinders;
- The upper plate is cast in a single step. The weight of the upper plate is supported by temporary supports;
- The concrete is poured for the ventilation channels on the lower side and for the sampling boxes from the storage cylinders;
- The pouring of concrete in the air inlets is completed. This stage is performed separately to facilitate the removal of the formwork;
- In the final stage, the ventilation and exhaust lines of the storage cylinders are welded on the embedded sections, various steel elements are installed, the inside of the module and the air circuits are cleaned, the mounting gap is closed, ending the civil construction works of the module.
- În etapa finala, liniile de aerisire și evacuare ale cilindrilor de stocare sunt sudate pe sectiunile inglobate, diverse elemente din otel sunt instalate, interiorul modulului și circuitele de aer sunt curatate se inchide golul de montaj, incheind lucrările de construcții civile ale modulului.

The storage cylinder of the module is made of galvanized carbon steel. Once filled with spent fuel bins, the permanent plug, which is made of concrete lined with steel, is mounted on the top of the storage cylinder and the top is welded to the storage cylinder.

The cylinders are supported only by the floor of the module at the bottom, they are free and have seismic limiters, with the part containing the fuel, suspended in the space inside the module. At the lower part of the storage cylinder, a seismic limiter is provided that allows the free thermal expansion of the storage cylinders in the vertical direction, while restricting horizontal movements. The upper part of the storage cylinder is covered with a flat metal cover mounted over the permanent plug.

The cooling of the storage cylinders is achieved by natural convection and thermal radiation from the surface of the storage cylinders and by conduction to the upper floor of the module.

The storage cylinders are embedded in the upper floor of the module, providing a gap that allows the fuel bins to be loaded. Each cylinder is provided with a sealing plug made of steel-lined concrete that provides shielding and closes the storage cylinder enclosure in the upper part. During the transfer period, the permanent sealing plug is replaced by the temporary charging assembly plug to reduce personnel exposure and to help meet radiation protection requirements during charging. Once the loading of the storage cylinders is complete, the permanent sealing plug is repositioned over the loaded cylinder.

In carrying out the DICA-MACSTOR 400 project, SNN SA –Cernavoda NPP benefits from the results of the research and development programs carried out at AECL's Whiteshell laboratories and from the experience of operating such modules.

1.6.5.3 Temporarily and permanently occupied land surface

The information is presented in subchapter *1.6.4 Land use requirements.*

1.6.5.4 The land areas occupied by each of the permanent components of the project

The information is presented in subchapter *1.6.4 Land use requirements.*

1.6.6 Natural resources, raw materials and energy required to carry out the project

1.6.6.1 Natural resources

The realization of the RT-U1 and DICA-MACSTOR 400 project is done in the spirit of sustainable development.

No resources from protected natural areas in the vicinity of Cernavodă NPP are used for the project.

The renewable natural resources used for the execution of the project are:

- river stone, sand, wood - will be provided by the contractor;
- the soil - the terrain on the Cernavodă NPP site, on which the two sub-projects will be developed;
- water – from the holder's local water supply systems.

The needed mineral resources are extracted from licensed/regulated mines both from an environmental point of view and in compliance with the rules of mineral resource exploitation.

1.6.6.2 Raw materials and energy

Subproject RT-U1

During the preparatory phase of the refurbishment sub-project, materials will be used for site organisation, construction/renovation of buildings, workshops, storage areas for the materials needed for the refurbishment activities and for the storage of generated wastes, platforms and roads - where appropriate.

The construction work related to the refurbishment subproject requires excavation works with the displacement of a volume of 39196 m^3 soil for fundations.

The main categories of construction materials and the estimated total quantities to be used for the construction/arrangement of these constructions are:

- Concrete = 56000 m^3
- Ballast = 16000 m^3
- Rocks= 6000 m^3
- Sand = 10000 tonnes
- Water = 15000 m^3

The concretes will be supplied by authorized concrete mixing facilities, with certified concrete mixers.

The fuels - diesel and gasoline - necessary for the operation of vehicles and equipment will be obtained from authorized operators.

Estimated monthly energy consumption – 17 MWh.

Subproject DICA - MACSTOR 400

The preparation of the sub-project requires the provision of physical protection, the extended storage facility will be fenced with two fences (interior and exterior), with a distance of 8.00 m between them. The inner fence is made of galvanized wire mesh supported by metal poles, with a height of 3.15 m, with an overhang of about 0.60 m made of a row of barbed wire and a roll of NATO barbed wire. The outer fence is made of bordered mesh panels supported by metal posts, with a height of 2.00 m, with an overhang of about 0.60 m made of two rows of barbed wire and a roll of barbed wire. The two fences provided with a reinforced concrete base are part of the physical protection system of the DICA site and have an estimated total area of approx. 3135 m^2.

The implementation of the subproject involves the phased construction of modules 20 type MACSTOR 400, with a frequency of 1.5 years/module, starting from 2025.

The construction of the 20 MACSTOR 400 type modules (each module with a surface of 320 m^2 and a height of 7.6 m), requires the construction of 2728 m^2 of roads, as well as 3323 m^2 of concrete platforms. The storage modules are made as a reinforced concrete structure, the walls and floor of the modules with a minimum thickness of 965 mm also having the role of biological protection.

The completion of the 20 MACSTOR 400 type modules on the extended DICA site involves excavation works with the displacement of a total volume of soil estimated at 123300 m^3.

The main categories of construction materials and the estimated total quantities to be used are:

- Ballast = 3943 m^3
- Rocks = 4447 m^3
- Sand = 4608 m^3
- Concrete = 120954 m^3

The materials required for the execution of the sub-project will be delivered by the suppliers, in a phased manner, correlated with the execution of each stage, with equipment and vehicles suitable for the transport of each type of material.

During the execution of the subproject, the following water consumption is estimated:

- drinking water for the contractor's personnel - 2 m^3/month - is provided by the contractor through a supply contract with specialized companies
- process water for site activities - 5 m^3/month - is provided by the contractor through tanks fed from the Cernavoda town network.

During the execution of the subproject, a monthly electricity consumption of approx. 1200 kWh is estimated. Electricity is provided from the internal network of Cernavoda NPP.

During the execution of the sub-project, the following fuel consumption is estimated for the vehicles and machines that serve the transport of personnel involved in the construction activities, the supply of materials and the actual construction activities:

- 0.46 tons of diesel/month
- 0.01 tons of gasoline/month.

Gasoline and diesel will be provided from authorised operators.

1.6.7 Equipment and other means that will be required

Subproject RT-U1

During the implementation of the Unit 1 reactor refurbishment project, a series of equipment specific to retubing operations will be used: feeder access platform, local control system of the fuelling machine, PHTS circuit drying system, channel access platform fuel etc.[27]. Also, a series of means of handling and transportation of the resulting or necessary materials for the planned activities will be used. These can be machines from the premises of the reactor building, the service building and the new DIDR building, such as: overhead cranes, trolleys, hydraulic loaders, etc., as well as specialized means of transport, such as: the radioactive waste transfer machine.

For example, waste containers will be handled with forklifts and machines specific to these maneuvers. The transport of containers with non-radioactive waste for temporary storage or transfer to other entities will be done by electric runabout, tractor, truck, authorized for the transport of non-hazardous or hazardous waste (on a case by case basis), with the appropriate anchoring of the transported products. [28]

Subproject DICA - MACSTOR 400

For the construction of the module, there are used vehicles and machinery that consume fuels derived from petroleum (diesel, gasoline).

For the ***transport of personnel*** involved in construction activities and ***for the supply of materials***, trucks, vans (up to 3.5 t), cars, bus/microbus for workers, concrete mixers, cranes are used daily.

Bulldozers, 0.5t compactor cylinder, crawler excavator are used for ***the construction works***.

The work schedule on the construction site does not exceed 10 hours per day.

1.6.8 Linear works - The route, horizontal and vertical alignments, excavations, and earthworks

The route, horizontal and vertical alignments, excavations, and earthworks are presented in subchapter *1.6.4 Land use requirements.*

The situation plan of the project in which the roads, platforms and travel routes, horizontal alignments are figured will be made available to the Ministry of Environment, Water and Forests by the project owner.

1.6.9 Additional services necessary for project development

For the intermediate storage of low and medium radioactive waste (equipment, tools, pressure tubes, calandria tubes) resulting from the refurbishment works of Unit 1, the new DIDR-U5 will be set up.

For the safe transfer of this waste, transfer containers will be used, designed and tested for the purpose of the sub-project, according to the norms applicable for the approval of containers for radioactive waste, depending on the level of radioactivity.

[27] Technical Solution to Replace Nuclear Fuel Channels, Calandria Tubes, and Feeders (ICCTCF) of the Cernavoda NPP U1 Reactor, Doc. 79-01000-PLA-002 Rev. 0
[28] Presentation Memoir - "*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules"*, November 2021

1.6.10 Further developments that may occur as a result of the project

The roads and platforms used temporarily in the process of Unit 1 refurbishment could be used - as the case may be - during the refurbishment of Unit 2 and for the continuation of the construction and completion of Units 3 and 4 at Cernavoda NPP.

The permanent buildings built as part of the RT-U1 and DICA extension project will be used for future projects that will be developed on the Cernavoda NPP site.

1.6.11 Existing activities that will be modified or changed because of the project

Currently, the activity of the nuclear facilities U1, U2 and DICA on the Cernavoda NPP platform is regulated by the Environmental Authorization approved by *"GD no. 84/2019 regarding the issuance of the environmental authorization for the National Company "NUCLEARELECTRICA" - S.A. - Branch " Cernavoda NPP - Units 1 and 2 of the Cernavoda Nuclear Power Plant*”.

Also, Cernavoda NPP holds CNCAN Authorizations for the operation of Unit 1, Unit 2, for DIDSR and DICA for the intermediate storage of solid radioactive waste and respectively for dry spent fuel, resulting from the operation of Units 1 and 2.

The implementation of the RT-U1 and DICA-MACSTOR 400 project involves the set-up of the new DIDR-U5 for intermediate radioactive waste storage.

Thus, after the refurbishment, 2 (two) facilities for the intermediate storage of radioactive waste will operate on the Cernavoda NPP site - respectively DIDSR and the new DIDR-U5 and a facility for the intermediate storage of dry spent nuclear fuel – the extended DICA.

The operation of these repositories will be regulated by the nuclear activities regulatory body and by other competent authorities, which will impose additional monitoring and reporting requirements.

1.6.12 Existing or future relevant projects on the Cernavoda NPP site

Currently, the following projects are approved for development at the Cernavoda NPP site:

Tab. 3 Complex projects approved for development on the Cernavoda NPP site

Crt. No.	Project	Regulatory act	Status
1	***Nuclear Spent Fuel Interim Storage Facility (DICA)*** - Dry storage of spent fuel, based on the phased construction of MACSTOR 200 modules, on the 24.000 m^2 area of DICA	- Environmental Agreement no. 2058/22.04.2002 issued by the Constanta Environmental Protection Inspectorate. - DICA is integrated in the Environmental Authorization of Cernavoda NPP approved by GD no. 84/2019	- ongoing project since 2003
2	***Continuation of construction works and completion of Units 3 and 4 at Cernavoda NPP, with CANDU 6-PHWR type reactors*** - Electricity generation: capacity ~2×700 MWe	Environmental Agreement by GD no. 737/2013.	- Estimated construction period: 2026-2030/2031

Crt. No.	Project	Regulatory act	Status
3	***Construction works of the Cernavoda Tritium Removal Facility*** - Tritium removal from the heavy water (catalyzed isotopic exchange in liquid form and cryogenic distillation) at the Cernavoda NPP site	- Environmental Agreement no. 1/30.01.2023.	- Estimated implementation period: 2023 – 2027
4	***Works required to change the destination of the buildings existing on the site of Unit 5 from that for a nuclear power plant, in that for other useful support objectives during the lifetime of the Units 1 and 2 in operation and the future Units 3 and 4 of Cernavoda NPP, in order to ensure their operation in safe nuclear conditions and the fulfillment of all legal requirements*** - Relocating some existing support objectives of Units 1 and 2 and adding some additional functions, to satisfy the imposed requirements according to CNCAN, NSN-07.	- Decision of the scoping stage (DEI) Nr. 6983RP/12.07.2016 and Annex from 1.05.2020 – issued by EPA Constanța.	- Estimated implementation period: 01.08.2023 – December 2024

1.6.13 Associated/ auxiliary works that are excluded from the assessment

The works associated/auxiliary to the project, of small scale excluded from the environmental assessment are:

- relocation works of overpasses, water/heating pipes and cable routes, over a length of approx. 150 m.
- relocation of the medium voltage line LEA 20 kV from the DICA extension area, with the dismantling and relocation of 8 reinforced concrete poles
- mounting and dismounting of containers for the personnel serving the activities of the site organization.

1.6.14 Site restoration works in the area affected by the execution of the investment. Subsequent uses of temporarily occupied land

The execution of the project does not require ecological reconstruction works, the location of the project being located in the industrial zone, on the Cernavoda NPP platform - intended for carrying out activities in the nuclear field.

The land related to the "RT-U1 and DICA - MACSTOR 400" Project consists of parcels located on the Cernavoda NPP site, which is the property of SNN-SA, according to the Land Ownership Certificate, series M03, no. 5415, issued by the Ministry of Industries and Resources, on 25.04.2000.

During the execution of the construction works of the spaces required for the RT-U1 Subproject, limited portions of the soil around the construction will be affected. After the completion of these works, the land will be rehabilitated by scarification, topsoil and inerables, if necessary.

1.6.15 The size of any structures and other development works as part of the project

The information is presented in subsections *1.6.4 Land use requirements* and *1.6.6.2 Raw materials and energy*.

1.6.16 Technological tests and commissioning stage for RT-U1

The technological testing and commissioning phase of the reactor after refurbishment is essential in preparing the unit for re-entering commercial operation.

According to their status during the planned refurbishment outage, reactor systems are classified as follows:

- ***Systems that remain functional during the retubing work***. These systems may require temporary modifications to ensure the necessary functions during the shutdown of the unit for the purpose of refurbishment (e.g. instrument air system, water cooling systems, ventilation systems)
- ***Systems that will be shut down or taken out of service, either fully or partially***. This category includes systems that will need to be disconnected or partially disassembled to allow proper access to work areas for retubing (eg Liquid Injection Shutdown System, Reactor Building Ventilation, Fuel Handling System) and/or other work areas related to planned works at this outage.
- ***Systems with components and equipment that will be replaced during the outage period*** (e.g. Primary Heat Transport System, Moderator System and Ring Gas System, systems and circuits in the classic part of the unit).

Activities required for pre-commissioning testing of circuits and equipment shall be carried out according to specific procedures developed for this purpose, based on the related design configuration and operational test procedures prior to any power-up.[29]

1.7 The main characteristics of the operational stage of the project

1.7.1 Description of the installation and technological flows

Subproject RT-U1

According to the ***Nuclear Safety Guide regarding the preparation for the refurbishment of nuclear installations, dated 12.12.2018,*** art. 4 para. (2): ***by refurbishment a nuclear installation*** it is understood ***capital repair, modernization and improvement by replacing and/or modifying some equipment or systems of the installation, in order to significantly extend its operating life, in accordance with nuclear safety analyzes and evaluations engineering;*** refurbishment creates the opportunity to improve nuclear safety to the level required by modern regulations and standards, including by using the latest technical solutions and knowledge in the field of designing and operating nuclear installations; ***refurbishment does not imply changing the technology of the nuclear installation as a whole***.

The refurbished Unit 1 at Cernavoda NPP will produce electricity as it does now, with the help of a turbogenerator, using the steam produced from a CANDU-PHWR-600 type nuclear reactor,

[29] Technical Solution to Replace Nuclear Fuel Channels, Calandria Tubes, and Feeders (ICCTCF) of the Cernavoda NPP U1 Reactor, Doc. 79-01000-PLA-002 Rev. 0

under conditions of nuclear safety and economic efficiency, ensuring the safety of personnel and of own installations, the public and the surrounding environment.

The refurbished Unit 1 of Cernavoda NPP will provide electricity for another operation cycle based on the same operating policies and principles (OP&P).

The design and operating configuration of the refurbished Unit 1 will be ensured and maintained in accordance with the original design and the latest international nuclear industry standards applicable to the CANDU 600 project. This nuclear installation consists of a nuclear reactor Canadian type Deuterium Uranium 6 - Pressurized Heavy Water Reactor (CANDU 6 – PHWR) with a thermal power of 2061.4 MWt and a turbogenerator with an electrical power of 706.5 MWe.

The following figure shows the simplified scheme of such a plant:

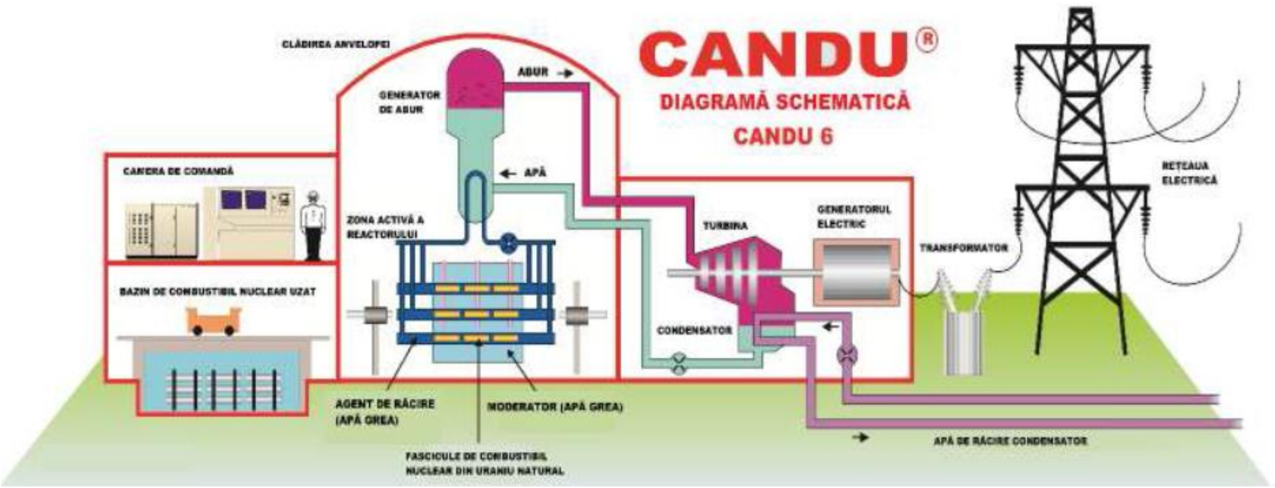


Fig. 12 Simplified technological diagram of the CANDU 6 nuclear power plant

The fuel is natural uranium (with a content of about 0.7% U-235) in the form of charge-discharge bundles from the reactor during operation under load.

Fuel bundle features:

- Cylindrical shape;
- 37 elements;
- Length ≈ 500 mm
- Diameter ≈ 100 mm
- Mass ≈ 24 kg
- Radioactivity: depending on the burn-up degree.

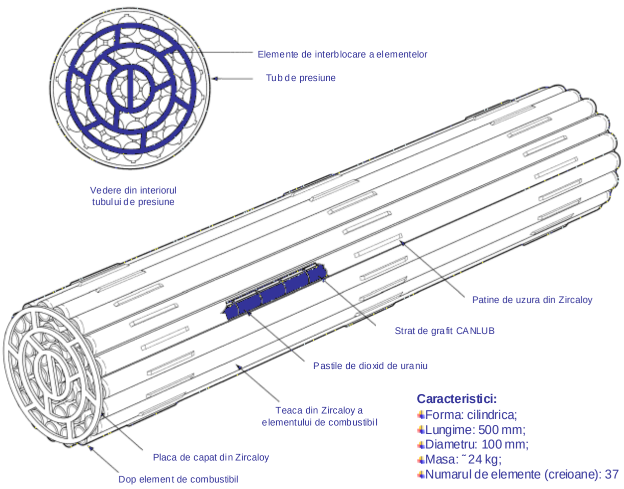
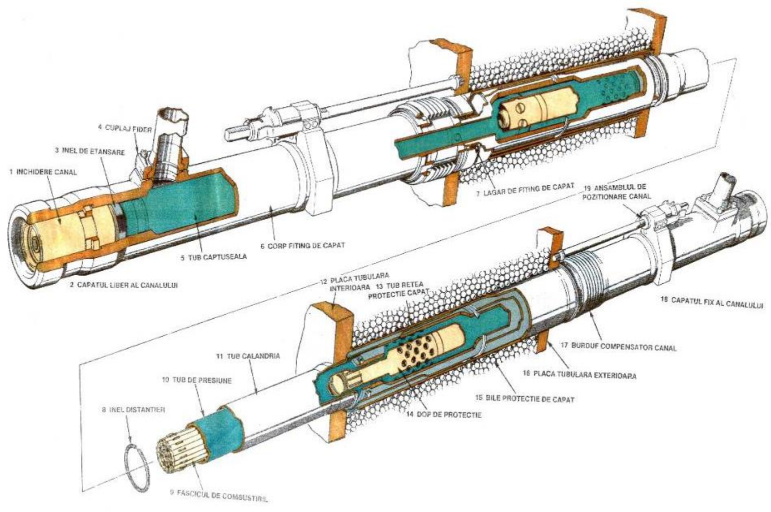


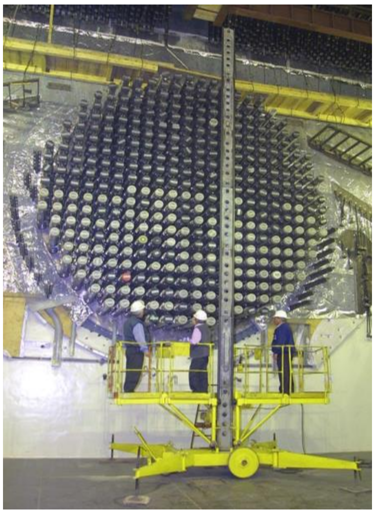
Fig. 13 Fuel bundle for the PHWR-CANDU 600 reactor

The reactor consists of a horizontal cylindrical vessel (the calandria vessel) equipped with 380 horizontal fuel channels, arranged in a square network.

The fuel channel consists of two concentric tubes: the calandria tube and the pressure tube.



The structure of a fuel channel



Fuel channels grid

Fig. 14 Fuel channels in the PHWR- CANDU 600 reactor

Each six-meter-long fuel channel contains 12 fuel bundles.

The coolant - heavy water - circulates through the pressure tubes.

The reactor vessel (calandria vessel) is filled with heavy water as a moderating agent and reflector of neutrons resulting from the nuclear fission reaction.

The reactor vessel is placed in a steel-clad concrete containment filled with light water (the calandria caisson). Light water provides additional shielding and at the same time adequate cooling of the outside of the calandria vessel.

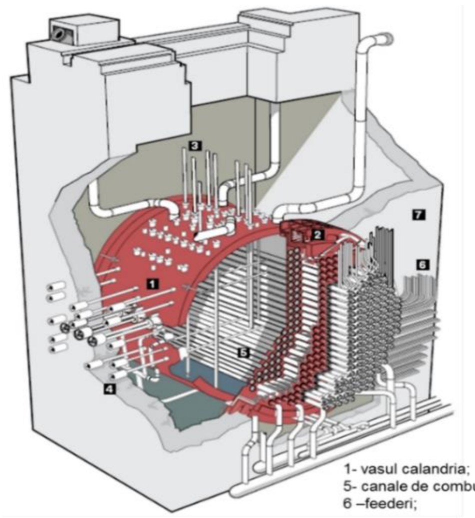


Fig. 15 PHWR-CANDU-600 Reactor

Reactivity control is provided by the absorbent bar control system, the adjuster bar control system, the liquid zonal control system, the liquid poison insertion system into the moderator, and the moderator purification system.

The Unit 1 reactor at Cernavoda NPP is equipped with two systems for fast shutdown of the nuclear fission reaction, each of these systems being able to independently stop the nuclear reaction, for any postulated accident.

The reactor has a system for transporting the heat generated in the nuclear fuel to the four steam generators that produce steam from light water. The system is a closed circuit with two independent loops.

Saturated steam produced in steam generators expands in the **condensing turbine**, producing mechanical work, and is then condensed using cooling water At the Cernavoda NPP, the cooling water is taken from the Danube River, through the open adduction channel and the Race I of the Danube - Black Sea Canal (CDMN). The turbine used by Cernavoda NPP Unit 1 is composed of a high-pressure body and three low-pressure bodies. The turbine is provided with 5 non-adjustable steam intakes, in different stages of expansion, for the purpose of regenerative preheating of the light water supplying the steam generators. The turbine condenser consists of three independent bodies, one for each low-pressure body of the turbine.

The mechanical energy of the turbine is transformed into electrical energy with the help of **the electric generator**, of synchronous type, directly coupled to the turbine.

Fig. 16 PHWR-CANDU-600 turbogenerator

The electric power produced by the electric generator is delivered through **two 440 MVA transformers** connected in parallel, to the 400 kV, station connected to the national energy grid.

Fig. 17 Transformer 440MVA

The main characteristics of the refurbished Unit 1 are:

- Thermal Power 2062 MW(t)
- Gross electrical power 706.5 MW(e)
- Consumption of internal services <8%
- Number of fuel channels 380
- Number of loops 2
- Number of steam generators 4
- Pressure (D_2O) in the primary circuit 9.89 MPa
- Temperature at the exit from the primary circuit 310 ^{0}C
- Saturated steam pressure (H_2O) 4.6 MPa
- Water supply temperature 187.20 ^{0}C

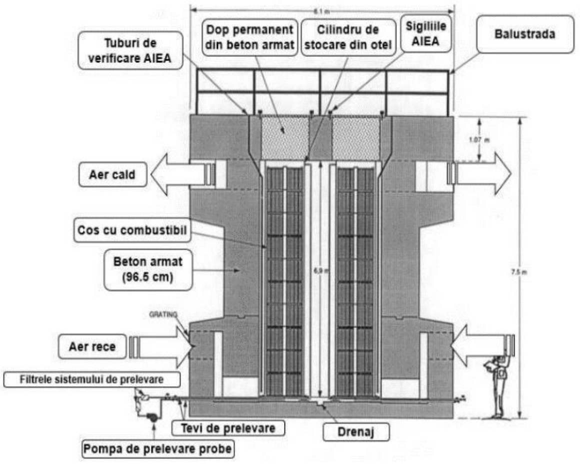
Subproject DICA-MACSTOR 400

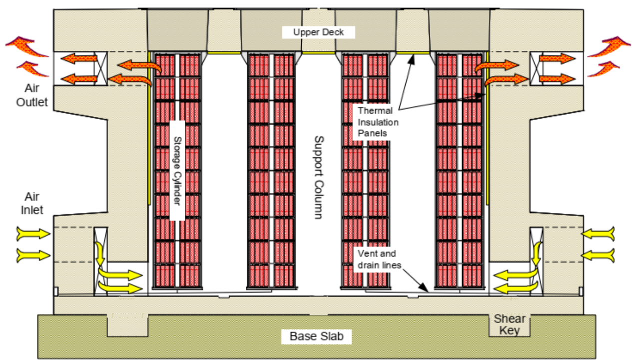
As a result of the implementation of this subproject, the configuration of the extended DICA-MACSTOR 400 storage facility will be as follows:

	Current, authorized DICA	DICA-MACSTOR 200 + 400
Surface of the storage facility (within the outer fence)	24000 m^2	40000 m^2
Number and type of modules	27 modules MACSTOR 200	37 modules MACSTOR out of which: - 17 modules type MACSTOR 200 - 20 modules type MACSTOR 400
Layout of modules on rows	- on row 1: 7 modules MACSTOR 200 (completed); - on row 2: 10 modules MACSTOR 200 (modules 8 - 16 completed, module - 17 will be completed in 2024); - on row 3: 10 modules MACSTOR 200 (modules 18 - 27).	- on row 1: 7 modules MACSTOR 200 (completed); - on row 2: 10 modules MACSTOR 200 (modules 8 - 16 completed, module 17 completed at the end of semester 1 of 2024); - on row 3: 8 modules MACSTOR 400 (modules 18 - 25); - on row 4: 8 modules MACSTOR 400 (modules 26 - 33); - on row 5: 4 modules MACSTOR 400 (modules 34 - 37).
Storage capacity of dry spent fuel in the modules at the interim storage site	27 modules MACSTOR 200 x 12000 bundles/module = 324000 bundles	684000 bundles out of which: - 17 modules MACSTOR 200 x 12000 bundles /module = 204000 bundles - 20 modules MACSTOR 400 x 24000 bundles /module = 480000 bundles

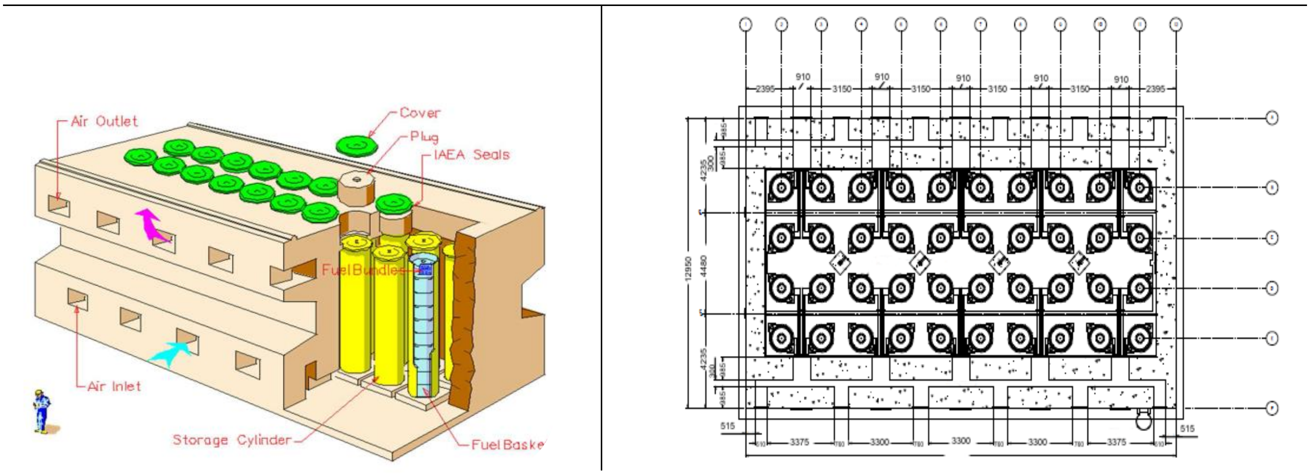
The following figure shows the MACSTOR 400 modules compared to the currently operated MACSTOR 200 modules:

Module MACSTOR 200	**Module MACSTOR 400**





a) Cross section through the module



b) Arrangement of cylinders within a module

Fig. 18 Current MACSTOR 200 module vs. MACSTOR 400 module in the project

The characteristics of the MACSTOR 200 modules currently used and the MACSTOR 400 modules intended to be used for the dry storage of the spent fuel bundles resulting from the Cernavoda NPP are presented in Appendix no 6 – Comparative characteristics of MACSTOR Modules.

The block diagram regarding the transfer of spent fuel from the wet storage basins to the modules for intermediate dry storage, at the Cernavoda NPP site, can be found in the following figure:

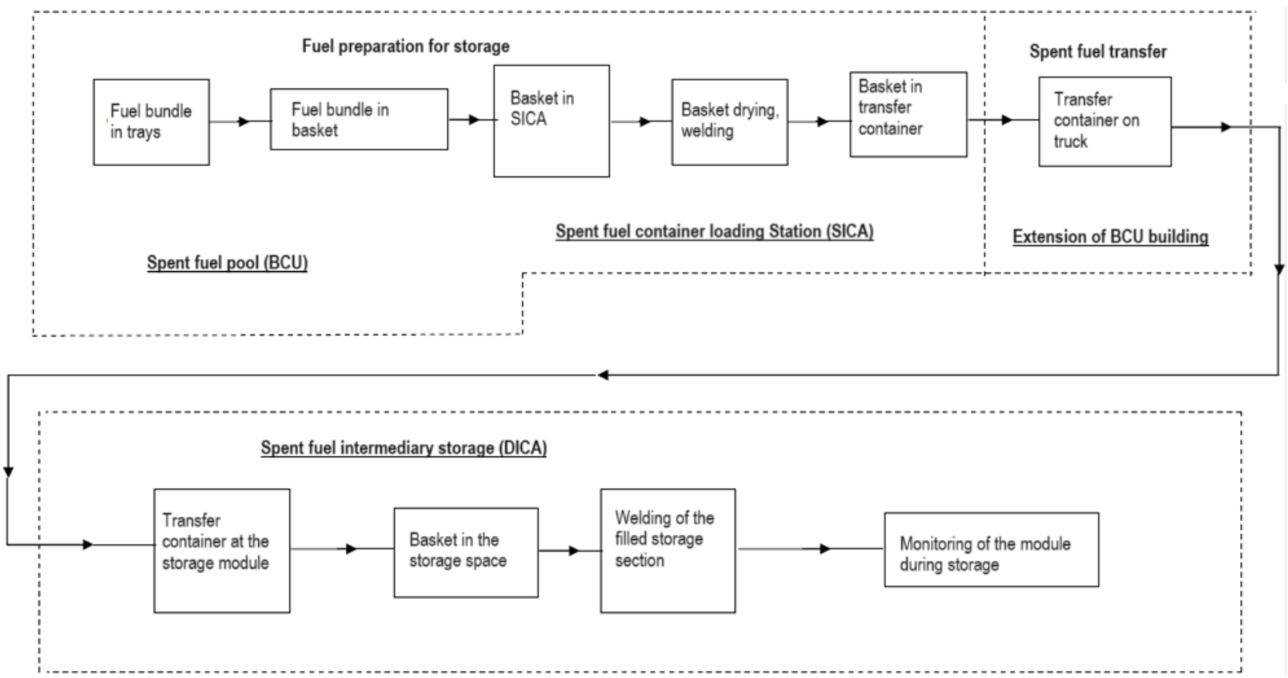


Fig. 19 Main activities required for the transfer of the spent fuel from Cernavoda NPP Units 1 and 2 to DICA

1.7.2 Raw materials, energy and fuels used and the way they are provided

For the operation of the refurbished Unit 1, the types of raw and auxiliary materials as well as the estimated consumptions are similar to those of the current normal operation of Unit 1. The technological flows are those mentioned in the Environmental Authorization approved GD no. 84/2019 and does not change through the implementation of the refurbishment project.

In ***the operating stage of the refurbished Unit 1***, the same raw materials will be used as during the first operation cycle:

- ***Raw materials***: nuclear fuel bundles (UO_2) - manufactured by the Nuclear Fuel Factory Branch - FCN Pitesti within SN Nuclearelectrica SA.
- ***Auxiliary Materials***: heavy water (D_2O), SUVA - 134A, helium (he), nitrogen gas (N_2), liquid nitrogen, carbon dioxide (CO_2) for cover gas, carbon dioxide for generator, hydrogen (H_2) purity 99.98% for generator, hydrogen purity 99.995%, gadolinium nitrate, hydrazine 35%, morpholine 99%, lithium hydroxide, RGCC-100 (sodium nitrite corrosion inhibitor, ARQUAD MCB – 50 (biocide), hydroxide sodium 48÷50%, hydrochloric acid 32%, ferric chloride 40%, sulphur hexafluoride, sodium chloride (min. 97%) (for STA and STAP), liquid antiscalant NALCO 3DT 449 for modernized STA, flocculant PRAESTOL A3040L for modernized STA, conventional (regenerable) resins, lubricating oil, thick greases.
- ***Classic fuels:*** diesel, light liquid fuel (LLF) - used at CTP to start the U1 unit.

Tab. 4 Raw materials – Fuel bundles, according to the Environmental Authorization (GD no. 84/2019)

Raw materials	Packaging method	Storage	Estimated average annual quantity for the refurbished U1
nuclear fuel bundles (UO_2)	Polyethylene coating, expanded polystyrene molds and wooden pallets	fuel depot with controlled access	approx. 5227 bundles/year at U1 – average of 1997-2016

Tab. 5 Auxilliary materials

Auxiliary materials	**Packaging**	**Storage (per unit)**	**Estimated quantities/average annual consumption U1**
Heavy water (D_2O)	200 litre stainless steel drums	- 4 tanks of 71 m^3 for D_2O used currently (approved) - stainless steel drums for heavy water reserve and degraded water (approved) - in nuclear systems	initial inventory: (MS and SPTC) 510 t average annual losses forecast: 5.2 t (project value) average annual losses: U1 - 3.75 t/year
SUVA- 134A (refrigerant)	cylinders 935 kg, 13.6 kg and 65 kg	Warehouse OB 020 (U3)	1200 kg
Gadolinium nitrate 99.9%	Plastic cans 1 kg	Chemical laboratory SEIRU, 5C	approx. 28 kg/year (S.A.)
Boric anhydride 99.9% CAS 1303-86-2	Plastic cans 1 kg	Chemical laboratory	Note: No longer used in the system but stock is kept for U1 refurbishment. Estimated consumption 5-10 kg when U1 is put back into service after the end of the refurbishment project
Hydrazine solution 35% CAS 302-01-2	Plastic barrels 200 l	SEIRU 5B T/B, CTP	900 kg (S.A.)
Morpholine 99% CAS 110-91-8	metal or plastic barrels 200 l	SEIRU 5B T/B, CTP	11100 kg (S.A.)
Lithium hydroxide Concentration>98%	plastic cans 1 l	SEIRU 5B Chemical laboratory	approx. 8 kg/year
RGCC-100 (sodium nitrite corrosion inhibitor)	60 l plastic cans; 25 l	SEIRU, 5B T/B	approx. 25 kg/year
Nitrogen (N_2) -	Ultrapur cylinders	warehouse	approx. 6500 m^3

Auxiliary materials	Packaging	Storage (per unit)	Estimated quantities/average annual consumption U1
(technical)	7.45 m^3		
Nitrogen-liquid	Store in liquid nitrogen tank (by rental agreement)	warehouse 01	approx.. 6800 l
Helium	7,45 m^3/cylinder	warehouse	7200 m^3
Carbon dioxide (CO_2)	cylinder 30 kg	warehouse	3800 kg used as cover gas
Carbon dioxide (CO_2)	cylinder 30 kg	warehouse	15000 kg used in the electric generator
Hydrogen - (99.85% purity)	6 m^3 cylinders and in 180 m^3 tanks	warehouse	450 m^3
Hydrogen - (99.995% purity)	6-8 m^3 cylinders	warehouse	150 m^3
ARQUAD MCB-50 (biocide)	plastic container 900 Kg	SEIRU	4500 kg/year (S.A.)
Sodium hydroxide 48÷50%	Delivered in bulk in auto tankers	vertical tanks TK-LES 4 x 40 m^3	90 t/year (S.A.)
Hydrochloric acid 32% CAS 7647-01-0 EC 231-595-7	Delivered in bulk in auto tankers	vertical tanks 4 x 63 m^3	150 t/year (S.A.)
Ferric chloride 40% CAS 10025-77-1 EC 231-729-4	Delivered in bulk in auto tankers	vertical tanks 2 x 25 m^3	25 t/year (S.A.)
Sulphur hexafluoride CAS 2551-62-4 EC 219-854-2	In U2, 110 kV station, shut down equipment	Supplied directly into the equipment (switches)	Stock: 26.1 kg U2 (in 87 ABB*0.3kg circuit breakers) 226.2 kg in 110kV Station (in enclosed equipment)
Chlorine gas (groundwater purification) CAS 7782-50-5 EC 231-959-5	50 Kg cylinders	Chlorination chamber with STAP cylinders	600 kg/year
Sodium chloride (min 97%) (for STA and STAP) CAS 7647-14-5 EC 231-598-3	25 kg sacks	SEIRU, 5A	52 t/year (S.A.)
Liquid Antiscalant NALCO 3DT 449 for modernized STA	200 l barrel	SEIRU, 5B	approx. 2380 kg/year 3D TRASAR (Nalco) product was replaced in 2021
Sodium hypochlorite Min 12.5% STA CAS 7681-52-9 EC 231-668-3	PVC container 720 kg (600 l)	SEIRU	250 kg (S.A.)
Flocculant PRAESTOL A3040L for modernized STA	60 l plastic barrel	SEIRU, 5B	approx. 379 kg/year Currently it is used for the production of demineralized water
Conventional (regenerable) resins	50 l sacks	SEIRU, 5B	Maximum 5 m^3 /year if needed, for additions

Auxiliary materials	Packaging	Storage (per unit)	Estimated quantities/average annual consumption U1
Lubricating oil	barrels, cans	SEIRU, 5B	-
Consistent grease	barrels, cans	SEIRU, 5B	-
Fyrquel EHC fluid	metal barrel 200 l	SEIRU 5A	1500 l
Isopropyl alcohol	plastic cans 20 l	SEIRU 5C	50 l
Refined white spirit (nuclear varsol)	metal barrel 200 kg	SEIRU 5B	100 kg
Odacon F To preserve the secondary circuit	plastic container 1000 kg	SEIRU	3000 kg (to be used only once in the last 2 months of operation of Unit U1, prior to shutdown for refurbishment)

NOTES:
1. The consumption of chemical substances represents the estimated consumption for the operation of the refurbished U1 and of the common auxiliary systems, which work for the needs of U1 and U2;
2. S.A. = active substance, representing the amount calculated at 100% concentration compared to the actual concentration in the solution;
3. According to the design documentation, Helium of 99.995% purity is used as the cover gas for the Calandria vessel and the Primary Agent D_2O Storage Tank because it is an inert gas and, compared to air, has the following advantages: (i) low corrosive effect; (ii) low content of Argon 41, resulting in low gamma dose rates;
4. The helium in the system is recirculated in a closed circuit and pressure maintenance is ensured by continuous feeding from a standard cylinder manifold via two pressure regulators, series-connected PRVs. There are 4 manifolds, each with 8 cylinders connected, located in chamber S1-121;
5. The volume of gas in the system varies between 7.65 m^3 and 12 m^3, depending on the operating temperature and moderator level. The volume of gas in the cylinders of a manifold is: 8x 43.8 l = 350.4 l;
6. The normal operating pressure of the Moderator Cover Gas System is 24÷26 kPa(g). The gas pressure in the manifolds is: 15 Mpa(g). The cylinders used are standard type of technical helium - according to ISCIR C5/2003.
7. Liquid antiscalant 3D TRASAR (Nalco) is no longer used in the technological process of water treatment, only NALCO 3DT 449 from 2021, Additional Act ABADL no. 4973/15.03.2022, respectively the Water Management Authorization no. 72/2021 amending the Water Management Authorization no. 58/2021.

- ***Substances used in the conservation program to preserve plant systems and equipment:*** The following substances will be used to preserve the plant's systems: hydrazine, morpholine, lithium hydroxide.

With the refurbishment of U1, ODACON®F solution is introduced for the conservation of the plant systems, for which an eco-toxicological impact study has been carried out to determine the discharge limit for which there are no adverse effects on aquatic flora and fauna. The use of the solution will be applied on the basis of the discharge limit approved by the Water Management Permit/Authorization issued by the competent authority in the field of water.

Tab. 6 Estimated fuel consumptions

FUELS (classics)	STORAGE METHOD	Average annual consumption for refurbished U1
Diesel	Underground tanks 2 x 22.4 t (Diesel, Emergency Power Supply) Semi-buried tanks 8 x 180 t (Stand by Diesel Generators)	190 t/year
LLF Used for quarterly CTP tests	Liquid fuel Household	17 t/year

The electricity used to operate Unit 1 is provided by internal services and represents about 8% of the electricity produced by the unit.

1.7.3 The type and quantity of finished products resulting from the project

Subproject RT-U1

The main activity of the refurbished Cernavoda NPP Unit 1 **is the same as the current activity of Unit 1, namely the production of electricity for another operation cycle** with the estimated delivery to SEN of approximately **151668193 MWh.**

After the refurbishment of Unit 1, Cernavoda NPP will continue to supply thermal energy for heating in Cernavodă town. At the level of 2023, Cernavoda NPP delivered 81.2 thousand Gcal for this purpose.

Subproject DICA – MACSTOR 400

Following the extension of DICA and the commissioning of the MACSTOR 400 modules, the extended DICA site will provide intermediate dry storage of spent nuclear fuel for two operating cycles for the two units U1 and U2 of the Cernavoda NPP.

The total intermediate storage capacity of the extended DICA will be 684000 bundles, out of which 480000 bundles in the 20 MACSTOR 400 type modules.

1.7.4 Installations for the retention, evacuation and dispersion of liquid and gaseous pollutants (effluents) in the environment

1.7.4.1. Installations for the retention, evacuation and dispersion of liquid radioactive effluents from the RT-U1 project [30]

Radioactive liquid wastes produced both <u>during the implementation of the RT-U1 project</u> and <u>during the operation of the refurbished U1</u> will be directed to the Aqueous Liquid Radioactive Waste Management System within Unit 1, where they are collected in 5 tanks with a capacity of 50 m^3 each, located in the basement of the service building.

The processing of this liquid waste is done in accordance with the liquid effluent monitoring program of the nuclear unit. Liquid waste processing begins when the volume of liquid radioactive waste reaches a maximum of 25m^3. The content of a tank is mixed and a sample is taken and analysed in the chemical laboratory of the Cernavodă NPP, in terms of pH and radioactivity concentration - by gamma spectrometry and tritium analysis with liquid scintillator.

If the measured values are lower than the limits set for discharge, the contents of the tank are discharged into the condenser cooling water channel. During the discharge, the effluent is continuously monitored by the liquid effluent monitor which measures the gamma radioactivity of releases and stops the discharge in case the set alarm threshold is exceeded. The condenser cooling water is discharged through the Seimeni discharge channel into the Danube, where additional dilution is carried out. All tanks for which the activity of gamma radionuclides exceeds 0.05% of annually DEL, will be decontaminated by filtering on columns equipped with ECODEX resins that retain gamma radionuclides and the process is resumed. During the discharge the LEM (liquid effluent monitor) continuously collects a sample. The collected sample is analyzed in the dosimetry laboratory and the values are reported.

The resin used for decontamination is sent to the waste resin collection and storage system.

[30] Cernavoda NPP – Environmental balance level I, 2018

In the Active Components Building, which is in direct connection with the new DIDR-U5, repair and decontamination of tools is carried out. The building has a radioactive drainage system (RDS) that collects radioactive and potentially radioactive liquid waste, including liquid waste from showers and floor drains. The collected liquids are evacuated by gravity to the collection tank in the Active Components Building, from where they are loaded into barrels and then transferred to the Aqueous Liquid Radioactive Waste Management System within Unit 1/2.

Also, in order to monitor the phreatic aquifer in the area adjacent to the new DIDR-U5, observation boreholes will be executed in accordance with ANAR and INHGA requirements.

1.7.4.2. Installations for the retention, evacuation and dispersion of gaseous radioactive effluents from the RT-U1 project [31]

The radioactive gaseous effluents generated <u>both during the implementation period of the RT-U1 project</u> and <u>during the operation period of the refurbished U1</u> will be directed to the collection, treatment and evacuation systems within Unit 1.

The limitation of the possibility of radioactive elements contaminating the air from the access areas of the personnel inside the plant or being evacuated into the environment is achieved with the help of ventilation systems that ensure the collection, treatment, and control of gaseous radioactive effluents from all areas where they may appear.

The collection of gaseous radioactive effluents from the nuclear side is done with the help of 4 ventilation systems, equipped with specific treatment means for each area of action.

The ventilation systems are designed in such a way as to ensure adequate ventilation of the working spaces, and the air circulation is directed from the areas with low contamination potential to those with high contamination potential, following that finally, after filtering, the air being evacuated in a controlled manner through the ventilation stack.

The reduction of radioactive gas emissions is ensured by:

a. drying the air in the heavy water vapor recovery system
b. air filtration before discharge into the atmosphere, to retain particles and radioactive iodine, by means of the filtration systems in the ventilation installations
c. evacuation through the ventilation stack at a height that allows good dispersion in the environment.

a. Heavy water vapor recovery system

It has the role of recovery of heavy water losses and reduction of tritium activity from accessible and inaccessible spaces in the reactor building to allow access and intervention of personnel. At the same time, the air introduced into the ventilation system is dried, the concentration of tritium and other contaminating aerosols in the air is reduced, and the plant's radioactive emissions are reduced.

The system consists of several drying facilities grouped into 5 subsystems, where the air collected from several areas of the reactor building is recirculated, and the tritiated heavy water vapors are adsorbed on molecular sieves, respectively:

- the steam recovery subsystem from the reactor sides and Steam Generators, served by 4 drying towers, with a nominal flow rate of 6800 m^3/h, containing approx. 1900 kg molecular sieve, serving the inaccessible areas of the reactor building

[31] Cernavoda NPP – Environmental balance level I, 2018

- the air vapor recovery subsystem from the MID auxiliary rooms and, served by 2 drying towers, with a nominal flow rate of 6800 m^3/h, containing approx. 500 kg molecular sieve, related to the accessible rooms in the reactor building.
- the vapor recovery subsystem from the moderator premises, served by 2 drying towers, with a nominal flow rate of 3400 m^3/h, containing approx. 900 kg molecular sieve, dedicated to the moderator systems enclosure
- the vapor recovery subsystem from the Steam Generators room served by a dryer with 2 drying towers
- part of the recirculated air flow (approx. 1000 m^3/h) is passed through an additional drying stage after which it is directed to the ventilation system and exhausted, ensuring the proper circulation of the air flow.

Heavy water retained in the drying mass is cycled off with an electrically heated air stream to 260^{o}C and it is recovered in the condensers and sent to the purification and enrichment plant for reuse.

The system recovers 95% of the heavy water vapour and tritium discharged, reducing tritium emissions by at least 20 times.

b. The monitoring system of tritium in air

The presence of tritium vapors in the atmosphere from several locations in the reactor building and nuclear auxiliary services is continuously monitored by the tritium air presence monitoring system (tritiated water vapor). It has the role of detecting variations in the flow rate equivalent to the dose given by the presence of tritium, indicating possible losses of heavy water and at the same time reducing the risk of personnel contamination and allowing access to the respective rooms.

The system consists of 5 local air tritium monitoring units consisting of a tritium monitor, an air sampling unit, a programmable process control unit, pipelines, control and data transmission cables, computer for information management.

Local monitoring units normally operate in automatic sampling mode, but the system can operate sequentially or manually.

c. Filtration systems for radioactive gaseous effluents

c_1 The ventilation system in the reactor building

During normal operation, the system ensures the ventilation of the spaces in the reactor building, in an open system, without recirculation, with air evacuation through a complex filter unit. The system can be used to depressurize and purify the containment atmosphere in accident situations.

The system has several functions:

- limiting the increase in the level of radioactivity in the access areas by performing air exchange
- maintaining the reactor building at a negative pressure as compared to the environment of approx. 63.5 mm H_2O and regulating the balance of pressures to direct the air from areas with higher activity to those with lower radioactive potential
- filtering of the air input and output
- ensuring the continuity of operation of the ventilation system and the containment systems of radioactive leaks by keeping a 100% reserve in the exhaust fans
- monitoring leaks through containment penetrations and fast closing of air circuits.

The ventilation system ensures the circulation of an air flow of 17000 m^3/h for which it achieves the temperature and humidity conditions required for carrying out the activities (18 -25 ^{o}C, 35% humidity).

The collected air is passed through a complex three-stage filtration unit composed of:

- high-efficiency filter for retaining contaminated particles, composed of a pre-filter (minimum efficiency 85% according to ASHRAE) and a high-efficiency filter (HEPA), (99.97% for particles of 0.3 microns).

- active carbon filter to retain the radioactive iodine present in the contaminated air in the form of elemental iodine or methyl iodide; efficiency is 99.99% (for elemental iodine) and 99.90% (for methyl iodide).
- high-efficiency filter (HEPA) identical to the one existing in the first filtration stage, to retain any activated carbon particles carried by the air flow.

After the filter unit, radioactivity monitoring systems are installed on the exhaust circuit, connected to the alarm systems and the containment isolation flaps.

c_2 Ventilation systems in the nuclear auxiliary services building

The nuclear auxiliary services building comprises several technological areas with specific requirements regarding environmental conditions. The ventilation mode of these spaces achieves:

- ensuring the normal operating conditions of the facilities and the comfort of the staff, namely temperatures of 17-29^{o}C and humidity of 50 ± 10% for personnel areas and temperatures of 13-40^{o}C for technological areas
- controlling the direction of air movement from clean areas to those with increased probability of contamination
- air filtration to remove radioactive contamination
- removal of the heat generated by technological equipment.

Ventilation in this building is achieved through the central air intake system, which provides a flow rate of 38 m^3/s preheated, humidified, cooled, or heated filtered air depending on the season and several ventilation subsystems, intended for different technological zones, depending on existing contamination possibilities.

$c_{2.1}$ The ventilation system in the spent fuel transfer and storage pool area

It has the role of ensuring conditions favourable for carrying out technological processes, removing the heat released by the equipment, maintaining the depression compared to the adjacent areas and filtering the air to remove radioactive aerosols.

As the spent fuel storage area presents a significant risk of contamination, ventilation is in an open loop, without recirculation, with 100% reserve and automatic connection on reserve.

The system circulates 9 m^3/s directing the air to the evacuation stack through a 3-stage filter unit similar to the one in the reactor building ventilation system:

- high-efficiency filter for the retention of contaminated particles, composed of an auxiliary pre-filter, pre-filter (85% efficiency according to NBS) and a high-efficiency filter (99.97%).
- active carbon filter to retain the radioactive iodine present in the contaminated air in the form of elemental iodine or methyl iodide; efficiency is 99.99% (for elemental iodine) and 99.90% (for methyl iodide).
- high-efficiency filter identical to the one existing in the first filtration stage, to retain any activated carbon particles carried by the air current.

$c_{2.2}$ The contaminated air evacuation system from rooms with possible radioactive load in the building of nuclear auxiliary services

It is intended for the evacuation of air from areas with possible contamination located in the building of auxiliary services such as the decontamination center, the rooms of the air ventilation systems, the chemical and radiochemical control laboratory, the D_2O vapor recovery facility, the area of the biological protection cooling systems, the household area of heavy water, radioactive waste storage area, MID machine service area, etc. The system evacuates air with a flow rate of 84240m^3/h.

Before evacuation, the system ensures the retention of contaminated particles with the help of a high-efficiency filtration unit composed of an auxiliary pre-filter, a VARICEL pre-filter (efficiency 90-95% NBS) and a high-efficiency HEPA filter (99.97% for particles of 0.3 microns according to DOP test).

$c_{2.3}$ <u>Air conditioning and evacuation systems for rooms without radioactive load</u>

They are represented by several ventilation installations that can operate independently and include the central uncontaminated exhaust system, intended for the evacuation of air from spaces without radioactive load, the air conditioning system for the Chemical Laboratory, the instrument air conditioning system, etc.

c_3 **The ventilation system in the heavy water reconcentration tower**

It is designed to create the necessary conditions for the technological processes in the heavy water re-concentration tower (13 – 40 ^{o}C), maintain the depression in the building of the re-concentration tower and control the direction of air movement. The system allows the evacuation of a flow rate of 40000 m^3/h in fresh air mode, with the possibility of recirculationre.

d. Evacuation of radioactive effluents into the atmosphere

After filtering, the gases collected by the ventilation systems are directed to the dispersion stack located in the heavy water tower building. The ventilation stack allows the evacuation of an air flow of approx. 170000 m^3/h at a height of 50.3 m. The evacuation is done in a controlled manner, after continuous monitoring through sampling and measurements of nuclide concentrations carried out with the help of the gaseous radioactive effluent monitoring system located at the stack. Exceeding the radioactive gaseous effluent emission thresholds is signaled in the control room through an alarm system and actions for alarm confirmation, source identification and remedial actions are initiated.

The new DIDR-U5 will be equipped with a ventilation system, HEPA filter filtration and a monitoring system for evacuated air.

1.7.4.3. Installations for the retention, evacuation and dispersion of liquid radioactive effluents from the DICA-MACSTOR 400 project

The rainwater (meteor) sewerage network, related to the DICA site, consists of collecting channels made of tubes, made of polyester reinforced with glass fiber (PAFS), on which are placed PAFS inspection manholes. The collector channels are located underground, below the frost depth.

The rainwater drains, related to each row of modules, gravitationally evacuate the collected waters in the rainwater drain located at the base of the slope of the DICA platform.

Regarding the DICA platform, the only possible sources of pollution are rainwater, which may or may not be radioactively contaminated. Water samples are taken from the manifold to check for possible radioactive contamination.

If the collected water, resulting from the precipitation falling on the platform, is radioactively contaminated (in the case of not falling within the limits established by CNCAN), it is transported to the radioactive aqueous liquid waste management system in Unit 1.

If this water is not radioactively contaminated, the valve in the valve stack opens, and the collected water is evacuated by gravity into the sewerage collector of the water from the precipitation falling on the DICA platform.

To prevent the exfiltration from gutters and manholes of the collected waters, potentially radioactively contaminated, they are waterproofed.

During a campaign to store the nuclear spent fuel, the valve in the stack of valves corresponding to the module being loaded is in the closed position, in order to be able to retain the water from the precipitation falling on the related platform.

For the control of the quality and level of the groundwater on the platform corresponding to DICA, 4 (four) drilled wells (piezometric wells) have been installed. Along with the expansion of the

DICA site with MACSTOR 400 modules, there are plans to execute 2 observation boreholes for the purpose of monitoring the phreatic aquifer.

1.7.5 Utilities necessary for the operation of the project

The Cernavoda nuclear power plant was built near the town of Cernavoda, at a distance of 180 km from Bucharest, ***at the confluence of the Danube and the Danube - Black Sea Canal***, construction works started in 1979. Unit 1 was commissioned in December 1996.

The nuclear power generation technology at Cernavoda NPP is based on the CANDU type nuclear reactor concept, which operates with natural Uranium and uses heavy water (D_2O) as moderator and coolant.

The location of the Cernavoda NPP power plant primarily took into account: the geological structure of the soil, ***the source of cooling water - the Danube - Black Sea Canal***, the degree of seismicity of the Dobrogea region, etc.

The analysis of the activities carried out at Cernavoda NPP, in order to perform the RT-U1 sub-project - takes into account the way to ensure the water supply for all the activities of the refurbishment process, as they are presented in subchapter 1.6.2.

1.7.5.1 Water supply

The provision of water supply for all specific consumptions during the RT-U1 sub-project will be carried out similarly as in the case of the normal operation of Unit 1.

Regarding the provision of water supply for hygienic and sanitary purposes for the personnel who will serve the activities of the new DIDR-U5, this objective will be connected to the current water supply system on the Cernavoda NPP premises, through installations that will ensure the necessary water specific to the consumption needs of this objective.

Currently, the owner of the SN NUCLEARELECTRICA SA project – Cernavoda NPP branch holds a regulatory act issued by the Romanian Waters National Administration, **for the purpose of water supply and waste water evacuation for Units 1 and 2 from Cernavoda NUCLEAR POWER PLANT**, Constanta County – Water Management Authorization No. 72 of September 6, 2021 modifying the Authorization No. 58/01 July 2021. (attached to this documentation*).*

The water supply of the Cernavoda NPP objective is done as follows:

- ***for drinking and sanitary purposes:***
  - *from underground*, own source, through 3 deep bored water wells (700 m)
  - *from the public water supply network of Cernavoda town*, through a branch with Dn 200 mm to the town main supply pipe.
- ***for technological purposes*** **–** surface water, the Danube River - race I of the Danube Black Sea Canal, through the derivation channel, as a source of cold water for the technological cooling water circuits of the plant, with a degree of assurance of use of 97%.

An agreement between Cernavodă NPP SC RAJA SA Constanta has been concluded in order to use as a water source the public supply system of Cernavodă town.

a) Drinking water

In order to ensure the necessary water for ***hygienic-sanitary consumption*** for the employed personnel, there are 3 deep water boreholes executed, as follows:

- in January 2002, the Fj1 borehole was executed, located in the southern extremity of the fixed front;
- in January 2003, the Fj2 borehole was executed, located near the distribution basin, face to face with Pavilion 2;
- in April 2003, drilling Fj3 was executed, located in Campus 2.

The hydraulic characteristics of the operated aquifer, the way of operation, as well as the quality of the water pumped into the water supply system of Cernavoda NPP were carried out at the during the time of the putting into operation of the three drilled water wells.

The boreholes are equipped with Grundfoss submersible pumps, positioned at a depth of 32 m from the ground, the protection of these pumps being ensured by level transducers placed at depths of 30 m each, with the role of following the evolution of water levels in the boreholes and ensure the protection of the pumps in the event of the accidental occurrence of unevenness, which may exceed the depth of the installation of the pumps, as it follows:

- Fj1: pump type SP- 95-3 Rp 5”, Grundfos, Q = 26 l/s; P = 13 kW, H = 38 mCA; n = 2870 rpm;
- Fj2: pump type SP- 95-2 Rp 5”, Grundfos, Q = 28,5 l/s; P= 9,5 kW, H=20 mCA; n = 2870 rpm.
- Fj3: pump type SP- 95-3 Rp 5”, Grundfos, Q = 26 l/s; P= 13 kW, H=38 mCA; n = 2870 rpm.

The supply of water for **hygienic-sanitary** purposes at the Cernavodă NPP site is done as follows:

- **from underground** - own source - through 3 deep boreholes. Two boreholes are located on the Cernavoda NPP premises and one borehole is located in the NPP Campus area:

Fj1	H = 700 m;	Nhs = 4 m;	Nhd = 10 m;	Q = 16 l/s;
Fj2	H = 700 m;	Nhs = 3.1 m;	Nhd = 5 m;	Q = 28.5 l/s;
Fj3	H = 700 m;	Nhs = 5.17 m;	Nhd = 5.92 m;	Q = 21.2 l/s.

Authorized volumes and flows of groundwater:

Q daily max. = 2865 m^3/day (33.15 l/s) Vannual max.= 1045.7 thousand m^3;
Q daily avg. = 2660 m^3/day (30.8 l/s) Vannual avg.= 970.9 thousand m^3.

- **from the zonal drinking water supply system of Cernavoda town** (through the local operator S.C. RAJA S.A. Constanța).

Authorized water volumes and flows from the drinking water supply network of Cernavodă town:

Q daily max. = 2160 m^3/day (25.0 l/s) Vannual max.= 788.4 thousand m^3;
Q daily avg. =1910 m^3/day (22.1 l/s) Vannual avg.= 697.15 thousand m^3.

The operating regime of the objective is permanent, 365 days/year, 24 hours/day.

From the deep wells, water is extracted by Grundfoss submersible pumps and pumped into the Drinking Water Treatment Plant (STAP).

The water treatment including filtration station (STAP) is placed in the vicinity of the warm water discharge channel in the CDMN race II, it ensures the treatment and filtration of the water from the two boreholes Fj1 and Fj2; the station is equipped with BIRM automatic filters, AM 7200 softeners, Willo pumping group, automatic air injection system and perhydrol. The filtering capacity of the station is 100 m^3/h of water.

The chlorination station is located near Fj1, in an above-ground building ensuring water disinfection by dosing with chlorine gas. The capacity of the chlorination station is 720 m^3/h of water.

After treatment, the water is directed by pumping into 2 (two) above-ground tanks, made of reinforced concrete, provided with a storage volume V = 1000 m^3 each; from these tanks, by pumping, the water is directed through an underground pipe made of PEHD with Dn 180 mm, which ensures the distribution of water by pumping in the plant premises through the metal pipe with Dn 400 mm.

The drinking water distribution network in the premises is branched type. The pipes that ensure the distribution of water at the consumption points, - the Administrative Building/Pavilion and Units U and U2 - are made of carbon steel and have diameters between 50 - 400 mm, and those that ensure the distribution of water at pavilion 2 (CPPON) are made of PEHD and are provided with Dn 63 mm.

Manholes with isolation valves and drain/vent valves are provided on the distribution network. The permanent pressure in the distribution network is 6 atm. and it is ensured by means of housewater supply plants (hydrophores), powered by electric pumps that operate automatically according to needs. The drinking water distribution network provides the drinking water supply to the Administrative Building and Pavilion 2.

The drinking water distribution network is common for both the conventional and the nuclear parts of the plant.

Storage – Drinking water tanks

On the Cernavoda NPP premises, 2 (two) tanks made of reinforced concrete are provided, sized for the maximum daily flow required for 5 nuclear units, provided with a storage volume V = 1000 m^3 each.

The hydraulic installations in the valve room related to the tanks consist of:

- inlet pipe: Dn 200 mm;
- overflow pipe: Dn 250 mm;
- outlet pipe: Dn 400 mm;
- drain pipe: Dn 150 mm.

Any leaks produced in the valve chamber are collected in the basins – gutters, from where they are evacuated to the rain sewer, with the help of a drainage pump (1-7150 - P008).

In the control room in the Drinking Water Pump Station, optical and acoustic signals are provided for the maximum level allowed, the intermediate level corresponding to the emergency reserve, the minimum water level in the drinking water tanks and the functioning of the electric pump EPEG - 7150 - P008 in the emptying tank.

Of the two storage tanks, one is in service, and the other is kept clean, isolated, drained. The transition from one reservoir to the other is done at most every six months or whenever necessary (e.g. if the results of the physical-chemical analyze regarding the quality of the underground water do not correspond to the provisions of the regulatory acts, respectively in accordance with Law 311 /2004 for the amendment and completion of Law 458/2002 on the quality of drinking water).

Tanks are disinfected with sodium hypochlorite (NaOCl) solution).

Drinking water tanks are drained to the rain sewer.

Measurement and control installations

To control the operation of the pumps, level and pressure transducers are installed on each well.

Periodically, Cernavoda NPP reports to ANAR the status of the allocations regarding the volumes of water taken from the supply sources.

Operation of the drinking water system

According to the operating manuals: 0-1-71500-71510-71540-OM-001 – Drinking water operation manual and 2-71500-OM-001 – Drinking water distribution system operation manual, the operation is done as follows:

Normal operation

The electric pumps in the Drinking Water Pumping Station absorb the water from the storage tanks and push it into the distribution network. The pumped fluid (drinking water) is accumulated in the hydrophore type containers, compressing the existing air cushion above the water, up to the maximum limit value of 7 bar. When this pressure is reached, the electric pumps stop, and the consumption in the premises is ensured from the reserve accumulated in the pressurised containers.

Electric pumps start as follows:

- at 6 bar pressure 1-7150 - P1;
- at 5.5 bar pressure 1-7150 - P2;
- at 5 bar pressure 1-7150 - P3 (stand-by).

Pumps 1-7150-P4 and 1-7150-P5 are in reserve or under repair. The stop pressure of all electric pumps is 7 bar. The air cushion above the water in the pressure tank container is provided by an electro compressor, which is put into operation manually, whenever it is needed.

Operation in failure situation

The possibility of a breakdown on the drinking water distribution network does not pose the problem of a total interruption of the supply of drinking water to the facility within the plant premises, becuase the network is provided in gridiron system carrying water to any spot from more than one direction.

In the event of a malfunction at the underground source of water supply to Cernavoda NPP, there is the possibility that all consumption points will be temporarily supplied with water from the water reserve constituted by the storage tanks (each with a volume of V= 1000 m^3) and from the three 5m^3 pressure tanks in the house water supply plant.

b) Technological water

The technological (industrial) water supply source of the Cernavoda NPP objective is the Danube River - race I of the Danube - Black Sea Canal, through the derivation channel, upstream of the Cernavoda lock's holding port

The degree of assurance of the use of raw water, for technological purposes for Cernavoda NPP, from the Danube is 97%.

Cadastral code for the water intake:
XV-1.010b.00.00.00.0 (B.H. Litoral), Hm 604 (race 1 Danube– Black Sea Canal).

The most important tributary of the Danube in Cernavoda zone is Carasu River on which the Danube-Black Sea Canal (CDMN) was built. The canal starts near the town of Cernavoda and goes alond the former Carasu Valley. In front of Cernavoda NPP, the channel forks, on one of the branches is the derivation channel used for cooling water at Cernavoda NPP, and on the other branch a watergate is installed.

The Cernavoda and Agigea locks divide the CDMN into three distinct races/biefuri, namely:

1) race 1 – between km 64+410 (km 0+000) and the upstream head of the Cernavoda lock, with a length of 4.105 km, having a direct connection to the Danube, and the water levels correspond to the free flow regime on the Danube;
2) race 2 - between the downstream head of the Cernavoda lock and the upstream head of the Agigea lock, with a length of 57.991 km, the water levels being characteristic of the CDMN operating regime;
3) race 3 – between the downstream head of the Agigea lock and the waters of the Constanta Sud seaport, with a length of 1.510 km, and the characteristic levels are those of the Black Sea at Constanta.

- Characteristics of the area of detachment from the Danube: opening to the Danube at normal level: 400 m; abstraction with free level; trapezoidal section; bottom share = - 1.50 mrMB; the water depth is 8.00 m at average level on the Danube and 4.50 m at minimum level; the longitudinal speed for the discharge of flood flows is 0.9 m/s; the passing over flows – at average level on the Danube: 500 - 600 m^3/s, and at minimum level: 227 - 257 m^3/s.
- The canal route – includes 17 alignments with a total length of 44.3 km and 16 curves with a total length of 20.1 km.

The water intake - *through the constructions and installations related to taking water from the Danube river source* - and **the water supply system from the source to the consumer**, ensures the necessary cooling water specific to the operating regime, at maximum power as well as for keeping the two units of the plant U1 and U2 in off state, under guaranteed safety conditions.

The technological water is used within the Cernavoda NPP as follows:

- ***condenser cooling water***: Q_{max} = 92.0 m^3/s (total, for both nuclear units);
- ***technical service water for cooling some equipment, other than the condenser:*** Q_{max} = 15.66 m^3/s (total, for both nuclear units);
- ***backup service technical water*** – in the case of unavailability of the technical service water system - provides an alternative source of cooling for the backup Diesel generators and for the heat exchangers (chillers), related to the chilled water system (through the 4 pumps that provide Qexpl = 420 m^3/h) (only in U1);
- ***water for emergency situations:*** by means of 4 pumps with Qinst = 114 l/s (two pumps corresponding to each nuclear unit);
- ***water for extinguishing fires*** - Qie = 0.155 m^3/s, included in the flow rate taken as cooling water. The flow is taken only in case of fire and/or when restoring the intangible volume of fire water);
- ***water for the production of demineralized water*** (after the exit from the turbine condensers) used in different systems of the plant, clarified water and internal consumption, Qmax = 0.140 m^3/s.

The major process circuits for each nuclear unit of Cernavoda NPP are:

- Primary heat transport circuit (C1)
- Moderator Circuit (C2)
- Condensate and Steam Generator Feed Water Systems (C3)
- Intermediate Cooling Circuit (C4)
- Condenser Cooling Water Circuit (C5)
- Technical Service Water Circuit (C6)

The first two circuits (C1, C2) are closed and use heavy water as a heating agent, circuits C3 and C4 use demineralized water, and circuits C5 and C6 are open circuits that use Danube water.

The adduction system ensures the transport of water to the distribution bay through an open adduction channel, provided with L = 370 m with trapezoidal section, with the base width 34 m, bottom elevation -1.00 mdMB, slopes 1:4.5 protected with anchorages posed on a fascine mat and a reverse filter. The crowning of the contour dykes is at +13.5 mdMB elevation, and the 2 m wide berms at +7.5 mdMB and +10 mdMB elevations respectively.

The distribution bay allows the uniform access of water to the screen house related to the plant units. The distribution bay is bordered by slopes identical to those of the adduction channel which close on the side retaining walls of the screen house.

The screen house has the role of ensuring the mechanical cleaning of raw water necessary for cooling the condenser and heat exchangers (circuits C5, C6) and is provided with mechanically raking course and fine screens set at a steep angle with the horizontal provided wioth rakes which sweep the screen area, cofferdams for stream partitioning and rotary strainers cleaned with brushes.

The technological water, after the mechanical removal of coarse solid suspensions, is directed to the Pump House from where it is pumped into the Machine Room to ensure the cooling of the condensers and other consumers and heat exchangers, related to the plant's systems.

The execution of the intake with free level was established on the basis of studies on the model and had in mind the intake of water from the Danube with minimal hydraulic losses, at water levels in the Danube coresponding to the elevation + 2.75 mdMB.

In case of increases in the Danube's water level above the + 3.00 mdMB level, and water flows higher than 400 m^3/s, the effect of taking water from the Danube for the use of Cernavoda NPP is insignificant.

Condenser cooling water *(Qmax = 92.0 m^3/s)* – is directed from the Pumping Station to the Machine Room, by means of two metal pipes, embedded in concrete, with a diameter of Dn3600 mm, interconnected with a connecting strap of a diameter of 2800 mm, with separation valve to ensure flow balance on the two pipes.

In order to provide cooling water for U1 and U2, the circulation water pumping station related to the *Condenser Cooling Water Circuit* - (C5) is equipped with 8 electric pumps type NMV2000 RA, each having Qinst=11.5 m^3/s, H=12÷24.2 mCA and n=295 rpm. (4 pumps for each unit).

The condenser cooling water circuit – C5, within Unit 1 – C5 has the following equipment:

- 4 course screens 1-7111-STR 001+004 of 4.5 x 4.00 – 60/3
- 4 cofferdams for insulation 1-7111-BA 001 +004
- 1 rake for cleaning course screens – common for Unit 1 and Unit 2
- 4 fine screens with rotary brushes 7111-STR 021+024 of 5 x 5.00 x 5/3 each
- 4 rotary strainers 1-7111-SC 001+004 with stainless wire mesh with 4x4 mm mesh
- 4 cofferdams 1-7121-BA 001-004 for the isolation of the strainer’s rooms
- 1 screen washing installation Qmax = 100 m3/s and floating discharge – common for U1 and U2

Technical service water for cooling some equipment, other than the condenser: Qmax = 15.66 m^3/s - is directed, by pumping from the Pumping Station to consumers, by means of two metal pipes with a diameter of 1500 mm, interconnected and embedded in concrete.

- In order to provide technical service water for U1 and U2, the technical water pumping station for the Technical Water Circuit - (C6), is equipped with 8 electric pumps type NMV1000 RA, each having Qinst = 2.61 m^3/s, H = 25 ÷40 mCA and n =740 rpm. (4 pumps for each unit).

Unit U1 - **Technical water circuit - C6 within Unit 1 has the following facilities:**

- 2 course screens1-7111-STR 005+006 de 4.5 x 4.00 – 60/3
- 2 cofferdams for insulation 1-7111-BA 005 +004
- 2 raking screens on an inclined plane 1-7111-STR 011+012 de 5 x 5.00 x 5/3
- 2 rotary strainers 1-7111-SC 005+006 with stainless wire mesh with 2x2 mm mesh
- 2 cofferdams 1-7131-BA 001-002 for the isolation of the strainer’s rooms.

Backup technical service water - it exists only at U1 and its main function is to provide an alternative source of cooling water for the chillers and back-up Diesel generators, in the event of the unavailability of the technical service water system.

The system is supplied with filtered technological water, taken from the suction sump of the fire water system pumps, through a pumping station equipped with 4 centrifugal type pumps, each having Q=420m^3/h, P=93.5kW, n=1470rot / min. This collector is connected to the suction basin of the technical service water (main supply) and to the distribution basin (stand-by supply). The transportation of technological water from the pumping station to the stand-by water supply system is done by means of two branched pipes, having a diameter of 400 mm, which join before the water treatment station, in a collector with a diameter of 500 mm. The chemical water treatment station is supplied with technological water on the same route.

Emergency Water – The emergency water supply system is a system with a nuclear safety function. The Danube water the is abstracted through the distribution bay. The emergency water supply system ensures the removal of residual heat in the event of failure of the normal heat removal systems. The system provides an independent source of water for the steam generators, the heat exchangers in the core failure cooling system and for supplying the primary heat transport system. In order to provide water for U1 and U2 in case of failure, the system is equipped with 2 pumps, type NMV 253 x 3, located in the EWS pump building, each with a flow rate Q inst= 114 l/s each (respectively 456 l /s for 2 units), Hp = 79.2 mCA, N = 140 kW, n = 1500 rpm, having the minimum allowed flooding of 1650 mm, which ensures the distribution of the raw water needed for the systems served by the water supply system in case of failure.

The supply pipe Dn 914 mm ensures the connection between the distribution bay and the suction common well of the pumps. Suction is done from two separate compartments, each compartment being equipped with one pump that serves U1 and one pump that serves U2. The discharge manifolds are buried from the EWS building to the service building, where they branch off to supply the serviced heat exchangers (ECCs) and steam generators.

During the normal operation of U1 and U2, the system is in standby mode.

Water for extinguishing fires - Qie = 0.155 m^3/s – The source is the water abstracted from the Danube, taken either from the derivation channel after passing through a mesh filter with Φ 0.5 mm, or after passing it through the rotating bolters related to the water system service technique, and Brassert filters related to the fire extinguishing water system.

The fire water is stored in 2 tanks made of concrete with V = 1500 m^3 each and represents the intangible fire reserve for the entire Cernavoda NPP platform.

The fire water network also ensures the supply of the Administrative Pavilion, through PEHD Dn 110mm connections.

The fire extinguishing water system provides fire protection by supplying fire extinguishing water to the following areas:

- Administrative pavilion U1+U2 (Pav. 0),
- Administrative building U1 (Pav. 1),
- Personnel Training Center (Pav. 2),
- Reception area (Pav. 9),
- Unloading station LLF,
- Pavilion 3 (Mechanical Shop),
- Temporary containment space for radioactive industrial waste,
- Intermediate Solid Radioactive Waste Storage Facility
- Unit 0 (STA, CTP),
- Electric Unit,
- 110 kV Station,
- Transformers area,
- U1 and U2.

The recovery flow of the intangible fire reserve is Q = 200 – 400 m^3/h.

The recovery time of the intangible fire reserve is 7.5 ÷ 4 hours/tank.

The external supply network is annular and is sized to maintain a pressure of 9.5÷10.3 atm. The external network is provided with external fire hydrants, with Dn 100 mm and/or 150 mm, Pn 10 atm, isolation valve manholes, mobile means connection manholes and fire extinguishing surface hydrants.

In order to improve the response to a severe accident, new lines, seismically qualified, independent of the routes provided by the project, were installed both at U1 and U2, for:

- the supply of demineralized water to the spent fuel storage bay (BCU);
- the backup supply from the fire extinguishing system of the spent fuel storage bay (BCU).

These lines ensure the water supply from the fire extinguishing system of BCU-U1 and BCU-U2, in the event of a severe accident, from outside the services building, through the inlet connections to which fire hoses are connected in order to supply either with the help of the fire truck, or with the help of motor pumps directly from the suction basin.

In case of interruption of the electricity supply, the motor pump, operated by a Diesel engine, will automatically start, which allows the supply of water to extinguish the fire, if necessary.

Two water storage tanks are planned to be built, additional to the existing and regulated reserve on the Cernavoda NPP site, by setting up the infrastructure of the objectives that will serve the specific activities of the RT-U1 subproject.

Additional water supply for the fire will be equipped with a pumping station, which will be set up in the area of new objectives specific to the sub-project RT-U1.

Circuits C1-C4 are closed circuits and use heavy water or ***demineralized water*** as heating agent, and circuits C5-C6 are open circuits and use water from the Danube River.

The C4 intermediate cooling circuit is a closed system, filled with demineralized water, chemically conditioned (hydrazine, morpholine addition) for corrosion protection. The circuit has the role of taking over the heat generated from the basic technological circuits, during normal operation: the moderator circuit, auxiliary systems of the circuit of the primary heat transport agent, etc.

Water for the production of demineralized water – The supply water of STA is the circulation water (raw water from the Danube River), after leaving the condensers, during the winter period.

This is taken after the condenser with the help of 6 pumps (three for each unit) located in the turbine building at the height of 93 mdMB and directed through a pipe with a diameter of Dn500 mm located on the technological overpass, being then stored in two related STA raw water tanks, each with a capacity of 100 m^3.

During the shutdown of the nuclear units, the intermediate circuit ensures the full recovery of the heat generated by all energy consumers. The heat is taken by the demineralized water from the circuit (C4) and transferred to the technical service water circuit (C6).

During the summer time, the Danube River water delivered through the backup technical water system is used.

The volumes and water flows authorized for the operation of the 2 units in a permanent regime 365 days/year and 24 hours/day are:

$Q_{\text{daily maximum}}$ = 9331200 m^3/day (108000 l/s) $V_{\text{annual maximum}}$= 3405888 thousand m^3

$Q_{\text{daily average}}$= 6863616 m^3/day (79440 l/s) $V_{\text{annual average}}$= 2505220 thousand m^3

The influent and effluent water temperature measurement points, as well as the measurement frequency, are in accordance with the provisions of the Protocol on the methodology of monitoring the use of water resources and receiving waste water in water resources, concluded between the Water Basin Administration Dobrogea Litoral Constanta– Cernavoda NPP and which is part of the water management authorization.

Water treatment systems abstracted from the Danube river and used for technological purposes

Water abstracted for industrial purposes from the surface source of the Danube River is carried on through the intake with a free level on the derivation channel of the Danube-Black Sea canal - Race I.

The supply system allows the transport of water through the open adduction channel provided with the length of L = 370 m, base width 34 m, bottom elevation -1.00 mdMB, slopes 1:4.5 protected with anchorages placed on a mattress of fascines and reverse filter up to the distribution bay.

The crest of the contour dykes is at +13.5 mdMB elevation and the 2 mm wide berms are at +7.5 mdMB and +10.0 mdMB elevations.

The Distribution Bay ensures the connection between the adduction channel and the screen house, the access of water to the screen house being uniform.

The Distribution Bay is bordered by slopes identical to those of the adduction channel which close on the side retaining walls of the screen house.

The Chemical Water Treatment Plant (STA) produces, stores, and delivers demineralized water to be used in various systems of U1 and U2.

The water treatment system consists of the pretreatment of the raw water, by dosing ferric chloride and coagulation aids and filtration, followed by the demineralization of the pretreated water through ion exchange technology.

The inputs to the STA are as follows:

- raw water through a pipe Dn 500 mm, installed underground and above ground on the main overpass, between Engine room U1÷U2 and STA;
- steam from the Thermal Power Plant (CTP) on the Dn 150 mm pipe;
- steam from U1 on 2 pipes Dn 300 mm each, with a flow rate of 7÷10 t/h steam, 6 atm, 185ºC;
- compressed air (service) on a Dn80 mm pipe.

The outputs from the STA are the following:

- totally demineralized water, through 2 pipes Dn250 mm, between STA and U1÷U2;
- totally demineralized water, for addition, through a Dn150 mm pipe between STA and CTP;
- neutralized water discharged through 2 Dn250 mm pipes, between the STA and the siphon basins;
- water from overflowing raw water storage tanks, discharged into storm sewers;
- filtered water for equipment cooling through 2 pipes Dn250 mm, between STA and Pump House;
- filtered water for cooling bearings through a Dn80 mm pipe, between STA and CTP.

Through the modernization of the STA installation, the volumes of processed raw water did not change and the authorized discharge indicators were completed for the two new products introduced in the modernization stage. The modernization of the STA included changes compared to the original installation and concerned the following systems, as follows:

- The STA is operated according to the operating manuals and approved procedures for the STA-71610, 71620, 71630, 71660, 71680 systems.
- Pretreatment of raw water is carried out in two stages: clarification and filtration.

Pretreatment system: *lime removed from the pretreatment technology*.

- the slurry is recirculated via clarifiers and the excess is discharged intermittently from the system to the siphon basin, along the existing route (maximum flow rate 5 m^3/h);
- the multilayer filters are equipped with plates with nozzles and sand catchers, thus avoiding sand escapes;
- the waste water resulting from washing the multilayer filters is recovered via clarifiers;
- filtered water is distributed to consumers (to the demineralization and to the Pump House) by separate pumps;
- the technological process is controlled through the SCADA automation system, which involves much reduced operating maneuvers, and the information about the process and physico-chemical parameters, implicitly the state of the equipment, is provided to the operators, in real time;
- manual operation is greatly reduced and equipment reliability is greatly improved.

Pretreatment Reagent System:

- *the facilities for storing hydrated lime, preparing and dosing lime milk are no longer used;*
- *the existing facility for preparing and dosing $FeCl_3$ 2% solution is no longer used;*
- the coagulation aid (polyelectrolyte) preparation and dosing facility is provided: Flocculant Praestol A3040L;
- a NaOH dosing facility is provided in the filtered water distributed at the Pump House to control the pH within the specified limits;
- a Nalco 3D Trasar 3DT149 antiscalant dosing installation is provided, to eliminate temporary hardness;

- equipment/path disinfection facility by dosing with sodium hypochlorite (1-2 times/year), when the increase in the content of organic substances in the supply line of the biofilters in the demineralization system is observed;
- the dosing of reagents is automatically controlled by the SCADA automation system, being correlated with the established process parameters.

The Demineralization System includes:

- the biofiltration facility for removing biopolymers from the filtered water (three biofilters mounted in parallel, average processed flow = 125 m^3/h);
- two degassers with four air blowers and two air filters to remove CO_2 from decationized water;
- three scavenger columns for retaining organic substances before anion exchangers;
- the regeneration of ion exchange columns is done by backward flow, the volumes of regenerants used and those of the resulting waste water are lower than those of the replaced installation;
- demineralized water storage tanks are made of stainless steel, to preserve the quality of totally demineralized water;
- the technological process is controlled automatically, through the SCADA automation system, which leads to much reduced operating maneuvers;
- the equipment replaced is reliable, maintenance activities being greatly reduced.

Resin regeneration system:

- the modernized plant uses 32% HCl solution, respectively 48% NaOH for ion exchange resins and saturated solution for scavenger resin regeneration, and the regenerants are automatically dosed directly from the storage tanks through the SCADA automation system.
- efficient HCl vapor collectors are used;
- mobile ion-exchange resin transfer vessels and facilities for their cleaning (biofouling) are provided once every 3-5 years of operation (two storage tanks and two dosing pumps 0-224 l/h for dosing peracetic acid 0.2%).

The neutralization system

- homogenization of waste water is greatly improved due to the nozzles provided in the neutralization tanks;
- pH control of the neutralized waters is done automatically, including the dosing of the neutralizer, their evacuation and control being monitored by the process computer of the automatic SCADA system.

The service ***compressed air*** from the two existing tanks in the non-modernized installation ensures the consumption in the stage of loosening the filters, in the stage of mixing resin masses from the mixed bed for regeneration and fluid for the transfer of reagents (HCl 32%, NaOH 48%, $FeCl_3$ 40%) from the car tanks to the tanks on the chemical storage platform.

The instrumental air is a new system provided for the supply of automation and control components in the modernized plant (two compressors, a storage vessel, a compressed air drying device, a filtration system).

SCADA system – new system that is provided with a process computer to control the automated operation of plants and processes.

In order to control the quality of the water distributed and of the wastewater discharged from the STA, automation loops are provided to continuously ensure compliance with the specified technical requirements.

The filtered water for the cooling circuits in the Pumps House is conditioned to prevent deposits in pipes, equipment, components. To maintain the pH of the cooling water in the range of 7 ÷ 8.5, a NaOH dosing unit with two dosing pumps 0-7166-P-N7.1 P-N7.2 is provided; the control system automatically puts one of them into operation if the pH value of the filtered water becomes lower than 7 units.

Conclusions regarding the provision of water supply required for the RT-U1 and DICA MACSTOR 400 project

- ***Ensuring water supply in the Project Implementation Stage – which takes place in two distinct intervals, respectively:***
  - *The setting up and execution phase of the infrastructure and support constructions for the project, which includes the design of DIDR-U5, constructions within DICA – MACSTOR 200/400 modules, construction of necessary RT-U1 support buildings; (starting with the year 2025).*
    On site, U1, U2 and DICA-MACSTOR 200 are in operation.
  - *U1 Shutdown, retubing and tests phase, which includes: DIDR-U5 in operation, DICA MACSTOR in operation, U1 shut down for retubing, U2 operating, constructions at DICA-MACSTOR 400. (2027 – 2029).*

it will be done from the existing water supply system at the Cernavoda NPP site, by connecting the consumption points to the existing network.

The activities in the refurbishment phase (*U1 shutdown, retubing, tests*) will mainly take place inside Unit 1, and the existing facilities related to the water supply system will ensure the water requirement for the specific consumption of these refurbishment activities.

Ensuring the water supply necessary for the set-up activities of the new DIDR-U5 will be made from the existing local system on the Cernavoda NPP site, by extending the water distribution system to this facility.

The water supply required for the extension activities of DICA-MACSTOR 400 will be done under the same conditions as in the case of the execution of MACSTOR 200 type modules, from the local water supply system provided on the site, in the area of the current DICA warehouse, as regulated in the current *Water Management Authorization No. 72 of September 6, 2021 amending Authorization No. 58/01 July 2021. (attached to this documentation).*

The water supply for extinguishing fires - will be made from the same source, as regulated in the *Water Management Authorization No. 72 of September 6, 2021 amending Authorization No. 58/01 July 2021. (attached to this documentation),* the water being abstracted from the Danube River, taken either from the derivation channel after passing through a mesh filter with openings of 0.5 mm, or after passing it through the rotating strainers related to the technical water system service, and Brassert filters related to the fire extinguishing water system. The fire water is stored in 2 tanks made of concrete with V = 1500 m^3 each and represents the intangible fire reserve for the entire Cernavoda NPP platform.

- ***Ensuring the water supply in the operation stage of the refurbished U1 and DICA-MACSTOR 400, will be done as follows:***
  - For the operation of the refurbished U1 - from the current water supply system provided within the U1 Unit, through the same existing supply points and provided for in the current regulatory document issued by ANAR.
  - For the operation of the new DIDR-U5 - by connecting to the current water supply system provided at Cernavoda NPP site, by expanding the distribution system of the water supply network.
  - For the operation of DICA MACSTOR 400 - from the current water supply system provided on the site, through the same existing supply points and regulated in the current act to be issued by ANAR *

    Note* – *In the case of DICA MACSTOR 400, the water requirement will be specific to the hygienic-sanitary consumption of the personnel as well as to ensure the fire reserve related to the DICA warehouse. (no technological water consumption is required for the operation of this objective).*

Water supply for firefighting - The operation stage of the refurbished U1 and DICA-MACSTOR 400 will be done on the one hand, from the same source, the Danube, by storing in 2 existing tanks made of concrete provided with V = 1500 m^3 each, for the entire platform Cernavoda NPP, as regulated in Water Management Authorization No. 72 of September 6, 2021 amending Authorization No. 58/01 July 2021. (attached to this documentation**) to which 2 fire water storage tanks will be added, which will ensure the fire reserve for the new facilities and equipment resulting from the Project.**

1.7.5.2 Water evacuation

Currently, the discharge of water - domestic, technological and rainwater - generated by the operation of objectives U1, U2 of Cernavoda NPP and the Intermediate Spent Fuel Storage Facility (DICA) is regulated by the following acts:

- Water Management Authorization No. *72 of September 6, 2021* amending Authorization No. 58/01 July 2021. *(attached to this documentation).*
- Water Management Authorization No. 94 of 28.06.2022, regarding "Cernavoda Spent Fuel Intermediate Storage (DICA)", issued by ANAR, ABADL.

a) Domestic wastewater - not radioactively contaminated

Currently, domestic wastewater - not radioactively contaminated - generated from the activities related to the RT-U1 sub-project, will be discharged through the same systems as during the normal operation of U 1, they are directed by gravity to the Pumping Station 7175-SP1 (equipped with 2 +1 pumps with Q=92.5 m3/h, Hp= 36 mCA), located in the premises of Unit 1, from where domestic water is pumped into the Pumping Station 7175-SP2 (equipped with 3+1 pumps with Q= 80 m3/h , H= 20 m), located between Units 3 and 4. From SP2 domestic wastewater is directed by pumping to the pumping station - SP "Valea Cismelei" of the city of Cernavoda, for the final evacuation into the urban sewerage network of Cernavoda town.

b) Technological wastewater

- **Technological wastewater that does not require purification**

The technological waste water resulting from the Cernavoda NPP activities, through the operation of U1 and U2, is represented by ***the technological circulation wastewater and warm technical water.***

The evacuation of hot technological water that does not require purification is done as follows:

- through channel and circulation water drainage pipes, siphon basins and special manholds;
- through ducts and hot technical water discharge pipes;
- through the hot water-cold water mixture channel for injection during the cold periods of the year;
- through warm water drainage tunnels to the Danube River.

The evacuation of the hot water from the condenser (C5 circuit) is done by means of 6 pipes with a diameter of Dn 2000 mm, connected to 2 pipes with a diameter of Dn 3600 mm. These pipes are continued with a box channel with a volume of $30m^3$ (2x3x5 m) that ensures the connection to the channels in the "U" string. These channels, by means of the siphon basin and valve chambers, allow the evacuation of hot water, either: in the second race of the Danube - Black Sea Canal, or to the Danube River.

The time to switch from one outlet to another is approx. 30 minutes.

The two warm water discharge channels in the second race of the Danube - Black Sea Canal are sized for the operation of 4 nuclear units. The channel through which hot water is discharged from Units 1 and 2 has a length of approx. 850 m, with a section of 5.5 x 6.0 m, and continues with an open channel provided with a volume of 136 m^3 respectively (2 m x 8m x 8.5m), on which the Hydroelectric Power Plant for S.C. Hidroelectrica S.A – Buzau Hydropower Branch is located.

The hot water - cold water mixing channel for injection is located at the boundary of Unit 1 premises, and it is made of a metal pipe with Dn 3600 mm, embedded in concrete. The channel length measures approx. 400 m. Warm water outlet in the Distribution Bay is done through a reinforced concrete channel provided at the bottom of the intake channel, with water directing windows to the circulating water and technical water Pumping Station

The evacuation of the cooling water from Units 1 and 2 in the Danube (during normal operation) is done through a circuit made up of boxes, tunnel (L = 2780 m, D = 5.4 m), concrete open channel type and earth channel with outlet in the Danube. The circuit starts from the siphoning basin I, undercrosses Valea Cismelei, the hill between Valea Cismelei and Valea Seimeni and continues at the base of the left slope of Valea Seimeni. After crossing the Cernavoda - Harsova road, it crosses the Danube Meadow and flows into the Danube at Km 296+000.

The circuit is dimensioned in such a way as to ensure the evacuation of a flow of 100 m^3/s on a gallery lane (with the role of taking over all the flows from the simultaneous operation of 2 nuclear units).

The circuit consists of: a double box section with a section of 5.75 x 5.75 m through which the connection is made with the valve box in Valea Cismelei, which has the role of connecting the upstream and downstream races.

The discharge of the technological wastewater is as it follows:

I. In normal operating situations:
- in the Danube River, through the gallery, canal and Seimeni Valley
- in the second race of the Danube-Black Sea Canal, with the approval of the "Romanian Waters" National Administration and the Dobrogea-Litoral Water Basin Administration, as well as with the acceptance/permit/notification of the other competent authorities according to the legal provisions (National Company "Administration of Navigable Channels " S.A., authorities from the Ministry of Health, etc.)

The regulatory act regarding ***"Water supply for and wastewater discharge from units U1 and U2 of Cernavoda Nuclear Power Plant",*** issued by ANAR - The supporting technical documentation was issued in April 2021 and provides the following sections for the discharge of technological wastewater:

- in the Danube River - normal situations
  XIV – 1.000.00.00.00.0 (Danube)
  hectometer 779 (Danube)
- in CDMN – normal situations
  XV – 1.010B.00.00.00.0. (Litoral)
  hectometer 594 (race 2 Danube – Black Sea Canal)
- în CDMN – situații de avarie (by Cișmelei Valley)
  XV – 1.010B.00.00.00.0 (Litoral)
  hectometrul 611 (race 1 Danube – Black Sea Canal).

All hydraulic constructions related to the arrangement of waste water discharge sections are classified in the first class of importance and in category 1 according to STAS 4273/83.

During the winter period, a fraction of the warm water flow (25%÷70%) is discharged into the Cernavoda NPP Distribution Bay, with the aim of preventing the formation of ice brashes. The evacuation is done under special conditions, only with the notification of the representatives of the National Administration "Romanian Waters", as well as of the Dobrogea Water Basin Administration - Litoral and the National Company " Administration of Navigable Channels " S.A., based on the mutually agreed procedures, without the thermal influence of the water from the derivation channel and from race 1 of the Danube - Black Sea Canal.

II. In situations of failure of the discharging systems
- in race II of the Danube - Black Sea Canal and in the Danube River:
- in race I of the Danube - Black Sea Canal, through the Cismelei Valley.

Evacuation of cooling water from Units 1 and 2 into the Danube (in case of failure):
The sluice house is equipped with a side spillway for discharging warm water into the Danube and the Danube - Black Sea Canal through bief II, for short periods.

- **Technological wastewater that requires purification**

The technological wastewater resulting from the area of the liquid fuel household, before being discharged into the rain sewer, is passed through a liquid fuel separator, and the meteoric waters and those from the inactive drainages in the premises are passed through a grit chamber before being discharged into the Distribution Bay.

c) Rain water

The evacuation of rainwater from the Cernavoda NPP objectives is regulated by the following documents:

- Water Management Authorization No. *72 of September 6, 2021* amending Authorization No. 58/01 July 2021. *(attached to this documentation).*
- Water Management Authorization No. 94 of 22.06.2022, regarding "Cernavoda Intermediate Spent Fuel Storage Facility (DICA)", issued by ANAR, ABADL

Cernavoda NPP has a contract with SC RAJA SA Constanta for the supply from and for the discharge to the public supply/discharge system.

The sewage system is partitioned. The rainwater drainage system is sized for the evacuation of rainwater collected on the platform of five initially designed nuclear units, to ensure the evacuation of a flow rate of 3.2 m^3/s. The main rainwater collector is provided with dimensions between 1200 mm - 1600 mm.

The rainwater sewage network ensures the evacuation of the following types of water:

- washing water from drinking water filters;
- rainwater from roofs, roads and platforms, access ways;
- water from the washing of hydrogen tanks (accidentally) or rainwater from the surface of the hydrogen storage;
- waters from the washing of biofilters, overflows from the demineralized water tanks and filtered water from the modernized Chemical Water Treatment Station;
- condensate, drainage, ventilation from auxiliary boilers (CTP);
- water from the underground water inside the protective screen that surrounds the nuclear buildings;
- inactive drainages from the Turbine Building (U1, U2), from the siphon basin (U1, U2), Back-up Diesel Building (U1, U2), Cooler Building (U1, U2);
- drainage of accumulated water in the ground and under the foundation of the Services Building (U1, U2) and under the radiator (U1, U2).

Based on the regulatory act in force, ***rainwater***, including that from underground drainage (water drainage from the underground water), is collected through a main collector, from where it is discharged into the Distribution Bay of Cernavoda NPP, after passing through a settling tank provided upstream of the final collector.

The evacuation of rainwater from the collector into the Cernavoda NPP Distribution Bay is done through a metal pipe provided with Dn 1600 mm.

The drainage of the water collected in the storm sewer of Unit 2 is done through the water sewer system of Unit 1.

The rainwater accumulated in the soil around and under the foundations of the Reactor Building and the Services Building (U1+U2) is directed by gravity into the basins, from where it is subjected to analysis from the point of view of radioactivity (gamma and tritium analysis) and is finally discharged in the storm sewer only if the results of the analyzes do not indicate a radioactive level, above the limits, of these types of water.

In the case of the presence of radioactivity in the composition of these types of waters, the waters are pumped into the management system of low and moderately radioactive liquid waste.

Other wastewater treatment and control facilities

Drainage systems - *with the role of draw off underground water*, related to buildings with various functions:

- external screen and drainage - related to the main buildings of each unit;
- at the spent fuel storage bay;
- at the reactor building;
- at the Spent Fuel Intermediate Storage Facility;
- at the radioactive waste collection centres;
- at the fuel household for the Start-up Thermal Power Plant;
- at the fuel household related to the back-up Diesel groups.

a) Screen and external drainage

Control of the circulation of underground water and protection against variations in the groundwater level in the nuclear part of each unit is carried out through a shielded protective enclosure (reinforced concrete screen) around the building, executed between the surface of the land (elevation 15.80 mdMB) and layers of impermeable marl. The shielded enclosure was made by cement injections up to 40 m deep, in the limestone layer and concrete in the upper layer of fillings. The evacuation of water from inside the premises U1, respectively of Unit 2, is done through a pumping drainage system (capable of evacuating a maximum flow of approx. 20 ÷ 40 l/s for two units). The waters are evacuated outside after the radioactivity analyzes (tritium and gamma) are carried out. In case of accidental contamination, the waters are transferred to the liquid radioactive waste management system and the causes of the contamination are investigated.

Each unit is provided with its own drainage system, composed of:

- collector system, consisting of 6 wells drilled at U1 and 7 wells drilled at U2, executed in a hydraulic system, with a maximum depth of 40 m, with reverse circulation. Each borehole consists of a reverse filter, a filter column equipped with slots for the collection of underground water, a final column for strengthening the wall, supporting the filter and the pumping equipment;
- hydraulic installations equipped with 3 submersible electric pumps at U1 and 4 electric pumps at U2, fittings, passage valves with valve for sampling, water gauge with counters, pressure indicators and level indicators;
- 11 piezometric wells (measuring the water level in the underground water) at U1 and 8 wells at U2, located inside and outside the screened enclosure;
- collection and evacuation pipes;
- electrical automation installations.

All signals are displayed both in U1 and U2 on local panels and the pumps can be controlled manually. The automation system ensures the operation of the pumps as follows:

- pump shut-down: in the range -9.7 mMB (U1) and -5.00 mMB (U2);
- pump start at level: 8.00 mMB (U1) and 8.50 mMB (U2).

b) Drainage at the nuclear auxiliary services building

Drainage at the services building is carried out in two stages: collection and evacuation.

The water is collected through a network of PVC pipes Dn 160 x 7.7 mm perforated at the bottom, which are placed under the CSAN in the permeable material between the level of the floor at 93.90 mdMB and leveling concrete at the level of 90.20 mdMB. The location quotas are from 92.95 mdMB to 91.40 mdMB. These pipes flow into the well no. 1 of CSAN (Nuclear Auxiliary Services Building). The discharge in the well is at the rate of 91.40 mdMB.

The discharge of water from the well is through steel pipe of Dn 114.3 x 6.02 mm to the liquid radioactive waste treatment system.

c) Drain at the spent fuel pool

The water in the spent fuel intermediate pools (Spent Fuel Unloading Pool and Spent Fuel Transfer Pool) is demineralized water, circulated in a closed circuit, to ensure its cooling and purification. The maintenance of the water inventory in the basins is achieved through the periodic addition from the Demineralized Water Distribution System, in order to compensate for losses through evaporation. The chemical control of water is carried out by mechanical and ionic purification through filter columns, in accordance with the requirements of the Chemical Control Manual, OM-78210/34410.

In the event of the need to drain the basins for maintenance works (repairs of walls or epoxy protection), they are isolated from the spent fuel and defective fuel storage basins, and the water is transferred to the Liquid Radioactive Waste Management System and processed according to the requirements of OM- 79210. Drainage at the spent fuel tank is carried out in two stages: collection and evacuation. Water collection is done through a PVC pipe, Dn 160 x 7.7 mm, perforated on the inside and buried in the permeable material between the walls of the spent fuel tank, the leveling concrete and the related screen between elevations 90,91 and 90 ,40. The leaked water is collected in a well, from where it is pumped through a steel pipe to the radioactive waste treatment system.

d) Drainage at the reactor building

Drainage at the reactor building is carried out in two stages: collection and evacuation. The collection of water around the reactor building is done through three pipes DN 160 x 7.7 mm perforated at the bottom and which are buried between the walls of the reactor (tire) and its related screen, in the permeable material between elevations 91.34 and 91.20. The infiltrated water is collected in two wells and from here by pumping through a Dn 88.9 x 5.49 mm pipe it is discharged into the drainage discharge pipe related to the nuclear auxiliary services building. Through the technological scheme, the necessary pipes and fittings were provided for the possibility of water transfer to the liquid radioactive waste collection system.

e) Drainage at the spent fuel intermediate storage facility

The water resulting from the washing of the concrete platforms or from precipitation around the storage modules is collected through concrete gutters in the collection manholes equipped with 2 cast iron valves, with sphere and flange, one for service and one as spare part, having Dn150. A level switch is installed in each collector chamber which sends an alarm signal to the Main Control Room U1 when a predetermined level is reached (approx. at half the height of the chamber). After carrying out the radioactivity analyses, depending on the result, it is discharged into Cismelei Valley or transferred to the liquid radioactive waste system of Cernavoda NPP, where it is processed in accordance with the established NPP procedures.

f) Drainage at the diesel household related to the backup Diesel groups

Each tank is surrounded by a concrete wall to protect against possible leaks. In case of leaks from these tanks, the household is equipped with drainage pumps.

g) Drainage at radioactive waste collection centres

The storage spaces are marked and managed in a way that can allow the identification and elimination of accidental spills. All containers are stored on pallets and labeled accordingly. Wastewater resulting from possible liquid waste leaks will be collected in closed basins provided in each of the two storage spaces. From the basins, the waters are transferred into metal barrels by means of a pump, the barrels being taken over by authorized economic agents for waste disposal according to the legislation in force.

h) Drainage at the fuel household for CTP

The technological waste water from the fuel household area, as well as the rain water from the vats / bases of the oil and fuel tanks, before being discharged into the rain sewer, are passed through a petroleum product separator to avoid water pollution with petroleum products. Before discharge into the Distribution Bay, the waters from the rain sewer are passed through a grit chamber. The petroleum product separator is composed of two compartments, one standby, each sized for 40 m^3/h. The concrete used was B 200. The scraper was insulated with successive layers of asphalt cardboard and cut bitumen. The connection between the tank drains and the separator is made through a fireproof chimney, and from it further with the help of a metal pipe. The entire amount of grease/oil separated at the surface of the water and discharged through a chute at the downstream end of the separation chamber is collected in a side sump, from where it is pumped back into the storage tanks. To avoid spilling fuel or contaminating the water discharged into the storm sewer, the fuel separator is operated according to specific procedures and the level is checked through daily routines

CONCLUSIONS regarding the wastewater disposal systems generated by the RT-U1 and DICA-MACSTOR 400 Project

- ***Ensuring the evacuation of wastewater generated during the project implementation stage - which takes place through two distinct periods, respectively:***
  - *The setting up and execution phase of the infrastructure and constructions supporting the project, which includes the design of DIDR-U5, constructions within the framework of DICA – MACSTOR 200/400 modules, construction of buildings, necessary RT-U1 support buildings; (2024 – 2026).*

    In operation on site are U1, U2 and DICA-MACSTOR 200.
  - *U1 Shutdown, retubing, tests Phase, which includes: DIDR-U5 in operation, DICA MACSTOR in operation, U1 is shut down for retubing, U2 is operating, constructions at DICA MACSTOR 400. (2027 – 2029).*

will be managed as it follows:

- non-radioactively contaminated water will be directed into the technological water collection system that does not require purification
- radioactively contaminated waters will be directed into the radioactively contaminated wastewater collection system.

- ***Ensuring the evacuation of waste water generated during the Operation Stage of the refurbished U1 and DICA-MACSTOR 400 will be carried out, similarly as in the current operating situation of the 2 nuclear units through the same evacuation systems provided within the Cernavoda NPP plant authorized by the current regulatory act.***
  - **In the case of the Active Components Building, the repair and decontamination of tools** – it will be installed a new system for the collection of radioactive aqueous liquid waste.
  - The dimensioning of the protection zones for the purpose of monitoring the phreatic aquifer at the new DIDR-U5 will aim at the execution of some piezometric wells on the DIDR-U5 site.

- **Regarding the sub-project DICA-MACSTOR 400 -** the expansion area of the current DICA will be provided with a collection system made up of concrete gutters, equipped with road metal grates and collecting channels, on which there are located manholes and provided drains with grills. The collecting chambers together with the gutters are designed to collect and retain from the DICA-MACSTOR 400 platform, the maximum volume of rainwater resulting from 24 hours of rain, with a return period of once every 5 years.
- This protection measure will ensure a sufficient time interval for checking the quality of the collected rainwater and its evacuation according to the results of the laboratory analyses. A level switch will be installed in each manifold which, upon reaching a predetermined level, transmits an alarm signal to U1 Main Control Room.
- Water samples will be taken from the collection tank and subjected to laboratory analysis to check for possible radioactive contamination.
- After carrying out the radioactivity analyses, depending on the result, these types of waters will be discharged into the Cismelei Valley or transferred to the radioactive liquid waste system of the NPP, where they will be processed in accordance with the Plant's procedures in order to meet the requirements of CNCAN and Water Management Authorization for U1 and U2.
- In order to control the quality and level of the water in the groundwater on the **DICA-MACSTOR 400 related platform, additional piezometric wells will be provided along with the 4 existing wells.**

1.7.6 Hazardous materials used, stored, handled or generated during project operation

The following tables show the hazardous materials stored, handled or generated during the operation of the project, as notified by the owner of the site to the competent authorities, according to Law no. 59/2016 and Order no. 1175/39/2020).

Tab. 7 Inventory and classification of dangerous substances

No. crt.	**Name of the hazardous substance/mixture**	**Hazard statement code**	**Hazard class**	**Hazard category**	**Existing quantity**		**Maximum on-site storage capacities**		**State**	**Storage Mode**	**Storage/operating conditions Atm/^{0}C**	**Location within the site**
					m^3	tone	m^3	tone				
1.	Hydrazine 35% (Hydrazine hydrate 55%) CAS 302-01-2	H311 H331 H302 H400 H410 H350 H318 H314 H317	Acute Tox. Acute Tox. Acute Tox. Aquatic Acute Aquatic Chronic Carc. Eye Dam. Skin Corr. Skin Sens.	3 3 4 1 1 1B 1 1B 1	-	**9**	-	**9**	Liquid	in original metal barrels of 200 liters	In original barrels from the manufacturer. The barrels are stored on pallets provided with a device to take over any leaks. Storage: shed 5B, locked premises, limited access.	In the SEIRU warehouse In the installation: At Unit 1, Turbine Building, elevation 93, a maximum of 2 barrels are stored (one full/sealed and one from which it is consumed). The frequency of addition is at 4-5 days, added quantities ~10 liters: stock about 0.4 tons Unit 2 elevation 93 (same above): about 0.4 tons Unit 0 (at CTP): The frequency of addition in the cooling water circuits is 1-2 times per month, the amount added is approx. 5-8 liters. Stock < 0.2 tons
2.	Diesel Euro 5 CAS 68334-30-5	H332 H411 H304 H351 H226 H315 H373	Acute Tox. Aquatic Chronic Asp. Tox. Carc.Cat. Flam. Liq. Skin Irrit STOT RE	4 2 1 2 3 2 2	-	**1399**	-	**1537 (1399 + 135 + 3)**	Liquid	Tanks of various capacities	Buried or semi-buried diesel tanks, as appropriate	Fuel Storage management for Reserve and Emergency Diesels on the Cernavoda NPP site

No. crt.	**Name of the hazardous substance/mixture**	**Hazard statement code**	**Hazard class**	**Hazard category**	**Existing quantity**		**Maximum on-site storage capacities**		**State**	**Storage Mode**	**Storage/operating conditions Atm/^{0}C**	**Location within the site**
					m^3	tone	m^3	tone				
3.	LLF Light Liquid Fuel CAS 92045-14-2	H332 H411 H304 H351 H226 H315 H373	Acute Tox. Aquatic Chronic Asp. Tox. Carc.Cat. Flam. Liq. Skin Irrit STOT RE	4 2 1 2 3 2 2	-	**1080**	-	**1100**	Liquid	Tanks of various capacities	1 tank capacity of 1000 tons + 1 tank capacity of 80 tons	Fuel Storage managemnet for the Start-Up Thermal Power Plant on the Cernavoda NPP site
4.	Acetylene (technical and welding)CAS 74-86-2	H220 H280 H230	Flam. Gas Gas under pressure Danger of explosion	1	-	**0.418**	-	**0.418**	Gas	Original manufacturer's cylinders of 6 kg and 10 kg	Technical gas stores– the cylinders are placed in an upright position and are secured against tipping over by rubber or plastic fastening chains.	Technical gas storage
5.	**Fire-resistant hydraulic fluid (FRF)** Fyrquel EHC	H410 H360F H373	Aquatic Chronic Repr. STOT RE	1 1B 2	-	**3.6**	-	**3.6**	Liquid	Manufacturer barrels – 200 liters	According to SDS Stored on spill collection pallets	1. Seiru Warehouse 2. U1 turbine building – FRF room – elevation 100 – max. 2 barrels -3 cubic meter tank
6.	Compressed Hydrogen CAS 1333-74-0	H220 H280	Flammable Compressed gas	-	-	**0.28**	-	**0.3214**	Gas	Original cylinders of the manufacturer and 2 tanks of 50 m^3 each	In the technical gas store – the cylinders are placed in an upright position and are secured against tipping over by rubber or plastic clamping chains.	1.Technical gas storage 2.In the installation -Hydrogen Storage and Distribution System - Technical gas distribution system for the Chemical Laboratory

No. crt.	Name of the hazardous substance/mixture	Hazard statement code	Hazard class	Hazard category	Existing quantity		Maximum on-site storage capacities		State	Storage Mode	Storage/operating conditions Atm/^{0}C	Location within the site
					m^3	tone	m^3	tone				
7.	Morpholine 99% and Morpholine for synthesis CAS 110-91-8	H311 H331 H302 H318 H226 H314	Acute Tox. Acute Tox. Acute Tox. Eye Dam. Flam. Liq. Skin Corr.	3 3 4 1 3 1B	-	**16.2**	-	**16.2**	Lichid	Manufacturer barrels – 200 liters	According to SDS Stored on spill collection pallets in warehouse 5 (SEIRU)	1. Seiru Warehouse 2.U1/U2 turbine building – chemical addition chamber elevation 93 – max. 2 barrels in each unit. 3. U0 (in CTP max. 1 morpholine barrel 70% for additions in cooling water circuits U1 and U2) and max 1 morpholine barrel 70% for addition in CTP)
8.	Compressed oxygen CAS 7782-44-7	H270 H280	Ox. Gas Compressed gas	1	-	**1.133**	-	**1.196**	Gas	Cylinders	Technical gas stores– the cylinders are placed in an upright position and are secured against tipping over by rubber or plastic fastening chains.	1.Technical gas storage – reserve stock 2. Racks U1 and U2 technological spaces with connections to the seismically qualified gas supply plant
9.	Chlorine (liquefied gas) CAS 7782-50-5	H331 H400 H319 H280 H270 H315 H335	Acute Tox. Aquatic Acute Eye Irrit. Liquefied gasOx. Gas Skin Irrit STOT SE	3 1 2 1 2 3	-	**0.2**	-	**0.2**	Gas	Original cylinders of the manufacturer (47 kg chlorine / cylinder)	Racks – in compliance with the conditions of anchoring and securing according to the applicable rules	Water Treatment and Chlorination Plant (permanently 2 cylinders in the installation: one connected and one spare).
10.	BIOCID ARQUAD MCB-50	H302 H400	Acute Tox. Aquatic Acute Aquatic Chronic	4 1	-	**16.2**		**16.2**	Liquid	Tank/container of the Manufacturers	According to SDS Stored on spill collection pallets in warehouse 5 (SEIRU)	SEIRU warehouse

No. crt.	Name of the hazardous substance/mixture	Hazard statement code	Hazard class	Hazard category	Existing quantity		Maximum on-site storage capacities		State	Storage Mode	Storage/operating conditions Atm/^{0}C	Location within the site
					m^3	tone	m^3	tone				
		H410 H318 H314	Eye Dam. Skin Corr.	1 1 1B								
11.	Argon-Methane mixture (mixture P10) CH4 10 %; Ar 90 %	H220 H280	Flam. Gas Compressed gas	1	**-**	**4.08**	**-**	**4.08**	Gas	6m^3 original cylinders, of the manufacturer	Technical gas stores– the cylinders are placed in an upright position and are secured against tipping over by rubber or plastic fastening chains.	Technical gas store
12.	DILUENT WSXla (WHITE-SPIRIT)	H411 H304 H226 H315 H336	Aquatic Chronic Asp. Tox. Flam. Liq. Skin Irrit STOT SE	2 1 3 2 3	**-**	**0.87**	**-**	**0.87**	Liquid	20 liter metal canisters	According to SDS Stored on spill collection pallets in warehouse 5 (SEIRU)	SEIRU warehouse

Note: 1. In the table above, those substances/mixtures that were on the site in quantities greater than or equal to 2% of the relevant quantity for lower-level sites provided in column 2 in the tables in Part 1 and Part 2 of Annex 1 of Law no. 59/2016 respectively were considered.

Tab. 8 Inventory and classification of hazardous waste

No. crt	Name of waste	Waste code	Hasardous property (HP1-HP15)	Hazard phrases of substances present in waste	Hazard category (H, P, E)	Existing quantity		Maximum on-site storage capacities		State	Storage mode	Storage/operating conditionsAtm/ ^{0}C	Location within the site
						m^3	tone	m^3	tone				
1	Organic waste containing hazardous substances	160305*	H 4 Irritating H14 Ecotoxic	Hydrazine H302, H311, H331, H314, H317, H350, H400, H410 Morpholine H226, H302, H311, H331, H314, H318	Hydrazine H2 acute toxicity category 3 E1 Hazardous to the aquatic environment Acute Category 1 and Chronicle 1 P5c flammable liquids categ 3 H2 toxicity	-	0	-	14.114	Liquid	200 l barrels	The barrels are stored on spill collection pallets	Landfill located in U3

Hydrazine is a substance used for the chemical conditioning of demineralized water systems having the role of oxygen reducing agent:

- to minimise the dissolved oxygen content in the secondary circuit of the U1 and U2 steam generators (closed circuit);
- to minimize dissolved oxygen from steam generators during wet storage;
- to reduce the dissolved oxygen in the demineralized water respectively to minimize the corrosion of the carbon steel in the closed cooling circuits of the plant (recirculated cooling water, cooled water, sprinkler system in the envelope, cooling system of the active area in case of emergency);
- to reduce/control the dissolved oxygen in the demineralized water of the biological protection system (and to minimize radiolysis).

In the Turbine Building of U1 and U2 respectively, the hydrazine, in its original packaging, is stored in the chemical addition chamber (elevation 93). In this room there is an approved storage space in which the stock of max. 2 barrels of hydrazine and max. 2 barrels of morpholine necessary for additions is located in two tanks, in which these chemicals are diluted with demineralized water according to the applicable field procedures. The concentration of hydrazine in 1-45400-T004 and 2-45400-TK004 respectively is about 0.8%.

The additions are carried out by trained personnel and according to approved procedures, with the taking of measures to protect the personnel and the environment. The addition chamber is equipped with a drain collection basin, so hydrazine is not discharged into the sewer. When the base is filled, it is emptied into properly labeled barrels and treated as hazardous waste.

The solution from the tank is injected into the suction of the main pumps related to the steam generators' supply system. Here hydrazine reacts (is consumed) with the oxygen dissolved in the feed water.

In the case of the closed cooling systems of the plant, there is also a tank in which hydrazine is added (about 20 liters) for conditioning the closed cooling systems of the plant (recirculated cooling water, chilled water). Hydrazine is also added to the sprinkler system in the envelope (approx. 200 litres hydrazine 35% at one addition, with a frequency of 1/year) and to the cooling system of the active area in case of emergency.

In CTP, hydrazine intended for additions in cooling water circuits, in the original packaging, is stored in an approved space where there is max. 1 barrel of 35% hydrazine and max. 1 barrel of 70% diluted morpholine.

In the CTP there is a maximum of one barrel of 35% hydrazine and a barrel with morpholine to ensure the dosage of chemical substances of the water from the auxiliary steam boilers.

Petroleum products: diesel – used as fuel for the Diesel Emergency Generators (EPS) and Backup Diesel Generators (SDG), the Fire Extinguishing Water Pump (SPAI), the Backup Diesel Generator in SEIRU, the Backup Diesel Generator in DICA, the Backup Diesel Generator in CCUA, the 3 Generator Sets (GE), the 4 Mobile Diesel Generator Sets (MDG).

The backup power supply system (SDG = Stand-by Diesel Generator) ensures the production of electricity for vital consumers in the event of a breakdown of the power supply system. The Emergency Power Supply System (EPS = Emergency Power Supply) ensures the production of electricity for vital consumers in the event of a breakdown of the power supply system, more precisely, it will provide a reserve of electricity for the safe shutdown of the reactor and for the discharge of waste heat from the reactor if all other energy sources are unavailable.

There are 4 spare diesel units (SDG) for U1, 2 spare diesel units (SDG) for U2, 2 diesel backup units (EPS) for U1, 2 diesel backup units (EPS) for U2, a motor pump of the fire extinguishing system and 1 spare diesel in SEIRU.

At U1, the fuel store is equipped with 4 x 200 m^3 semi-buried diesel tanks located in concrete caissons, with a maximum storage capacity of 4 x 180 t diesel. In the Diesel building there are 4 x 4.5 t diesel tanks for daily consumption, a 1 t tank and a collection tank with a capacity of 16 t. Each diesel tank with a capacity of 180 t is fenced with a concrete wall to protect against possible leaks. In cases where leaks would occur from these tanks, the fuel store is provided with drainage pumps.

At U2, the fuel store is equipped with 4 x 200 m^3 semi-buried diesel tanks, with a maximum storage capacity of 4 x 180 t diesel. In the Diesel building there are 2 x 7 t diesel tanks for daily consumption, tanks for collecting any diesel leaks 2 x 1.7 t, diesel buffer tanks 2 x 110 liters and an oil tank 3.2 t. Each diesel tank with a capacity of 180 t is fenced with a concrete wall to protect against possible leaks. In cases where leaks would occur from these tanks, the fuel store is provided with drainage pumps.

At U1 and U2, the fuel households for the breakdown power supply system are composed of 2 tanks of 22.4 t for each unit - buried outside the buildings, and 2 tanks of 0.9 t for each - located in the building of the Diesel groups. All rooms of the building are artificially ventilated, continuously. The vents are located in close proximity to the tanks.

The fire water pump is located within the fire water pump system (SPAI) building and the diesel tank for supplying the motor pump is located outside the SPAI building, in a specially designed manhole. The tank capacity is 702 liters (about 0.656 t). Through the project "REHABILITATION AND MODERNIZATION OF FIRE WATER PUMPING STATION EQUIPMENT (SPAI)" which was carried out in 2018, the capacity of the diesel tank was changed from 1000 litres to 702 litres.

In SEIRU there is a tank of about 2 tons, from which the Diesel generator on the SEIRU site is refueled. Within the SEIRU Project, the tank will be relocated to the new location.

The supply of MDG, GE, Diesel DICA and Diesel CCUA is made from the TK8 tank related to the SDG U1 fuel store. These are backup generators and are tested periodically.

The 1675 kVA (1340kW) MDG 1 and MDG 2 have 2000 liter diesel tanks and the 110 kVA (88kW) MDG 3 and MDG 4 have 195 liter tanks. The GDM diesel units and the tanks associated with each of them form a closed container that is isolated from the outside. Mobile diesel generators are intended to supply vital consumers in the NPP in the event of a total loss of power supply. They are currently temporarily located in unit 5 and will be moved to the specially designed area at the end of the Project U5.

The generator sets are backup diesel generators, related to the NPP access control points and have the following capacities: GE1 – 200kW, GE2 – 151kW. GE3 – 151kW. They are currently installed in position and will be received by Cernavoda NPP.

The DICA diesel generator with a power of 69 kW has the role of supplying electricity for the equipment of the DICA objective, in case of emergency. The capacity of the diesel tank is 500 liters.

The CCUA diesel generator with an electric power of 108 kW has the role of supplying electricity to the equipment of the CCUA objective, in case of emergency. The capacity of the diesel tank is 350 liters.

Within the U5 Project, 2 stationary diesel units of 900 kVA are planned, and within the CTRF project 2 diesel units of 600 kW. Within the U5 project there will be: 2 buried tanks, of 60 m^3 each, in which the diesel for diesel generators will be stored and 2 1-day tanks, one for each DIESEL group, of 10 m^3 each.

Petroleum products: LLF - used as fuel for the Thermal Start-Up Power Plant (CTP). The Start-up Thermal Power Plant has the role of supplying steam during the shutdown of the nuclear units and when they are restarted. CTP is used to restart a nuclear-electric unit only in the situation where both NPP units are switched off and it is necessary to start one of them. However, the 2 functional boilers of CTP are tested periodically (quarterly).

The LLF is stored in a 1000 ton capacity tank + 1x 100 ton capacity tank.

Acetylene (technical and industrial). It is delivered in 6 kg and 10 kg cylinders. The 6 kg cylinders are used for welding for various works, and the 10 kg cylinders are used for flamphotometry analysis in the Chemical Laboratories.

The industrial acetylene is stored in the specially designed outdoor area of CSAN U1 (gas storage OB 14) and in the gas chamber 2-S331 (chamber with gas cylinders).

Technical acetylene for welding is stored in the technical gas deposit.

FRF – hydraulic oil used as turbine control fluid. It is delivered in original 200 liter barrels of the manufacturer and is stored in SEIRU, in warehouse 5A. In U1 there is a 3.4 ton tank, TK80 (3 m^3 tank). Another type of oil, FRF PLUS, is used in U2, which is classified as non-hazardous.

Hydrogen is used for the following systems:

- The hydrogen addition system in the primary circuit has the function of keeping the deuterium concentration within normal limits to limit the corrosion effect caused by the oxygen released by heavy water radiolysis.

- The Hydrogen Storage and Distribution System consists of two tanks (of 50 m^3 each) as well as the related equipment: Reinforcement Cabinets; Safety Valve Stands, as well as the Trailer Download Platform. The two hydrogen distribution lines are mounted on piers and follow the route to the consumers they serve, from the Machine Room.The hydrogen is distributed to the consumers inside the Cernavoda NPP through two 2" pipes, drawn on the pier, with the possibility of operating each tank on both lines. The hydrogen tanks and the hydrogen distribution system provide the storage, conveyance, distribution of hydrogen for the cooling of the electric generator of Unit 1 and the electric generator related to Unit 2, through the hydrogen cooling system of the electric generators.

- The technical gas distribution system for the Chemical Laboratory consists of a network of pipes, with a diameter of 1/4" as follows:

- an "interior route" from room S-334 where the 28 inert gas cylinders are located (6 cylinders of He, 2 cylinders of Ar, 7 cylinders of nitrogen, 9 cylinders of standard mixtures, 2 spare cylinders);

- an "exterior route" from the hydrogen and acetylene cylinder box (1 hydrogen cylinder, 1 acetylene cylinder and 1 spare cylinder) located outside, to rooms S-305 and S-307. The flammable gas cylinders (1 hydrogen cylinder, 1 acetylene cylinder and 1 spare cylinder) are located in a box adjacent to the hydrogen cylinder depot, related to the hydrogen addition system and the hydrogen consumers are located in room S-305, in the Services Building and the acetylene consumers are located in room S-307 in the Services Building. Room S307 is intended for the chemical control laboratory and is located in CSAN, elevation 109.22 and room S305, also intended for the chemical control laboratory, is located next to room S307.

The hydrogen will also be used in the Detritium Plant (CTRF Project) - it is estimated to be approximately 0.01934 tons.

Morpholine – has several uses:
- corrosion inhibitor,
- for pH control in the secondary circuit (chemical conditioning),
- as an analytical reagent in chemical laboratories.

Morpholine is delivered in the manufacturer's original 200-litre barrels and in a one-litre laboratory reagent container.

The morpholine delivered in barrels is stored in warehouse 5 of SEIRU. In the plant it is stored in the chemical addition area, elevation 93 of U1 respectively U2 and U0 (CTP).

Morpholine used as a laboratory reagent is stored in S309 in flammable substance metal cabinets in the Chemical Laboratories.

Oxygen (technical and ultra-pure) - It is purchased in the original cylinders of the manufacturer and is of several types:
- Ultrapure oxygen - used for addition to systems (to prevent the formation of an explosive mixture). It is purchased in 43.8 liter cylinders.
- Technical oxygen - for welding. It is purchased in 40-liter cylinders.
- Oxygen to breathe for medical emergencies. It is purchased in 0.4 m^3 cylinders.

The cylinders are stored in the Gas Deposits.

The oxygen will also be used in the Detritiation Plant (CTRF Project), an estimated quantity of approximately 0.1369 tons.

Liquefied chlorine – It is used as a disinfectant for drinking water. The cylinders are stored in the cylinder room of the Chlorination Plant related to the Drinking Water Treatment Plant.

BIOCIDE ARQUAD MCB - 50 – It is used for macrofouling control in the RSW BSI 71310 system; U1 and U, in the warm season, the water temperature being higher than 12^{o}C. The use of the Biocide MCB-50 product is done only on the C6 circuit – industrial water, when conditioning the cooling circuit and only after notifying the territorial water management authorities, in order to monitor the quality of the receivers. The loaded wastewater, resulting from the biocide process, is discharged only into the Danube, through the Seimeni canal (the requirement of the water management permit issued by ANAR for Cernavoda NPP).

Argon-Methane Mixture (P10) – It is purchased in the manufacturer's original 6m^3 cylinders. The cylinders are mounted on U1 and U2 inter-zonal monitors (for each monitor there are 2 or 4 cylinders, depending on their type). These cylinders are also mounted on the global alpha-beta measuring devices located in the Environmental Control Laboratory and in the Dosimetry Laboratories (one cylinder for each device).

WSXla Thinner (WHITE-SPIRIT) – used by the Maintenance and Repair Department and the Warehouse Management Service for:
- cleaning the surfaces of the equipment in the classic systems, respectively
- degreasing preserved products from warehouses.

It is purchased in 20-liter metal canisters. It is stored in the original and sealed containers, stored on plastic pallets, in the 5B SEIRU warehouse.

1.7.7 The transport of raw materials, auxiliar materials and the increase in traffic involved during the implementation of the two subprojects

Subproject RT-U1

For the completion of the RT-U1 subproject, the activities will take place at the Cernavoda NPP site.

The specific activities of maintenance, repairs related to the shutdown for refurbishment of Unit 1 – retubing, modernization/replacement of equipment and circuits related to nuclear and classical systems will be carried out inside the building of Unit U1.

The supply of equipment and materials necessary for the implementation of the refurbishment process from authorized and qualified suppliers - as the case may be, will be done in containers or other types of packaging specific to the purchased products, in compliance with the regulations applicable to both forms of transport and product categories. Packages will be labeled, packed in conditions that ensure the integrity of the contents, according to the supplier's instructions.

The specific tools that will be used in the reactor retubing operations will be stored in specially arranged spaces related to the new infrastructure that will be built for the Unit 1 refurbishment project.

For the set-up of the new DIDR-U5, the supply of construction materials will be made from certified and/or authorized/qualified suppliers - as the case may be, according to the requirements related to the purchased product categories, with appropriate means of transport.

The routes for the internal transfer of the equipment and materials necessary for the implementation of the refurbishment subproject are thus established so as not to interfere with the current activities of the objectives operating on the site (Unit 2, DIDSR, DICA-MACSTOR 200) nor with the related activities of the projects under development on site.

The transport of the personnel involved in the implementation activity of the refurbishment subproject will be carried out with the means of transport specially sized and allocated for the period of the activities.

Subproject DICA-MACSTOR 400

Construction materials (ballast, stone, sand, concrete, reinforcements), storage cylinders, monitoring equipment, etc. will be supplied for the realization of the MACSTOR 400 type modules.

For ***the supply of materials*** and for ***the transport of personnel*** involved in construction activities, the following are used daily - on average: truck - 1 pc., van (up to 3.5 t) - 1 pc., concrete mixer - 1 pc. respectively bus/minibus for workers - 1 pc., cars - 2 pcs.

To ***carry out the constructions***, the following works daily: bulldozer - 1 pc., compactor cylinder of 0.5t - 1 pc (approx. ½ hour/day), crawler excavator - 1 pc. (approx. ½ hour/day).

The transport of the personnel involved in the construction will be carried out with the means of transport specially allocated during the period of activities.

It is estimated that, through the quantities supplied and the supply rate, and considering the ratio between the volume of works and their duration in the case of the two types of modules, the increase in traffic compared to the current situation will be insignificant.

On the other hand, under the ***conditions of the operation*** of the two nuclear units (U2 and refurbished U1), the rate of nuclear fuel transfer will not change compared to the current situation - of simultaneous operation of the two units. Also, the means of transport and transfer used will be the same as for the situation of storing spent nuclear fuel in MACSTOR 200 type modules.

1.7.8 Environmentally relevant social and socio-economic implications

The Unit 1 refurbishment project brings significant socio-economic and cultural benefits, such as [32]:

- local and regional development by ***creating jobs*** both during the refurbishment project and during the subsequent exploitation and decommissioning phases;
- creation of ***indirect jobs***, through subcontractors.

Development of the internal supply chain for refurbishment:

- capacity building for the national nuclear sector (for example, the involvement of all engineering branches at different levels is expected, including technicians, engineers, researchers, etc.);
- provision of centralized heating for the city of.

The right to equal opportunities is a fundamental right within the European Union. It is the concept that all human beings are free to develop their personal abilities and make choices, without limitations imposed by strict roles. This concept is based on ensuring the full participation of every person in his economic and social life, regardless of ethnic origin, gender, religious orientation, age, disability or sexual orientation.

The principle of equal opportunities, non-discrimination, gender equality will be the basis of the refurbishment project and will include at least the following measures:

- the distribution of tasks within the project teams of the holder/contractor will be done exclusively on the basis of the competence criterion and will capitalize on the experience of each member regardless of age, gender, religious orientation or social status;
- the awarding of works and service contracts will be done in accordance with the legal provisions applicable to public beneficiaries, in accordance with the principles of transparency, efficiency and equal opportunities, both in the awarding phase and in the execution phase;
- the necessary premises for the generation of temporary jobs will be created during the execution of the works, regardless of age, sex, religious orientation or social status;
- solutions will be adopted to allow the unrestricted access of people with disabilities, with the aim of increasing their degree of social inclusion and, respectively, to respect the principle of equal opportunities;
- project management will be carried out in accordance with the principle of "Distribution of Responsibilities", whereby the responsibilities of the project team members are distributed according to their individual experience and capabilities in relation to the specific activities.

Generation of direct jobs during refurbishment

According to the information from the Feasibility Study, made available by the owner, during the refurbishment of Unit 1, the following staff allocation is projected:

- approximately 1700 full-time employees at Cernavodă NPP. An equal division of these can be estimated between the two units, given that both reactors are served in equal proportions by staff members.
- during the refurbishment project, a staff redistribution scheme is foreseen, whereby part of the employees involved in the normal operation of Unit 1 will focus on the refurbishment.

[32] Feasibility Study for the Refurbishment Project of Cernavoda NPP Unit 1, version v1, 17.01.2022

− in addition, new employees are expected to join the SNN project team. It is expected that a similar number of staff to the first life-cycle of Unit 1 will be maintained when normal operation resumes.

For the implementation of the DICA subproject, indirect jobs will be generated in the local economy, of which approximately 30 people will be involved in the construction of each module.

Generation of direct and indirect jobs in the local economy

− Cernavoda NPP has created more than 11000 jobs since commissioning (including horizontally) and has the possibility to increase the number of jobs to 19000 for the operation of Unit 1 in the second operating cycle as well as the operation of the extended DICA with MACSTOR 400 type module.

1.8 Estimation by type and quantity of expected waste and emissions

1.8.1 Radioactive waste and emissions of radioactive effluents

1.8.1.1. Radioactive waste from the refurbishment of Unit 1 and from the operation of Units 1 and 2

The refurbishment project generates radioactive waste, which must be adequately managed.

Retubing operations result in a large amount of radioactive waste that includes reactor components that are removed from the reactor for replacement. These components are placed in suitable containers for radioactive waste. Measures are taken, where possible, to reduce the volume of this waste. For example, the volume reduction system for the removal of pressure tubes and Calandria tubes is used to fragment and reduce the volume of tubes into smaller compact segments, allowing more efficient use of space in waste containers, compared to the situation where the tubes would be stored in the state in which they were removed from the reactor. Other wastes generated from retubing operations include single-use personal protective equipment and equipment/tools that were used in the retubing operation that are not economically feasible to decontaminate, as well as active liquid wastes.[33]

Technical solutions are also provided for the strict control of gaseous and liquid radioactive emissions, for example:

- Draining and drying the Calandria vessel and moderator system using the vapor recovery system for heavy water recovery.
- Active liquid waste (generated during retubing activities) includes aqueous waste produced from decontamination of equipment and tools. This active waste will be treated in the radioactive aqueous liquid waste management System at Cernavoda NPP Unit 1 before discharge. Additional waste may include VRS cooler water, hydraulic fluids. The overall liquid waste treatment process will involve collection of waste in 220 liter drums, chemical analysis, separation and subsequent disposal using environmentally approved practices.

[33] Technical Solution to Replace Nuclear Fuel Channels, Calandria Tubes, and Feeders (ICCTCF) of the Cernavoda NPP U1 Reactor, Doc. 79-01000-PLA-002 Rev. 0

- Liquid waste generated in tool decontamination will be collected, tested, treated and disposed of accordingly.
- The active ventilation system is a retubing instrumentation system used to control the spread of radioactive aerosol contamination and to prevent contamination inside the reactor building during retubing activities. Waste from this system consists largely of used dry filters, contaminated vacuum hoses, and vacuum collection vessels that cannot be reused or decontaminated.

The types and quantities of solid radioactive waste predicted to be produced as a result of the Unit 1 reactor refurbishment activities were evaluated, based on international experience and taking into account the technical solutions to be adopted in the pre-disposal stage, within the study *KHNP, Feasability Study on Management of Radwaste Generated during Unit 1 Refurbishment and Operation of Unit 1,2 in Cernavoda NPP – Environmental Issues Report*.

These wastes are divided into two categories, from the point of view of the mechanism by which the radioactive contamination of the materials occurred in the reactor facilities. The first category, of activated waste, includes: pressure tubes, calandria tubes, spacers and side structural components. The second category is constituted by contaminated waste and includes components and equipment located outside the active area, as well as radioactively contaminated equipment, tools and consumables as a result of refurbishment activities. In the case of the first category, the quantities and level of contamination were estimated by using activation calculation programs, while for the second category, the estimates were made by rescaling the quantities of waste produced during the retubing of Unit 1 at Wolsong, in specific conditions of Unit 1 Cernavoda NPP.

The table below shows the amount of radioactive waste estimated to result from the refurbishment activities of Unit 1.

Tab. 9 – Inventory of solid radioactive waste estimated to result from the retubing of Unit 1 of Cernavoda NPP

<table>
<tr><th colspan="2">Source of radioactive waste</th><th>Estimated volume after compaction [m³]</th><th>Volume reduction factor</th><th>Gross volume [m³]</th></tr>
<tr><td colspan="2">Pressure tubes</td><td>8.62</td><td>2.8</td><td>23.98</td></tr>
<tr><td colspan="2">Calandria tubes</td><td>5.710</td><td>5.5</td><td>31.48</td></tr>
<tr><td colspan="2">Calandria tube inserts</td><td>0.72</td><td>N/A</td><td>0.72</td></tr>
<tr><td colspan="2">Lateral structural components</td><td>54.5</td><td>N/A</td><td>54.5</td></tr>
<tr><td colspan="2">Feeder pipelines</td><td>198.4</td><td>N/A</td><td>198.4</td></tr>
<tr><td colspan="2">Other reactor components and low activity waste (tools).</td><td>52.7</td><td>N/A</td><td>52.7</td></tr>
<tr><td colspan="2">Highly active wastes from shielding tools</td><td>32.4</td><td>N/A</td><td>32.4</td></tr>
<tr><td colspan="2">Low active waste from shielding tools</td><td>62.9</td><td>N/A</td><td>62.9</td></tr>
<tr><td rowspan="6">Solid radioactive waste</td><td>Vinyl</td><td>129.4</td><td>8.55</td><td>1106</td></tr>
<tr><td>Paper</td><td>111.8</td><td>9.50</td><td>1062</td></tr>
<tr><td>Metal</td><td>90.4</td><td>3.22</td><td>291</td></tr>
<tr><td>Textile</td><td>69.6</td><td>8.49</td><td>591</td></tr>
<tr><td>Plastic</td><td>39.6</td><td>11.74</td><td>465</td></tr>
<tr><td>Other</td><td>91.7</td><td>8.94</td><td>820</td></tr>
<tr><td colspan="2">Spent ionic resins *</td><td>21.0</td><td>N/A</td><td>21</td></tr>
<tr><td colspan="2">Used filters</td><td>3.6</td><td>N/A</td><td>3.6</td></tr>
<tr><td colspan="2">Total</td><td>973.05</td><td></td><td>4816.2</td></tr>
</table>

Note: Spent ion resins will be stored in the spent ion resin storage tanks in Unit 1

The table below presents an estimate of the quantities of liquid radioactive waste that will result from the Unit 1 reactor re-retubing activities.

Tab. 10 – Estimated amounts of liquid radioactive waste resulting from Unit 1 reactor retubing [34]

Liquid radioactive waste	Estimated quantity [L]
Demineralized water from the VRS cooler	200
Demineralized water from the CTI cooler	2000
CRC lubricating oil	80
Ethylene glycol	< 400
Hydraulic oil	< 400

1.8.1.2. Radioactive waste management program

The radioactive waste management program refers to the management of radioactive waste from the retubing of the Unit 1 reactor and from the operation of Units 1 and 2 at Cernavoda NPP.

The management of radioactive waste resulting from the refurbishment of Unit 1 and from the operation of Units 1 and 2 will be carried out in a similar way, in an integrated manner with the existing radioactive waste management plan from Cernavoda NPP[35].

The radioactive waste pretreatment process to be applied in the Unit 1 retrofit project is based on the experience of Unit 1 retrofit and retubing at Wolsong NPP. Radioactive waste generated from reprocessing and retubing activities will be processed using the on-site treatment facilities, and the intermediate storage facility building (the new DIDR) will act as storage and host the following pretreatment activities:

- Sorting and shredding of solid radioactive waste;
- Solidification of organic liquids and organic solid-liquid mixtures;
- Drying of wet waste.

Dry active waste (clothing, gloves, etc.) generated during the refurbishment and concentrated waste (organic liquids and organic solid-liquid mixtures) generated during the operation of the nuclear power plant after retrofitting will be transferred to the new DIDR and will be processed in specific or dedicated facilities.

Condensate water that may be generated in the summer and liquid waste from the active components building attached to the new DIDR-U5 will be transferred to the existing treatment facility in Unit 1. The main waste treatment process is described below:

- The pressure tubes, Calandria tubes and Calandria tube inserts will be fragmented after removal from the reactor and will be placed in Small Waste Containers – SWC. These containers only ensure waste containment and not radiation shielding. Therefore, for transport and transfer in storage structures, special containers are needed: Small Waste Transfer Flask (SWTF) for SWC - that ensures shielding and transport under radiological

[34] Technical Solution to Replace Nuclear Fuel Channels, Calandria Tubes, and Feeders (ICCTCF) of the Cernavoda NPP U1 Reactor, Doc. 79-01000-PLA-002 Rev. 0
[35] Report on the Feasibility Study on the Management of Radioactive Waste Generated during the Refurbishment of Unit 1 and during the Operation of Units 1 and 2 from Cernavoda NPP after Refurbishment, Doc. RWM-E-T8-001R1, April 2021

security conditions from the controlled area of Unit 1 to the Hall for unloading the radioactive waste containers and for waste container storage, where SWC will be transferred from SWTF to K-BOX.

- The end fittings, removed from the fuel channels with retubing tools, are inserted into large unshielded containers (LWC) that is loaded into a large shielded transfer flask (LWTF) which ensures shielding and transport under radiological safety conditions from the controlled area of Unit 1 to the Hall for unloading the radioactive waste containers and for waste container storage, where LWC will be transferred from LWTF to K-BOX.
- Feeder pipes and other metallic materials from retubing are segregated depending on the material and cut to appropriate sizes for storage in A type containers. These containers are transferred from the Unit 1 building to the new DIDR-U5 building where they are stored in places established by the project.
- Filters resulting from the refurbishment are processed in existing on-site facilities.
- The spent resins are transferred to the spent resin storage tanks at Unit 1 for long-term intermediate storage on site.
- Dry active waste (clothing, gloves, etc.) is transferred to DIDR-U5 where it is subjected to the pre-treatment process such as sorting, shredding and drying of solid waste so that it can be introduced into the compaction installation.
- Organic liquids and solid-liquid organic mixtures of concentrated waste are transferred to DIDR-U5 where they are solidified with polymers.

The figure below schematically shows the management plan for radioactive waste from the Unit 1 reactor refurbishment process, the operation of the new DIDR and the operation of Unit 1 after refurbishmen.

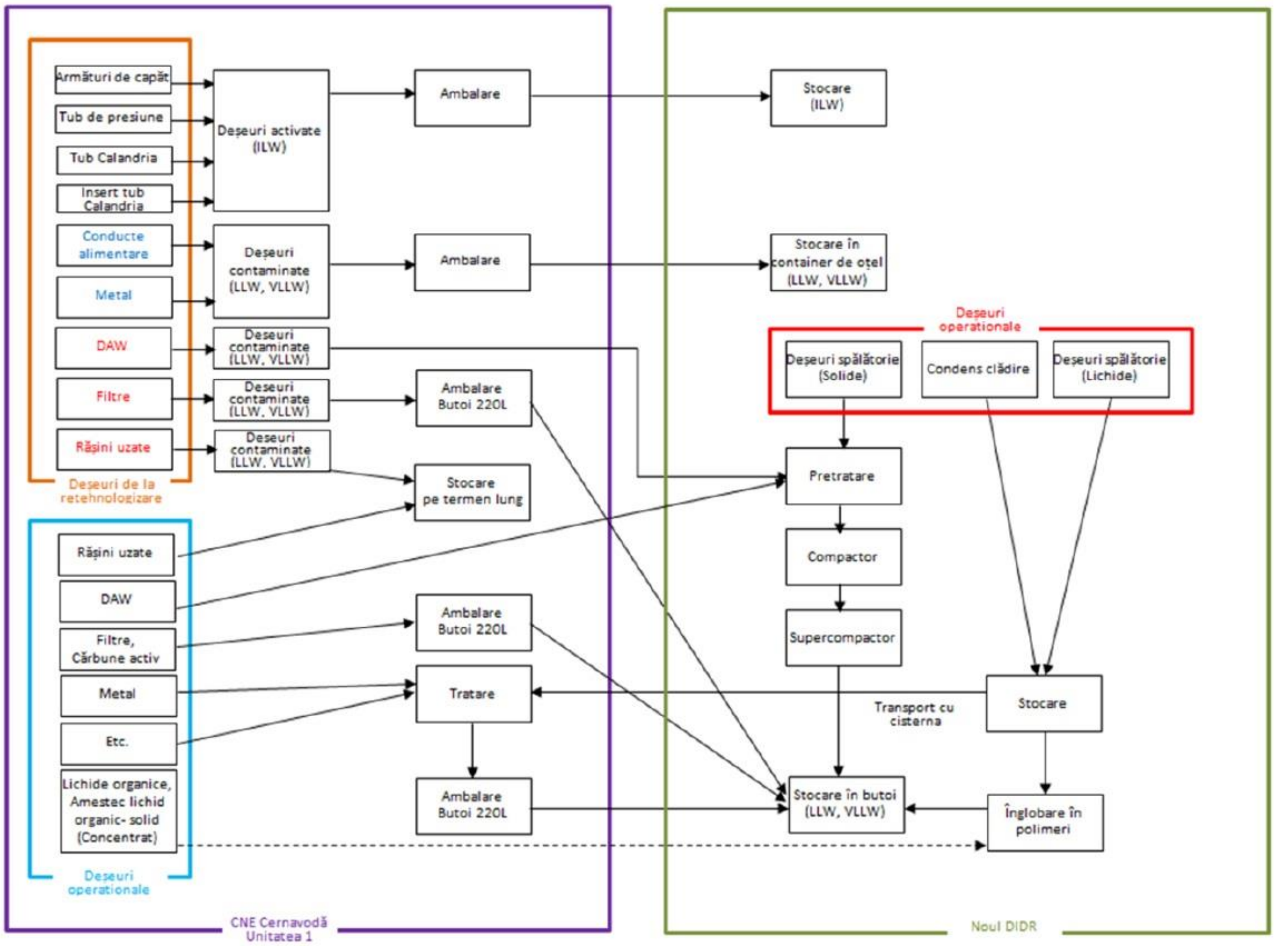


Fig. 20 The radioactive waste management plan from the Unit 1 reactor refurbishment process, the operation of the new DIDR and the operation of Unit 1 after the refurbishment

According to the National Medium and Long Term Strategy for the Safe Management of Spent Nuclear Fuel and Radioactive Waste, approved by GD 102/2022, the low- and intermediate-level radioactive waste from the refurbishment and operation activities of the Cernavoda NPP units will be permanently stored according to their classification, completed in the pre-storage stage, based on the content of radionuclides.

Thus, low- and intermediate-level radioactive waste containing short-lived radionuclides (LILW-SL) will be disposed to DFDSMA, a repository intended to be built in the exclusion zone of the Cernavodă NPP. The first phase of the DFDSMA is scheduled to be completed in 2028, with 8 cells to be built in this first phase. The LILW-SL radioactive waste will be permanently stored in the DFDSMA, after treatment and conditioning by the authorization holder.

Low and intermediate-level radioactive waste containing long-lived radionuclides (LILW-LL), will be intermediately stored in the on-site facilities, such as DIDSR and the new DIDR-U5, to be definitively stored in a Deep Geological Repository, when it becomes available.

1.8.1.3. Emissions of radioactive effluents during the refurbishment of Unit 1

The emissions of radioactive effluents during the period of shutdown for refurbishment, carrying out retubing activities and commissioning after retubing the reactor of Unit 1 at Cernavoda NPP is expected to be within the authorized limits for the period of operation of this unit. In support of this statement, the data provided by CANDU Energy can be used, in addition to the report on *Technical Solutions for the replacement of fuel channels, Calandria tubes and feeders from the U1 reactor of the Cernavoda NPP*. These data were sent by Cernavoda NPP to the authors of this report through the accompanying documentation with the address CNE_FRZI32-1707/06.06.2023.

From the analysis of the radioactive emissions of the Point Lepreau nuclear power plant (PLGS) and the Bruce A and Bruce B nuclear power plants, during the refurbishment processes and during the commissioning period after the refurbsihment of the units involved, it can be postulated an evolution of the radioactive emissions of Unit 1 of Cernavoda NPP during a similar refurbishment process.

The figure below shows the evolution of total annual tritium emissions at PLGS, a plant with a single CANDU 6 unit, similar to Units 1 and 2 at Cernavoda NPP. On the red background, the values of the total annual emissions from the period of refurbishment, commissioning and trial operation of the power plant were highlighted. The refurbishment works for PLGS took place between 2008 and 2012, with milestones: May 2008 - completion of emptying fuel and circuits, September 2009 - completion of disassembling feeders and channels and November 2012 - completion of tests and trial operation - return to service.

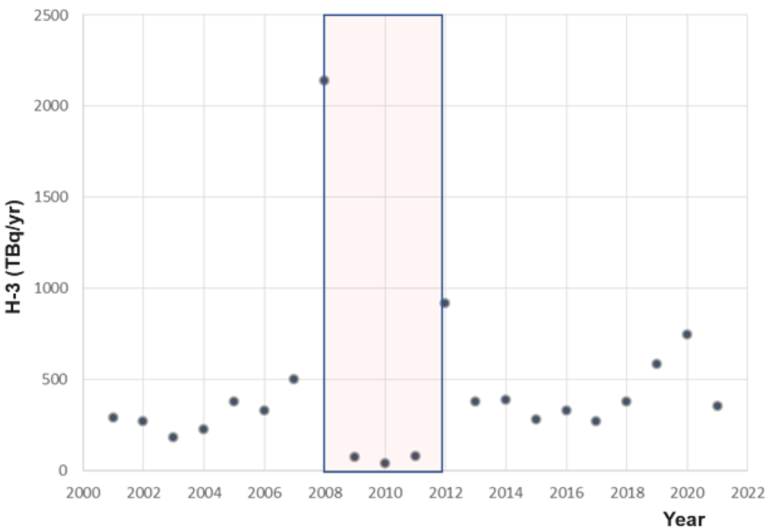


Fig. 21 The evolution of total annual tritium emissions at the PLGS plant in the period 2000 - 2022

An increase in total annual emissions can be observed in 2008, by almost an order of magnitude above the average of previous years, this period corresponding to the interval in which the fuel removal and emptying and washing operations of the plant's active circuits were carried out (preparatory activities for retubing).

Similarly, the figure below shows the evolution of annual emissions of C-14 and radioactive aerosols from the PLGS plant.

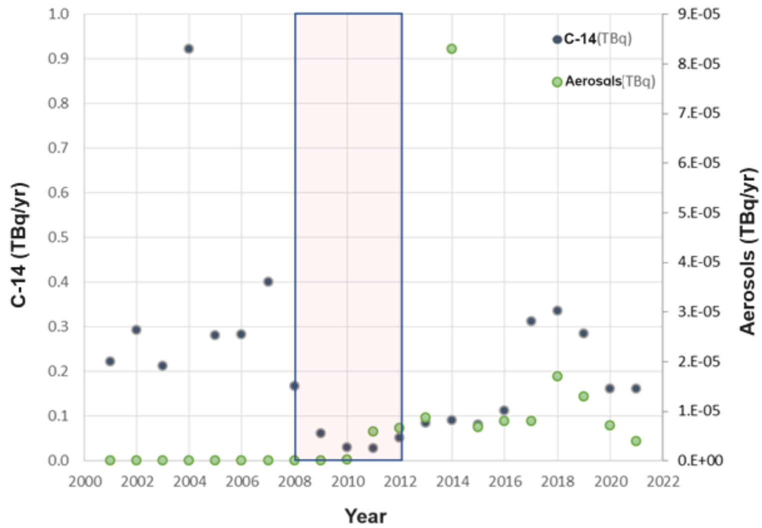


Fig. 22 The evolution of the total annual emissions of C-14 and radioactive aerosols at the PLGS plant during 2000 – 2022

It should be noted that the emissions of C-14 and radioactive aerosols were reduced during the period in which the refurbishment works were carried out, returning, after the commissioning of the reactor, to levels comparable to those reached in the years prior to the refurbishment.

In conclusion, the only radioactive emissions whose significant increase could be anticipated, as a result of the refurbishment activities, are those of tritium, but an increase of an order of magnitude in the annual emissions is unlikely to lead to exceeding the limits derived from the emission approved for Unit 1, taking into account that they are more than ten times higher than the recorded levels of emissions during the period of operation (see Tab. 63 and Fig. 58).

Also, although less relevant for the refurbishment project at Unit 1 Cernavoda, the emissions monitoring data from the Bruce B plant show that during the refurbishment of Unit 6 (January 2020 – quarter 4 2023) no values were recorded for radioactive emission, at the site, above the usual levels recorded in previous periods. It should be noted, however, that the plant operates four CANDU 750B units, and the available data refer to the plant's total annual emissions. To illustrate the above, the following figure shows the evolution of total annual tritium emissions at the Bruce B plant, starting with 2001.

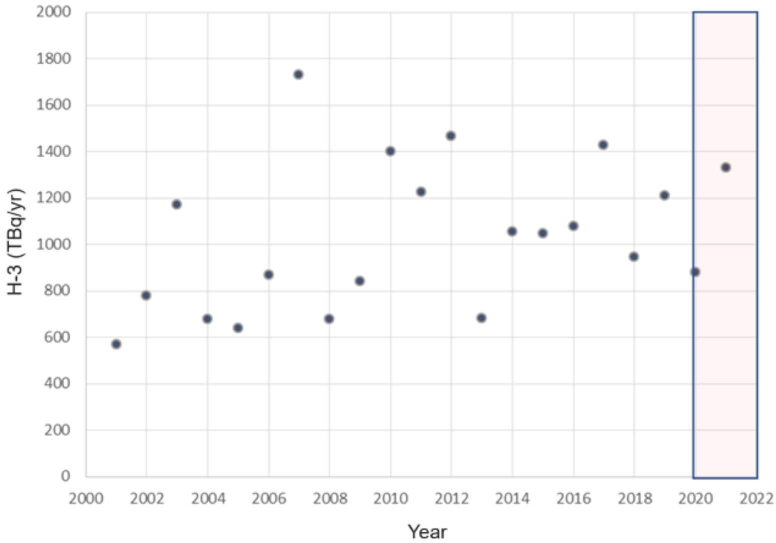


Fig. 23 Evolution of total annual tritium emissions at the Bruce B plant since 2001

1.8.1.4. Monitoring radioactive emissions

The gaseous radioactive effluents, coming from the ventilation systems of the Reactor Building and the Services Building, are discharged through the unit stack, having a height of 50.3 m and an internal diameter of 2.3 m. The total flow of air discharged to the stack is 175140 m^3/h during the summer, respectively 142520 m^3/h in winter. This air is collected from the Reactor Building and the Services Building, the Spent Fuel Pool enclosure, the D_2O Enrichment Tower and the MID Equipment Maintenance Workshop Extension (5200 m^3/h). A fraction of the exhaust air through the stack is continuously extracted and directed to the Gaseous Effluent Monitor (MEG) for sampling and measurement. Particles, radioactive iodine, total tritium (tritiated water vapor and tritium gas) and total C-14 (carbon dioxide, carbon monoxide, organically bound carbon) in the sampled air are collected or absorbed on filters for further analysis in the Staff Dosimetry Laboratory of the NPP. The filters are changed as follows:

- particles and iodine filters - every 24 hours;
- the tritium collector - every 24 hours;
- the C-14 collector - every 24 hours[36].

In the case of the activities carried out in the building of the new DIDR, the potentially radioactive gaseous effluents are constituted by the air exhausted through the ventilation system of the building.

The radiation monitoring system within the new DIDR includes a radiological effluent monitoring system, with the aim of determining the radioactivity of the gaseous effluents released through the ventilation system of the new DIDR building. Some of the constructive and functional features of this system are listed below: [37]

- Monitoring of radiation levels in gaseous effluents from the new DIDR.
- All sampling systems for particulate monitoring shall include a blower or air pump with a flow regulator to ensure a constant flow of sampled air, for representative sample.

[36] Final Nuclear Security Report Unit 1, Doc. 79-01320-FSAR-CAP11/2022
[37] Feasibility Study of Radioactive Waste Management - Environmental Issues Report Task 5.2.7, Doc. RWM-T-T5-013R2, April 2021

- Particle detectors will be designed to detect beta radiation and iodine detectors will detect gamma radiation.
- Filters used for particle monitoring will provide a minimum 99% retention rate for particles 1 micron in diameter or larger.
- All effluent monitoring systems will be designed to ensure a certain sampling flow rate. In the situation where this flow rate cannot be reached, the system will signal the corresponding deficiency so that corrective actions can be taken.
- The system will include adaptations to allow temporary sampling, upstream of the monitoring devices, in the event of their failure.
- The gaseous radioactive effluent monitor will provide indication of measurements and/or allow isolation of radioactivity in the exhaust air path.
- Any potential escape route for gaseous effluents will be continuously monitored or periodic sampling of effluents will be carried out during normal operation or during operational events.

The activity of the ***liquid effluents*** resulting from the radioactive liquid waste management activities in the plant is monitored with the Liquid Effluent Monitor (MEL).

The MEL monitor provides the following functions:

- constant monitoring of all discharged liquid waste, through continuous sampling of representative samples;
- permanent recording and display on demand of time variation of the activity concentration in the exhaust channel;
- determination, by integration in relation to time and flow, of the total activity released daily and monthly;
- detection and measurement of gamma radiation emitted by liquid effluents and display of the measured activity;
- permanent availability for detection and measurement of the activity, regardless of whether there is pumping or not;
- detecting and measuring activities in real time;
- accepting inputs and providing outputs/interlocks that will terminate a pumping sequence in situations such as adverse operating conditions or monitor unavailability/failure;
- providing an output signal, to another panel (Radioactive Liquid Waste system panel), to close the exhaust valve in cases where the activity concentration or the total activity are greater than or equal to the preset limits;
- high activity alarm in the Main Control Room;
- providing an analog output signal to the recorder, a signal corresponding to the net activity concentration of the sample (Ci/m^3).
- displays and indications about the quantities to be measured and the status of the monitor at a given time;
- communication and input/output command signals to the control panel of the radioactive aqueous liquid waste management System, to automatically stop the discharge when a pre-set threshold is exceeded;
- an output signal for continuous recording of data on a recorder.[38]

[38] Raport final de securitate nucleară Unitatea 1, Doc. 79-01320-FSAR-CAP11/2022

1.8.1.5. Radioactive waste and radioactive effluents in the DICA extension subproject

No radioactive materials are used in the construction stage of MACSTOR modules. Thus, the production of radioactive waste or radioactive effluents is not anticipated for this stage.

During the operation period of the facility, the engineering barriers established by the project ensure the containment of the radioactive material, without the risk of dispersion in the environment.

During the intermediate storage period, the main monitoring operations consist in the periodic sampling (with the frequency approved by CNCAN) of air samples from the atmosphere of each storage cylinder according to a specific procedure, with the aim of verifying the capacity of the stack and the storage cylinder to maintain the containment barrier of radioactive isotopes from the spent fuel. The air inside the storage cylinder is drawn through a particulate filter, an activated carbon filter and a drying unit, which condenses the water vapor. The particulate filter traps solid contaminants, the activated carbon filter is analyzed for I-131, and the water is analyzed for tritium content.

The waters on the DICA platform come from precipitation and/or from the washing of the concrete platforms. The waters on the DICA platform are collected through a system of concrete gutters covered with roadable metal grates, collecting channels on which there are manholes and drains equipped with grates.

The collecting manholes together with the gutters are able to collect and retain from the DICA platform the maximum volume of water resulting from 24 hours of rain (considering events with a return period of 5 years). When the water collected in the collecting tank reaches a predetermined level, water samples are taken for laboratory verification of possible radioactive contamination. After carrying out the radioactivity analyses, depending on the result, the water is discharged into the Cismelei Valley or transferred to the liquid radioactive waste management system of the NPP, where it is processed in accordance with the NPP's procedures in order to fulfill the requirements of CNCAN and the Water Management Authorization for U1 and U2 in effect.

The methods for estimating the identified radioactive emissions, as well as the uncertainty related to these estimates, can be found in subchapter 6.1 *Methodologies for estimating radioactive emissions, for pollutant dispersion modeling. Uncertainties and difficulties in radiological impact assessment.*

1.8.2 Non-radioactive waste and emissions of non-radioactive pollutants

1.8.2.1 Non-radioactive waste

Non-radioactive waste is the waste generated within the project and which falls into one of the categories regulated by GEO no. 92/2021 *on the waste regime*.

The main categories of non-radioactive waste estimated to be generated during the execution period of the RT-U1 and DICA - MACSTOR 400 project are presented in the following table.

Tab. 11 The main categories of non-radioactive waste generated during the project and management options

Type of non-radioactive waste	Codes - Classification*	Physical condition (Solid-S, Liquid-L, Semisolid-SS	Management options	
			Recovery	Disposal
Waste from construction materials, absorbent materials, polishing materials, filters and protective clothing				
concrete	17 01 01	S	X	
concrete mixtures, bricks, tiles and ceramic materials, other than those specified in 17 01 06	17 01 07	S	X	X
iron and steel	17 04 05	S	X	
metallic waste	17 04 07	S	X	
wood waste	17 02 01	S	X	
plastic materials	17 02 03	S	X	
soil contaminated by diesel leaks, oils, etc	17 05 03*	S		X
earth and stones, other than those specified at 17 05 03*	17 05 04	S	X	X
insulating materials, other than those specified in 17 06 01* (containing asbestos) and 17 06 03* (consisting of or containing dangerous substances)	17 06 04	S	X	
absorbents, filter materials (polishing materials, protective clothing contaminated with dangerous substances)	15 02 02*	S		X
polishing materials and protective clothing, other than those specified in 15 02 02*	15 02 03	S	X	
Packaging waste				
paper and cardboard packaging	15 01 01	S	X	
plastic packaging waste	15 01 02	S	X	
wooden packaging	15 01 03	S	X	
packaging of composite materials	15 01 05	S	X	
packaging that contains residues or is contaminated with dangerous substances	15 01 10*	S		X
Municipal and assimilated waste				
paper and cardboard waste (from administrative, office activities)	20 01 01	S	X	
glass waste	20 01 02	S	X	
plastic materials	20 01 39	S	X	
metals	20 01 40	S	X	
household waste (mixed municipal waste), generated by staff activity	20 03 01	S		X

* Codes according to GD no. 856/2002 regarding the record of waste management and for the approval of the list including waste, including hazardous waste.

During the project implementation period, the estimated quantities/volumes for the main categories of non-radioactive waste are:

- concrete (code 17 01 01 according to GD 856/2002): 25664.07 c.m. ,
- mixed metals (code 17 04 07 according to GD 856/2002): 15 tons
- fertile soil and rocks resulting from excavations for foundations (code 17 05 04 according to GD 856/2002): 44747.70 c.m.

Waste management plan for the period of RT-U1 and DICA - MACSTOR 400 project execution

During the realization of the RT-U1 and DICA MACSTOR - 400 Project, in order to ensure an adequate waste management during the construction works, within the site organization, in addition to the legal provisions relating to the effective management of waste, the following will also be observed:

- Cernavoda NPP procedures;
- project-specific procedures;
- measures to prevent and/or reduce accidental leaks;
- waste management procedures resulting from construction-assembly activities;
- periodic maintenance activities of machines and vehicles;
- proper handling and storage of fuels and materials.

Cernavoda NPP will transfer the responsibility for proper waste management, including monitoring, control and reporting, to the organization responsible for construction/assembly, testing and commissioning activities, detailing the requirements of the Environmental Agreement and other authorizations, approvals, etc. within the contract and its annexes (Environmental Protection Convention, etc.).

All the necessary measures will be taken for the collection and temporary storage in appropriate conditions of the non-radioactive industrial waste generated during the implementation of the project and to ensure that the collection, transport, disposal or recovery operations are carried out by specialized and authorized companies.

The generated waste will be collected separately, by type of waste (code), taking into account the nature of the materials and the possibilities of reuse/recovery, as well as the degree of contamination with dangerous substances. Thus the following categories of waste are temporarily stored:

- recyclable waste / non-recyclable waste
- non-hazardous waste / hazardous waste.

The temporary storage of the waste generated during the construction/assembly stage of the buildings and spaces related to the RT-U1 Project will be done according to the applicable legislation and internal procedures of Cernavoda NPP, only in spaces specially set for this purpose.

The contractor will hand over the recyclable/non-recyclable construction waste to economic operators authorized in terms of environmental protection, according to the provisions of GEO 92/2021 on the waste regime, as amended and supplemented.

No asbestos containing construction materials will be used and consequently no construction waste – insulating materials and construction materials containing asbestos code 17 06 according to GD no. 856/2002 - will be generated. (If materials containing asbestos are identified during project execution works related to the refurbishment process, they will be removed by authorized operators.

The machinery, equipment and vehicles used for the construction-assembly stages will be provided by a service contract, their maintenance and repair being exclusively the responsibility of the contractor and will be carried out by specialized units.

Waste prevention and reduction programme during the RT-U1 and DICA - MACSTOR 400 Project execution period

During the RT-U1 and DICA - MACSTOR 400 Project works, a series of measures will be taken with the aim of preventing and reducing/minimizing the amount of non-radioactive waste generated, such as:

- judicious planning/optimization of the quantities of raw materials/materials necessary to be used in the execution of the project, so as to avoid the formation of unnecessary stocks (especially for raw materials/materials that have an expiration period or that could suffer degradation over time);
- reuse of materials/raw materials/packaging where this is possible;
- temporary storage of materials/raw materials in appropriate conditions so as to avoid their possible degradation;
- the use of prefabricated, equipment sub-assemblies, with finishes made at the place of their production (eg pre-finished metal panels for the walls of the building, supply of concrete mixers instead of concrete preparation on-site, at Cernavoda NPP);
- proper handling of raw materials/materials/equipment in order to avoid losses, accidental leaks;
- staff awareness of compliance with the provisions of the environmental legislation in force, of the importance of preventing the generation of waste for the health of the population and the environment.

The following shall be respected: the provisions of the environmental legislation in force, the measures and conditions imposed by the permits/agreements/authorizations issued by the regulatory authorities, the procedures and measures for the prevention and/or reduction of accidental leaks, the management procedures for the waste resulting from construction-assembly activities, periodic machinery and vehicles maintenance activities, as well as proper handling and storage of fuels and materials.

Non-radioactive waste generated by the activities carried out on the Cernavoda NPP platform, after Unit U1 refurbischment and the entry into operation of the DICA–MACSTOR 400

During the operation of Unit 1 after refurbishment, the same types of non-radioactive waste will be generated in quantities similar to those generated in the first operation cycle.

The main categories of non-radioactive waste generated at Cernavoda NPP are classified as:

- chemical waste, resulting from the use - or being obsolete - of various substances and mixtures of substances;
- industrial waste;
- household waste - similar municipal waste.

The types of nonradioactive waste generated by the operation of nuclear facilities at the Cernavoda NPP site are presented in the following table.

Tab. 12 Types and quantities of non-radioactive waste estimated to be generated at the Cernavoda NPP site

No.	Waste type	Waste code according to GD 856/2002	Annual amount (tonnes)	Recovery Code EO 92/2021 - Appendix 3	Disposal Code EQ 92/2021 -Appendix 7
1.	Used oils	13 07 01*/ 13 02 08*	20 - 40	R12	–
2.	Halogen-free oils	12 01 09*/ 13 05 07*	10 – 76	–	D9
3.	Waste containing organic substances	16 10 01*/ 19 02 08*/ 16 03 05*	0.5 – 42	–	D15
4.	Hydraulic Turbine Fluid (FRF)	13 01 11*	Included in waste oil	–	D15
5.	Sulphuric acid - solution	16 06 06*/ 11 01 06*	–	–	D15
6.	Absorbents, filters and polishing materials	15 02 03	0.5 – 1.5	–	D15
7.	Used ion exchange resins	19 09 05	0.2 – 40	–	D15
8.	Plastic waste (containers for biological samples)	18 01 03*	0.8 – 1.5	–	D15
9.	Construction waste (concrete, soil and gravel etc.)	17 05 04/ 17 01 01/ 17 01 07/ 20 02 02	3000 – 10000	R10	D5
10.	Antifreeze (ethylene glycol)	16 01 14*	6 – 25	–	D15
11.	Batteries and accumulators	16 06 01*	0 – 13	R12	–
12.	Transformer oils - PCB free	13 03 07*	0 – 76	R12	–
13.	Laboratory reagents containing dangerous substances/mixtures	16 05 06*	1 – 13	–	D15
14.	Expired medicines (KI)	18 01 09	0 – 25	–	D10
15.	Wood waste	17 02 01	2 – 12	R1	–
16.	Iron and copper waste	16 01 17 / 17 04 05 / 17 04 01/ 15 01 04	20 – 630	R12, R4	–
17.	Paper waste	19 12 01 / 15 01 01 / 20 01 01	15 – 25	R12	–
18.	Plastic waste	15 01 02 / 16 01 19	0,3 – 1	R12	–

No.	Waste type	Waste code according to GD 856/2002	Annual amount (tonnes)	Recovery Code EO 92/2021 - Appendix 3	Disposal Code EQ 92/2021 -Appendix 7
19.	Absorbents, filters, polishing materials contaminated with dangerous chemicals	15 02 02*	5 – 55	–	D9
20.	Activated alumina (inorganic hazardous waste)	16 03 03*	0 – 3	–	D15
21.	Polyurethane waterproofing/glass wool	17 09 04	4 – 30	–	D15
22.	Aluminum waste	17 04 11/ 17 04 02	< 1	R12	–
23.	Household waste	20 02 01/ 20 03 01	19620 m^3	–	D5
24.	DEEE	16 02 03*/ 16 02 11*/ 16 02 13*/ 20 01 21*	0.5 – 15	R12	–
25.	Electrical and electronic waste	20 01 36/ 16 02 14	1 – 10	R12	–
26.	Used ceramic insulators	16 02 16	< 1	R12	–
27.	Plastic packaging waste	20 01 39/ 15 01 02	< 1	R12	–
28.	Plastic or glass packaging, contaminated with dangerous substances	17 02 04*	< 1	–	D15
29.	Used toners	08 03 17*	< 1	R12	–
30.	Polyurethane foam waste	17 06 04	< 4	–	D15
31.	Glass waste	15 01 07 16 01 20	< 1	R5 R13	–

Notes:

1) * - hazardous waste

2) Estimated annual amounts of waste based on the waste management record at Cernavoda NPP during 2018 ÷2023

3) The name of the reported recovery operations - Code according to EO 92/2021- Appendix 3

- R1 Use principally as a fuel or other means to generate energy
- R4 Recycling/reclamation of metals and metal compounds
- R5 Recycling/reclamation of other inorganic materials
- R10 Land treatment resulting in benefit to agriculture or ecological improvement
- R12 Exchange of waste for submission to any of the operations numbered R 1 to R 11
- R13 Storage of waste pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where the waste is produced)

4) Name of the reported disposal operations - Code according to EO 92/2021- Appendix 7

- D5 Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.
- D9 Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12 (e.g. evaporation, drying, calcination, etc.)
- D10 Incineration on land
- D15 Storage pending any of the operations numbered D 1 to D 14 (excluding temporary storage, pending collection, on the site where the waste is produced).

Non-radioactive waste management after the refurbishment of Unit 1 and the entry into operation of DICA MACSTOR-400

The management of non-radioactive waste will be carried out according to the provisions of the applicable normative acts in force, the regulatory acts and the specific procedures approved and implemented by Cernavoda NPP:

- Emergency Ordinance no. 92/2021 on the waste regime
- GD no. 856/2002 regarding waste classification and specific legislation for certain categories of waste
- Law no. 249/2015 regarding the management of packaging and packaging generated waste, with subsequent amendments and additions,
- Emergency Ordinance no. 5/2015 on waste electrical and electronic equipment waste
- GD no. 1061/2008 regarding the transport of waste on the territory of Romania, with subsequent amendments and additions
- Cernavoda NPP Environmental Authorization, approved by GD no. 84/2019 regarding the issuance of the environmental authorization for the National Company "NUCLEARELECTRICA" - S.A. – "Cernavoda NPP Branch " - Unit 1 and Unit 2 of Cernavoda Nuclear Power Plant"
- SI-01365-A033 – procedure regarding the management of non-radioactive industrial waste at Cernavoda NPP.

Non-radioactive waste, including chemical waste, is collected in the temporary storage space set up in U1 and U2, in the Turbine Building, elevation 100 mdMB, and is managed according to Cernavoda NPP internal procedure SI-01365-A033 "*Management of non-radioactive industrial waste at Cernavoda NPP*" , which consists of inspecting labelling, packaging integrity, sampling for tritium and gamma analysis and sealing containers (to avoid further contamination until transfer outside the radiological area).

Transportable containers with non-radioactive waste are handled with forklifts and machines specific to these maneuvers. All lifting equipment used is authorized by ISCIR and for use. The transport of containers with non-radioactive waste for temporary storage or delivery to other entities is carried out by electric car, tractor, truck, authorized for the transport of non-hazardous or hazardous waste (as applicable), with the appropriate anchoring of the transported products. Delivery to authorised economic operators for temporary storage, disposal or recovery is carried out on the basis of a service contract, the transport being ensured by the service provider with means of transport authorised for the categories of waste transferred. Plastic bags with solid waste are transferred to metal containers, or to the packaging provided by the authorized Service Provider, to eliminate incidents caused by damage to the bags.

In the approved non-radioactive waste storage areas, within the protected premises, there are large containers with a capacity of 3 m^3, identified separately for each type of non-radioactive solid waste collected. After filling, the containers designated for wood, ferrous and non-ferrous metal waste are transported outside Unit 1 or Unit 2, to adequate arranged storage spaces of Cernavoda NPP and are subsequently transferred to authorized operators for recovery/disposal, as appropriate.

The temporary storage, until the delivery of non-radioactive waste/expired chemical substances, is done by Cernavoda NPP (as a waste generator), in specially arranged spaces on the Cernavoda NPP site.

The hazardous non-radioactive waste disposal from the site is done by authorized operators, on a contract basis, according to the environmental regulations in force.

Household waste, resulting from workplaces and accommodation spaces of Cernavoda NPP, is selectively collected and disposed/recovered by authorized operators, on a contract basis.

Arrangements and measures for environmental protection

The waste generated in the second operating cycle of Unit U1 will be managed by the holder, similar to the current operating situation of the two nuclear units U1 and U2, currently regulated.

The temporary storage spaces at the generation site are delimited and marked so that their destination can be easily identified.

Non-radioactive waste, including some chemical waste, is collected in the temporary holding space set up in U1 and U2, in the Turbine Building, quota 100 mdMB.

The buildings are equipped with isolated sumps, calculated to receive all the amount of liquid waste designed for storage, in the event of a major incident, without the possibility of evacuation in the water drainage systems of the area. Outside the buildings, there are concrete platforms on which the waste container handling maneuvers are carried out. These platforms also have insulated sumps and are calculated at the appropriate slope to allow any accidental spills collection. The interior spaces are equipped with specially built storage racks. The storage spaces are provided with boxes with sand to contain any accidental spills. Maintenance personnel carry out periodic inspections to verify the integrity of containers and to avoid destruction or loss of labels. The temporary storage areas are also provided with emergency cabinets equipped with intervention materials in case of accidental leak.

Spaces for temporary storage of hazardous non-radioactive waste are designed with proper ventilation and anti-Ex systems to prevent fires. Containers of non-radioactive liquid waste are stored on special pallets with leak containment capacity.

In the premises of the nuclear units, non-radioactive industrial waste is transported using the industrial means of transportation of the Depot Management Service. The transport outside the platform is provided by the service provider who takes this waste for recovery.

The control of the storage and **disposal of non-radioactive chemical waste** is carried out by:

- registration of inputs/outputs by category and quantity of chemical waste, in records belonging to each storage space;
- the archiving of waste transfer record forms and those for the transport of waste lots, completed and approved according to Cernavoda NPP internal procedure SI-01365-A033 *"Management of non-radioactive industrial waste at Cernavoda NPP*”;

- taking representative samples from the waste containers for their characterization through physical-chemical analyses; keeping counter-sample until the disposal/recovery of the respective waste (for hazardous ones);
- periodic inspection of the temporary waste storage spaces in the installation and the application of corrective actions where they are required;
- contracting transport services and waste recovery/disposal only with authorized suppliers, after verifying that they fulfill all legal requirements according to environmental regulations in the field of waste: presenting copies of authorizations, obtaining transport approvals according to the legal procedure;
- verification and approval of the transfer documents by the Cernavoda NPP Manager with non-radioactive industrial waste management.

Recoverable waste: Non-radioactive waste of paper, wood, ferrous and non-ferrous metals, lead batteries, plastic are given to authorized operators, on the basis of service contracts, for the purpose of recovery.

Non-radioactive waste prevention and reduction programme

In order to minimise the amount of non-radioactive waste generated during the operation of the refurbished Unit 1, the provisions of the environmental legislation in force, the provisions of the applicable authorizations, the NPP procedures on measures to prevent and/or reduce accidental spills, waste management, periodic maintenance activities of machinery/equipment, as well as the proper handling and storage of fuels and materials will be observed.

1.8.2.2 Circular economy

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.[39]

According to the National Strategy regarding the circular economy, approved by GD no. 1172/2022, the concept is based on the following three fundamental principles:

1. Phasing out non-recoverable waste and reducing pollution.
2. Keeping products and materials at their highest use value for as long as possible.
3. Regeneration of natural systems (biodiversity and ecosystem).

Within the management system of Cernavoda NPP, the maintenance and repair process and the reliability process are defined, through which the preventive and predictive maintenance activities of the system structures, components and equipment on the site are documented, a process that optimizes the prevention of premature wear and replacement.

Also, within the process of maintaining reliability, an aging management program is defined, based on which the tracking of equipment performance is ensured so as to maintain reliability throughout the life cycle recommended by the manufacturer. For the equipment with a long life cycle (the maximum being at the level of 30 years), complex periodic inspection programs are established. To prepare the Unit 1 for LTO (long-term operation), the activities expected to be carried out during

[39] https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits Circular economy: definition, importance and benefits

the refurbishment consider the replacement of components and/or equipment for a new operating cycle, a strategy that aligns with the general principles of the circular economy.

Also, the NPP procedures aim at the separate collection of different types of waste and the delivery of recyclable waste to authorized operators, for the purpose of recovery.

Through the non-radioactive waste management plan, Cernavoda NPP ensures the recovery of recyclable waste that can then be reintroduced into the economic circuit, as provided for by the principles of the circular economy.

1.8.2.3 Sources of non-radioactive gaseous emissions and associated pollutants. Estimated emissions for project stages

Construction phase of the objectives proposed by the project

The main activities during the construction period of both the infrastructure required for the refurbishment of unit U1 and the construction of a MACSTOR 400 type storage facility which are sources of air pollutants during the construction phase are the following:

- Earth handling operations: digging, loading into trucks;
- Breaking up of existing concrete in certain areas of the sites, stone/rock breaking for deep foundations;
- Earthworks: unloading of aggregate trucks, spreading/levelling/compaction of material;
- Asphalting of surfaces (application of emulsion primer, asphalt pouring (binder and wearing course) in case of internal roads/platforms/parks;
- Transport of soil/waste, materials;
- Transport of workers to the site.

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Tab. 13 – *Tab. 19* show the emissions associated with the construction works for the infrastructure required to refurbish the U1 reactor.

Tab. 13 Particulate matter emissions (hourly mass flow rates) from construction works infrastructure refurbishment reactor U1 (buildings) - unducted emissions

No.	**Work/operation category**	**Mass flow rates on the dimensional spectrum (kg/h)**		
		d<30 mm	**d <10 mm**	**d <2.5 mm**
Digging/Excavation				
1	Excavation + breaking + digging	1.348	0.254	0.142
2	Loading into trucks (excavator + loader)	0.005	0.002	0.000
Subtotal		**1.353**	**0.256**	**0.142**
Temporary earth storage[1)]				
3	Unloading of earth trucks	0.015	0.007	0.001
4	Soil levelling (bulldozer)	1.184	0.227	0.124
Subtotal		**1.199**	**0.234**	**0.125**

1) *These emissions can be found off-site*

Tab. 14 Particulate matter emissions (hourly mass flow rates) generated by the construction works for the refurbishment of the U1 reactor (storage platform) - unducted emissions

No.	Work/operation category	Mass flow rates on the dimensional spectrum (kg/h)		
		d<30 mm	**d <10 mm**	**d <2.5 mm**
Digging/Excavation				
1	Excavation + breaking + digging	0.449	0.085	0.047
2	Loading into trucks (excavator + loader)	0.002	0.001	0.000
Subtotal		**0.451**	**0.086**	**0.047**

Tab. 15 Particulate matter emissions (hourly mass flow rates) generated by the construction works for the refurbishment of the U1 reactor (parking lot) - unducted emissions

No.	Work/operation category	Mass flow rates on the dimensional spectrum (kg/h)		
		d<30 mm	**d <10 mm**	**d <2,5 mm**
Digging/Excavation				
1	Excavation + breaking + digging	0.449	0.085	0.047
2	Loading into trucks (excavator + loader)	0.002	0.001	0.000
Subtotal		**0.451**	**0.086**	**0.047**

Tab. 16 NMVOC emissions (hourly mass flow rates) from asphalt paving operation - Construction of infrastructure for refurbishment of U1 reactor (parking lot) – unducted emissions

Asphalting	VOC_{nm} (kg/h)
Emulsion primer application	0.286
Asphalt pouring	1.072

Tab. 17 Emissions of pollutants from mobile sources for the construction of infrastructure refurbishment of reactor U1 (buildings) - unducted emissions

	Total emissions (kg)																
	TSP	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**N_2O**	**CH_4**	**CO**	**PM_{10_exh}**	**VOC_{nm}**	**SO_2**	**Cd [10^{-3}]**	**As [10^{-3}]**	**Pb [10^{-3}]**	**Ni [10^{-3}]**	**Cr [10^{-3}]**	**HAP [10^{-3}]**	**Benzo(a)pyrene [10^{-3}]**
Equipment	2.114	2.114	2.114	33.824	2.960	0.254	126.839	2.114	10.993	0.440	0.220	0.000	0.000	1.539	1.099	3.738	0.660
Vehicles	10.315	2.141	0.608	5.531	0.086	0.155	0.266	0.061	0.025	0.011	0.000	0.000	0.027	0.000	0.005	0.035	0.002
Total	12.429	4.255	2.722	39.355	3.046	0.408	127.105	2.175	11.018	0.450	0.220	0.000	0.027	1.539	1.104	3.773	0.662

Tab. 18 Emissions of pollutants from mobile sources for the construction of infrastructure for the refurbishment of the U1 reactor (storage platform) - unducted emissions

	Total emissions (kg)																
	TSP	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**N_2O**	**CH_4**	**CO**	**PM_{10_exh}**	**COV_{nm}**	**SO_2**	**Cd [10^{-3}]**	**As [10^{-3}]**	**Pb [10^{-3}]**	**Ni [10^{-3}]**	**Cr [10^{-3}]**	**HAP [10^{-3}]**	**Benzo(a)pyrene [10^{-3}]**
Equipment	0.473	0.473	0.473	7.569	0.662	0.057	28.383	0.473	2.460	0.098	0.049	0.000	0.000	0.344	0.246	0.836	0.148
Vehicles	2.059	0.427	0.121	1.104	0.017	0.031	0.053	0.012	0.005	0.002	0.000	0.000	0.005	0.000	0.001	0.007	0.000
Total	2.532	0.900	0.594	8.673	0.679	0.088	28.436	0.485	2.465	0.101	0.049	0.000	0.005	0.344	0.247	0.843	0.148

Tab. 19 Emissions of pollutants from mobile sources for the construction of infrastructure for the refurbishment of the U1 reactor (park lot) - unducted emissions

	Total emissions (kg)																
	TSP	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**N_2O**	**CH_4**	**CO**	**PM_{10_exh}**	**COV_{nm}**	**SO_2**	**Cd [10^{-3}]**	**As [10^{-3}]**	**Pb [10^{-3}]**	**Ni [10^{-3}]**	**Cr [10^{-3}]**	**HAP [10^{-3}]**	**Benzo(a)pyrene [10^{-3}]**
Equipment	0.226	0.226	0.226	3.608	0.316	0.027	13.532	0.226	1.173	0.047	0.023	0.000	0.000	0.164	0.117	0.399	0.070
Vehicles	0.933	0.194	0.055	0.500	0.008	0.014	0.024	0.005	0.002	0.001	0.000	0.000	0.002	0.000	0.000	0.003	0.000
Total	1.159	0.419	0.281	4.109	0.324	0.041	13.556	0.231	1.175	0.048	0.023	0.000	0.002	0.164	0.118	0.402	0.071

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Tab. 20 și Tab. 21 show the emissions generated by the construction of a MACSTOR 400 module.

Tab. 20 Particulate emissions (hourly mass flow rates) from construction work on a MACSTOR 400 module - unducted emissions

No.	**Work/operation category**	**Mass flow rates on the dimensional spectrum (kg/h)**		
		d<30 mm	**d <10 mm**	**d <2.5 mm**
Digging/Excavation				
1	Excavation + breaking + digging	0.449	0.085	0.047
2	Loading into trucks (excavator + loader)	0.002	0.001	0.000
Subtotal		**0.451**	**0.086**	**0.047**
Temporary earth storage[1)]				
3	Unloading of earth trucks	0.005	0.002	0.000
4	Soil levelling (bulldozer)	0.395	0.076	0.041
Subtotal		**0.400**	**0.078**	**0.041**
Earthworks / compaction				
5	Unloading truck aggregates	0.007	0.003	0.000
6	Spreading/levelling material (bulldozer)	0.152	0.021	0.016
Subtotal		0.159	0.024	0.016

1) These emissions can be found off-site

Tab. 21 Emissions of pollutants from mobile sources for construction MACSTOR 400 module - unducted emissions

Source	**Total emissions (kg)**																
	TSP	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**N_2O**	**CH_4**	**CO**	**PM_{10_exh}**	**VOC_{nm}**	**SO_2**	**Cd**	**As**	**Pb**	**Ni**	**Cr**	**HAP**	**Benzo(a)pyrene**
											[10^{-3}]	**[10^{-3}]**	**[10^{-3}]**	**[10^{-3}]**	**[10^{-3}]**	**[10^{-3}]**	**[10^{-3}]**
Equipment	0.944	0.944	0.944	15.110	1.322	0.113	56.664	0.944	4.911	0.196	0.098	0.000	0.000	0.688	0.491	1.670	0.295
Vehicles	6.253	1.298	0.180	3.353	0.052	0.094	0.161	0.037	0.015	0.006	0.000	0.000	0.016	0.000	0.003	0.021	0.001
Total	7.197	2.242	1.125	18.463	1.374	0.207	56.826	0.981	4.926	0.203	0.098	0.000	0.016	0.688	0.494	1.691	0.296

Operational phase of the objectives proposed by the project

The main categories of sources/activities generating non-radioactive emissions into the atmosphere during the period of operation of both Unit U1 after refurbishment and for the operation of the DICA - MACSTOR 400 repository are the same as in the current situation, the operation of U1 in the first operating cycle and the operation of the existing DICA - MACSTOR 200.

As the refurbishment does not involve any change in the production capacity of Unit U1, its operation after refurbishment will generate the same non-radioactive pollutants and emissions as in the current situation.

Since the refurbishment will maintain the production capacity of Unit U1 and the efficiency of the nuclear fuel combustion process, the generation rate of consumed nuclear fuel will be maintained. Thus, under normal operating conditions, fuel storage activities will have the same periodicity and generate the same emissions as today.

Therefore, the main sources of non-radioactive emissions from the Cernavodă NPP site during the post-implementation operating period will be represented by:

- burning of LLF type liquid fuel in the boilers of the Start-up Power Plant (CTP) - 2 boilers;
- Diesel fuel combustion in the Diesel groups of the Standby Diesel Generator (SDG) - 4 groups in Unit 1 and 2 groups in Unit 2;
- Diesel fuel combustion in the diesel units of the Emergency Power System (EPS) - 2 units in Unit 1 and 2 units in Unit 2;
- Diesel fuel burn in the Fire Water System (SPAI) motor pump - is common to the fire water systems in the two nuclear units;
- diesel combustion in mobile diesel groups (GDM) - 4 mobile diesel units;
- Diesel fuel combustion in the Generating Sets (GE) - 3 diesel sets related to the NPP access control points;
- burning diesel fuel in the diesel generator for Burnt Fuel Storage (DICA);
- burning diesel fuel in the generator of the On-Site Emergency Control Centre (CCUA).

The following table summarises the main emission sources at the Cernavodă NPP site:

Tab. 22 Sources of non-radioactive pollutant emissions on the Cernavodă NPP site

No.	Source name	Rated thermal input (MW) / designed production capacity (t steam)	Status (e.g. in operation, in conservation, not in operation)	Year of commissioning
1.	CTP - boiler #2 type CR 30	23.66 MW / 30t steam at 250˚C	in operation	1988
2.	CTP - boiler #3 type CR 30	23.66 MW / 30t steam at 250˚C	in operation	1993
3.	SDG 1 - U1	11.04 MW	in operation	1996
4.	SDG 2 - U1	11.04 MW	in operation	1996
5.	SDG 3 - U1	11.04 MW	in operation	1996
6.	SDG 4 - U1	11.04 MW	in operation	1996
7.	EPS 1 - U1	11.04 MW	in operation	1996
8.	EPS 2 - U1	11.04 MW	in operation	1996
9.	SDG 1 - U2	18,354 MW	in operation	2007
10.	SDG 2 - U2	18,354 MW	in operation	2007
11.	EPS 1 - U2	1.88 MW	in operation	2007
12.	EPS 2 - U2	1.88 MW	in operation	2007

No.	Source name	Rated thermal input (MW) / designed production capacity (t steam)	Status (e.g. in operation, in conservation, not in operation)	Year of commissioning
13.	SPAI motor pump	0.268 MW	in operation	2019
14.	Mobil Diesel Group 1	1.340 MW	in operation	2013
15.	Mobil Diesel Group 2	1.340 MW	in operation	2013
16.	Mobil Diesel Group 3	0.086 MW	in operation	2013
17.	Mobil Diesel Group 4	0.086 MW	in operation	2013
18.	Generating Sets 1	0.2 MW	not in operation	2020
19.	Generating Sets 2	0.151 MW	not in operation	2020
20.	Generating Sets 3	0.151 MW	in operation	2020
21.	Diesel Generator for Burnt Fuel Storage (DICA)	0.069 MW	operation	2004
22.	CCUA Diesel Group	0.108 MW	operation	2009

The physical parameters of the dispersion stacks of the analysed installations, used as input data in the mathematical modelling of dispersion, are presented in the following table:

Tab. 23 Physical parameters of non-radioactive air pollutant emission sources at the Cernavodă NPP site

Emission source	Stack height from the ground (m)	Inside diameter at top of stack (m)	Gas temperature at stack exit (° C)	Gas velocity stack exit (m/s)
Start-up Power Plant - boiler 1 – stack 1	26	1.3	166	15
Start-up Power Plant - boiler 2 - stack 2	26	1.3	166	15
Standby Diesel Generator at Unit 1 - generator 1 - stack 1	22	0.8	410	12
Standby Diesel Generator at Unit 1 - generator 2 - stack 2	19	0.8	410	12
Standby Diesel Generator at Unit 1 - generator 3 - stack 3	19	0.8	410	12
Standby Diesel Generator at Unit 1 - generator 4 - stack 4	19	0.8	410	12
Emergency Power System at Unit 1 - Generator 1 - Stack 1	10	0.3	370	8
Emergency Power System at Unit 1 - Generator 2 - Stack 2	10	0.3	370	8
Standby Diesel Generator at Unit 2 - generator 1 - stack 1	22	0.91	365	15
Standby Diesel Generator at Unit 2 - generator 2 - stack 2	22	0.91	365	15
Emergency Power System at Unit 2 - generator 1 - stack 1	10	0.3	370	7
Emergency Power System on Unit 2 - Generator 2 - Stack 2	10	0.3	370	7

Emission source	Stack height from the ground (m)	Inside diameter at top of stack (m)	Gas temperature at stack exit (° C)	Gas velocity stack exit (m/s)
Diesel engine pump for the Fire Water System (SPAI)	7	0.3	300	1.4

For the study, Cernavoda NPP provided data on hourly fuel consumption and number of operating hours for the period 2018÷2022 for each emission generating plant. These consumptions were used to estimate the hourly emissions of non-radioactive pollutants for which dispersion modelling in the atmosphere was performed.

A summary of the fuel consumption for each of the combustion plants for the period 2018÷2022 is shown in the following table:

Tab. 24 . Annual fuel consumption by installation for the period 2018÷2022

Emission source	Fuel	Annual fuel consumption (tonnes)				
		2018	2019	2020	2021	2022
Start-up Power Plant (CTP)	LLF	11.50	844.51	6.00	38.00	12.00
Standby Diesel Generator (SDG) at Unit 1	diesel	100.31	115.55	152.91	129.12	140.50
Emergency Power System (EPS) at Unit 1	diesel	9.66	8.78	9.40	8.00	9.90
Standby Diesel Generator (SDG) at Unit 2	diesel	122.30	115.72	97.31	185.17	138.65
Emergency Power System (EPS) at Unit 2	diesel	5.90	8.06	6.37	9.79	6.22
Diesel engine pump for the Fire Water System (SPAI)	diesel	0.23	0.00	0.48	1.22	1.54
Mobil Diesel Group (GDM)	diesel	0.000	0.000	0.00	0.809	0.768
Generating sets (GE)	diesel	0.000	0.000	0.00	0.000	0.126
Diesel Generator for Burnt Fuel Storage (DICA)	diesel	0.000	0.000	0.00	0.032	0.034
Diesel Generator for On-Site Emergency Control Centre (CCUA)	diesel	0.000	0.000	0.00	0.056	0.079

The annual and hourly emissions thus calculated are shown in the following two tables:

Tab. 25 . Annual pollutant emissions from operation of PTC and diesel generators for the year 2022

Emission source	Fuel	Emissions (kg/an)			
		NOx	CO	SO2	PM10
Start-up Power Plant (CTP)	LLF	49.51	19.80	240.00	19.80
Standby Diesel Generator (SDG) at Unit 1	diesel	5620.50	775.65	2.81	179.00

Emission source	Fuel	Emissions (kg/an)			
		NOx	CO	SO2	PM10
Emergency Power System (EPS) at Unit 1	diesel	395.88	54.63	0.20	12.61
Standby Diesel Generator (SDG) at Unit 2	diesel	5546.42	765.43	2.77	176.64
Emergency Power System (EPS) at Unit 2	diesel	248.81	34.34	0.12	7.92
Diesel engine pump for the Fire Fighting Water System (SPAI)	diesel	61.45	8.48	0.03	1.96
Mobil Diesel Group (MDG)	diesel	30.73	4.24	0.02	0.98
Generating sets (GE)	diesel	5.03	0.69	0.00	0.16
Diesel Generator for Burnt Fuel Storage (DICA)	diesel	1.37	0.19	0.00	0.04
Diesel Generator for On-Site Emergency Control Centre (CCUA)	diesel	3.15	0.44	0.00	0.10

Tab. 26. Maximum hourly emissions of non-radioactive air pollutants generated by sources on the Cernavodă NPP site

Emission source	Fuel	Maximum hourly consumption (kg/h)	Emissions (kg/h)			
			NOx	CO	SO2	PM10
Start-up Power Plant - boiler 1 – stack 1	LLF	1500	6.1883	2.4753	30	2.4753
Start-up Power Plant -boiler 2 - stack 2	LLF	2000	8.2510	3.3004	40	3.3004
Standby Diesel Generator at Unit 1 - generator 1 - stack 1	diesel	807	32.2832	4.4552	0.0161	1.0281
Standby Diesel Generator at Unit 1 - generator 2 - stack 2	diesel	807	32.2832	4.4552	0.0161	1.0281
Standby Diesel Generator at Unit 1 - generator 3 - stack 3	diesel	807	32.2832	4.4552	0.0161	1.0281
Standby Diesel Generator at Unit 1 - generator 4 - stack 4	diesel	807	32.2832	4.4552	0.0161	1.0281
Emergency Power System Unit 1 - Generator 1 - Stack 1	diesel	200	8.0008	1.1041	0.0040	0.2548
Emergency Power System at Unit 1 - Generator 2 - Stack 2	diesel	200	8.0008	1.1041	0.0040	0.2548
Standby Diesel Generator at Unit 2 - generator 1 - stack 1	diesel	1337	53.4852	7.3812	0.0267	1.7034
Standby Diesel Generator at Unit 2 - generator 2 - stack 2	diesel	1337	53.4852	7.3812	0.0267	1.7034
Emergency Power System at Unit 2 - Generator 1 - Stack 1	diesel	213	8.5208	1.1759	0.0043	0.2714
Emergency Power System at Unit 2 - Generator 2 - Stack 2	diesel	213	8.5208	1.1759	0.0043	0.2714

Emission source	Fuel	Maximum hourly consumption (kg/h)	Emissions (kg/h)			
			NOx	CO	SO2	PM10
Diesel engine pump for the Fire Water System (SPAI)	diesel	72.34	2.8940	0.3994	0.0014	0.0922
Mobil Diesel Group (MDG) 1	diesel	140.948	5.6385	0.7781	0.0028	0.1796
Mobil Diesel Group (MDG) 2	diesel	140.948	5.6385	0.7781	0.0028	0.1796
Mobil Diesel Group (MDG) 3	diesel	14.348	0.5740	0.0792	0.0003	0.0183
Mobil Diesel Group (MDG) 4	diesel	14.348	0.5740	0.0792	0.0003	0.0183
Generating set (GE) 1	diesel	20.99	0.8397	0.1159	0.0004	0.0267
Generating set (GE) 2	diesel	15.85	0.6341	0.0875	0.0003	0.0202
Generating set (GE) 3	diesel	15.85	0.6341	0.0875	0.0003	0.0202
Diesel Generator for Burnt Fuel Storage (DICA)	diesel	3.798	0.1519	0.0210	0.0001	0.0048
Diesel Generator for On-Site Emergency Control Centre (CCUA	diesel	11.68	0.4672	0.0645	0.0002	0.0149

With regard to compliance with the limit values for medium combustion plants (with a rated thermal input greater than or equal to 1 MW and less than 50 MW) as laid down in ***Law No 188 of 18 July 2018 on the limitation of emissions of certain pollutants into the air from medium combustion plants***, it should be noted that all the plants described above operate for a small number of hours per year (during testing or in exceptional situations). According to Art. 20, Paragraph 1 of Law No. 188/2018, existing average combustion plants that do not operate more than 500 hours per year, calculated as a rolling average over a period of 5 years, ***are exempted from the obligation to comply with the emission limit values laid down by law***.

Other on-site sources (those associated with liquid fuel storage and management activities, internal vehicle traffic) do not generate significant amounts of emissions.

1.8.2.4 Noise sources for project stages

Cernavoda NPP is located in an industrial area, and by ensuring the exclusion zone related to each U1 and U2 nuclear unit, the existence of dwellings is not allowed less than 1000 m from each individual reactor.

On the territory of the Cernavoda NPP plant site, the noise sources are located, in the vast majority, at distances of at least 20 m from the site boundary.

The current activity of the objectives in the Cernavoda NPP premises implies the existence of some sources of noise and associated vibrations.

The project “ Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules” is taking place in several stages/phases.

With regard to the analysis of the noise related to the project, the existence of an activity schedule requires the assessment of noise and vibration levels in the planned phases, in order to assess compliance with the legal provisions, or if appropriate the adoption of appropriate corrective measures.

As a result, the evaluation of the noise emission was carried out as follows:

- ***Noise analysis in the current situation - the baseline scenario***

The previous environmental assessments carried out in order to regulate the activity on the Cernavoda NPP platform, showed that the noise and vibrations associated with normal operation on the site do not represent sources with a significant impact on sensitive receptors, nor on the conservation objectives of the protected natural areas Natura2000 Sites located in the vicinity.

- ***Noise Analysis in the Project Execution Phase - which proceeds as follows:***
    - The set-up and execution phase of the infrastructure and constructions supporting the project, which includes the set-up of DIDR-U5, constructions within the framework of DICA – MACSTOR 200/400 modules, construction of support buildings for RT-U1 refurbishment; (2024 – 2026).

      In operation on site there are U1, U2 and DICA - MACSTOR 200.
    - U1 Shutdown, retubing, tests Phase which includes: DIDR-U5 in operation, DICA MACSTOR in operation, U1 is shut down for retubing, U2 in operation, constructions at DICA MACSTOR 400. (2027 – 2029).

The construction site activities *related to the period of setting up and realizing the infrastructure as well as the planned objectives for the RT-U1 project and DICA - MACSTOR 400 extension* ***are activities generating additional noise and vibrations, through the internal traffic of means of transport and through the use of their specific machinery***.

The activities in the refurbishment phase (U1 shutdown, retubing, tests) do not represent significant sources of noise, most of them taking place inside the buildings related to Unit 1 and in the new DIDR-U5.

- ***Noise Analysis in the Operational Phase of the refurbished U1 and DICA-MACSTOR 400***

The activities carried out in this phase are similar to those carried out in the current situation.

The description of the relevant aspects of the current state of the environment (baseline scenario) on the Cernavoda NPP platform is presented in chapter 3, and the impact assessment for the implementation and operation phases of the project are presented in chapter 5.

1.9 Aspects concerning project's items decommissioning

The planning of the activities related to the decommissioning of the installation must be taken into account in all phases of its authorisation. Thus, according to the authorization requirements, in order to authorize the siting of a nuclear installation, the requested documentation must include an initial decommissioning plan, containing basic elements such as the decommissioning strategy

For the operational phase, the authorization documentation must include the updated decommissioning plan, which will be updated every five years and will contain details of major changes in the installation, operational experience and developments in the techniques envisaged for decommissioning activities.

As concerns the initiation of the decommissioning phase, in purpose of its authorization, the requested documentation shall include a final decommissioning plan, containing all the details of the decommissioning arrangements and activities.

The safety requirements regarding the decommissioning of nuclear and radiological facilities are detailed in the annex to the CNCAN's President Order no. 102 of 26.05.2022. Also, the requirements regarding the quality management system of the organization responsible for decommissioning activities are detailed in the annex to the CNCAN's President Order no. 75 of 30.05.2003 (Norms regarding specific requirements for quality management systems applied to the decommissioning of nuclear installations - NMC-11).

Considering the above, once the project reaches the final period of the exploitation phase, a closure and decommissioning plan will be drawn up, according to the provisions of the normative acts in force at that time. When planning the decommissioning activities, the applicable international standards will be used, as well as the experience gained in other similar decommissioning projects.

Up to the current date, **SNN - Cernavoda NPP has developed,** according to regulatory requirements, ***the preliminary decommissioning plan for the facilities in operation, namely: the two nuclear-electric units (U1 and U2), the intermediate spent fuel storage (DICA) and the intermediate storage facility for radioactive solid waste (DIDSR).***

This plan presents the options selected, at a strategic level, regarding the decommissioning of the nuclear facilities at the Cernavodă NPP site and the stages necessary for their implementation, depending on the availability of the two facilities for final radioactive waste disposal, to be developed by ANDR (The Final Repository for Low and Intermediate Level Radioactive Waste – DFDSMA and the Deep Geological Repository – DGR, for spent nuclear fuel and long-lived radioactive waste.

According to ***the medium- and long-term national strategy on the safe management of spent nuclear fuel and radioactive waste*** **-** approved by GD no. 102/2022, DFDSMA is intended to be implemented starting from 2028, and DGR, *around 2055*.

The preliminary decommissioning plan is based on the hypothesis of the refurbishment of Units 1 and 2 with the extension of their lifetime to two cycles totalling 50 or 60 years per unit (in the National Strategy the operating period of each unit is 52 years including the refurbishment).

Considering the above, **the strategy for decommissioning of Units 1 and 2, with deferred dismantling, was chosen. This involves bringing the reactor's active systems to a safe state after shutdown and discharging the spent fuel and heavy water from the moderator circuit and the primary heat transport system**.

Decommissioning activities can be classified as follows:

- ***The transition to decommissioning***, which includes preparing for a safe enclosure
- ***Making and maintaining the safe enclosure***
- ***Decontamination and dismantling of nuclear buildings***, ***dismantling of non-nuclear buildings***
- ***Partial radiological restoration of the site*** (including radiological monitoring)
- ***Final radiological restoration, including Final Radiation Survey***.

The waste resulting from the decommissioning activities will be finally disposed in the DFDSMA, or as the case may be, in the situation where they contain long-lived radionuclides, in the DGR.

The materials resulting from the dismantling of facilities and buildings belonging to the nuclear part, which following the radiological monitoring process will be found free of radioactive contamination or whose contamination will be below release levels will be recycled or, as the case may be, disposed of as conventional waste, following their clearance.

From the point of view of the current legislation that transposes Directive no. 2014/52/EU, the project concerning the decommissioning of facilities in operation, namely: ***those two nuclear power units (U1 and U2), the spent nuclear fuel storage facility (DICA) and the intermediate storage facility for solid radioactive waste (DIDSR***) will be submitted to the procedure for obtaining the environmental agreement, the activities of the decommissioning project are included in the ANNEX No. 1 List of projects which are subject to the environmental impact assessment, point 2 letter b).

Thus, ***the decommissioning project will be subjected to a distinct environmental impact assessment procedure***, following the procedural steps provided through the Law no. 292/2018 *regarding the assessment of the environmental impact of certain public and private projects*.

2. DESCRIPTION OF REASONABLE ALTERNATIVES

2.1 General considerations

The general guidance applicable to the stages of the environmental impact assessment procedure of 20.02.2020 provides information on the identification of significant effects of the alternatives considered for a project.

Thus, it is used multi-criteria analysis in which common criteria are established for assessing the significance of an impact, criteria which are quantified for each individual project.

For the project " Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules", it was considered appropriate to define specific criteria for the project, taking into account with discernment the recommendations of the General Guide, due to the following particular aspects:

- ***the location of the project*** is entirely within the Cernavodă NPP site, designated for nuclear activity by CNCAN, therefore alternative locations for the project cannot be considered
- ***the studied technological alternatives*** are specific to the nuclear field and are part of existing CANDU projects at the international level (***therefore their sustainability is certified***).

2.2 Alternative 0 - „do-nothing”

Alternative 0 - „*do-nothing*” – represents the lack of action by SN Nuclearelectrica SA regarding the life extension of Unit 1 of Cernavodă NPP and implicitly the continuation of the DICA investment as approved by the Environmental Agreement No. 2058 of 22.04.2002 for the intermediate storage of the spent fuel bundles resulting from the operation of 2 units of Cernavodă NPP, for a minimum duration of 50 years.

- **Alternative 0 – „do-nothing” - for the Subproject of Unit 1 Refurbishment**

The operation of Unit U1 only until reaching the economic operational lifetime of 30 years, *but limited to* 245000 effective operation hours at nominal power, **requires special measures for the SNN SA holder** in terms of preparing a **complex decommissioning process and /or preservation of the U1 nuclear power plant and at the same time considerable efforts consisting in much greater capital investments in new assets** than those required to extend the life of unit U1.

In the situation in which the re-engineering process of U1 will not take place, SNN SA will maintain its capacity as the holder of the site during all decommissioning activities. The management of Cernavodă NPP will be responsible for all the work carried out during the final shutdown and decommissioning of the nuclear unit.

At the same time, if the refurbishment of Unit 1 is not carried out, national energy production will be reduced by approx. 10 %, corresponding to the amount of energy produced by Unit 1.

As a result, going through the decommissioning process of Unit U1 requires the licensee to plan and carry out some steps that will be an integral part of the decommissioning strategy, as well as the elaboration of documentation and supporting studies for the authorisation of the decommissioning in question, the carrying out of a safety analysis, the elaboration of the environmental impact assessment study for the decommissioning activity, the assurance of the fulfilment of the clearance criteria following the final radiological control as well as the need to ensure sufficient qualified staff with the necessary technique and skills to carry out all activities important for nuclear safety.

The alternative chosen by the holder, namely the extension of the installed capacity life, avoids the need for much bigger capital investment in new assets, shortens and simplifies the licensing process, eliminates the need for training and authorization of personnel for new, more complex plant systems and uses the existing infrastructure. It is also expected that the project will contribute to the further development of the Cernavodă area, by supporting local businesses, by increasing the demand for goods and services.[40]

- **Alternative 0 – „do-nothing” – for the subproject DICA-MACSTOR 400**

If the U1 refurbishment sub-project is not carried out, this will require SNN SA to continue developing the DICA storage facility as approved in 2002, by building MACSTOR 200 type modules, so as to provide interim storage space for the spent fuel resulting from the operation of Unit U2 as well as that resulting from Unit U1 until the end of the first 30-year operating cycle.

As a result, the DICA storage development process will continue with the execution of the MACSTOR 200 type modules, from module 17 - which is expected to be completed in 2024 - to module 27.

- **Conclusions on Alternative 0 – „do-nothing”**

It is noted that in ***the General Guidelines for the stages of the environmental impact assessment procedure of 20.02.2020, "the do-nothing scenario cannot be considered as a feasible political option, as some projects are very clearly needed and are required by policies at national, regional or local level...".***

At this moment, the projects of Cernavodă NPP Unit 1 refurbishment and Extension of DICA with MACSTOR 400 type modules, which are of national importance and considered by the Romanian state as priority investment projects, are included in:

- **Romania's energy strategy 2025-2035, with the perspective of 2050**.
- **The National Integrated Plan in the field of Energy and Climate Change 2021-2030 (PNIESC) April 2020** – approved by GD no. 1076/2021.
- **The medium- and long-term national strategy regarding the safe management of spent nuclear fuel and radioactive waste** - approved by GD no. 102/2022.

Given that, through the information presented in the *Basic Scenario* chapter of this environmental assessment, it has been justified that the operation of unit U1 up to now has been done in safe conditions, *both for the operating personnel and for the environment*, **it appears that the U1 refurbishment and the execution of DICA-MACSTOR 400 are technically feasible**, allowing the extension of the operating life by another cycle of operation, under appropriate conditions of safety and economic efficiency.

[40] Feasibility Study for the Unit 1 Refurbishment Project Cernavodă NPP, version v1, 17.01.2022

2.3 Alternatives studied - design, technology, location, size and magnitude of the project

- **Alternatives for subproject RT-U1**

According to the Nuclear Safety Guide GSN-07, the refurbishment of a nuclear installation ***refers to the capital repair, modernisation and improvement by replacement and/or modification of equipment or systems of the installation, with a view to significantly extending its operating life***, as determined by nuclear safety studies and technical assessments. **Refurbishment creates the opportunity to improve nuclear security** to the level required by modern regulations and standards, including through the use of the latest innovative technical solutions and knowledge in the design and operation of nuclear installations. Refurbishment does not imply changing the technology of the nuclear installation as a whole.

According to the Guide NSN-22**, refurbishment activities represent a component of the operating activities of nuclear installations.**

The feasibility study is the technical-economic documentation through which the designer analyses, substantiates and proposes at least two scenarios or different technical-economic options, and recommends, justified and reasoned, the optimal scenario or technical-economic option to achieve the investment objective.

For U1 refurbishment project, **the reasonable technological alternatives** studied are based on the information from the "***Feasibility Study for the Cernavodă NPP Unit 1 Refurbishment Project***", version v1, 17.01.2022, prepared by Ernst & Young SRL.

Alternatives were identified from the need to accurately determine the current condition of the U1 unit, which naturally led to the identification of corrective actions necessary for long-term operation. In this regard, U1 was subjected to two processes:

- overall assessment of the condition of the installation and its structures, systems and components ("Condition assessment”) and
- a review of the technical design of the plant to ensure that relevant needs for mandatory modifications and improvements are identified.

The recommendations resulting from these two processes have led to the identification of a list of activities which, in turn, will serve the long-term operation and development of the scope of the refurbishment project. Essentially, the activities have been classified as:

- strictly necessary/mandatory or recommended;
- with or without nuclear security impact (exclusively for design changes).

From this list of activities, the strictly required/mandatory items represent ***the minimum scope of the U1 refurbishment*** while the ***recommended elements should increase safety, reliability and maintainability margins.***

Thus, the feasibility study presents 3 scenarios for the realisation of the refurbishment project, examined and **evaluated according to 5 sets of criteria** - *technical, nuclear safety, performance, sustainability, risk*, for which the following elements have been considered:

- Extending the lifetime of Unit 1 with an additional operating cycle of up to 30 years through retubing, refurbishment of other equipment and all necessary activities according to current requirements that are expected to ensure the long-term safe operation of the plant;

- Modernisation and improvement of the Cernavodă NPP equipment, which can lead to increased operational safety beyond the current minimum requirements;
- Ensuring the increasing electricity consumption, the affordability of electricity for the population and companies;
- Installation of facilities for handling and interim storage of radioactive waste to be used for the long-term operation of the Cernavodă NPP (Units U1 and U2) and possible expansion (Units U3 and U4);
- Reduction of electricity imports;
- Increase of grid stability, providing reliable coverage of baseload power.

- **Scenario 1 – "mandatory"** includes:
    - strictly necessary or recommended activities with or without impact on nuclear safety (exclusively for design changes)
    - minimum reliability objectives necessary to maintain economic efficiency.

- **Scenario 2 – "** ***enhanced safety*** **"** includes:
    - Scenario 1- “mandatory“
    - Recommended project changes, with an impact on nuclear security, respectively:
        - improvements to increase the nuclear and conventional security of Unit U1, which are not considered mandatory for the long-term operation of the plant, but would, if carried out, ensure that Unit 1 becomes more robust in terms of nuclear security, and closer to the Unit 2 design/configuration
        - changes that may become mandatory by CNCAN standards/norms.

- **Scenario 3 – " good to be done"** includes:
    - the activities from Scenario 2
    - recommended design changes that do not impact nuclear safety
    - recommended activities resulted from the SSC status assessment.

Scenario 3 may also provide increased robustness against failures, either through a lower probability of occurrence or a reduced response time, which, however, could not be technically quantified on the date of the feasibility study. Thus, while Scenario 3 (compared to Scenario 2) may help reduce human error and associated risks, it is likely to increase the complexity and inherent risk of the refurbishment process by adding new activities, so that any net financial benefit on the long term also becomes difficult to quantify properly. This is because the respective contribution of the additional activities in the third scenario regarding the capacity factor as well as the Opex/Capex improvements may fall within the margin of error associated with the estimate and therefore cannot be considered to have a positive (direct) financial impact at this stage.

There is currently no known methodology to accurately calculate a positive financial impact associated with the implementation of Scenario 2 or Scenario 3 (both consisting of improvements, but producing mainly non-financial value). Additionally, we underline the fact that the nominal power of the unit (706.5 MWe) will not change, regardless of the refurbishment activities carried out in the 3 scenarios. This is a direct consequence of the technical and regulatory restriction of the unit to the power nominal value. [41]

[41] Feasibility Study for the Unit 1 Refurbishment Project Cernavodă NPP, version v1, 17.01.2022

Regardless of the refurbishment activities carried out in the 3 scenarios**, it should be emphasized that the nominal power of unit U1 (706.5 MWe) will not change**, this being a direct consequence of the technical and regulatory restriction of the unit to the power nominal value

We further present the essential aspects of the alternatives, and finally we propose an assessment of the environmental impact of these alternatives.

- **Alternative 1 based on Scenario 1 from SF – "mandatory"**

Key activities specific to U1 refurbishment process under scenario 1 consist of:

- retubing activities;
- associated infrastructure for the refurbishment project;
- Activities classified as mandatory, as a result of SSC status assessments – (*Structures, systems and components*);
- Mandatory project changes, with nuclear security impact;
- Project changes that do not have a nuclear safety impact, which must be carried out.

Scenario 1 ensures that the facility receives all necessary upgrades and modifications to meet licensing requirements and prepare it for its second life cycle.

This delineates the specific activities that ensure that the future operating parameters of the plant remain unchanged, in addition to maintaining the capacity factor for the second life cycle at the same level as in the first life cycle.

The mentioned key activities to improve nuclear security in this scenario ensure the alignment with the current nuclear security standards.

- **Alternative 2 based on Scenario 2 from SF – "enhanced safety"**

The specific activities of U1 re-engineering refurbishment process in scenario 2 consist of:

- **Activities included in Scenario 1 – "mandatory";**
- **Recommended project changes with impact on nuclear safety.**

Scenario 2 includes all the activities of Scenario 1 plus improvements **to enhance the nuclear security** and conventional safety of Unit U1. These improvements **are not considered mandatory** for the long-term operation of the plant **but, if carried out, would ensure that Unit 1 becomes more robust in terms of nuclear safety and closer to the project/configuration of Unit 2.**

A better alignment of the project/configuration of Unit 1 with the project/configuration of Unit 2, reduces the problem of reliability of two units that have different configurations.

In addition, further improvements on the nuclear safety part may become mandatory under future revised rules and/or standards, thus implementing Scenario 2 avoiding potential future burdens.

In fact, all refurbishment activities involve the use of state-of-the-art equipment and materials, with increased reliability for the Structures, Components, Equipment and Systems related to the technological installations of Unit 1, at the level of the latest standards in the nuclear field, with a positive impact in ensuring nuclear, radiological, personnel, population and environmental safety for the nuclear-electrical unit that will enter the new stage of operation (Long Term Operation) after the completion of the refurbishing works.

Scenario 2 ensures measures to improve nuclear security/safety, radiological safety, physical protection and cybersecurity, health and safety of the population and employees, and of the environment, at a level of excellence in the field of nuclear energy and in conditions of optimal efficiency and cost-effectiveness.

From the point of view of the sustainability criterion, alternative 2 presents a strong social and cultural impact, with significant socio-economic and cultural benefits, by indirectly increasing employment as a result of the additional activities to be carried out compared to Scenario 1.

- **Alternative 3 based on Scenario 3 from SF – "good to be done"**

The specific activities of U1 refurbishment process in scenario 3 consist of:

- **Activities included in Scenario 2 – "enhanced safety";**
- **Recommended project changes, with no impact on nuclear safety;**
- **Additional activities recommended as a result of the status, security and nuclear safety assessments of the SSC** *(Structures, Systems and Components).*

Additional work is not required to be performed as part of the refurbishment project, but performing it during the shutdown for refurbishment can have a positive impact on the facility's future operating schedule.

Scenario 3 provides additional alignment of Unit 1 to Unit 2 in terms of design / configuration, thus reinforcing the benefits associated with this strategy.

Thus, while **Scenario 3 (**compared to Scenario 2) may contribute to reducing human error and associated risks**, it is likely to increase the complexity and inherent risk of the refurbishment process by adding new activities, so that any long-term net financial benefit also becomes difficult to properly quantify.**

This is due to the fact that the respective contribution of the supplementary activities in the third scenario, concerning the capacity factor, as well as the Opex / Capex improvements may fall within the margin of error associated with the estimate, and therefore cannot be considered to have a positive (direct) financial impact at this stage.

In terms of the sustainability criterion, this alternative has a strong social and cultural impact with significant socio-economic and cultural benefits compared to alternative 1 and alternative 2 through increased indirect employment compared to alternative 1 and 2 as a result of the additional activities to be carried out.

At the same time, it is expected that the approval procedure for the DICA-MACSTOR 400 extension will be delayed compared to alternative 2, which may also lead to the construction of the 18th MACSTOR 200 module.

According to the ***General Guide applicable to the stages of environmental impact assessment procedures, dated 20.02.2020,*** **"Reasonable alternatives" must be relevant to the proposed Project and its specific characteristics, and resources should be spent only on the evaluation of these alternatives. In addition, the selection of alternatives is limited in terms of feasibility. On the one hand, an alternative should not be excluded simply because it would cause inconvenient costs to the project owner. At the same time, if an alternative is very**

expensive or technically or legally difficult, it would be unreasonable to consider it as a feasible alternative.”

From an economic point of view, Scenario 3 involves the allocation by SNN SA of some financial funds related to the development of additional studies as well as costs resulting from the process of approval by the authorities of these support studies.

The choice of Scenario 3 for the sub-project RT-U1 would mean that the additional recommended changes would lead to important changes in the choice of scenario 2 of the DICA-MACSTOR 400 sub-project (including the execution of the module no. 18 of MACSTOR 200 type).

- **Studied alternatives regarding the extension of DICA facility – DICA-MACSTOR 400 Subproject**

Short history:

In 2014, SNN SA submitted to the Ministry of Environment and Climate Change (MMSC) applications for environmental permits for the following projects:

- ”*Construction works for the tritium removal facility - Cernavodă NPP*" (CRTF) for which the initial screening stage has been completed and the Decision of the Initial Screening Stage has been issued, and subsequently submitted
- NOTIFICATION regarding the intention to carry out the project "Expansion of the site for intermediate spent fuel storage and continuation with construction of MACSTOR 400 type modules" (DICA-MACSTOR 400 extension).

Thus, SNN SA requested the continuation of the regulatory procedure for a new project called Integrated Project, representing "CTRF + DICA-MACSTOR 400", representing the cumulation of the two projects mentioned above.

Following the evaluation of the submitted documents and as a result of the fact that the holder requested the continuation of the regulatory procedure for the integrated project "CTRF+Extension DICA-MACSTOR 400", the central regulatory authority decided:

a) Termination of the environmental impact assessment procedure for the CTRF project (address no. 10834/MF/02.04.2014)
b) Continuation of the regulatory procedure for the Integrated Project (CTRF+Extension DICA-MACSTOR 400), with the completion of the Presentation Memoir with the information sent via MMSC address no. 115265/OP/16.04.2014.

The environmental impact assessment procedure for this project was not continued.

Regarding the project about the realization of the DICA-MACSTOR 200 investment approved by the Environmental Agreement no. 2058 of 22.04.2002 and currently underway, starting with 2014, a series of alternatives regarding the development of the facility were studied, for different types of modules - MACSTOR 200 and MACSTOR 400 - so that the facility to ensure the intermediate storage of the spent nuclear fuel resulted from the operation of units U1 and U2, with two operating cycles each.

- **Alternative 1 to DICA-MACSTOR 400**

In 2015 the technical documentation "*Design services for the extension of the Intermediate Spent Fuel Storage (DICA) site and replacement of MACSTOR 200 modules with MACSTOR 400 modules starting with module 10*" was prepared, whereby the DICA objective was to be extended.

The extension of the interim storage capacity also implied an extension of the surface area of the facility by 7000 m^2 compared to the 24000 m^2 approved in the Environmental Agreement No 2058 of 22.04.2002, to finally result an area of 31000 m^2.

2 scenarios were analyzed:

- **Scenario I -** envisaged at that time that the DICA facility would eventually have 30 modules, as compared to the 27 modules approved under Environmental Agreement No. 2058/2002, represented as follows:
  - 9 modules type MACSTOR 200
  - 21 modules type MACSTOR 400.
- **Scenario II** - envisaged continuing the construction of MACSTOR 200 type modules up to module 51, compared to the 27 approved under Environmental Agreement No. 2058/2002.

- **Alternative 2 – Subproject DICA-MACSTOR 400**

Currently, the extension scenario of the DICA storage provides the placement of a total number of 37 modules (compared to the 27 modules approved by Environmental Agreement no. 2058/22.04.2002 for the existing facility) and at the same time the expansion of the current area of 24000 m^2 with about 16000 m^2 up to approx. 40000 m^2, so that this objective can ensure the intermediate storage of the spent nuclear fuel resulting from the operation of U1 and U2, with two operation cycles each.

The expansion of DICA represents the transition to the MACSTOR 400 type module, which represents the more compact version of the module developed by AECL in collaboration with KHNP (Korea Hydro & Nuclear Co.), starting from the MACSTOR 200 storage module project. The new module has a double capacity of storage (of 24000 bundles) compared to the storage capacity of the MACSTOR 200 module.

Regarding the allocation of the land area for the purpose of expanding the current area of the DICA, the land allows this addition as the nature of the foundation rock on the extension surface is also part of the good foundation area. According to the geological study issued by GEOTEC in 2000, the presence of the Barremian limestone as a rocky bedrock represented the reason for choosing this location in its western extremity, in front of reactor 5, where the bedrock is found at a depth of 2-6 m, high enough to allow the foundations to be built in good technico-economic conditions. [42]

At the same time, the extension of DICA:

- will allow intermediate storage of spent fuel resulting from the operation of units 1 and 2 of the Cernavodă NPP, with two operating cycles each;
- represents "activities for the safe management of spent nuclear fuel from the operation of nuclear power generation facilities and research reactors", according to the medium

[42] Studiu privind caracteristicile geologice, geotehnice și hidrogeologice ale amplasamentului DICA pentru avizarea terenului de fundare, Geotec SA, Decembrie 2000

and long-term National Strategy on the safe management of spent nuclear fuel and radioactive waste, approved by GD no. 102/2022.

2.4 Selected alternatives

After analyzing the alternatives studied for the purpose of extending the duration of operation of Unit 1 with the second cycle of approximately 30 years, the holder proposed the following feasible alternatives:

- **for the sub-project RT-U1 alternative 2 was chosen based on Scenario 2 from SF – "enhanced safety"** – ensuring measures to improve nuclear security/safety, radiological safety, physical protection and cybersecurity, health and safety of the population and employees, and of the environment, at a level of excellence in the field of nuclear energy and in conditions of optimum cost-effectiveness and efficiency.
- **the DICA-MACSTOR 400 subproject was chosen for the expansion of DICA because**:
  - provides interim storage space for two operating cycles for the U1 and U2 nuclear units by making more efficient use of available space due to increased storage density per unit area, taking into account the appropriate geological and geotechnical quality of the foundation soil.
  - keeps the same mode of operation by compatibility with existing equipment in the current DICA storage facility.

The alternatives selected for the two sub-projects provide sustainability from a technical-economic point of view.

The selected feasible alternatives were compared in the studied supporting documents also from the point of view of the positive effects brought to the environment. Thus, the selected alternatives led to the following positive effects:

- Improvements for nuclear security/safety, radiological safety, physical protection and cybersecurity, health and safety of the population and employees, and of the environment, so that the refurbished Unit 1 achieves the configuration of Unit 2 (which may become mandatory in future revised rules and/or standards
- positive impact in ensuring nuclear, radiological, personnel, population and environment safety;
- improving nuclear safety by promoting it before production, together with increased safety measures, increased reliability and improved operating configuration.
- complies with Romania's Energy Strategy 2025-2035, with the perspective of 2050.
- strong social and cultural impact, with significant social and cultural benefits (increase in indirect employment as a result of additional activities to be carried out).
- the new MACSTOR 400 module represents the more compact version of the module developed by AECL in collaboration with KHNP, having double storage capacity (24000 bundles).
- the area allocated to the current extension of the DICA is the optimal option studied because the nature of the bedrock is part of the good bedrock zone identified following

the analysis of the GEOTEC geological study (year 2000) which confirms the presence of Barremian limestone as a rocky bedrock (area in front of reactor 5 where the bedrock is 2-6 m deep), thus allowing the foundations to be built in good technical and economic condition.

- allows the storage of spent nuclear fuel resulting from the operation of the U1 and U2 units of the Cernavodă NPP for minimum 50 years, with two operating cycles each.
- complies with the National Medium and Long Term Strategy for the Safe Management of Spent Nuclear Fuel and Radioactive Waste, approved by GD No 102/2022.

In accordance with the provisions of the General Guidelines applicable to the stages of the environmental impact assessment procedure it is proposed the environmental impact assessment of the alternatives for the 2 sub-projects.

Although the continuation of activity U 1 is not considered - we include for the exercise the impact assessment of alternative 0, as it is considered good practice in Environmental Impact Assessment (EIA).

According to the Guide, the effects of the significance of the impact of the alternatives was analyzed from the perspective of two components - **the magnitude of the impact** and **the sensitivity of the receiver.**

- ***The magnitude of the impact*** given by the characteristics of the project and the effects generated by it, such as:
  - ***Nature of effect***: negative, positive or both;
  - ***Type of effect***: direct, indirect, secondary, cumulative;
  - ***Reversibility*** of the effect: reversible, irreversible;
  - ***Extent*** of effect: local, regional, national, cross-border;
  - ***Duration*** of effect: temporary, short term, long term;
  - ***Intensity*** of the effect: low, medium, high.
- ***Sensitivity of the receptor*** – understood as the sensitivity of the receiving environment on which the effect is manifested, including its ability to adapt to the changes the Projects may bring.
  - The sensitivity can be **low, medium** or **high**.

Tab. 27 Impact assessment for the studied altenatives for the sub-project RT-U1

	Magnitude of impact						Sensitivity of receptor			Costs of alternatives
	Nature of impact	Type of impact	Reversibility	Extent	Duration	Intensity	low	medium	high	
A0	negative	cumulative	irreversible	local + regional + transboundary	long term	high	–	–	yes	Unreasonable alternative
Scenario 1	positive	cumulative	irreversible	local + regional	long term	medium	–	yes	–	Unreasonable alternative
Scenario 2	positive	cumulative	irreversible	local + regional + transboundary	long term	high	yes	–	–	Reasonable alternative
Scenario 3	both	cumulative	irreversible	N/A	N/A	high N/A	N/A	N/A	N/A	Unreasonable alternative

Tab. 28 Impact assessment for the studied altenatives for the sub-project DICA-MACSTOR 400

		Magnitude of impact						Sensitivity of receptor			Costs of alternatives
		Nature of impact	Type of impact	Reversibility	Extent	Duration	Intensity	low	medium	high	
A0		negative	cumulative	irreversible	national	permanent	high	–	–	yes	–
A1	Scenario 1	we consider an environmental assessment of these alternatives is not necessary						–			–
	Scenario 2										
A2		positive	cumulative	irreversible	regional	long term	high	yes	–	–	–

Tab. 29 Impact assessment for the studied altenatives for the Project RT-U1 + DICA-MACSTOR 400

	Magnitude of impact						Sensitivity of receptor			Costs of alternatives
	Nature of impact	Type of impact	Reversibility	Extent	Duration	Intensity	low	medium	high	
Scenario 2 for sub-project RT-U1	positive	cumulative	irreversible	local + regional + transboundary	long term	high	yes	–	–	Reasonable alternative
A2 for sub-project DICA–MACSTOR 400	positive	cumulative	irreversible	regional	long term	high	yes	–	–	–
Project RT-U1 + DICA–MACSTOR 400	**positive**	**cumulative**	**irreversible**	**local + regional + transboundary**	**long term**	**high**	**yes**	**–**	**–**	**Reasonable alternative**

The significance of the **positive impact of the reasonable alternative chosen** for the RT-U1 + DICA-MACSTOR 400 Project **is major.**

3. DESCRIPTION OF THE RELEVANT ASPECTS OF THE CURRENT STATE OF THE ENVIRONMENT (BASELINE SCENARIO)

For the nuclear installation of Unit 1 at Cernavodă NPP, the Regulatory Authority for Nuclear Activities has issued authorizations for all authorization phases.[43]

History of Unit 1 of the Cernavodă NPP:

For the siting, construction, and commissioning of the nuclear facility Unit 1 at Cernavodă NPP, CNCAN has issued authorizations for all authorization phases, as described below:

The siting of Cernavodă NPP - On September 30, 1978, the State Committee for Nuclear Energy (CSEN) issued the ***Siting Authorization No. I/665*** for a CANDU-PHW type nuclear power plant of 4X660 MWe at the Cernavodă site, based on a technology developed by the Atomic Energy of Canada Ltd.
On November 8, 1985, through the letter No. ISCANACN-1/1609, the State Committee for Nuclear Energy extended the ***Siting Authorization No. I/665*** dated September 30, 1978 for Unit 5, also.

Construction of Unit 1 at Cernavodă NPP - In November 1986, according to the licensing strategy approved by CNCAN (ISCAN-ACN), the authorization process for the construction of Cernavodă NPP Unit 1 began, which was completed in 1993 with the issuance of the ***Global Construction Authorization no. 19123/19.08.1993***.
On August 19, 1993, the Ministry of Waters, Forests, and Environmental Protection - National Commission for the Control of Nuclear Activities issued ***the Construction Authorization no. 19.123 for Unit 1 - Cernavodă NPP***.

The Commissioning Phase of Unit 1 went through several stages for which CNCAN issued a series of approvals. ***Operating License No. 1/1995*** was initially issued on May 15, 1995, and based on the nuclear security documentation, which included the Final Security Report of Cernavoda NPP Unit 1, Phase 1, Rev. 1, 1995 edition, CNCAN issued *Revision 1 of this authorization through letter no.16.329/AD/1996*.

Trial operation of Unit 1 - On July 31, 1997, based on the nuclear security documentation complementing the RFS Unit 1, 1995 edition, CNCAN issued the *Trial Operation Authorization of Unit 1no. 16.367/DC*.

Currently, Cernavodă NPP holds *the Operating License of the Cernavodă Nuclear Power Plant, Unit 1, no. SNN Cernavoda NPP U1 – 01/2023, rev. 0*, effective from May 1, 2023, expiring on April 30, 2061.

[43] Final Nuclear Security Report Unit 1 - Summary, February 2023

The history of DICA - Location, construction, commissioning, and operation of DICA were carried out based on the following regulatory acts issued by CNCAN:

-***Authorization for the siting of the DICA facility No. CNE DICA - 06/2001***

-***Environmental Agreement No. 2058 from April 22, 2002***, issued by the Constanţa Environmental Protection Inspectorate for the intermediate storage of spent nuclear fuel of CNE-PROD Cernavodă; valid until the completion of the investment works, subject to compliance with the conditions imposed by it.

-***Authorization for conducting nuclear activities No. SNN DICA - 01/2003***, issued by the Ministry of Waters and Environmental Protection - National Commission for the Control of Nuclear Activities, for the commissioning of the Intermediate Storage Facility for Spent Fuel.

-***Authorization for conducting nuclear activities No. SNN DICA - 04/2018*** - Authorization for the operation and maintenance of modules 1, 2, 3, 4, 5, 6, 7, 8, and 9 of the Intermediate Storage Facility for Spent Fuel, hereinafter referred to as DICA, which comes into force on March 9, 2018, and valid until July 12, 2020.

-***Authorization for nuclear activities no. SNN DICA 04/2018*** - whereby CNCAN authorizes SNN S.A. to build modules 10 and 11 of DICA through the Cernavodă NPP Branch; effective from March 26, 2018, valid until March 25, 2021.

-***Authorization for nuclear activities No. SNN DICA -09/2023*** for the operation of Modules 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and of the Intermediate Spent Fuel Storage Facility (DICA) through the Cernavodă NPP Branch, valid until July 15, 2053.

-***Authorization for nuclear activities No. SNN DICA -11/2024*** for the operation of Modules 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 of the Intermediate Spent Fuel Storage Facility (DICA) through the Cernavodă NPP Branch, valid until July 15, 2053.

From the environmental regulations perspective, the operation of the nuclear facilities U1, U2, and DICA on the Cernavodă NPP site is based on the Environmental Authorization issued by the Ministry of Environment, published through "*GD no. 84/2019 regarding the issuance of the environmental authorization for the National Company "NUCLEARELECTRICA" - S.A. – Cernavoda NPP Branch - Unit 1 and Unit 2 of the Cernavodă Nuclear Power Plant*".

From the operational commissioning of Unit U1 until present, Cernavodă NPP has operated based on the following environmental permits issued according to the regulations in force at the time of their issuance.

- GD no. 234/1999 regarding the issuance of the environmental authorization for the National Nuclear Power Company - S.A. - Cernavodă NPP-PROD Branch, ENVIRONMENTAL AUTHORIZATION for the operation of Unit 1 of the Cernavodă Nuclear Power Plant located in Cernavodă, Medgidia Street no. 1, Constanța County
- GD no. 1008/2005 regarding the issuance of the environmental authorization for the National Nuclear Power Company Bucharest - S.A. - Cernavoda NPP - PROD Branch - Unit 1 of the Cernavodă Nuclear Power Plant ENVIRONMENTAL AUTHORIZATION No. 2 dated August 23, 2005
- GD no. 1515/2008 regarding the issuance of the environmental authorization for the National Nuclear Power Company - S.A. - NPP Branch - Unit 1 and Unit 2 of the Cernavodă Nuclear Power Plant ENVIRONMENTAL AUTHORIZATION No. 1 dated May 26, 2008
- GD no. 84/2019 regarding the issuance of the Environmental Authorization for the National Company "NUCLEARELECTRICA" - S.A. - Cernavodă NPP Branch - Unit 1 and Unit 2 of the Cernavodă Nuclear Power Plant"

– Permit no. 83/01.02.2013 regarding greenhouse gas emissions for the period 2013-2020, revised on 09.03.2018, issued for S.N.N. - S.A. Cernavodă NPP by the National Environmental Protection Agency - Ministry of Environment; it is valid as long as the activity carried out by the operator within the installation is in accordance with the issued permit.

Site description, existing land uses and surrounding area of the land associated with the project

The Cernavodă Nuclear Power Plant is located in Constanța County, approximately 2 km southeast of the city limits of Cernavodă, and about 1.5 km northeast of the first race of the Danube-Black Sea navigable canal, on the land in the area of the platform resulting from the excavations of the former Ilie Barza limestone quarry, at 44°20' north latitude and 28°01' east longitude. The NPP site is bordered to the northeast by the Cișmelei Valley, and to the southwest by DJ 223 (County Road 223).

The location of the Cernavodă Nuclear Power Plant (Cernavoda NPP) is in agreement with the provisions of ***Site Authorization No. I/665*** dated September 30, 1978, issued by the State Committee for Nuclear Energy for the placement of the facility.

The land occupied by Cernavodă NPP is owned by SNN-SA, as confirmed by the Certificate of Property Right issued by the Ministry of Industries and Resources, series M03, number 5415, dated April 25, 2000. It is situated within the urban area of the city of Cernavodă, according to the Urban Planning Certificate approved by the HCL No. 242/2014. The legal status of the land was established by the State Council Decree No. 31/27.01.1986 (for the establishment of Cernavodă NPP Units 1-5).

The lands associated with the Cernavodă NPP site are only used after obtaining the necessary permits, according to the nuclear regulations.

Within the Cernavodă NPP site, only constructions related to the operation of the nuclear power plant are allowed.

On-site uses

At the Cernavodă Nuclear Power Plant, two nuclear-electric units are in operation - Units 1 and 2. The installed nominal power of these two units is 706.5 MW for Unit 1 and 704.8 MW for Unit 2. At present, these two units in Cernavodă supply approximately 20% of Romania's energy consumption. Moreover, they supply thermal energy for more than 75% of the population in the city of Cernavodă.

On the site, there are constructions belonging to Unit 5. By the decision of the General Assembly of Shareholders (AGOA) no. 1/11.03.2014, the shareholders of SNN SA approved the cessation of works on Unit 5 as part of the investment project "Cernavodă Nuclear Power Plant 5X700MW" and the change of destination and use of the spaces and structures already completed, belonging to Unit 5, for other activities of SN Nuclearelectrica SA. The completion of the environmental procedure for these changes in the destination of the buildings was concluded by the issuance of DEI No. 6983RP on 08.11.2016 and the Annex on 11.05.2020 by EPA Constanța.

At present, on the site, there is DICA with MACSTOR 200-type modules, which provides the intermediate storage of dry spent fuel for the operational period of the two nuclear units, U1 and U2, with one operating cycle for each. The operation of DICA is carried out by gradually constructing storage modules, in parallel with the operation of the nuclear-electric units, U1 and U2.

Description of the surrounding land associated to the project

All activities to be carried out in all stages related to the project “Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules” will take place on the land within the Cernavodă Nuclear Power Plant site, where only activities and constructions related to the operation of the nuclear power plant are permitted.

For the Subproject Refurbishment of Unit 1 of the Cernavodă Nuclear Power Plant (RT-U1), the refurbishment activities consist of replacement, repair, and modernization works, which ***will be carried out inside Unit 1.***

To store the radioactive waste resulting from the refurbishment of Unit 1 and from the operation of the refurbished Unit 1 and Unit 2, space will be arranged inside the Unit 5 Reactor Building (***the new DIDR-U5***). A hall connected to the Unit 5 Reactor Building will be provided for unloading containers with radioactive waste and for loading storage containers.

The road assigned for transporting radioactive waste from RT-U1 to the new DIDR-U5 follows the route from CSAN-U1, continues behind U2, U3, U4, U5, and enters the Auxiliary Building (unloading hall) next to the new DIDR-U5. The trailer returns to U1 along the same route with a length of L= 1200 m. **The road is permanent, used both during the project implementation period and during the operation stage of the refurbished Unit U1**.

Regarding the allocated land for the expansion of the current site of the DICA storage facility, **the underlying rock allows the extension as is still part of the good foundation zone.**

The arrangement of the areas related to the two subprojects compared to other objectives on the Cernavodă Nuclear Power Plant site and the area related to the execution works are presented in Fig. 1 from Chapter 1.

The description of the relevant aspects of the current state of the environment (***baseline scenario***) aims to:

- Provide a description of the state and trends of environmental factors against which significant effects can be compared and evaluated
- Serve as the reference state against which ex-post monitoring is compared to measure changes once the project has been initiated.

In addressing the aspects arising from the General Guide applicable to the baseline scenario in the EIA, the developer, through certified experts in each field, presents a conservative synthesis based on the monitoring requirements imposed by regulatory acts issued for the operation of nuclear facilities (issued by CNCAN, the Ministry of Environment, Waters and Forests, ANAR/ABADL) - during operation, correlated with the results of previous environmental assessments and the results of the monitoring campaign conducted during the elaboration of the EIA report, in the summer of 2023.

Thus, the results of monitoring programs carried out by NPP's own laboratories, made available by the project owner, were taken into account, namely:

- ***The Monitoring Program for Liquid and Gaseous Radioactive Effluents at Cernavodă NPP*** (code SI-01365-RP006) - which includes the analysis of samples collected from the Radioactive Gaseous Effluent Monitor, samples collected from the Radioactive Liquid Effluent Monitor, and the analysis of samples of radioactive effluents collected from the Spent Fuel Intermediate Storage (DICA).
- ***The Environmental Radioactivity Monitoring Program for Cernavodă NPP*** (code SI-01365-RP015) - which involves sampling of environmental samples (air, water, soil, vegetation, food) and their preparation for global activitiesmeasurements, gamma spectrometry, tritium measurements, and C-14 measurements.
- ***The management of radioactive waste at Cernavodă NPP*** (code SI-01365-RP007) - the current concept of radioactive waste management at Cernavodă NPP consists of pretreatment, treatment, and intermediate storage of radioactive waste, aiming to keep the volume of generated waste at the lowest reasonably possible level and to ensure acceptable protection levels for the environment, population, and exposed personnel.

  The radioactive waste characterisation program consists of determining the physical, chemical, mechanical, radiological and biological characteristics, in order to subsequently identify the processing, interim and/or final storage, transport and disposal methods, and is used at various times in the pre-disposal of radioactive waste.

  The characterization of radioactive waste is conducted by measuring the total radioactivity and specific radioactivity of "key nuclides" (Easy To Measure - ETM) and measuring or estimating the inventory of radionuclides using reference samples. The radioactivity of Difficult To Measure (DTM) nuclides - typically represented by beta and alpha-emitting radionuclides (C-14, Ni-63, Pu-239) - for each radioactive waste stream is obtained by multiplying the activity of ETM radionuclides (Co-60 and Cs-137 produced along with DTM and transferred into waste) by a coefficient (Scaling Factor - SF), calculated based on sample collection and radiochemical analyses.
- The program for controlling and monitoring of the circulation of controlled radiation sources (code SI-01365-RP001) - describes the activities of acquisition, use, transfer and transport of controlled radiation sources (**other than nuclear fuel and radioactive waste that are generated in the Cemavodă NPP facilities**), which are carried out under the program for controlling and monitoring of the circulation of controlled radiation sources, as part of the process "Control of radioactive materials" implemented at the Cernavodă NPP**.**

  The process covers the measures and activities necessary for confining radioactive materials. Multiple barriers are provided to prevent the escape of radioactive materials outside the sources.

  Documenting evidence of controlled radiation sources involves permanent records regarding the inventory and storage location of both sources belonging to Cernavodă NPP and those not owned by Cernavoda NPP but temporarily stored within the plant premises, the corresponding authorizations and certificates for these sources, the description of the sources, supplier/sender/recipient information - as applicable, as well as the ***results of leakage tests conducted for sealed sources and the testing method at the manufacturer.*** [44]

[44] Cernavoda NPP Environmental baalance level I, 2018

- ***The Personnel Dosimetry Program at Cernavodă NPP***

  Cernavodă NPP has the obligation to ensure radiological monitoring of the work environment as well as monitoring the individual exposure of occupationally exposed persons and visitors.

  The Personnel Dosimetry Program at Cernavodă NPP is conducted according to the following procedures:

  - *Radiation Exposure Control of Personnel* (code RD-01364-RP002) – which describes the specific activities of the process ensuring the protection of both own staff and contractors against the effects of ionizing radiation
  - *Personnel Dosimetry Program at Cernavodă* NPP (code SI-01365-RP018) – which outlines the method for monitoring individual exposure during normal operation, planned and unplanned shutdowns, in situations of radiological emergency, and severe accidents. The monitoring is carried out through an accredited dosimetric body.

  The procedures outlining the dosimetry activities of personnel are developed and approved within the framework of Cernavoda NPP and, where applicable, approved by CNCAN, also constituting the subject matter of the documentation underlying the approvals or authorizations issued by CNCAN for regulated activities (e.g., Notification of the Dosimetry Laboratory, radiation protection authorizations, operating permits, etc.).

  The primary purpose of the dosimetry program is to measure, evaluate, assign, record, and track the evolution of all significant doses caused by radiation, received by an individual (worker or visitor) over a certain period, regardless of whether these are the result from of the whole-body exposure or exposure of a body part. It aims at keeping these records in an appropriate form for quantitative monitoring of the doses received and for ensuring preventive measures to limit the doses, following the ALARA principle. Additionally, it serves to demonstrate compliance with legal and administrative limits.

The routine environmental monitoring program at Cernavodă NPP was developed and approved in 1995 through internal procedure RD-01364-RP7, titled "Environmental Radioactivity Monitoring Program". Implementation of this program began in March 1996. In April 1999, revision 3 of this document was issued, and its implementation started in June 1999. Through this revision, new monitoring points, new types of samples, and somesampling intervals were modified in order to enhance the efficiency of the program and improve understanding of the plant's impact on the environment. In 2004, new sampling points and sample types were introduced to meet the environmental radioactivity monitoring requirements for the DICA and DIDR objectives, as well as for monitoring deep waters in the area. In September 2005, CNCAN approved the revision of this program, which was transformed into Cernavodă NPP internal procedure "Environmental Radioactivity Monitoring Program for Cernavodă NPP," with the code SI-01365-RP015. The latest revision (3) of this procedure was approved by CNCAN in 2019. These procedures include the legal requirements specified by Law 111/1996, as amended and supplemented thereafter. Additionally, this revision introduced a new sample type - spontaneous vegetation collected from the site.

Starting from 2008, the Environmental Control Laboratory and the Individual Dosimetry Laboratory have been participating in performance tests of procedures and equipments with the National Physics Laboratory (NPL) in England. The Environmental Control Laboratory continues its participation in the COG project for the measurement of OBT (Organically Bound Tritium) in environmental samples. The main purpose of participating in this interlaboratory tests project is to validate the working methods, measurement techniques, equipment calibration methods, and quality control methods for this type of measurement.

In addition to the analyses carried out by its own laboratories, Cernavodă NPP ***conducts analyses through specialized third parties*** (organizations/institutions/companies with relevant accreditations and laboratories accredited according to ISO/IEC 17025 standard and/or notified by CNCAN) ***on a contractual basis***, such as:

- Analysis to determine the concentrations of non-radioactive pollutants in liquid effluents to verify compliance with the limits established by Water Management Authorizations - carried out with external accredited laboratories according to ISO 17025 Standard.
- Analysis for the classification of radioactive and non-radioactive waste, etc. - analyses carried out within authorized monitoring programs.

Additionally, following the requirements of the banking consortium that financed U2 and based on the recommendations from the COG Guide, a study was conducted between 2008 and 2012 titled "*The Impact of the Operation of the Cernavodă Nuclear Power Plant on Aquatic and Terrestrial Organisms in its Area of Influence* " - carried out by ***specialized third parties***. This study was continued through the implementation of a monitoring program to assess the impact of the Cernavodă Nuclear Power Plant operation on aquatic and terrestrial organisms in its area of influence, with investigation stages in the years 2013 to 2016. Cernavodă Nuclear Power Plant intends to continue this program in the upcoming period.

This monitoring program was intented to highlight the thermal, mechanical, chemical, and radiological impact on aquatic and terrestrial organisms resulted from the operation of the Cernavodă Nuclear Power Plant. The investigated area covered the 30 km area of influence. The investigation points were selected to ensure the representativeness of the results across sectors (cardinal points; wind directions), mainly arranged along the course of the Danube River, and at distances of interest within the area of influence of the Cernavodă Nuclear Power Plant (1 km ... 5 km, 10 km, 15 km, 30 km).

The main environmental aspects related to the nuclear units in operation at the Cernavodă Nuclear Power Plant are assessed by performing an environmental analysis according to the internal procedure code SI-01365-P082, referred to as "Environmental Analysis, Determination of Environmental Aspects, and Identification of Significant Environmental Aspects at the Cernavodă Nuclear Power Plant”.

As a result, the baseline scenario involves identifying the current state of the environment based on the monitoring results of each environmental factor, both radiological and non-radiological. This allows for quantification of significant effects on the environmental factors at the end of the analysis, whether the project is implemented or not.

3.1 Environmental factor WATER

This chapter presents the state of natural waters located in the Cernavoda NPP siting area, with the functions they perform (uses).

3.1.1. Surface waters

The surface waters in the Cernavoda NPP area are:

1. ***Danube River*** – it is a branched riverbed from km 374.8 to km 240. From the main riverbed, the Borcea branch branches off to the left at km 370.8 and the Bala branch at km 345.

   The Danube-Black Sea Canal - fed by the Danube River, has a length of 64432 + 29000m and it is a river navigation artery that crosses Dobrogea between Cernavoda and the port of Constanta - Agigea, respectively Midia Navodari. It consists of three races separated by the Cernavoda, Agigea, Midia Navodari locks.

2. ***Cismelei Valley*** – borders the Cernavoda NPP site on the north-east and west sides. The characteristic flows down this valley with a torrential regime can be up to 458 m^3/s.

3. ***Valea Vițeilor*** - is located outside the NPP area, and which it does not directly influence.

Hydro-development constructions at Cernavoda NPP:

- The adduction channel - with the role of water cathment from the derivation channel of the Danube - Black Sea Canal and transporting it to the screen house and the pumping station, ensuring the water flow necessary for cooling the condensers, technical cooling water, firefiting water and cooling water in case of failure; the adduction channel was dimensioned in such a way that at low levels in the Danube it could transit the maximum flow of cooling water required for five units;
- The Distribution Bay - with the role of making the connection between the adduction channel and the screen house and to buffer the water supply to the pumping station.

For Cernavoda NPP, the Danube River fulfills the following two functions:

a) Ensures the necessary industrial water supply to Cernavoda NPP, through CDMN, the derivation channel to the water Distribution Bay, for all nuclear units;
b) It is a receiver of the technological waters discharged from Cernavoda NPP.

Through CDMN, additional functions are performed, for example: maritime transport, irrigation, water supply of populated centers.

Quantitative aspects

The average multiannual flow (1976 – 2019) of the Danube is of 5380 m^3/s in the Bazias section and of 6493 m^3/s at Isaccea [45].

The maximum flow transported on CDMN is 225 m^3/s, and the maximum supply flow to Cernavoda NPP is 53 m^3/s per unit operating at full power.[46]

[45] The Danube river flood risk management plan – 2020, *https://www.mmediu.ro/app/webroot/uploads/files/PMRI_ciclul%20II_fl%20Dunărea.pdf*
[46] Cernavoda NPP, Safety Report 2018 ed. rev 1/2021, *https://www.nuclearelectrica.ro/wp-content/uploads/2022/08/Raportul-de-Securitate-RS.pdf*

The technological cooling waters are discharged into the Danube, downstream of the CDMN connection to the Danube.

The volume of industrial waste water, represented by technological circulation wastewater and technical water resulting from the activity of Cernavoda NPP, is discharged into the Danube through the Seimeni channel, in proportion of 91% of the total volume taken from the race I of the CDMN.

The following tables show the volumes of water intake from the Danube, via CDMN and derivation, in the period 2018 – 2022, respectively the volumes of water returned in this period.

Tab. 30 The volumes of cooling water used annually at Cernavoda NPP during 2018 ÷ 2022, broken down by the two nuclear power units U1 and U2, according to the Monthly Reports on the results of non-radioactive liquid influent and effluent monitoring

Volumes of water at **U1** (thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Total volume	***1201104.4***	***1272235.3***	***1163632.4***	***1260725.5***	***1125234.8***
Fresh water volume	1081872.5	1171373.8	1070339.8	1167611.0	995447.6
Recirculated volume	119231.9	100861.5	93292.6	93114.5	129787.2
Volumes of water at **U2** (thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Total volume	***1275967.8***	***1208063.2***	***1276104.7***	***1188095.8***	***1278589.9***
Fresh water volume	1158895.3	1113655.0	1183363.3	1071511.4	1138561.1
Recirculated volume	117072.5	94408.2	92741.4	116584.4	140028.8

The 2018 environmental balance showed that water consumption for cooling, with the Danube River as source, was at relatively constant levels, both for the period when only the U1 unit operated (1997-2006), and after Unit 2 was put into commercial operation (2007-2016) - when there was a proportional increase in the consumption of technological cooling water.

From a quantitative point of view, in the period 2018 ÷ 2022 the volumes of water used annually were at the level of those presented in the 2018 environmental balance, below the maximum annual volume of 3405888 thousand cubic meters authorized by ANAR.

Tab. 31 The volumes of water returned by Cernavoda NPP into receivers, during 2018 ÷ 2022, broken down by the two nuclear power units U1 and U2 [47]

Volumes of water from **U1** (thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Volume of technological water discharged into Danube	1081872.5	1171373.8	1070339.8	1167611.0	995447.6
Volume of technological water discharged into CDMN - race II	0	0	0	0	0
Volumes of water from **U2**(thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Volume of technological water discharged into Danube	1158895.3	1113655.0	1183363.3	1071511.4	1138561.1
Volume of technological water discharged into CDMN - race II	0	0	0	0	0

Analyzing the period 2018 ÷ 2022, based on the reports, it can be seen that water restitution was exclusively into the Danube, through the Seimeni channel. The returned water volumes represented, on average, 91% of the total volumes of water taken annually for each of the two nuclear units, similar to the situation found in the previous environmental assessment (Environmental Balance - 2018).

Water quality – non-radiological pollutants

The evaluation of the Danube water quality was based on the results of analyzes carried out over the years, until 2023. The physico-chemical status of river water was considered taking into account the significant characteristics: dissolved oxygen regime, salts content, nutrients (N, P) concentrations, and specific pollutants (phenols, oils, detergents, pesticides and heavy metals) concentrations, water temperature.

The oxygen deficit is around 70% in the Danube water, and the load in organic substances, expressed by the characteristic parameters, is:

- CCO-Mn: 4 – 4.8 mg O_2/l
- CCO-Cr: 11.5 – 13.5 mg O_2/l
- CBO_5: 2.4 – 2.7 mg O_2/l.

It can be concluded that the activity of Cernavoda NPP and the city of Cernavoda does not influence the quality of the Danube River in terms of organic load.

Dissolved salts - expressed by electrical conductivity below 500 uS/cm, or by fixed residue 270 – 325 mg/l, alkalinity - around 3 milliequivalents/l, total hardness 8.5 – 9.9 German degrees, of which 6.6 – 7.9 temporary hardness, are stationary in the Danube water, **without detectable influences of the discharges from Cernavoda.** Chloride concentrations increase from km 851 to km 18, and sulfates from 35 to 50 mg/l, but not due to of discharges from Cernavoda NPP.

Nutrients concentrations in the Danube:

- Ammonium NH_4^+ : 0.3 – 0.5 mg N/l with a slight increase along the Danube;
- Nitrates: 1.8 – 2 mg N/l;
- Phosphorus: 0.16 – 0.22 mg P/l

The concentrations of specific pollutants in the Danube:

- Phenols: 0.002 – 0.003 mg/l;
- Petroleum products: 0.1 – 0.26 mg/l;
- Heavy metals: present slight local influences along the Danube but without noticeable influences around Cernavoda town and Cernavoda NPP.

The CDMN water quality corresponds to the water quality of the Danube. The same in the derivation channel and the adduction to the Distribution Bay. In the Distribution Bay, the raw water is mixed with recycled water, to buffer the temperature of the water distributed to the reactors.

Cernavoda NPP has two sections for the discharge of technological wastewater regulated by ANAR, for the normal operating situation: into Danube - through the gallery and the Seimeni channel, downstream from Cernavoda town and - *as a reserve* – into CDMN race II - downstream the derivation channel.

Monitoring results of the quality of technological water discharged from Cernavodă NPP – non-radioactivity indicators, during 2018 ÷ 2022

The results obtained through the monitoring program carried out by Cernavoda NPP during 2018÷2022, according to the last regulatory act issued by the Ministry of Environment, Water and Forests regarding the NPP operation, are presented synthetically, as annual averages, in the following tables:

Tab. 32 The evolution of the annual averages determined for the physico-chemical indicators analyzed in the influent and effluents of Cernavoda NPP

No. crt.	Indicator	MU	Evacuation limits	Sampling point	2018	2019	2020	2021	2022
1.	pH	-	**6.5 – 9.0**	Danube	8.06	8.1	8.12	8.1	8.0
				Bridge NPP	8.14	8.1	8.17	8.1	8.1
				Bridge Seimeni	8.15	8.1	8.17	8.1	8.1
				Bridge CPPON	-	-	-	-	-
2.	Suspended matter	mg/l	**25**	Danube	19.50	17.3	15.8	15.5	11.8
				Bridge NPP	16.50	12.9	12.8	13.2	10.1
				Bridge Seimeni	16.75	14.8	16.1	15.2	11.1
				Bridge CPPON	-	-	-	-	-
3.	Total ionic iron	mg/l	**1.5**	Danube	0.38	0.4	0.38	0.43	0.26
				Bridge NPP	0.30	0.4	0.33	0.39	0.27
				Bridge Seimeni	0.36	0.4	0.36	0.44	0.30
				Bridge CPPON	-	-	-	-	-
4.	Chloride	mg/l	**250**	Danube	21.00	22.3	20.3	20.8	23.2
				Bridge NPP	18.50	23.3	20.4	21.7	23.8
				Bridge Seimeni	21.25	23.5	20.3	20.9	23.8
				Bridge CPPON	-	-	-	-	-
5.	Sulfates	mg/l	**200**	Danube	27.50	26.8	26.4	27.9	26.8
				Bridge NPP	27.75	27.3	26.3	28.4	27.4
				Bridge Seimeni	27.75	25.8	26.1	28.3	27.3
				Bridge CPPON	-	-			
6.	Ammonium (only in case of use)	mg/l	**3**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	-	-	-	-	-
				Bridge CPPON	-	-	-	-	-
7.	CBO5	mg/l	**15**	Danube	6.00	5.3	5.2	3.1	2.7
				Bridge NPP	6.08	5.5	5.2	3.5	3.7
				Bridge Seimeni	6.40	5.4	5.2	3.2	2.8

No. crt.	Indicator	MU	Evacuation limits	Sampling point	2018	2019	2020	2021	2022
				Bridge CPPON	-	-	-	-	-
8.	Sodium	mg/l	**100**	Danube	14.00	16.0	15.8	16.0	16.3
				Bridge NPP	14.50	16.5	15.8	15.9	16.8
				Bridge Seimeni	14.25	16.3	15.8	15.9	16.4
				Bridge CPPON	-	-	-	-	-
9.	Calcium	mg/l	**150**	Danube	38.75	33.8	44.2	45.0	41.9
				Bridge NPP	37.50	34.5	43.9	44.9	41.9
				Bridge Seimeni	38.75	34.8	44.3	45.1	42.1
				Bridge CPPON	-	-	-	-	-
10.	Magnesium	mg/l	**50**	Danube	14.8	11.3	12.1	12.6	12.3
				Bridge NPP	14.8	11.3	12.0	12.3	12.3
				Bridge Seimeni	14.8	11.5	11.9	12.3	12.3
				Bridge CPPON	-	-	-	-	-
11.	Hydrazine	mg/l	**0.1**	Danube	-	-	-	-	-
				Bridge NPP	-	-	<0.003	<0.003	<0.003
				Bridge Seimeni	<0.003	<0.003	<0.003	<0.003	<0.003
				Bridge CPPON	-	-	-	-	-
12.	Morpholine	mg/l	**0.4**	Danube	-	-	-	-	-
				Bridge NPP	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
				Bridge Seimeni	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
				Bridge CPPON	-	-	-	-	-
13.	Lithium hydroxide	mg/l	**0.025** (Li calc. < 0.007)	Danube	-	-	-	-	Li: 0.005
				Bridge NPP	-	-	Li: 0.005	Li: 0.005	Li: 0.005
				Bridge Seimeni	Li:0.004	Li: 0.006	Li: 0.005	Li: 0.005	Li: 0.005
				Bridge CPPON	-	-	-	-	-
14.	RGCC-100	mg/l	**1.0** (NO_2 calc. <0.2)	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	NO_2^- <0.03	NO_2^- <0.03	NO_2^- <0.03	NO_2^- <0.03	NO_2^- <0.03
				Bridge CPPON	-	-	-	-	-
15.	Oils	mg/l	**Absent**	Danube	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)
				Bridge NPP	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)
				Bridge Seimeni	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)
				Bridge CPPON	-	-	-	-	-

No. crt.	Indicator	MU	Evacuation limits	Sampling point	2018	2019	2020	2021	2022
16.	Ethylene glycol	mg/l	**1.0**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	< 1	< 1	< 1	< 1	< 1
				Bridge CPPON	-	-	-	-	-
17.	Petroleum products	mg/l	**5.0 (fără irizații)**	Danube	-	-	-	-	-
				Bridge NPP	<0.05	< 0.24	< 0.24	< 0.2	< 0.1
				Bridge Seimeni	<0.05	< 0.24	< 0.24	< 0.2	< 0.1
				Bridge CPPON	-	-	-	-	-
18.	Biocide MCB-50	mg substanță activă/l	**5,2**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	0	0	-	0	SLD
				Bridge CPPON	-	-	-	-	-
19.	PRAESTOL A3040L	mg/l	**3**	Danube	-	-	-	-	-
				Bridge NPP	<0.1	<0.1	<0.1	<0.1	<0.1
				Bridge Seimeni	<0.1	<0.1	<0.1	<0.1	<0.1
				Bridge CPPON	-	-	-	-	-
20.	NALCO 3DT149*	mg/l	**500**	Danube	-	-	-	-	-
				Bridge NPP	<24	<24	-	-	-
				Bridge Seimeni	<24	<24	-	-	-
				Bridge CPPON	-	-	-	-	-
21.	NALCO 3DT449 ** expressed as Total Phosphorus	mg/l	**P_{Total}<1**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	0.07
				Bridge Seimeni	-	-	-	-	0.07
				Bridge CPPON	-	-	-	-	-
22.	Free residual chlorine ***	mg/l	**0,2**	Danube	-	-	-	-	-
				Bridge NPP	-	-	<0.1	<0.02	<0.2
				Bridge Seimeni	-	-	<0.1	<0.02	<0.2
				Bridge CPPON	-	-	-	-	-

* NALCO 3DT149 – it was no longer used in the technological process in STA from 01.09.2019.
** NALCO 3DT449 – started to be used at STA in April 2022; control concentration determined in March 2022, before the start of use: 0.05 mg P_{total}/l)
*** only in case of discharge of hypochlorite solution resulting from washing the drinking-water tanks.

During 2018 ÷ 2022 Cernavoda NPP did not discharge technological waters into the Danube-Black Sea canal. Moreover, during the entire period of operation of the nuclear units, the evacuation in the CDMN was sporadic and was carried out only with the approval of the competent authorities.

From the results of the monitoring of the chemical parameters of the water discharged from the Cernavodă NPP, it can be seen that the average annual loadings have been within the

limits imposed by the regulatory acts and do not show significant variations in the effluent compared to the influent, similar to the situation recorded since the commissioning of the nuclear units, U1 in 1997 and U2 in 2008.

The temperature of the influent and of the technological effluent are monitored on a daily basis, at points established by the Protocol concluded with ABADL.

Starting from September 2020, an automatic water temperature monitoring system was commissioned at points NPP Bridge – for the influent and respectively at the spillway from the Seimeni Valley concrete channel – measuring section 1 for the effluent discharged into the Danube.

The system complements the existing one, which continues to operate at Cernavoda NPP and which covers the following 4 measuring sections downstream, so that it is possible to verify compliance with the regulated limits for discharge into the Danube River (maximum 10°C above the water temperature of the Danube River – at the debouch, but not more than 35°C after passing through the mixing zone). If the temperature measured automatically at the Seimeni spillway exceeds 35°C, the temperature is measured downstream, in the additional control sections in the mixing area, according to Protocol no. 163 12/17.09.2020 concluded between the NPP and ABADL, for compliance verification. For the situation in which, in the cold season, technological water is recirculated in the distribution bay, the temperature of the influent is the one measured in the bay.

The following table shows the monthly averages related to the monitoring of water temperatures during 2018÷2022.

Tab. 33 Monthly averages of water temperatures in influent and the technological effluent from Cernavoda NPP

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
		Average temperature (°C)											
2018	Influent	11.9[1]	9.2[1]	10.1[1]	11.7[1]	21.0	25.1	24.8	26.7	23.3	16.2	11.0[1]	12.4[1]
	Effluent	18.5	15.2	15.9	17.6	27.0	32.6	32.4	34.9	31.4	24.9	16.1	17.6
2019	Influent	10.6[1]	11.8[1]	11.6[1]	12.7	17.5	22.6	26.6	27.0	22.7	17.8	13.2	10.9[1]
	Effluent	16.1	17.4	18.3	20.8	23.3	29.5	34.5	35.0	30.1	26.4	21.7	18.2
2020	Influent	10.4[1]	11.2[1]	10.1[1]	12.5	19.2	21.9	25.4	26.2	23.3	17.5	10.8	10.3[1]
	Effluent	18.2	18.8	18.6	20.8	27.6	28.8	31.1	33.7	31.9	26.1	19.2	17.1
2021	Influent	11.3[1]	10.7[1]	9.5[1]	11.4	17.9	21.9	27.7	27.1	21.2	14.4	10.9	9.3[1]
	Effluent	17.7	17.7	17.2	19.5	24.4	28.8	< 35[2]	< 35[2]	29.6	22.9	19.2	17.1
2022	Influent	10.2[1]	11.1[1]	12.3[1]	12.7	19.4	25	27	27.1	22.3	16.9	13.4	10.6[1]
	Effluent	18.1	19	19.8	21.1	26.5	31.4	33.4	< 35[2]	31.1	25.6	22.1	18.3

1) the influent temperature measured in the distribution bay, water recirculation taking place.
2) the temperature measured in section 2 and confirmed in section 5, according to the protocol. In section 1, before the debouch into Danube, the average temperature was 35.2 – 35.3°C.

The evolution of the water temperature is, broadly speaking, synchronous with the air temperature regime, except for the cold periods of the year when the Danube waters register monthly averages higher with +1.1 – +3.8 °C.

The results of the monitoring of water temperatures during 2018÷2022 show compliance with the limits regulated by the water management authorizations and respectively by the environmental authorizations – similar to the situation found in the environmental assessments carried out throughout the period of operation of the nuclear units.

Requirements of regulatory authorities

The quality indicators of discharged non-radioactive waters are regulated in the Water Management Authorization no. 72/06.09.2021 amending Authorization no. 58/01.07.2021, regarding "Water supply and waste water discharge for Units 1 and 2 from the Cernavoda Nuclear Power Plant, Constanta County" issued by the National Administration “Romanian Waters”, the holder of the authorization being S.N. "NUCLEARELECTRICA" S.A./ Branch of CERNAVODA NPP. The water management authorization imposes the maximum values allowed for discharge quality indicators, depending on the category of discharged water (technological water, rainwater including inactive drainage, domestic wastewater) and depending on the authorized receiver (Danube, Danube – Black Sea Canal, urban sewage network). The document "Operation Regulation - Operation and Maintenance, code U1/ U2-03700-ST", rev.3 - part of the Authorization - is aimed to remain unchanged by the water management authority. The quality indicators of the waters discharged from the Cernavoda NPP U1 and U2, according to the Water Management Authorization no. 72/06.09.2021 are presented in the following table:

Tab. 34 Non-radioactive liquid effluents regulated for water discharges from Cernavoda NPP and maximum allowed values

Category of discharged water	Quality indicators	Maximum allowed values mg/l
Domestic wastewater (not radioactively contaminated)	According to GD no. 188 - NTPA 002/2002 modified and supplemented by GD 352/2005, and to the contract concluded with S.C. RAJA. S.A. Constanta	
Technological waters	Temperature	*
	pH	6.5 – 9.0
	Suspended matter	25
	Total ionic iron	1.5
	Chloride	250
	Sulphates	200
	Amonium	3
	Phosphorus	1
	CBO5	15
	Sodium	100
	Calcium	150
	Magnesium	50
	Petroleum product	5 (no iridescence)
	Free residual chlorine	0.2
	Hydrazina	0.1
	Morpholine	0.4
	Cyclohexylamine	0.1
	Lithium hydroxide	0.025
	Mixture of hydrazine + lithium hydroxide	0.1 + 0.025
	Mixture of hydrazine + morpholine	0.1 + 0.4
	Mixture of hydrazine + morpholine + cyclohexylamine	0.1 + 0.4 + 0.1
	Rhodamine - with evacuation into CDMN - with evacuation into Danube	2.0 10.0

Category of discharged water	Quality indicators	Maximum allowed values mg/l
	Fluorescein - with discontinuous discharge	0.25
	RGCC-100	1.0 commercial product
	Biomate 5716	1.0
	Biocid ARQUAD MCB - 50	5.2 active substance 0.01 (ml/l) commercial product
	Ethylene glycol	< 1.0
	Scintillation liquid Ultima Gold LLT	0.001 active substance 0.00195 commercial product
	PRAESTOL A3040L	3
Rainwater, including that from underground drainage and that stored in the external drainage sump	In accordance with the reference objectives for the classification of surface water quality.	

* Regarding the temperature of the discharged technological waters:

- into CDMN - race II (in the stilling basin of the CHE Recuperare) - it is of maximum 10°C above the water temperature of race I of the CDMN, so that the water temperature in race II, downstream the discharge point of the canal, does not exceed 25°C;
- *into Danube* - it is of maximum 10°C above the water temperature of the Danube River, but not higher than 35°C, after passing through the mixing zone.

Systems using ethylene glycol (glycolated water systems and for Diesel groups) are closed systems. Any accidental spills can be discharged into the emissary, only if bellow than the allowed limit. The commercial name of the ethylene glycol product is to be notified to the issuer of the regulatory act (A.N.A.R.) and to Dobrogea-Litoral Water Basin Administration, at least 30 days before use.

The reagent PRAESTOL A3040L (commercial name – Flocculant PRAESTOL A3040L) is used only in the modernized installation of the Water Treatment Plant (STA), in the water pretreatment system.

The reagent NALCO 3DT149 (commercial name – Liquid Antiscalant 3D TRASAR 3DT149, manufacturer - company Nalco) previously used only in the modernized installation of the Water Treatment Plant (STA), in the bearing/motor cooling water system in the condenser cooling systems (circuit C5) and in the technical water-cooling system (C6) in the Pump House, was replaced with the NALCO 3D TRASARTM 3DT449 reagent. The maximum allowed value for the concentration of the 3DT449 product in the discharged water is expressed in total phosphorus concentration.

The use of the biocidal product ARQUAD MCB - 50 is done only on the C6 circuit - technical water, when conditioning the cooling circuit and only after notifying the territorial water management authority, at least 5 days before, to monitor the quality of the receivers. Wastewater resulting from the biocidal process is only discharged into the Danube, through the Seimeni channel.

The values of the indicators regarding the organic content and the suspended matter can be exceeded at discharge only when they are exceeded in the Danube section - upstream of the water intake of the water supply system of the Cernavoda NPP. In this case, the values of these quality indicators cannot be higher than the corresponding values, determined in the control section.

For the non-nominated quality indicators, the discharge into natural receivers of technological waste water and water from precipitation is allowed only in compliance with the regulations in force and falling within the limits provided by the regulations in force, and under compliance with the provisions of GD no. 570/2016 regarding the approval of the "Program for the gradual elimination of discharges, emissions and losses of priority hazardous substances and other measures for the main pollutants".

The obligation to determine the values of the quality indicators rests with Cernavoda NPP. The frequency of determination and the method of monitoring the physico-chemical quality indicators of non-radioactive liquid effluents are established by the Protocol concluded between Cernavoda NPP and the Dobrogea - Litoral Water Basin Administration within the "Romanian Waters" National Administration, an act that is an part of the Water Management Authorization.

Routine monitoring program of the physico-chemical parameters of non-radioactive liquid effluents

This program is intended for monitoring under normal operating conditions of the nuclear power plant and has the following objectives:

- demonstration of compliance with the conditions imposed by the environmental authorizations for Cernavoda NPP (U1 and U2);
- to provide an evaluation based on measurements of the control measures of non-radioactive emissions in discharged waters;
- demonstration of compliance with the conditions imposed by the water management authorization in force for the operation of the Cernavoda NPP (U1 și U2).

The physical-chemical monitoring program of the non-radioactive liquid effluent is carried out according to the provisions of the following regulatory acts:

- The water management authorization in force - which identifies the chemical substances that may be present in the discharged water, the discharge path and the maximum admissible concentrations;
- The protocol signed with ABADL – which identifies the physico-chemical parameters to be analyzed, the frequency and sampling points.

The monitoring program comprises two parts:

- the routine monitoring program of the physico-chemical parameters of the discharged water;
- the monitoring program in case of accidental spills of chemical substances.

The sampling points are established in such a way as to ensure the representativeness of the samples, both for the influent and for each discharge path of the non-radioactive liquid effluent.

The sampling points, established by the Protocol signed with ABADL, are:

- For the Influent:
  - Danube: Hinog water treatment station, before the Cernavoda NPP supply point;
  - NPP Bridge: bridge on DJ 223, over the derivation channel;
- For the Effluent:
  - Seimeni bridge: the bridge over the Seimeni drainage channel, when the water is discharged into Danube;
  - CPPON bridge: bridge on DJ 223, over the discharge channel, at the hydropower plant, when the water is discharged into the CDMN – race II.

The sampling frequencies for the analysis of the different indicators are established by the Protocol signed with ABADL within the National Administration "Romanian Waters" – document part of the Water Management Authorization.

The influent and effluent temperature measurement points are established by the Protocol signed with ABADL, at relevant points on the banks of the channels (derivation channel, Seimeni discharge channel, discharge canal into CDMN). The temperature is measured daily.

The monitoring program is carried out by Cernavoda NPP through its own Chemical Laboratory and through specialized third-party laboratories.

Cismelei Valley, located in the vicinity of the Cernavoda NPP, was developed to collect non-radioactive rainwater from the Cernavoda NPP site and to discharge a maximum flow (with 0.01% assurance) of 458 m^3/s into race I of CDMN. At the same time, Cismelei Valley fulfills the function of receiving 54 m^3/s of technological water from the nuclear units in case of failure.

Non-radioactively contaminated meteoric waters from the DICA platform are also discharged into the Cișmelei Valley, according to the Cernavodă NPP procedures.

Viteilor Valley collects the meteoric waters from the area adjacent to the Cernavoda NPP premises, which are discharged into race I of CDMN.

3.1.2. Groundwater

Groundwater, as a natural source, provides the drinking water supply necessary for Cernavoda NPP.

Another drinking water supply solution is the public water supply system of town of Cernavoda, system operated by RAJA SA Constanta.

The description of the water supply system of the Cernavoda NPP objective is presented in subchapter 1.7.5.1.

Quantitative analysis of the exploited aquifer

With the commissioning of the water supply wells (January 2002), the hydrotechnological parameters of the exploited aquifer, the mode of operation, as well as the quality of the water pumped into the water supply system of Cernavoda NPP were monitored.

The monitoring of the hydrotechnological parameters of the Fj1 and Fj2 wells in operation is carried out by means of the automation installation, which functions as a data acquisition system, the automated elements installed locally being represented by transducers that allow continuous measurement of the ***level, pressure, and pumped flow***.

In the last environmental assessment (2018) it was found that the results of the 2016 monitoring of the hydro-technological parameters of the two boreholes in operation ***indicated a good quantitative status of the two wells*** and the falling of the hydrological parameters of exploitation within the limits authorized by the Management Authorization of Waters in force.

Tab. 35 The evolution of the volumes of underground water and from the public supply network, used for hygienic and sanitary purposes on the Cernavoda NPP platform, during 22018 ÷ 2022

Volumes annual water intake	**2018**	**2019**	**2020**	**2021**	**2022**	**Maximum annual authorized volume**
	(thousand c.m./year)					
Total volume from Underground source	265.471	264.909	276.013	284.103	33.865	**1045.7**
Total volume from The drinking water network of the Cernavodă town	45.760	35.200	14.106	0.001	13.936	**788.4**

The volumes of water intake are within the range previously recorded and reported by Cernavoda NPP, the values being below the authorized annual maximums. Thus, the annual volumes from the underground source did not exceed 32% of the authorized volume, while the annual volumes from the public network were below 6% of the authorized volume.

Also, in the previous environmental assessment (Environmental Balance-2018) it was shown that the ***National Management Plan updated in 2016, related to the national part of the Danube River basin***, mentioned that **from a quantitative point of view, *"no underground water body of was identified as being at risk of not achieving good status***.

According to the National Management Plan for the part of the international river basin of the Danube River that is included in the territory of Romania - **updated to the level of 2021** - ***all groundwater bodies present a good quantitative status***.

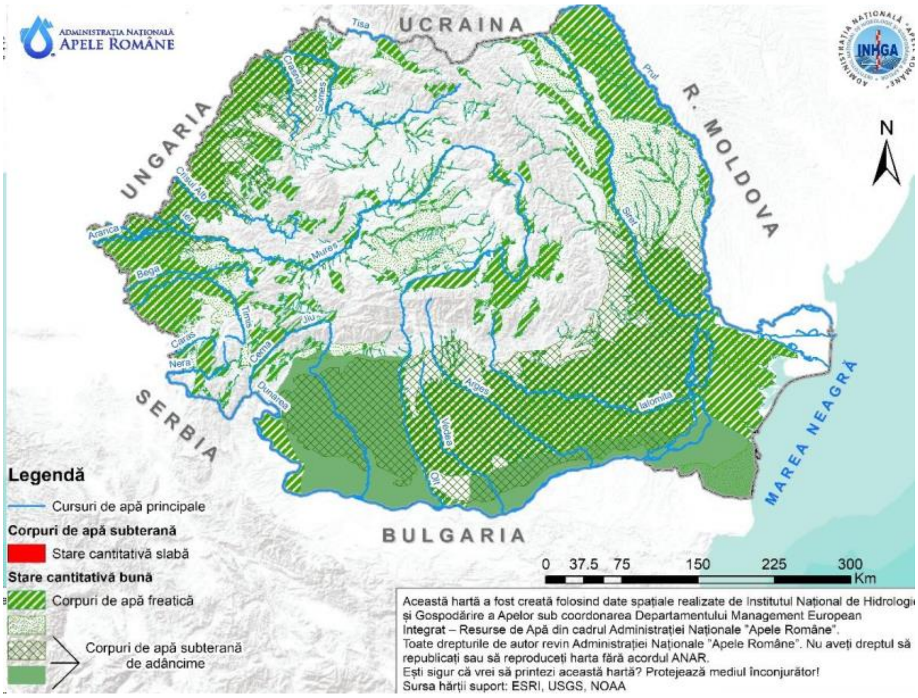

Fig. 24 Quantitative status of groundwater bodies – National Management Plan updated 2021

Qualitative analysis of the exploited aquifer

The monitoring of the underground water quality in terms of its chemistry was carried out with the commissioning of the two wells Fj1 and Fj2, starting from January 2002 and April 2003, respectively.

In the ***2018 environmental balance***, it was mentioned that the reports on the services of operating the water supply system drilled wells Fj1, Fj2, Fj3, the Treatment Station and the Chlorination Station indicated that ***at the level of internal users on the Cernavoda NPP platform*** - after completion of all stages of treatment (filtration, softening, chlorination) - ***the water fell within the drinking limits established by Law no. 458/2002 (r1) - in force on the date of the environmental assessment, both from a physico-chemical point of view*** (following the reduction of the typically high iron concentration in deep underground waters) ***and microbiological.***

Water quality monitoring from the two wells is done weekly by specialized laboratories, with which Cernavoda NPP has concluded contracts.

Tab. 36 Values of the physical-chemical indicators determined for the deep wells, treated and delivered to the internal network from the Cernavoda NPP site in September 2016

Indicator	UM	Fj1	Fj2	Internal user	Limits regarding the quality of drinking water*
pH	unit pH	7.6	7.6 – 7.7	7.8 – 8.1	6.5 – 9.5
Oxidizable organic substances (KMnO4)	mgO_2/l	1.76 – 4.42	1.66 – 2.49	0.54 – 0.99	Max. 5
Sulphides and H_2S	mg/l	< 0.04	< 0.04	< 0.04	Max. 0.1
Total hardness	ºDH	15 - 18.77	17.09 – 17.3	7.04 – 11.5	Min.5
Ca^{2+}	mg/l	58.4 - 65.6	61.6 – 65.6	24 – 34.4	–
Mg^{2+}	mg/l	29.8 - 41.97	35.6 – 37.08	16.1 – 29.3	–
Na^+	mg/l	64.6 - 71.7	65.8 – 79.7	142 - 197	Max. 200
NH_4^+	mg/l	< 0.064	< 0.064	< 0.064	Max. 0.5
Fe total	ug/l	227 - 285	141 - 299	28.2 - 152	Max. 200
Mn^{2+}	ug/l	1.6 - 2.17	2.79 – 2.81	2.07 – 8.47	Max. 50
NO_3^-	mg/l	< 1	< 1	< 1	Max. 50
NO_2^-	mg/l	< 0.002	< 0.002	< 0.002	Max. 0.5
SO_4^{2-}	mg/l	65.6 - 68	67.2 – 72.6	64.2 - 76.3	Max. 250
Cl^-	mg/l	72.34 – 75.87	75.16 – 84.38	75.16 - 83.67	Max. 250
Conductivity	uS/cm	716 - 721	714 - 721	724 - 738	Max. 2500
Fixed residue at 105ºC	mg/l	475 - 530	476 - 530	492 - 542	–
TDS	mg/l	534 - 539	533 - 539	541 - 551	–
Salinity	g/l	0.3	0.3	0.3	–

* Values provided by Law 458/2002 (r1), with subsequent amendments and additions

To characterize the physico-chemical quality of groundwater in the Cernavoda NPP area, in the August 8, 2023 campaign, the following groundwater samples were taken:

- Groundwater from the ***deep wells*** (H=700 m) from the Cernavoda NPP site - used for drinking purposes
- ***Shallow*** underground water - water from the a well located in the Faclia locality - approx. 5.4 km SSE of the Cernavoda NPP site - used for domestic/household needs by the locals.

Tab. 37 Values of the physico-chemical indicators determined for the samples of underground water, with potable use, taken in the August 8, 2023 campaign

Indicator	MU	Deep drilling on the NPP site (H=700m Fj1)	Shallow well – Făclia locality (H < 50 m)	Limits regarding the quality of drinking water*
pH	pH unit	7.5	7.1	6.5 ÷ 9.5
Electrical conductivity at 20°C	µS/cm	824	1348	2500
Amonium (NH_4^+)	mg/L	< 0.05	< 0.05	0.50
Chloride (Cl^-)	mg/L	65.985	85.640	250
Calcium (Ca^{2+})	mg/L	56.11	144.29	-
Magnesium (Mg^{2+})	mg/L	43.2	74.5	-
Sodium (Na^+)	mg/L	23	32	200
Sulphates (SO_4^{2-})	mg/L	61	105	250
Hydrazine	mg/L	< 0.03**	< 0.03**	-
Morpholine	mg/L	< 0.01**	< 0.01**	-
Iron	µg/L	113.700	34.205	200
Total suspended matter (MTS)	mg/L	< 2**	< 2**	-
Nitrites (NO_2^-)	mg/L	0.065	0.099	0.5
Biochemical oxygen consumption (CBO_5)	mg/L	< 4**	< 4**	-
Chemical oxygen consumption (CCO-Cr)	mg/L	< 30**	< 30**	-
Total phosphorus (Pt)	mg/L	< 0.05**	< 0.05**	
Petroleum products (THP)	µg/L	0.44	0.520	-

* Admissible values provided by Ordinance no. 7/2023 *regarding the quality of water intended for human consumption*

** „<” Values lower than detection limit.

It can be seen that the values determined for the physical-chemical indicators analyzed in the groundwater used for drinking purposes on the NPP site and respectively for domestic needs (Făclia well) fell within the limits allowed by Ordinance no. 7/2023 *regarding the quality of water intended for human consumption* **-** Annex no. 1.

The results of the determinations for the water sample taken from the well in Faclia locality - downstream of the Cernavoda NPP, do not reveal an influence of the activities carried out on the NPP platform on the quality of the waters downstream.

Also, during the August 8, 2023 campaign, a water sample was taken from the observation well located between the U1 and U2 nuclear units - for qualitative characterization under non-radioactive aspect. (note: the shallow drilling serves for radioactive monitoring of the water aquifer in the area of the nuclear units in operation).

Tab. 38 Values of the physico-chemical indicators determined for the groundwater sample from the observation well, taken during the August 8, 2023 campaign

Indicators	**MU**	**Determined values**
pH	pH unit.	9.0
Electrical conductivity at 20°C	µS/cm	645
Amonium (NH_4^+)	mg/L	1.584
Chloride (Cl^-)	mg/L	16.496
Calcium (Ca^{2+})	mg/L	17.64
Magnesium (Mg^{2+})	mg/L	0.751
Sodium (Na^+)	mg/L	17
Sulphates (SO_4^{2-})	mg/L	51
Hydrazina	mg/L	< 0.03*
Morpholine	mg/L	< 0.01*
Iron	mg/L	0.139
Total suspended matter (TSP)	mg/L	34
Nitrites (NO_2^-)	mg/L	0.045
Biochemical oxygen consumption (CBO_5)	mg/L	< 4*
Chemical oxygen consumption (CCO-Cr)	mg/L	< 30*
Total phosphorus (Pt)	mg/L	< 0.05*
Petroleum products (THP)	mg/L	0.0003

* „<” Values lower than detection limit.

The values determined for the physico-chemical indicators analyzed in the underground water taken from the observation well located between the nuclear units U1 and U2, were generally below the values determined for the water sample taken from the shallow well in the locality of Făclia, downstream of Cernavoda NPP. Therefore, **there is no evidence of a transfer of pollutants through groundwater outside the platform, as a result of the activity of the Cernavodă NPP**.

3.1.3. Wastewater not radioactively contaminated

The description of the radioactive uncontaminated wastewater disposal system is presented in subchapter 1.7.5.2 – points a and b.

Discharged volumes of domestic wastewater

From a quantitative point of view, the volumes of domestic wastewater discharged annually into the urban sewerage system managed by RAJA Constanta, during 2018 ÷ 2022, were at the level of those presented in the 2018 environmental balance, significantly below the annual maximum volume of 899.360 thousand cubic meters authorized by ANAR.

Tab. 39 The evolution of the volumes of domestic wastewater discharged into the public urban sewer network, during 2018 ÷ 2022, broken down by the two nuclear power units U1 and U2[47]

Unit	**Volume of domestic wastewater discharged [thousand cubic meters]**				
	2018	**2019**	**2020**	**2021**	**2022**
U1	264.471	264.909	276.013	284.103	335.866
U2	45.760	35.200	14.106	0.001	13.936

Results of domestic wastewater quality monitoring discharged during 2018÷2022

The following figure graphically shows the evolution during 2018 ÷ 2022 of the monthly averages for the physico-chemical parameters monitored in the domestic wastewater discharged by Cernavoda NPP into the urban sewerage managed by RAJA Constanta, the urban wastewater being subsequently treated in the Wastewater Treatment Plant of the city of Cernavoda.

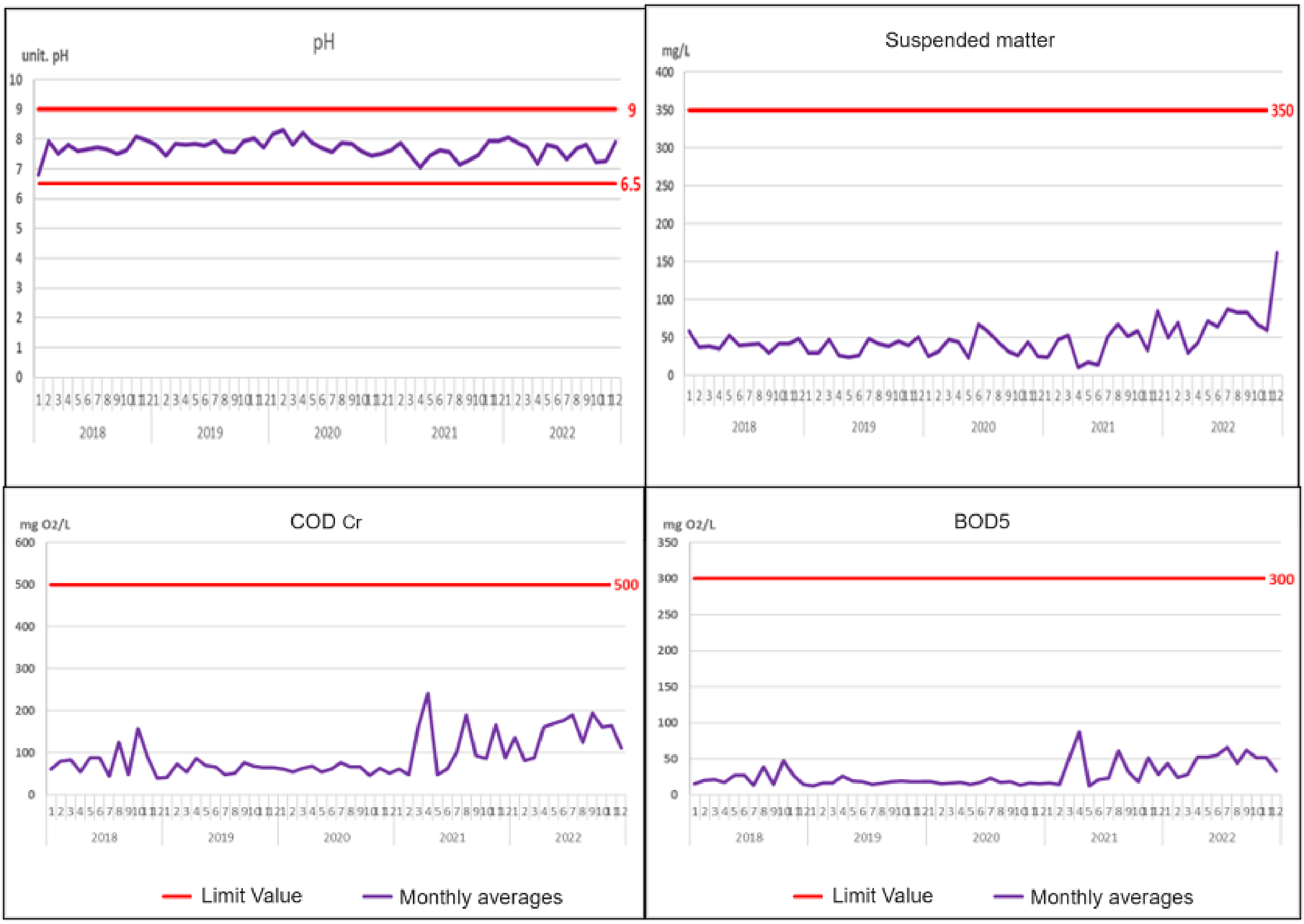

Fig. 25 Evolution of monthly averages during 2018÷2022 for the quality indicators of domestic wastewater discharged from Cernavoda NPP

The results show compliance with the regulated limit values.

[47] Monthly reports on the non-radioactive liquid influent and effluent monitoring

3.2 Environmental factor AIR

3.2.1 Sources of non- radioactive pollutants

The sources influencing the air quality in the Cernavoda NPP site area are:

- nearby industrial sources belonging:
  - Cernavodă - Saligny industrial area;
  - Cernavodă port area;
- Local surface sources, represented by:
  - road traffic in the vicinity, especially on the A2 (Cernavodă - Constanța section), DN 22C (Cernavodă - Basarabi), DJ 223;
  - ship traffic on the Danube-Black Sea Canal and the navigable arms of the Danube;
  - rail traffic on the Bucharest - Constanta Magistrala railway line;
  - residential heating;
  - the cultivation of plants and livestock by the population.

These source categories mainly generate the following pollutants:

- stationary and mobile combustion sources: nitrogen oxides (NOx), carbon monoxide (CO), heavy metal particles, volatile organic compounds (VOC);
- industrial and port activities in the vicinity: nitrogen oxides, carbon monoxide, particulates, volatile organic compounds;
- plant cultivation and animal husbandry by the population: nitrogen oxides, particulate matter, volatile organic compounds.

3.2.2 Concentrations of non-radioactive pollutants in ambient air

According to the Orders of the Minister of Environment no. 1206/2015, 598/2018, 2202/2020 and Order no. 1952/2023 *on the approval of the lists of administrative-territorial units drawn up following the classification in management regimes of the areas in the zones and agglomerations provided for in Annex no. 2 to Law no. 104/2011 on ambient air quality*, Constanța County is maintained **in management regime II**. This regime represents the areas in zones and agglomerations where the levels for sulphur dioxide, nitrogen dioxide, nitrogen oxides, particulate matter PM10 and PM2.5, lead, benzene, carbon monoxide **are lower than the limit values**, respectively for arsenic, cadmium, nickel, benzo(a)pyrene, particulate matter PM2.5 are **lower than the target values** set out in Annex No 3 to Law no. 104/2011.

The national air quality monitoring network does not include a representative station for the area of influence of the Cernavodă NPP, the closest being the industrial type monitoring station located at ca. 18 km ESE, in Medgidia.

Air quality assessment by mathematical modelling of pollutant dispersion at national/regional scale carried out for the reference year 2019 within the framework of the "National Air Pollution Control Programme" approved by Government Decision No 119/2023 No 119 of 8 February 2023, revealed the following ranges of background concentration values in the area in the vicinity of the site:

- NO_2 – annual average has values in the range 6 – 8 $\mu g/m^3$
- $PM_{2.5}$ – annual average has values in the range 14 – 16 $\mu g/m^3$
- SO_2 – annual average has values in the range 3.5 – 5 $\mu g/m^3$.

At the same time, indicative, short-term measurements were carried out in this study in the measurement campaign of 08 August 2023.

Tab. 40 Short-term concentrations for non-adiological pollutants in indicative measurements in the 8 August 2023 campaign

Pollutant	Unit	NPP site boundary - DICA zone -	NPP site boundary - DISPENSAR zone -	Limit values*
Measuring range	h	1	1	
PM_{10}	µg/mc	55.40	28.63	-
Carbon monoxide (CO)	µg/mc	18.5	137.5	-
Nitrogen dioxide (NO)$_2$	µg/mc	4.3	19.4	200
Sulphur oxides (SO_2)	µg/mc	6.3	157.2	350
Volatile organic compounds (TVOC)	mg/mc	0.03	0.03	-
Weather conditions:		16 ^oC, RH=96%, v=5.56 m/s, VNV, 1015 mbar, partly overcast sky (25%)	19 ^oC, RH=83%, v=6.67 m/s, VNV, 1015 mbar, partly overcast sky (25%)	

* short-term limit values (1h) according to Law no. 104/2011 on ambient air quality

The results of the indicative determinations were below the limit values required by Law No 104/2011 *on ambient air quality*.

3.3 Environmental factor SOIL/SUBSOIL

3.3.1 Topography

The Cernavodă Nuclear Power Plant is located on the left bank of the Danube-Black Sea Canal, in a region bordered to the west by the Danube River and the Romanian Plain, and to the east by the Dobrogean Plateau. The low plain, where Cernavodă area is situated, is part of the relief unit known as the Southern Dobrogea Platform, the confluence area between the deltaic plain near the Danube and the western extremity of the Carasu Plateau.

From a morphological perspective, Southern Dobrogea is a plateau whose altitude decreases from the northern part of the Dobrogea central unit towards the south, reaching its lowest point in the Carasu Valley, then gradually rising towards the towns of Petroşani and Osancea. The height of this plateau decreases slightly towards the west, to the Danube, and towards the east, to the Black Sea. The highest altitude of this plateau is recorded in the eastern part of the site along the line Petroşeni - Cobadin - Medgidia - Dorobanţul - Pantelimonul de Sus. Also, the height of the plateau decreases both towards the east, to the Black Sea, and towards the west, to the Danube. The central part of Dobrogea, between the Casimcea and Carasu valleys, represents the Tortoman Plateau, which continues to the west with the Dobrogea Danubian Plateau. Along the Carasu Valley, there is a depression area called the Carasu Corridor.

The site is integrated into the surrounding relief. ***The heights of the hills in the vicinity of the plant site are comparable to the heights of the buildings within the site***.

3.3.2. Geology. Foundation Conditions

From a morphological point of view, the Cernavodă Nuclear Power Plant site is located in the floodplain area of the Carasu Valley, characterized by a gentle relief with low energy and slopes, ***which do not favor the occurrence of rapid geomorphological processes***.

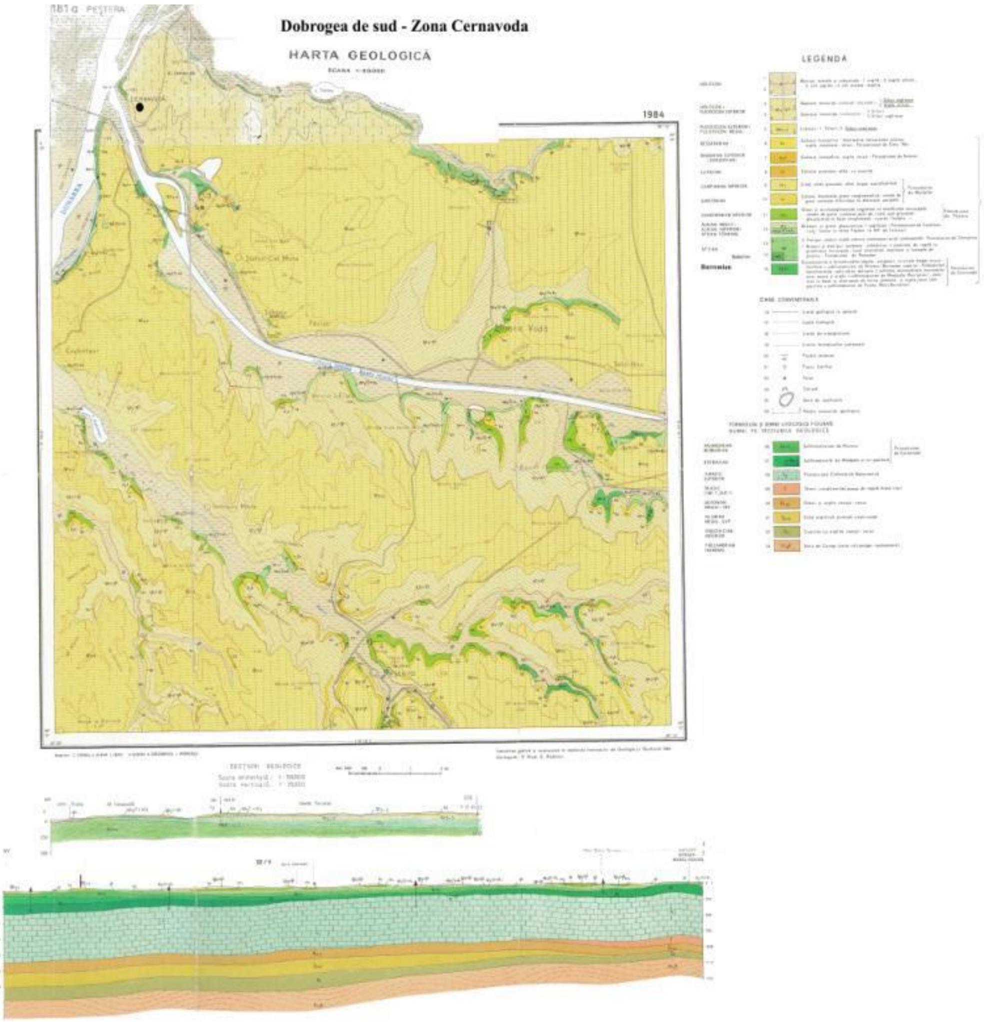

Fig. 26 The geological map of the Cernavoda NPP site area

From a geological point of view, the Cernavodă NPP site belongs to the geological, morphological, tectonic, and structural unit of Southern Dobrogea. This unit is bordered to the north by the Capidava Ovidiu fault, to the south by the partially identified Sabla Călăraşi Urziceni fault, to the west by the Danube fault, and to the east by the Black Sea coastline.

The studies conducted in the area by specialized institutions have allowed for the delineation of a comprehensive stratigraphy of the Cernavodă zone: [48]

The simplified stratigraphic column includes the following formations:

- Crystalline basement: Present at a depth of approximately 1700 meters, represented by green schists - the Carasu series - arkosic sandstones and microconglomerates with clayey - sandy, schistose intercalations;

[48] Update of the feasibility study for DICA, DI-08230-SF01, 2001

- Paleozoic sedimentary cover: found at a depth between 1100 and 1700 meters, consisting of quartzites, argillites, and quartzitic sandstones;
- Upper Jurassic limestones: represent a geologically significant section in the Dobrogea region, these formations flank the main aquifer that supplies water to the city of Constanţa and the coastal resorts. In the Cernavodă area, these formations are submerged at depths of over 400 meters, with thicknesses of up to 800 meters, with dolomite being the main petrographic component;
- Marls with intercalations of Valanginian limestones: with thicknesses of up to 100 meters;
- Barremian limestones: the foundation rock for the Cernavoda NPP reactors, hosting the main aquifer of the Cernavodă area;
- Clays with sand lenses in the Aptian-Sarmatian interval: The sandy lenses sometimes host minor water accumulations;
- Quaternary deposits: Covering the entire Cernavodă area, with thicknesses of up to 60 meters, presenting two distinct levels: Quaternary red clay and loess.

The shallow depth formations are Quaternary deposits, consisting of loessoid-clayey deposits and Aptian deposits, composed of dense clays and sands, laid over the bedrock represented by the Barremian limestone.

The Cernavoda NPP site is located within the developmental boundaries of the Cretaceous formations. At the foundation level of the nuclear buildings, Barremian limestones and Valanginian marls are found.

The Barremian limestone in the nuclear platform area looks like a massive limestone with an insular shape and limited surface extension, approximately 300 meters in the north-south direction and approximately 800 meters in the east-west direction. The limited extension of the limestone at the surface is due to intense post-Cretaceous erosion, reaching levels as low as -20 mnMB and even -30 mnMB, both in the northern area towards the Cismelei Valley and in the southern area towards the Carasu Valley.[49]

The Barremian limestone is composed of Cernavodă limestones, which are varied petrographically, leading to their division into two horizons, B1 and B2.

- B1: The upper horizon consists of white, hard, fissured limestones; yellow-white porous limestones; shell-bearing limestones; yellowish sandy-clay limestones, oolitic limestones; chalky white friable limestones, arranged in almost horizontal layers with thicknesses ranging from 0.20 to 1.00 meters, with a slight curvature towards the center of the quarry. The thickness of the B1 layer ranges from 11 to 26 meters.
- B2: This horizon consists of yellow-brown limestones with intercalations of porous, fissured white limestones, forming a transition layer between marls and the B1 limestones. This horizon appears heterogeneous both in thickness and composition, averaging 30-40% limestone and 60-70% clayey limestones, yellowish compact limestone clays, and compact sands. The thickness of the B2 layer ranges from 6 to 10 meters.

The Valanginian marls are compact, with no fissures or cracks, with some areas being coarser and others more clayey. In some cores, millimeter-thin sand layers have been noticed. The surface of the

[49] Feasibility Study of Radioactive Waste Management - Site Data Summary Report (includes Geological Survey) Task1.5, Doc. RWM-T-T1-005R0, June 2020

marls shows a curvature in front of Unit 4 and a descent towards Unit 1, with a thickness of approximately 50 meters.

The area of nuclear objectives U1 and U5, related to refurbishment

The geological studies conducted for the Cernavodă Nuclear Power Plant site showed that the geological structure of the location provides good stability and foundation conditions for the plant's buildings.[50]

To construct the platform for the power plant in the former Ilie Barza quarry, certain works were carried out to address the existing conditions in the quarry and the site requirements for a nuclear installation. These works included: [51]

- Excavations in loess;
- Rock removal in limestone up to the +15 md MB;
- Filling up to the +16 md MB;
- Slope stabilization works towards the northeastern part of the site;
- Construction of the cooling water supply channel;
- Installation of a protective screen for the nuclear facility;
- Improvement of the foundation rock quality through crack grouting and rock injections.

The Barremian limestones, which cover 95% of the nuclear site surface, serve as the foundation rock for all reactor buildings on the Cernavodă NPP site. This layer varies in thickness from 10 meters in the area of Reactor 5 to 30 meters in the area of Reactor 1.

The actual refurbishment works for Unit U1 will not affect the foundations of the buildings belonging to nuclear unit U1.

To identify the lithology, stratification, and determine the geotechnical characteristics of the foundation soil for the new DIDR-U5, a geotechnical study was conducted in 2020. This study revealed that the foundation rock on which the U5 reactor envelope is constructed (within which the new DIDR-U5 spaces will be organised) consists of B2 limestone approximately 1 meter thick, followed by a massive zone of Valanginian clay marls, providing good stability and foundation conditions for the Unit 5 reactor building. [50]

DICA Extension Area

The DICA site is located in front of the Unit 5 Reactor Building (new DIDR U5), approximately 1.2 km southeast of the town of Cernavodă, within the South Dobrogea geotectonic unit.

The geological sequence within the DICA site has been established based on existing documentation dating back to 1978, supplemented in 2000 with a detailed study of the current site.

In positioning the storage modules, efforts were made to adapt to the terrain conditions so that areas where limestone is closer to the surface could be used with maximum efficiency.

The site expansion will extend approximately 54 linear meters towards Reactor 5. According to the "Technical Study on the Expansion of the DICA Objective," code: CO-35370-6100-ST-01/Rev.1,

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[50] ESPOO Notification for the Project RT-U1 și DICA-MACSTOR 400, March 2022

[51] Nuclear Security Report for the Intermediate Solid Radioactive Waste Storage Facility at Cernavodă NPP – Summary, 03.03.2023, https://www.nuclearelectrica.ro/wp-content/uploads/2023/03/Anexa-1-RFS-DIDSR-Rezumat-von.pdf

issued by CITON Bucharest in 2008, this area has Barremian limestone positioned high enough to allow the construction of foundations under good technical and economic conditions.[52]

The areas selected for the refurbishment works of Unit U1 and the extension of the DICA are situated in the zone with optimal foundation conditions for nuclear objectives available at the Cernavodă NPP site, meeting nuclear security requirements.

3.3.3. Types and Quality of soil

The Cernavodă Nuclear Power Plant is situated in the area of a former limestone quarry, named Ilie Barza, on the left bank of the Carasu Valley.

The pedoclimatic, geological, and geomorphological conditions have led to the development of soils characteristic of low coastal plains, formed on loess or loess-like deposits.

On the right bank of the Danube, alluvial soils are present. These are young soils, either incompletely or partially developed. As part of the class of undeveloped soils, these soils do not have a differentiated profile and are characterized by a significant heterogeneity, both in terms of grain size composition and chemical composition. Alluvial deposits range in texture from sandy to clayey, with finer grain sizes towards the terrace, though vertical texture differences can also occur. These soils are rich in calcium carbonate, giving them a moderately basic character (pH ≈ 8).

The embankment of the Danube limited the flooding and receding of waters, allowing the development of a primary soil structure and promoting the accumulation of humus. These conditions have created a favorable environment for vegetation growth in the area.

Moving westward, the alluvial soils gradually transition to grey soils, characteristic of the arid climate regions in the southeast of the country. These grey soils are relatively rare, primarily found in Dobrogea, along the Danube, north of the Carasu Valley, in the Medgidia-Cernavodă sector, and around the Razelm complex. The parent material is mainly represented by loess or loess-like deposits, but with a lower content of fine particles.

Under the influence of reduced humidity, the processes of weathering and leaching are less intense. Due to weak leaching and the alkaline reaction, predominantly humic acids have formed, and the colloidal complex is fully saturated with basic cations, especially calcium. This explains the moderately alkaline reaction (pH 8 – 8.3). These soils have a undifferentiated relative profile; the upper horizon is dark yellowish-brown, unstructured or with a small and very fine granular structure. Grey soils are quite poor in humus (2 - 3%) and nutrients.

Although they have fairly good physical properties, due to the low amount of precipitation, its distribution throughout the year, and intense evaporation, grey soils do not retain sufficient amounts of water. Consequently, for most of the year, these soils experience a humidity deficit.

[52] SNN SA's long-term strategy for the development of the Intermediate Spent Fuel Storage Facility (DICA) and licensing with a view to extending the lifetime of Units 1 and 2, revised and harmonized with the requirements and recommendations of CNCAN and the Ministry of the Environment, respectively, 2019

In the previous environmental evaluations (Environmental balance -2018), the results of investigations regarding pH values and concentrations of heavy metals – Cr, Cu, Mn, Ni, Pb, Zn – in soil samples collected during campaigns conducted in the periods 2010-2011 and 2013-2016 were presented and analyzed. These investigations were part of the environmental monitoring program carried out by the Cernavodă NPP through third-party laboratories.

The sampling points were located as follows:

- Points located on the right bank of the Danube:
  - Upstream of the Cernavodă NPP (Oltina, Vlahii, Rasova)
  - At the discharge point of the cooling waters into the Danube and
  - Downstream (right bank of the Danube at the discharge point, Seimeni, Sat Dunărea, Capidava, Topalu).
- Points not located along the Danube (Valea Cișmelei – in the proximity of the Nuclear Power Plant, Seiru and Mircea Vodă - on the bank of the CDMN, Ivrinezu Mare, Lake Țibrinu).

The results of the ***pH*** determinations revealed that most of the measured values were in the range of 7 – 8.

Both for the pH indicator and the concentrations of heavy metals, the multi-annual averages indicated relatively similar values for the two sampling depths (5 cm below the soil surface after the vegetation layer was removed and at 30 cm), without showing significant transport in the soil layer.

The evolution of heavy metal concentrations and their spatial distribution indicated a correlation with a wide range of other activities/sources existing within a 30 km radius around the Cernavodă Nuclear Power Plant (NPP), such as road transport, naval transport (e.g., barges carrying ores, uncontrolled tank residue discharges), agricultural work, construction sites, etc. ***Evaluating the activities conducted at the Cernavodă NPP site, it was found that they do not show sources of soil pollution with heavy metals.***

Taking into account the measurement history and the sites where the current project will be developed, the measurement campaign on August 8, 2023, involved measurements of total petroleum hydrocarbons (TPH) and heavy metals concentrations in areas of interest within the Cernavodă Nuclear Power Plant (NPP) site: the tank and transformer areas, the DICA – new DIDR area, and the protected area of Unit U1.

The table below presents the TPH concentrations in the soil from samples taken on **August 8, 2023**, compared to the thresholds established by Order no. 756/1977 *for the approval of the Regulation on environmental pollution assessment, for less sensitive uses*.

Tab. 41 Values of petroleum hydrocarbons (TPH) in soil vs. thresholds established by Order no. 756/1997

Sampling point	**Sampling depth**	**Determined values 2023**	**Thresholds according to OM 756/1997 (for less sensitive uses)**		
			Normal values	**Alert threshold**	**Intervention threshold**
		mg/kg. d.s.	**mg/kg. d.s.**		
LLF Tank area (CTP)	5 cm	**850**	**<100**	**1000**	**2000**
	30 cm	540			
Diesel Tanks Area (U1)	5 cm	8			
	30 cm	11			
Transformers Area (U1)	5 cm	11			
	30 cm	12			
Transformers Area (U2)	5 cm	6			
	30 cm	7			
Area S101 U2 (boundary between U1 and U2)	5 cm	11			
	30 cm	12			
DICA– New DIDR U5 Area	5 cm	9			
	30 cm	15			

Note: d.s. = dry substance

The results indicate that the values fall within the normal range, significantly below the thresholds stipulated by Order no. 756/1997 for less sensitive uses, except the LLF tank area associated with the CTP, where the surface sample is found to be near the alert threshold.

Tab. 42 Heavy metals concentrations in soil vs. thresholds established by Order no. 756/1997

Indicator	**Sampling depth**	**Sampling point/ Determined values 2023**		**Thresholds according to OM 756/1997 (for less sensitive uses)**		
		DICA – new DIDR	**Diesel tanks U1**	**Normal values**	**Alert threshold**	**Intervention threshold**
		mg/kg. d.s.		**mg/kg. d.s..**		
Cadmium (Cd)	5 cm	0.38	0.52	**1**	**5**	**10**
	30 cm	0.31	0.44			
Cobalt (Co)	5 cm	2.5	0.88	**15**	**100**	**250**
	30 cm	1.4	0.53			
Chromium $_{total}$ (Cr $_{total}$)	5 cm	26	31	**30**	**300**	**600**
	30 cm	25	32			
Copper (Cu)	5 cm	22	26	**20**	**250**	**500**
	30 cm	21	25			
Manganese (Mn)	5 cm	304	425	**900**	**2000**	**4000**
	30 cm	319	358			
Nickel (Ni)	5 cm	25	22.2	**20**	**200**	**500**
	30 cm	23	24.2			
Lead (Pb)	5 cm	15	19	**20**	**250**	**1000**
	30 cm	16	18			
Zinc (Zn)	5 cm	44	91	**100**	**700**	**1500**
	30 cm	76	89			

The results indicate that the values fall within the normal range, significantly below the thresholds stipulated by Order no. 756/1997 for less sensitive uses, without showing a trend of transport into deeper layers.

3.3.4. Land use

The land occupied by the Cernavodă Nuclear Power Plant (NPP) is owned by SNN-SA, according to the Certificate of land ownership, series M03, no. 5415, issued by the Ministry of Industries and Resources on April 25, 2000. It is located within the urban area of Cernavodă, according to the Urban Planning Certificate approved by HCL no. 242/2014. The legal status of the land was established by the State Council Decree no. 31/27.01.1986 (for the construction of Cernavodă NPP Units 1-5).

The lands associated with the Cernavodă NPP site are used only with the assent of the National Commission for the Control of Nuclear Activities (CNCAN) and Cernavodă NPP, being located in the exclusion zone defined according to the "NSR-01 Fundamental Norms of Radiological Safety". Only constructions related to the operation of the nuclear power plant are allowed.

The map of land use (Fig. 27) provides general information on both the receptors exposed to the impact generated by the Cernavodă NPP and the existence/distribution of other potential impact sources in the area of interest, and possibly even on the power plant itself.

In the neighboring counties, land use is of the type "discontinuous urban structure" or "industrial or commercial units". Cernavodă NPP is the only nuclear facility in the area.

The economic activity in the influence area of the Cernavodă NPP consists of:

- Extractive industry (limestone quarries, sand, diatomite, bentonite, clay).
- Industrial units concentrated in the existing industrial zones in the towns of Cernavodă, Feteşti, and Medgidia (electricity production in wind farms, metal processing, construction/assembly, ship repairs, metal fabrication, reception/storage/delivery of petroleum, sorting of quarry products, wood processing, etc.).
- River, railway, and road transportation.
- Agro-industrial units spread across rural areas in the vicinity.

In the areas between localities, the predominant land use is agricultural, with small vegetation and forested areas. Based on the land use pattern in the siting area, most of the land is arable land, but there are also large areas of pastures, vineyards, and fewer orchards.

Main activities in the area are agriculture, animal husbandry, viticulture, and fish farming.

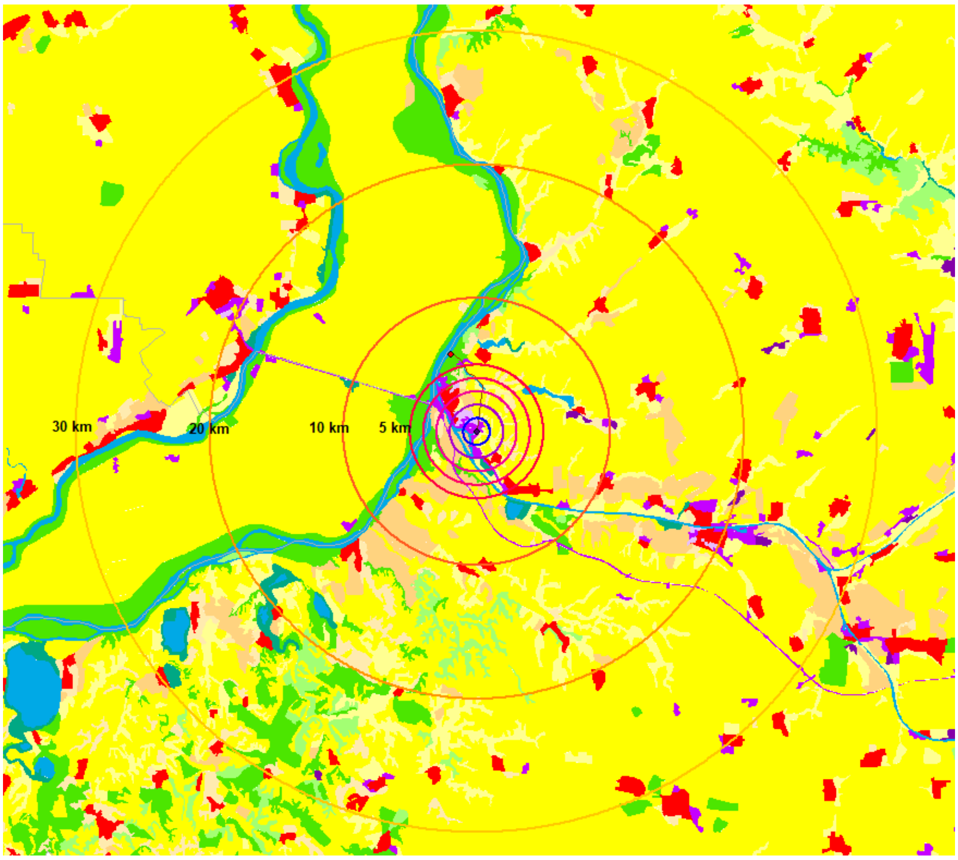
Vineyard areas are spread around Cernavodă, Cochirleni, Rasova, Aliman, Medgidia, Mircea-Vodă, and Tortomanu; the most compact orchard areas are to the east of Cernavodă, in the Mircea-Vodă and Medgidia areas. Cereals (corn, wheat), oilseeds (sunflower), and fodder plants dominate the arable lands.

Hilly areas with rugged terrain, less subject to human intervention, are covered with trees and small vegetation.

The forests in the area cover an area of 8023 hectares, organized into five production units. Only 22 hectares are private property (in accordance with Law 18/1991 - Flamurgea Forest, etc.) and are located 23 km from the Cernavodă NPP.

The forests within the area of interest generally have a multifunctional role, grouped into two categories:

- Forests and lands intended for afforestation with a protection and timber production function to obtain valuable assortments;
- Forests and lands intended for afforestation with special protection functions subject to a conservation regime that are not subject to timber harvesting.



- Distanțe față de U1

1 km
2 km
3 km
4 km
5 km
10 km
20 km
30 km

- Counties (Data provided by ANCPI, www.geoportal.gov.ro)

- Discharge channel

- Discharge point into Danube

CORINE Land Cover 2018 (vector), Europe, 6-yearly - version 2020_20u1_ *(Generated using European Union's Copernicus Land Monitoring Service information; DOI (vector): https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0, copernicus_v_3035_100_m_clc-2018_p_2017-2018_v20_r01)*

Urban fabric_Structurăa urbană
Industrial, commercial and transport units_Unități industriale, comerciale și transport
Mine, dump and construction sites_Mine, halde, șantiere
Arable land_Teren arabil
Heterogeneous agricultural areas_Terenuri agricole heterogene
Permanent crops_Culturi permanente
Pastures_Pășuni
Artificial, non-agricultural vegetated areas_Suprafețe artificiale, non-agricole
Scrub and/or herbaceous vegetation associations_Tufișuri și/sau plante ierboase
Forests_Păduri
Open spaces with little or no vegetation_Spații deschise cu vegetație puțină sau absentă
Inland wetlands_Zone umede interioare
Maritime wetlands_Zone umede maritime
Inland waters_Ape interioare
Marine waters_Mări

Fig. 27 Land use in Cernavoda NPP area (CLC2018 _Label2)

3.4 BIODIVERSITY

Biodiversity analysis within the base scenario takes into account the habitats on the lands to be occupied by the project as well as the surroundings of the site, as presented in subchapter 1.5.4.3 *Distances from protected natural areas*.

During the analysis of the potential impact regarding the biodiversity environmental factor, the following perimeters were established for the analyzed project at the level of which the categories of impact are manifested:

Area “0” – the level at which the direct impact assumed by the generation of the footprint of the built objectives associated with it is manifested (buildings, access ways, shading areas, etc.).

Area of influence – at the level at which the potential for the manifestation of the radiation generated by the objective is evaluated, in a single manner, respectively cumulatively with the other sources of emissions, taking into account the functional specifics of this objective.

In fact, the two areas of manifestation of the impact also coincide with the project implementation stages: the area "0" being associated with the construction stage, and the influence area being associated with the operation stages.

The area of influence was divided into three distinct manifestation perimeters with radii of 15, 30 and 40 km respectively (see Fig. 28).

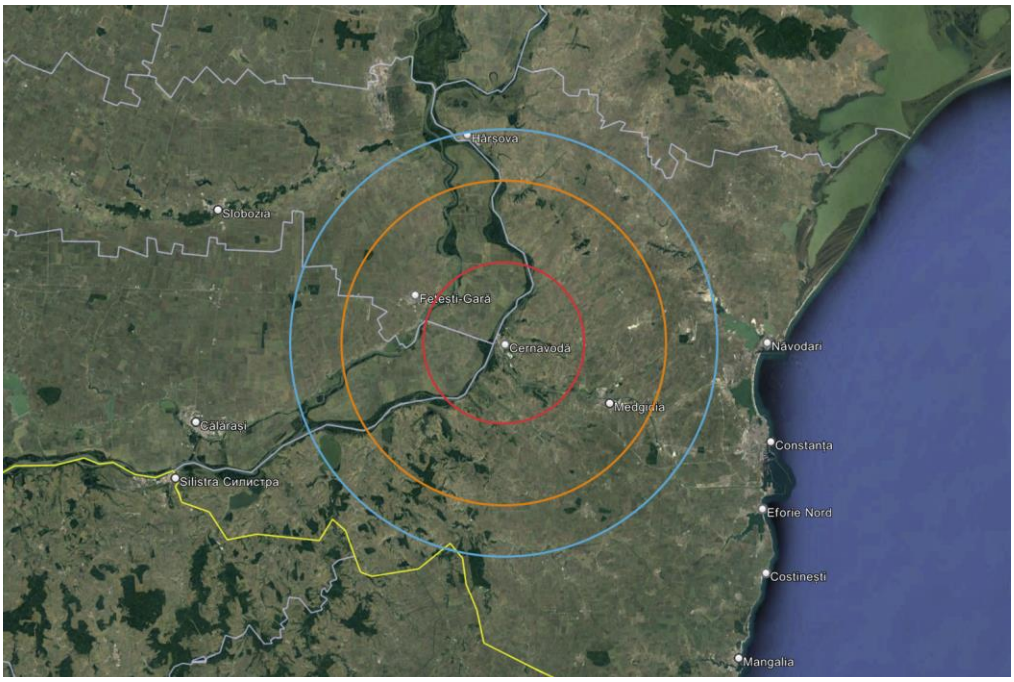


Fig. 28 Perimeters of influence established at 15, 30, and 40 km radius from the project implementation area

From a biogeographic point of view (see: Török, Zs. – GIS used for delimiting the European Biogeographical Regions from Romania, 2008) the area of influence of the project completely overlaps with the steppe bioregion.

Fig. 29 The perimeter of maximum influence (40km) superimposed on the map of bioregions at the national level

Regarding the overlap with biome categories, at the level of the area of influence there is a wide variety of types, reflected by the overlap of ecosystem categories with CORINE habitat categories by analyzing the cartographic elements of the model generated by the EEA Grants project available as a free resource accessible (www.geo-spatial.org/download/datele-corine-landcover-reproiectate-în-stereo70). We show that this model started from an initial assessment in 2000, followed by a revision in 2006, being later detailed at the level of 2012. In our approach, we took the information from the year 2006, which offers a sufficient degree of detail from the perspective of the assessment completed within the project.

The situation regarding the distribution of CORINE habitats, at the level of the studied area, agroecosystems remain **dominant (84.4%), natural and semi-natural areas representing (a modest) percentage of 11%**.

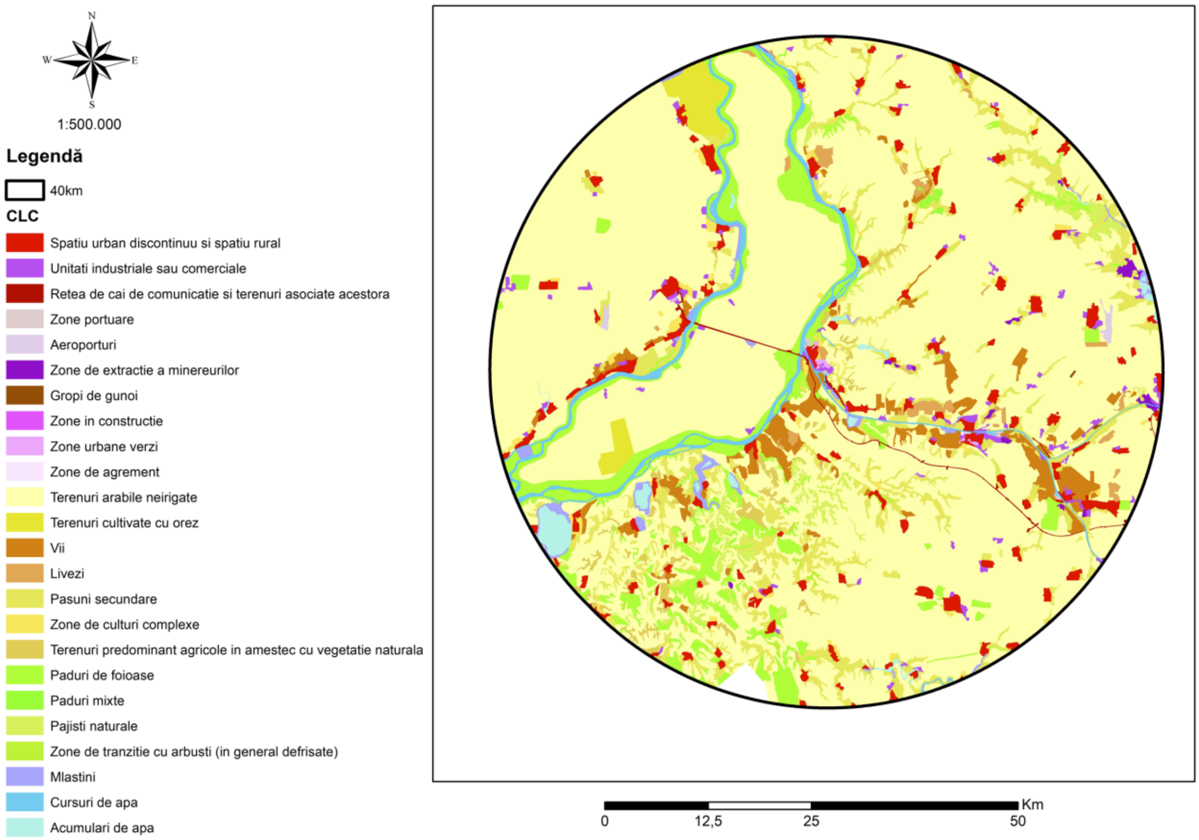


Fig. 30 The perimeter of maximum influence (40km) superimposed on the CORINE biome map

In areas of influence, the effects are associated with radiological impact.

Going through some documentation made in relation to the objective represented by the Cernavodă Nuclear Power Plant[53], the development of associated projects[54], studies on similar objectives[55] or scientific studies that dealt with aspects related to radiological impact (including from the perspective of nuclear accidents)[56], to which are added the opinions of established specialists in the field[57] indicated an increased sensitivity of the components represented by vegetation (especially algal vegetation - phytobenthos and that associated with wet environments), insects, fish, birds and mammals, there being from this perspective a common denominator given by the increased sensitivity of taxa associated with wet environments, including marine ones[58].

From this perspective, if accumulation gradients are detected with the potential to manifest outside the maximum considered influence perimeter (40km), the considered impact perimeter can be

[53] Services for carrying out a study of the impact of the operation of the Cernavodă nuclear power plant on aquatic and terrestrial organisms in its area of influence - National Research Institute - development for Cryogenic and Isotopic Technologies (ICSI) Râmnicu Vâlcea, Contract 21775/2008

[54] Report on the environmental impact study for the construction works for tritium removal facility proposed to be located on the NPP Platform, Cernavodă town, Constanța county

[55] Environmental Impact Statement New Nuclear – Darlington Environmental Assessment NK054-REP-07730-00029, for Ontarioa Power Generation Inc, SENES Consultants Ltd., 2009

[56] Cannon, G., Kiang, J., G. (2022): A review of the impact on the ecosystem after ionizing irradiation wildlife population, Int J Radiat Biol. 2022; 98(6): 1054–1062. doi:10.1080/09553002.2020.1793021

[57] Kiang, J., G. personal communication

[58] Alexeev, D., K., Galtsova, V., V. (2012): Effect of radioactive pollution on the biodiversity of marine benthic ecosystems of the Russian Arctic shelf, Polar Science Vol. 6(2):183-195

extended along the Danube - Black Sea Canal, respectively along the Danube meadow, all the way downstream from Balta Mică a Brăila.

From this perspective, it can be stated that the area of influence of the project (in its most extensive area – 40 km), overlaps with a wide variety of biomes, the dominant ones being the anthropized type (agroecosystems), wetland habitats, occupying a small percentage. However, taking into account the potential expansion of the impact associated with the transport provided by the Danube on the two major routes (the natural course, respectively the Danube - Black Sea Canal), in the analysis carried out, particular attention was paid to the key taxonomic groups associated with these environments: phytobenthos, fish, insects associated with wet environments (eg Odonates) and birds associated with wet areas (waterfowls). From the perspective of the bioindicator value offered by lepidoptera, but also of their representativeness as key pollinating species, an analysis was also chosen from this perspective.

Area "0" – Currently, the land of the site maintains a limited relevance from a bio-ecocenotic point of view, the vegetal carpet ensuring a modest cover, and the vegetation facies maintaining a strongly ruderalized structure, dominated by xerophilous and xero-thermophilic species, a consequence of the seasonal conditions that have experienced profound transformations as a result of human intervention:

- rainwater collection and management systems were created through gutter networks, so as to eliminate the risks generated by rainwater infiltration into the deep strata
- concrete platforms and structured access ways were made
- a number of built structures are preserved on the site
- the structure of the soils was profoundly altered by the works carried out previously at the site level: foundation works, storage of excavated soil and backfilling, settlement, etc.

Fig. 31 The structure of the soil at the level of the studied location:
the modest layer of vegetal soil can be observed - the dominant one being a stony, skeletal structure, generated by the backfilling and morphological correction works carried out at the time of the Cernavodă NPP construction works

Fig. 32 Structural elements that contribute to the simplification of biocenoses at the local level:

structured access roads, accompanied by concrete gutter systems that drain and conduct rainwater, limiting the water supply processes of biocenoses, built structures for which deep foundation works were carried out;

the xeric and xero-thermophilic character of the elements that make up the vegetation carpet can be observed

Fig. 33 The modest structure of the vegetation carpet, dominated by grass species

Fig. 34 The modest structure of the vegetation carpet, dominated by grass species – the modest structure of the vegetation carpet and the dominance of ruderal, synanthropic species can be observed

In order to establish the support capacity of the target habitats to be affected by the implementation of the project, given the constraints of an objective nature (limitation of access to the area, limitation of the possibilities of carrying out some experimental stages of work, etc.), which allow a statistical interpretation of the results, proximal areas, similar in terms of their structure, were selected for the purpose of completing some study stages, which served as reference (comparative) perimeters. Also, an appeal was made to the owner's databases developed within some reference projects[59], from which data were extracted regarding the composition of the structure of the biocenoses on sites relevant in this sense and from which functional aspects were inventoried (specific inventory, structure of habitats, etc.). In approaching the theme, summary investigations of the location and the completion of comparative studies conducted at the level of proximal biocenoses were used in order to establish comparative and relational terms.

In this approach[60] established methodologies were used in order to establish the supporting capacity of the habitats to be affected, in order to complete a calculation of the ecological footprint of the project, respectively to size the measures to reduce the impact, so that the residual impact is minimized (or even cancelled).

Starting from the structure of the habitats on the site, it was possible to determine that most fall into the following types:

R8701 Anthropic communities allong communication pathways with. *Cephalaria transsilvanica, Leonurus marrubiastrum, Nepeta cataria* and *Marrubium vulgare*

Correlation:

NATURA 2000: –

EMERALD: –

CORINE: –

PAL.HAB: 87.2 Ruderal communities

EUNIS: –

Vegetation associations: *Dauco – Cephalarietum transsilvanicae* M. et Ana; Maria Coroi 1998, *Convolvulo – Agropyretum repentis* Felföldy 1943.

Distribution: Along the roads and railways throughout the country.

Surfaces: They occupy relatively narrow strips but tens or hundreds of km long, along the communication routes, all over the country.

Stations:

Altitude: from sea level to the mountain area;

Climate: T = 11,0–5,0 ºC; P = 450–1000 mm.

Relief: flat land, embankments along communication routes.

Rocks: gravels, sands, materials used to build roads and railway embankments.

Structure: Most of the plants characteristic of these phytocenoses are more than 50-60 cm tall and achieve 70-80% cover. The most common species are: *Artemisia vulgaris, Agropyron repens, Carduus acanthoides, Cirsium arvense, Conium maculatum, Leonurus cardiaca, Verbena officinalis, Ballota nigra.* The lower stage is less well represented, consisting of the species: *Cynodon dactylon, Taraxacum officinale, Geum urbanum, Glechoma hederacea, Capsella bursa pastoris, Cardaria draba.*

Conservative value: **reduced**.

Floristic composition:

[59] Contract 75/2017 project *Natural gas transport pipeline Black Sea Coast – Podișor*
Contract SNCF “CFR” SA - 18/2016-2022 *Biodiversity Monitoring* project
Contract consultanță 32/ *project Improving the state of conservation of biodiversity in protected natural areas in the custody of the Constanța Forestry Directorate CF Bucharest - Constanța*
Technical services contract RADJP CT 2022-2024 - Șipote Quarry perimeter extension, Deleni commune

[60] Franklin, J. (2010): Mapping species distribution – Spatial Influence and Prediction, Cambridge Univ. Press
Leps, J., and Colab. (2006): Quantifying and interpreting functional diversity of natural communities: practical considerations matter, Preslia 78:481-501

Edifying species: *Cephalaria transsilvanica, Agropyron repens, Conium maculatum.*

Characteristic species: *Cephalaria transsilvanica, Cynodon dactylon Leonurus cardiaca.*

Other important species: *Convolvulus arvensis, Cardaria draba, Verbena officinalis, Daucus carota.*

Selective literature: Coroi et Coroi 1998; Sanda, Popescu, Stancu 2001.

R8704 Anthropic communities with *Polygonum aviculare, Lolium perenne, Sclerochloa dura* and *Plantago major*

Correlation:

NATURA 2000: –

EMERALD: –

CORINE: –

PAL.HAB: 87.2 Ruderal communities

EUNIS: –

Vegetation associations: *Lolio – Plantaginetum najoris* (Linkola 1921) Berger 1950, *Sclerochloo – Polygonetum avicularis* (Gams 1927) Soó 1940.

Distribution: Vacant land, roadsides, paths, all over the country.

Surfaces: 500–600 ha nationwide.

Stations:

Altitude from sea level to 500-600 m, in hilly and sub-mountainous areas;

Climate: T = 11–8,5 ºC; P = 500–800 mm;

Relief: flat, gently sloping land with southern, eastern and western exposure.

Soils: sandy and sandy loam rich in decomposing organic matter, deficient in moisture in summer.

Structure: Most of the component plants are small, but two layers can be separated - the upper one is made by the species: *Lolium perenne, Lepidium ruderale, Matricaria perforata*.

The lower tier is made up of sudden or very short-stemmed species such as: *Amaranthus crispus, Polygonum aviculare, Sagina procumbens.*

Conservative value: **reduced**.

Floristic composition:

Edifying species: *Poa annua, Polygonum aviculare, Plantago major, Lolium perenne.*

Characteristic species: *Plantago major, Polygonum aviculare.*

Other important species: *Trifolium repens, Taraxacum officinale, Hordeum murinum, Matricaria perforata.*

In some places, there are thickets where you can find bouquets of *Rosa sp., Crataegus monogyna* and *Prunus cerasifera*, but they are regularly removed by cutting from the plot level (at least once every 3-4 years). Acacia (*Robinia pseudaccacia*) bouquets also appear in isolation, also constantly removed by the maintenance work undertaken at the level of the inner spaces of the fenced enclosures.

Under the given conditions, it was appreciated that from the point of view of biological productivity, as an indicative element for defining biodiversity indices, the taxonomic groups plants and birds, respectively, remain the defining elements.

The list of plant species identified at the site included a number of 31 species, as follows:

1. *Agropyron repens*
2. *Artemisia vulgaris / Artemisia sp.*
3. *Ballota nigra*
4. *Capsella bursa pastoris*
5. *Cardaria draba*
6. *Carduus acanthoides*
7. *Cirsium arvense / Cirsium sp.*
8. *Conium maculatum*
9. *Convolvulus arvensis*
10. *Crataegus monogyna*
11. *Cynodon dactylon*
12. *Daucus carota*
13. *Geum urbanum*
14. *Glechoma hederacea*
15. *Hordeum murinum*
16. *Leonurus cardiaca*
17. *Lolium perenne*
18. *Matricaria perforata/chamomilla*
19. *Medicago sativa*
20. *Plantago major*
21. *Plantago minor*
22. *Poa annua*
23. *Prunus cerasifera*
24. *Polygonum aviculare*
25. *Robinia pseudaccacia*
26. *Rosa sp.*
27. *Setaria verticillata*
28. *Taraxacum officinale*
29. *Trifolium repens / Trifolium sp.*
30. *Verbena officinalis*
31. *Xanthium strumarium*

The carrying capacity of habitats for bird species indicated a (maximum) nesting potential for:

- 2 pairs of parids (*Parus major*)
- 1 pairs of *Lanius minor*
- 1 pairs of *Alauda arvensis.*

3.4.1 Data on natural areas of community interest

Taking into account MO no. 46/2016[61], respectively GD no. 663/2016[62], the perimeter where the project is to be implemented is found in the **vicinity** of the sites:

- ROSCI0022 Canaralele Dunării;
- ROSCI0053 Dealul Alah Bair;
- ROSCI0071 Dumbrăveni - Valea Urluia - Lacul Vederoasa;
- ROSCI0172 Pădurea și Valea Canaraua Fetii – Iortmac;
- ROSCI0278 Bordușani – Borcea;
- ROSCI0319 Mlaștina de la Fetești;
- ROSCI0353 Peștera – Deleni;
- ROSCI0412 Ivrinezu;
- ROSPA0001 Aliman – Adamclisi;
- ROSPA0002 Allah Bair – Capidava;
- ROSPA0007 Balta Vederoasa;
- ROSPA0012 Brațul Borcea;
- ROSPA0039 Dunăre – Ostroave;
- ROSPA0054 Lacul Dunăreni.

Data on the criteria elements (species and habitats) that were the basis for the designation of the proximal Natura 2000 sites can be found summarized in Annex 6 BIODIVERSITY – 5.

[61] regarding the establishment of the natural protected area regime and the declaration of sites of community importance as an integral part of the European ecological network Natura 2000 in Romania, National Institute of Research - Development "Danube Delta", Tulcea, 2022

[62] regarding the establishment of the natural protected area regime and the declaration of areas of special avifaunistic protection as an integral part of the European Natura 2000 ecological network in Romania

3.4.1.1 Data on the Surface of Natura 2000 sites

ROSCI0071 Dumbrăveni – Valea Urluia – Lacul Vederoasa

Initially (2007[63]), the site was designated on an area of 18714 ha. Later (2011[64]), the area was reduced to 17971 ha. Currently, the surface of the ROSAC0071 site has an area of 18024.4 ha[65], the drawing of the limits was carried out based on several stages aimed at increasing the precision in the delimitation of the protected natural areas[66], steps which, however, assumed measures centered on cartographic approaches calling on remote sensing resources and less in field studies.

The site overlaps with the administrative territory of: Aliman, Ion Corvin, Dobromir, Rasova, Deleni, Cobadin, Chirnogeni, Independența, Dumbrăveni, Adamclisi.

ROSPA0001 Aliman - Adamclisi

Initially (2007[67]), the site was designated on an area of 19467.8ha. Later (2011[68]), the area was maintained at 19468 ha. Currently, the surface of the ROSAC0071 site has an area of 18908.7ha[69], as a result of drawing the boundaries with greater precision. The site overlaps with the administrative territory of: Aliman, Rasova, Peștera, Deleni, Adamclisi, Dobromir, Ion Corvin.

ROSCI0022 Canaralele Dunării

Initially (2007[70]), the site was designated on an area of 26064 ha. Later (2011[71]) the area was reduced to 25943ha, and currently the area of the ROSCI0022 Danube Canal site is 26109 ha.

ROSCI0053 Dealul Alah Bair

In 2007 the site was designated on an area of 187 ha, in 2011 the area of the site increased to 194, and currently the site ROSCI0053 Alah Bair Hill has an area of 193 ha.

[63] ORDER no. 1964 of December 13, 2007 regarding the establishment of the protected natural area regime of sites of community importance, as an integral part of the European Natura 2000 ecological network in Romania

[64] ORDER no. 2387 of September 29, 2011 for the amendment of the Order of the Minister of Environment and Sustainable Development no. 1.964/2007 regarding the establishment of the protected natural area regime of sites of community importance, as an integral part of the European Natura 2000 ecological network in Romania

[65] https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=ROSCI0071

[66] https://ibn.idsi.md/ro/vizualizare_articol/114334

[67] DECISION no. 1284 of October 24, 2007 regarding the declaration of avifaunistic special protection areas as an integral part of the European Natura 2000 ecological network in Romania

[68] DECISION no. 971 of October 5, 2011 for the amendment and completion of Government Decision no. 1284/2007 regarding the declaration of avifaunistic special protection areas as an integral part of the European Natura 2000 ecological network in Romania

[69] https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=ROSPA0001

[70] DECISION no. 1284 of October 24, 2007 regarding the declaration of avifaunistic special protection areas as an integral part of the European Natura 2000 ecological network in Romania

[71] DECISION no. 971 of October 5, 2011 for the amendment and completion of Government Decision no. 1284/2007 regarding the declaration of avifaunistic special protection areas as an integral part of the European Natura 2000 ecological network in Romania

ROSCI0172 Pădurea și Valea Canaraua Fetii – Iortmac

In 2007 the site was designated on an area of 14473 ha, in 20011 its area was reduced to 13631 ha, and currently it has an area of 13636 ha.

ROSCI0278 Bordușani – Borcea

In 2011 the site was designated on an area of 5,810 ha, and in 2016 its area was changed to 5847 ha.

ROSCI0319 Mlaștina de la Fetești

Initially (2011) the site was designated on an area of 2,020 ha, and in 2016 the area was increased to 2119 ha.

ROSCI0353 Peștera – Deleni

Initially (2011) the site was designated on an area of 2508 ha, and in 2016 the area was increased to 2649 ha.

ROSCI0412 Ivrinezu

The Natura2000 site ROSCI0412 Ivrinezu was designated in 2016 on an area of 411 ha.

ROSPA0002 Allah Bair – Capidava

Situla Natura2000 ROSPA0002 Allah Bair – Capidava was designated in 2007 on an area of 11645.1 ha, in 1011 the area was changed to 11645 ha, and currently its area is 11715 ha.

ROSPA0007 Balta Vederoasa

Initially (2007) the site was designated on an area of 2104.0 ha, following that the area was changed to 2144 ha in 2011, and the current area of the site is 2139 ha.

ROSPA0012 Brațul Borcea

The site was designated in 2007 on an area of 13096.8ha, later in 2016 the area was changed to 13097 ha, and currently the area of the site is 13299 ha.

ROSPA0039 Dunăre – Ostroave

In 2007 the site was designated on an area of 16223.6 ha, in 2011 the area was changed to 16224 ha, and the current area of the site is 16243 ha.

ROSPA0054 Lacul Dunăreni

The Natura 2000 site ROSPA0054 Lake Dunăreni was designated in 2007 on an area of 1003.8 ha, later (2016) it was changed to 1261 ha, and currently the area of the site is 1269 ha.

Tab. 43 Area of target sites considered in the designation process

Site Code, Name	**2007**	**2011**	**2016**	**Discussion**
	ha			
ROSCI0022 Canaralele Dunării	26064	25943	26109	Surface differences of up to 1%
ROSCI0053 Dealul Alah Bair	187	194	193	Surface differences of up to 4%
ROSCI0071 Dumbrăveni - Valea Urluia - Lacul Vederoasa	18714	17971	18024	Surface differences of up to 5%
ROSCI0172 Pădurea și Valea Canaraua Fetii – Iortmac	14473	13631	13636	Surface differences of up to 6%
ROSCI0278 Bordușani – Borcea		5810	5847	Surface differences of up to 1%
ROSCI0319 Mlaștina de la Fetești		2020	2110	Surface differences of up to 5%
ROSCI0353 Peștera – Deleni		2508	2549	Surface differences of up to 1%
ROSCI0412 Ivrinezu	411			
ROSPA0001 Aliman – Adamclisi	19467.8	19468	18908	Surface differences of up to 3%
ROSPA0002 Allah Bair – Capidava	11645.1	11645	11715	Surface differences of up to 1%
ROSPA0007 Balta Vederoasa	2104	2144	2139	Surface differences of up to 0,23%
ROSPA0012 Brațul Borcea	13096.8	13097	13299	Surface differences of up to 1,54%
ROSPA0039 Dunăre – Ostroave	16223.6.	16224	16243	Surface differences of up to 0,11%
ROSPA0054 Lacul Dunăreni	1003.8	1261	1269	Surface differences of up to 26%

It can be observed that in the designation process, in the absence of certain data acquired in field studies, the delimitation of the areas and the establishment of their surface experienced some dynamics[72].

3.4.1.2 Types of ecosystems

In the vicinity of the NPP site, agroecosystems remain dominant; an analytical situation on the categories of habitats at the level of the proximal Natura 2000 sites is made in Annex 6 BIODIVERSITY - 6 Types of ecosystems.

[72] according to the provisions of art. 56'1 (3) The modification of the limits of the protected natural areas of national interest, in the sense of delimiting a better precision, is done at the initiative of the administration structure/custodian of the protected natural area based on a scientific study, with the opinion of the scientific council, with the approval of the public authority centers for the protection of the environment and forests. In the case of protected natural areas of national interest, without identified limits until the approval of this Government emergency ordinance by law, the establishment of limits and their modification are made by Government decision, upon the proposal of the custodian of the respective protected natural area, based on a scientific study, with the approval of the Romanian Academy and with the approval of the central public authority for the protection of the environment and forests.

3.4.1.3 Data on the presence, location, population and ecology of species and/or habitats of community interest mentioned in the standard form of natural areas

Data on the presence, location, population and ecology of species/habitats of conservation interest were analyzed starting from systematic studies carried out by the EA[73] expert, or derived from the proposed Management Plan. The potential presence of some species was also considered, starting from the analysis of their ecological requirements.

On the basis of these elements, the situation of the criterion elements mentioned in the Standard Form on the basis of which the protected natural areas were designated, starting from the attributes assigned to them, was discussed.

Given the fact that the project is located in the area of several sites, the analysis was carried out separately, for each site separately, the aspects being presented in Annex 6 BIODIVERSITY -1.

3.4.1.4 Data on the presence, location, area and ecology of species and/or habitats of community interest mentioned in the standard site form

At the level of the target location, there are missing criterion elements that were the basis for the designation of Natura 2000 sites in the immediate vicinity or in the area of its influence (significant populations of certain criterion species, habitats of conservation interest, etc.).

Data on the presence, location, surface and ecology of the species and/or habitats of community interest mentioned in the standard site forms can be found summarized in Annex 6 BIODIVERSITY - 8.

3.4.2 Description of the current conservation status of the protected natural area of community interest, including developments/changes that may occur in the future

Where an analysis of the state of conservation of natural areas of community interest could be carried out, the situation was presented synthetically based on an expert analysis. Starting from the distribution of the major biomes described according to the Natura 2000 Standard Form for the targeted sites, the data held as a result of a large number of field studies carried out in the period 2019-present), their current state was evaluated considering 3 levels of impact:

- red = level of significant impact;
- yellow = moderate impact level;
- green = low impact level;

A synthetic analysis is covered in Appendix 6 BIODIVERSITY – 7.

Conclusion

The direct evidence generated so far[74] has not indicated the presence of radioactive contamination of the tissues of living organisms, respectively contained in the environmental factors water, air, soil.

[73] Contract 75/2017 project *Natural gas transport pipeline Black Sea Coast – Podisor*
Contract 18/2016-2022 Biodiversity *Monitoring project*
Consultancy contract 32/2012 project *Improving the state of conservation of biodiversity in protected natural areas in the custody of the Constanța Forestry Directorate CF Bucharest - Constanța*
And so on

[74] Services for carrying out a study of the impact of the operation of the Cernavodă nuclear power plant on the aquatic and terrestrial organisms in its area of influence - National Research&Development Institute - for Cryogenic and Isotopic Technologies (ICSI) Râmnicu Vâlcea, Contract 21775/2008
Report on the monitoring of liquid and gaseous radioactive effluents from the Cernavodă NPP site

3.5 NOISE AND VIBRATION

In order to verify the compliance of the Cernavodă Nuclear Power Plant (NPP) with the environmental legislation regarding environmental noise, the following activities have been planned:

- ***Conducting measurements*** in accordance with the provisions of the standard SR 10009/2017 Acoustics. Permissible limits of noise levels in the environment and
- ***Performing noise level modeling*** in accordance with the provisions of Law no. 121/2019 on the assessment and management of ambient noise, with subsequent amendments and additions, using the information from the following regulations
  - ***GD no. 1756/2006 on limiting the level of noise emissions in the environment, produced by equipment intended for outdoor use.***
  - ***BS 5228 – 1:2009 + A1:2014 Code of practice for noise and vibration control on construction open sites – Part. 1: Noise.***

The location of the reference points (1...7) representative for evaluating noise levels is illustrated in Fig. 35, and their coordinates are presented in Tab. 44.

Site investigations were conducted in August 2023, and the results from the characterization of existing sources (location, physical dimensions, acoustic powers, and frequency spectra) were entered into the SoundPlan 9.0 acoustic modeling and mapping software.

The measurements were performed with a measuring system consisting of an integrated sound level meter, 01 dB SOLO type, serial number 11343, manufactured by 01dB METRAVIB, France, meeting the conditions imposed by the following standards:

- IEC 651, class 1, edition 10-2000 IEC ; IEC 804, class 1, edition 10-2000;
- IEC 61672, class 1, edition 05-2002; IEC 1260, class 1, edition 07-1995;
- ANSI S1.11, class 1, edition 1986.

According to the investigation plan, both the evaluation of the contribution from the Cernavodă NPP and the contributions from other noise sources in the area of interest (e.g. road traffic) were pursued.

The results of the noise assessments are compared to the limits established by SR 10009:2017, *Chapter 4.3, Admissible Noise Level Limits at the Boundary of Functional Zones - Table 3*.

The noise modeling was conducted using the dedicated software SoundPlan 9.0, aiming to assess the contribution of the Cernavodă NPP sources. The modeling maps illustrate the contribution of various noise sources on the Cernavodă NPP site.

In environmental studies, legislation aims to protect sensitive receptors such as residences, schools, and hospitals, for which the SR 10009-2017 standard sets a limit of 50 dB(A).

Informative report - The results of the monitoring of environmental factors and the level of radioactivity in the Cernavoda area, in the period 1996 – 2022
EIA Report for Construction works of the Cernavoda tritium removal facility, "Danube Delta" National Research and Development Institute, Tulcea, 2022

However, for the nuclear power plant, the existence of inhabited areas within less than 1 km around the nuclear reactors is excluded. Therefore, in the present analysis, there is no concern about the population being affected by exposure to the noise generated by the Cernavodă NPP.

For the industrial zone, the maximum value imposed at the boundary of the analyzed unit is 65 dB(A). Even though there are no sensitive receptors outside the site, limiting the noise to 65 dB(A) is beneficial. This is because noise levels diminish at not too great distances, and this aspect is favorable for the protection of fauna in the nearby protected natural areas, such as Natura 2000 sites adjacent to the project.

For the creation of the digital acoustic model of the site, it is necessary to input the noise sources along with their characteristics: sound power level, spectral distribution, coordinates (x, y, z), type of source (point, line, surface), and directivity. Another essential element to consider is the approximate operating time of each source within the established reference duration.

Only noise sources with significant implications on the noise outside the buildings on the site were taken into account. For example, the following sources were considered:

- The pump network for water absorption from the Danube - Black Sea Canal (pump house)
- The transformer stations located near U1 and U2, on their eastern sides;
- The exhaust nozzle of the stacks for U1 and U2, situated at an elevation of 54 m (each exhaust stack contains a fan whose noise propagates without significant reductions to the exhaust nozzle).

An important source of noise located near the power plant premises is Medgidiei Street, a second-category road. The road experiences heavy traffic involving vehicles of all categories, and the noise generated significantly impacts the acoustic environment of the power plant premises adjacent to the road.

As evident from the noise maps for the current state (Board 1 of Annex 6 NOISE), appropriate sources have been attributed to the digital model of the area.

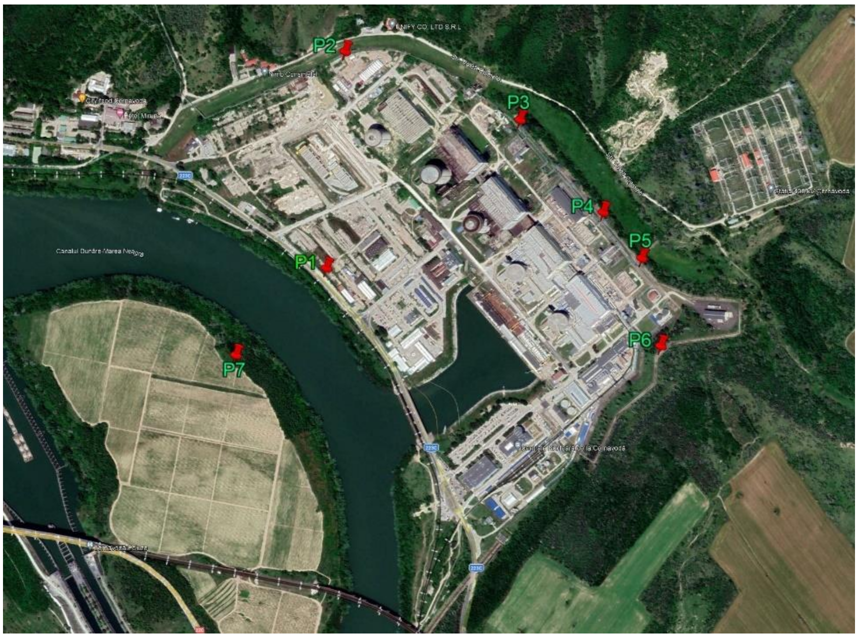


Fig. 35 The reference points marked on the map (Google Earth)

Tab. 44 The coordinates for the selected reference points

Point of reference	CoordinatesUTM 35N		Observations
	X	Y	
1	583 870	4 908 100	S-W, near the road
2	583 910	4 908 635	N, near U5 and DICA
3	584 345	4 908 472	N-E, near U3 and U4
4	584 553	4 908 246	N-E, near U2
5	584 650	4 908 134	N-E, near U1
6	584 697	4 907 918	E, near CTRF
7	583 650	4 907 882	External point

The noise maps corresponding to the current state are presented in Board 1: Distribution of noise levels for the current situation and in Board 5: Distribution of noise levels for Medgidiei Street (DN223C) from Annex 6 NOISE.

Conclusion

Following the analysis conducted to characterize the current state in the vicinity of the Cernavodă Nuclear Power Plant (NPP), it has been observed that the noise levels generated by the operation of the facilities on the premises fall within the limits established by SR 10009:2017, Acoustics. Admissible Limits of Noise Levels in the Environment.

3.6 CLIMATE AND CLIMATE CHANGE

In the year 2022, the national average temperature was 10.6ºC, which is 1.0ºC higher than the median for the 1991-2020 interval. Positive deviations were recorded in 9 out of the 12 months of the year, with the monthly average temperature across the country being higher than the median of the standard reference interval (1991-2020) with values ranging from 0.7ºC (May) to 2.6ºC (December). In the remaining months, the deviation was negative, ranging between 0.1ºC in September and 1.8ºC in March (Fig. 36). The year 2022 ranks third in the list of the hottest years in Romania, compiled for the period 1961-2021 using data from 129 weather stations. This ranking is confirmed by the analysis based on the average temperature across the country calculated from data collected at 29 meteorological stations with complete records from 1900 to 2022.[75]

[75] ANPM, Report on indicators for 2022; https://www.anpm.ro/documents/12220/2209838/RI+2021.pdf/5ee3ae8f-8e46-4b9c-bf85-396e5fb99708

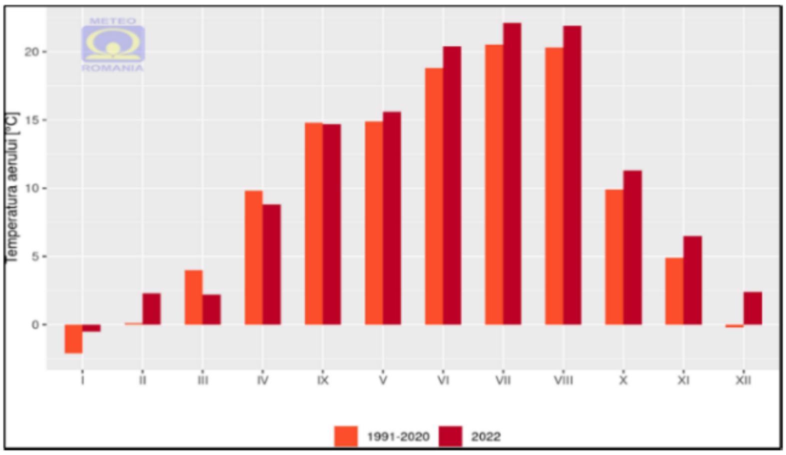


Fig. 36 The monthly average temperature in Romania in 2022, compared to the climatological normal for the period 1991-2020

According to studies and analyses conducted by the National Aeronautics and Space Administration (NASA), the Goddard Institute for Space Studies (GISS), the month of July 2023 was warmer than any other month in the global temperature record.[76]

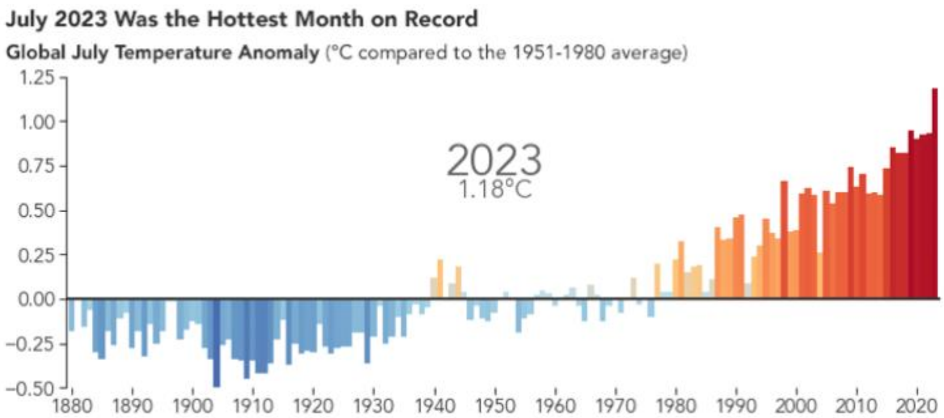


Fig. 37 The seasonal temperature anomaly reported for the reference period of 1951-1980 - the month of July 2023 - set a record

The temperature in July 2023 was 1.18°C warmer than the average for the month, setting a record as the warmest month in 143 years.

The following map displays global temperature anomalies for the meteorological summer of 2023 (June, July, and August).[77]

[76] July 2023 Was the Hottest Month on Record (nasa.gov)

[77] https://www.nasa.gov/news-release/nasa-announces-summer-2023-hottest-on-record/

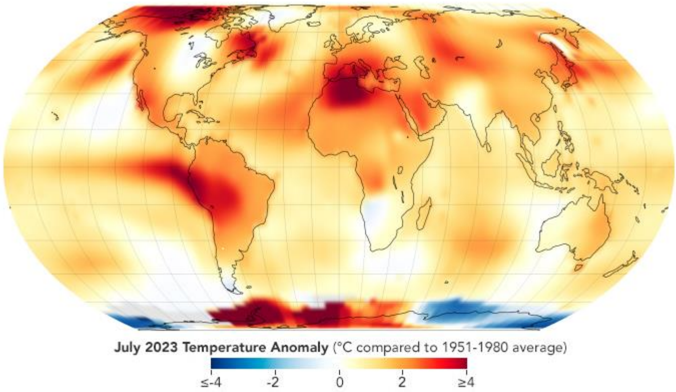


Fig. 38 Anomalies for the meteorological summer of 2023 (June, July, and August)

In June, July, and August 2023 combined, the temperatures were 0.23°C higher than any other average summer recorded by NASA between 1951-1980, with August being 1.2°C warmer than the average. The period of June-July-August is considered the meteorological summer in the northern hemisphere.

In the decade from 2013 to 2022, the global average near-surface temperature was approximately 1.13 to 1.17°C higher than the pre-industrial level, making it the warmest decade on record. Ground temperatures in Europe increased even more rapidly during the same period, by 2.04 to 2.10°C, depending on the dataset used. Member countries of the United Nations Framework Convention on Climate Change (UNFCCC) committed to limit the global temperature increase to below 2°C above pre-industrial levels and to pursue efforts to limit the increase to 1.5°C under the Paris Agreement. Current estimates indicate that without drastic reductions in global greenhouse gas emissions, even the 2°C limit could be exceeded before 2050.

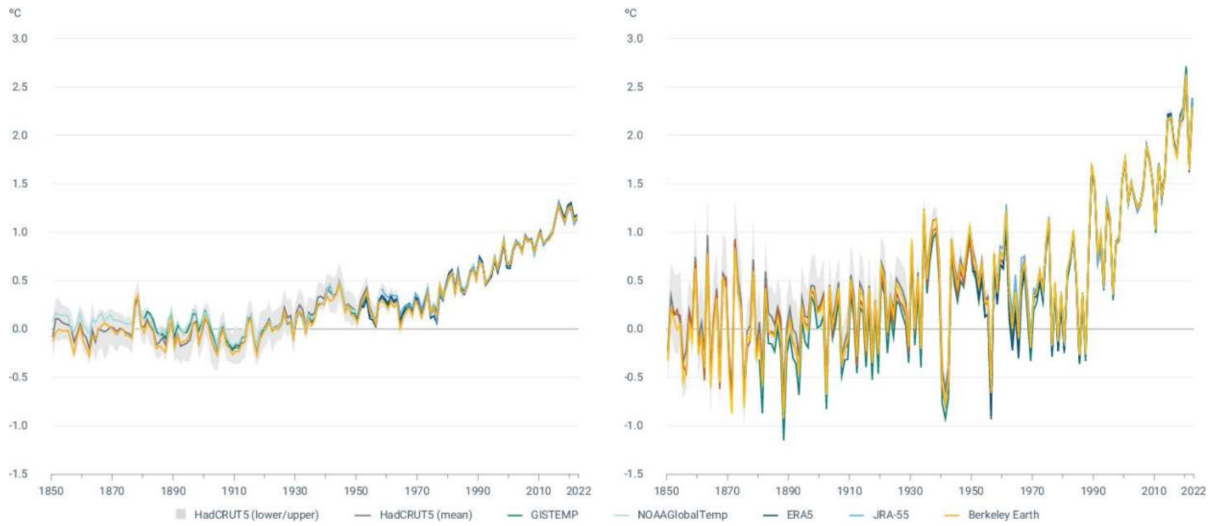


Fig. 39 The average surface temperature during the pre-industrial period from 1850 to 1900: global (left), European (right)

(Source: https://www.eea.europa.eu/en/analysis/indicators/global-and-european-temperatures)

Global temperature trends are an important indicator of the magnitude of climate change and its potential effects. The rate of increase has been particularly high since the 1970s, at approximately 0.2°C per decade, with anthropogenic activities, especially greenhouse gas (GHG) emissions, largely considered responsible for this warming.

Projections from the CMIP6[78] initiative suggest that temperatures in European land areas will continue to rise throughout this century at a faster rate than the global average. The Representative Concentration Pathway (RCP) scenarios used to develop climate projections include time series of emissions and concentrations of the full range of Green House Gases (GHGs), as well as aerosols and chemically active gases, and land use. RCP4.5 represents an intermediate stabilization trajectory where radiative forcing is limited to approximately 4.5 W/m2 in 2100, while RCP8.5 represents a higher trajectory leading to >8.5 W/m^2 in 2100.

The highest level of warming is forecasted in northeastern Europe, northern Scandinavia, and the inland areas of Mediterranean countries, while the lowest warming is expected in western Europe, especially in the United Kingdom, Ireland, western France, the Benelux countries, and Denmark.

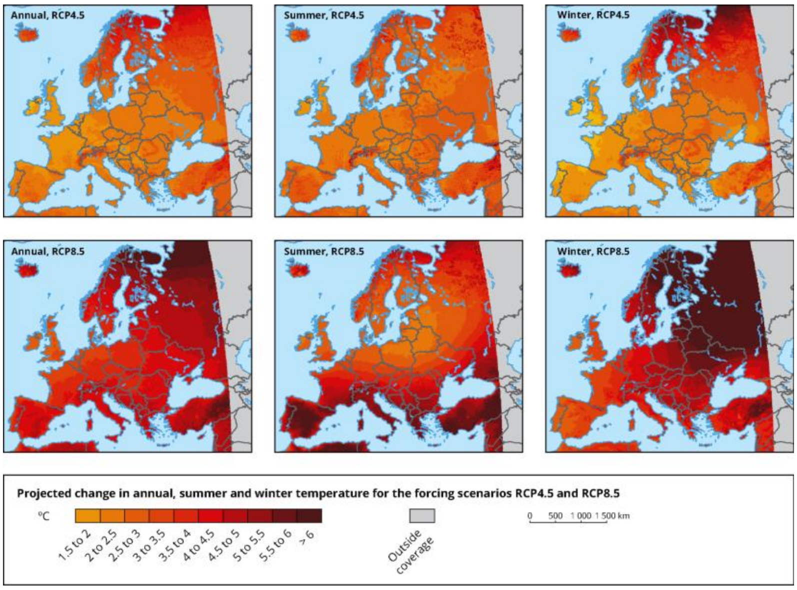


Fig. 40 Projections regarding the annual, summer, and winter temperature changes
(Source: https://www.eea.europa.eu/data-and-maps/figures/projected-change-în-annual-mean)

[78] Coupled Model Intercomparison Projects - CMIP – types of climate models

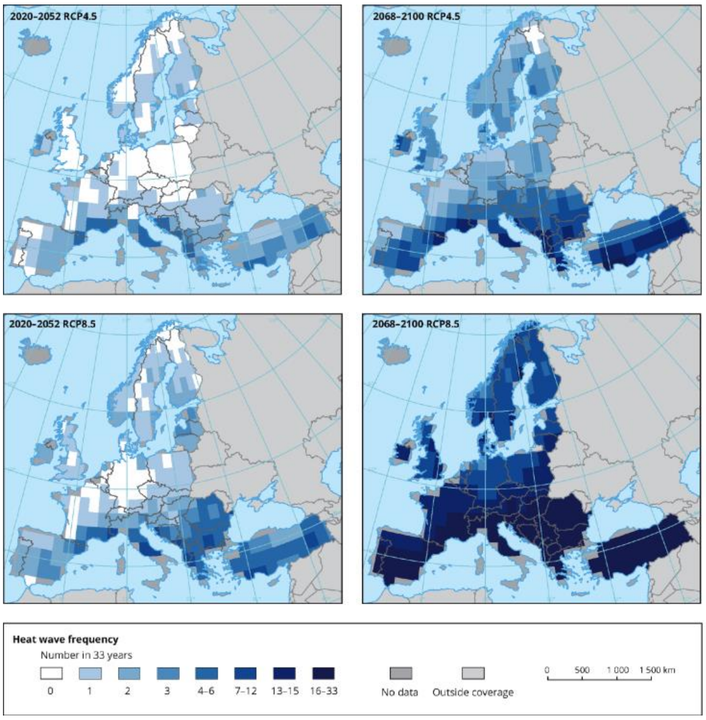


Fig. 41 The number of heatwaves in two climate scenarios
(Source: https://www.eea.europa.eu/data-and-maps/figures/projected-change-în-annual-mean)

3.6.1 Climate and Weather Conditions in the vicinity of the Cernavoda NPP

The Cernavodă Nuclear Power Plant site is located in a region bordered to the west by the Danube River and the Romanian Plain, and to the east by the Dobrogea Plateau. In the proximity of the site, to the south, lies the Danube-Black Sea Canal constructed along the Carasu Valley.

The area that includes the town of Cernavodă falls within the region with the most continental climate in Romania, despite being only 60 km away from the Black Sea, with the Danube River and the Danube-Black Sea Canal in close proximity. The degree of continentality is highlighted by large air temperature amplitudes, relatively low precipitation amounts, low relative humidity, and a long duration of sunshine.

The presence of the Danube River and the Danube-Black Sea Canal clearly influences the direction of the wind, favoring the channeling of air currents along these waterways, which is also reflected in the wind rose. Additionally, these bodies of water serve as sources of water vapor, which during the summer help attenuate temperature fluctuations, and during the cold season, promote an increase in the number of foggy days.

Although located approximately 60 km away, the Black Sea exerts a climatic influence primarily through the dispersion of cloud systems due to downward movements of air, resulting in high numbers of sunshine hours.

The more arid character of the area is also favored by the loess and fractured limestone substrate, causing the groundwater to be at considerable depths.

The region is characterized by a continental climate, which is manifested by:

- Large temperature amplitudes (approximately 68°C);
- High duration of sunshine (on average 2200 hours/year);
- Lower precipitation compared to the rest of the country (approximately 500 mm/year) - arid zone I.

During winter, there are periods of pronounced warming leading to snowmelting; thus, the multi-year average number of days with snow cover is 30.

Air circulation is channeled primarily along the Danube Valley in N-S directions, but significant frequencies also occur in E-W directions, representing circulation from the Romanian Plain. At higher altitudes, W-E directions are prevalent.

The proximity to the Danube also accounts for a high number of foggy days and a breeze phenomenon during the warm season.

The region is classified as semi-arid for vegetation. Plant associations are specific to the steppe, with poor soil.

At the Cernavodă Nuclear Power Plant site, a meteorological measurement program is conducted to acquire the necessary weather data for updating emergency response plans.

For the meteorological characterization of the site, studies by the National Institute of Meteorology and Hydrology [79], specifically conducted for the Cernavodă Nuclear Power Plant based on data provided at the Cernavodă weather station from 1986-1999, were used and updated with data from the ANM report.[80, 81]

Meteorological data from documents provided by Cernavoda NPP are presented, along with extreme meteorological phenomena and their statistical characterization based on measurements recorded at the Cernavodă, Medgidia, and Fetești weather stations, as well as climatic data retrieved from climate portals.

The extreme values of meteorological variables historically recorded by Cernavodă NPP are presented from the perspective of current climate variability for the mentioned weather stations; predictive estimates and evaluations of uncertainties resulting from modeling have been assessed for the evolution of meteorological data of interest in the area surrounding the Cernavoda NPP.

These analyses are based on the results of a set of 8 numerical experiments with regional climate models targeting the period 2018-2057, compared to the period 1971-2010.[82]

The data used come from the Automated Weather Station (AWS) at Cernavoda NPP, which includes a set of sensors (wind speed and direction, air temperature, precipitation), a data acquisition unit, a radio data transmission system, and two computers used as terminals (displays), one in the Main Control Room and the other in the Secondary Control Room. It is a modular construction whose configuration can be modified.

A set of weather sensors consisting of temperature, wind direction, and wind speed sensors is mounted at three levels—10 m, 30 m, and 80 m—on a meteorological tower with a height of 90 m. A precipitation sensor is mounted on the roof of the electronic equipment shelter of the meteorological tower, along with the radio transmitter and power supply.

The meteorological tower and the shelter are located approximately 1.4 km to the west of Unit 1, on a hill at an altitude of 43.8 mdMB.

[79] National Institute of Meteorology and Hydrology - Meteorological and dispersion study of pollutants in the area of Cernavodă NPP Unit 1-December 1987; December 1994; October 2000

[80] Assessment of maximum precipitation amounts in the Cernavodă area, Service subcontract.2/25.07.2011, ANM, August 2011; 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

[81] INFORMATIVE REPORT: IR-96200-057; 79-01320-RFS-DIDSR-CAP2/2022

[82] CERNAVODĂ NPP: 79-01320-RFS-DIDSR-CAP2/2022

3.6.2 Normal and Extreme Values of Meteorological Parameters

- **Wind (Horizontal Air Circulation):** is characterized by two parameters: wind frequency and wind speed in different directions.

The air circulation regime at ground level is influenced by the general circulation of atmospheric masses and local natural conditions. In the Cernavodă area, air mass movement occurs with minimal disruptions and deviations from the typical circulation regime, primarily due to the highly homogeneous natural conditions.

The following figures illustrate:

- The wind rose at the Cernavodă station based on hourly data recorded during 2001-2017
- The distribution of frequencies (in percentages) for daily average wind speed classes at Cernavodă for the same period (hourly data)
- The distribution of frequencies (in percentages) for wind gust speed classes.

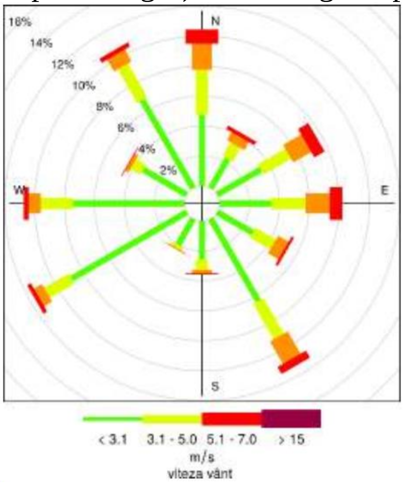


Fig. 42 Wind Rose at the Cernavodă Meteorological Station for the period 2001-2017 annual wind frequency by direction and speed thresholds (hourly data)

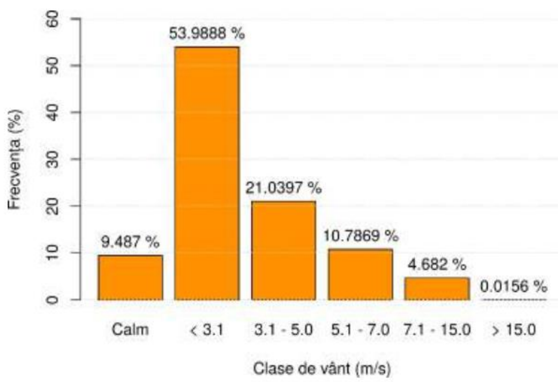


Fig. 43 Distribution of frequencies (in percentages) by daily average wind speed classes at Cernavodă for the period 2001-2017 (hourly data)

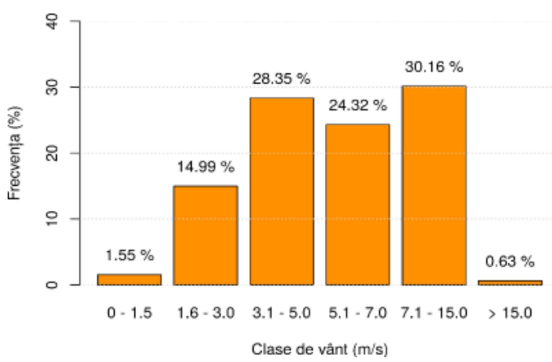


Fig. 44 Distribution of frequencies (in Percentages) by wind gust speed classes at Cernavodă for the period 2001-2017 (hourly data)

According to the wind rose from the Cernavodă meteorological station (Fig. 58), the highest frequencies are for winds from the W-SW, S-SE, and N-NW directions, ranging between 10-12%. Winds from the S-SW, W-NW, N-NE, and S directions have the lowest frequencies (< 5%). Winds with speeds exceeding 15 m/s occur more frequently from the N, E-NE, E, and S-SE directions. Winds with speeds between 5.1 and 7 m/s also have higher frequencies from these directions.

From the frequency distribution (in percentages) of daily average wind speed classes (Fig. 43), it can be observed that the highest percentage (53.989%) corresponds to speeds below 3.1 m/s. Speeds exceeding 15 m/s have a very small proportion of 0.0156%. Atmospheric calm accounts for 9.487% for the analyzed period.

From the frequency distribution (in percentages) of wind gust speed classes (Fig. 44), the highest percentage, 30.16%, belongs to the speed class ranging between 7.1 and 15 m/s.

The following table presents the hourly average wind speeds throughout a calendar year in the Cernavodă area.

Tab. 45 –Hourly average wind speeds in the Cernavodă area

Month	Jan.	Febr.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wind speed (km/h)	9.9	10.3	10.0	9.4	8.4	8.1	7.8	7.8	8.4	8.8	9.2	9.7
Wind speed (m/s)	2.75	2.86	2.78	2.61	2.33	2.25	2.17	2.17	2.33	2.44	2.56	2.69

The absolute maximum wind speeds recorded at the three weather stations are: 30 m/s at Cernavodă, 34 m/s at Fetești, and 34 m/s at Medgidia.

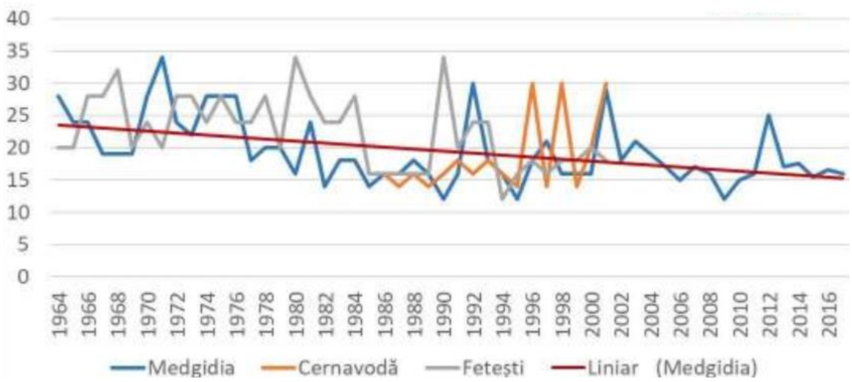


Fig. 45 The evolution of the annual maximum wind speed in the Cernavodă area

Strong winds can cause damage to the structures and components of NPP due to projectiles or objects carried by them.

The maximum duration of intense wind recorded at the Cernavodă station (for the period 2001-2014) was 700 minutes, on January 24, 2004.

The following table presents the maximum wind speed with different probabilities, namely return periods, with the lack of recordings at the Cernavodă station resulting in reduced relevance for return periods exceeding 50 years. [83]

[83] Nuclear Security Report for the Intermediate Solid Radioactive Waste Storage Facility at Cernavodă NPP - Chapter 2., Doc.79-01320-RFS-DIDSR-CAP2/2022

Tab. 46 Maximum wind speed with different probabilities and return periods in the Cernavodă area (with historical data covering the periods 1985-2017 and 1962-2017)

Probabilities (%)	20	10	5	2	1	0 .5
Return period (years)	5	10	20	50	100	200
Maximum speed (m/s) Cernavodă	20 .64	24 .64	29 .76	38 .92	48 .35	60 .69
Maximum speed (m/s) Medgidia	22 .84	26 .17	29 .63	34 .55	38 .5	42 .94
Maximum speed (m/s) Fetești	26 .88	29 .82	32 .39	35 .37	37 .38	39 .20

According to the application on the public portal RO-ADAPT (http://www.roadapt.ro/geoportal-harta-interactiva.php), the projections for changes in the average wind speed during the period 2025-2060 (with reference to 1971-2000) are small, below 0.5 m/s for both RCP4.5 and RCP8.5 scenarios. As for the wind gust speed, the change will be at most 1.2 m/s.

- ***Air temperature*** is the result of the interaction between circulation and radiation processes with the Earth's surface.

In Cernavodă, summers are warm and mostly clear, while winters are very cold, snowy, windy, and partly cloudy. Throughout the year, temperatures typically range from -4.4°C to 30.6°C, and rarely fall below -11.1°C or rise above 35°C.

(https://weatherspark.com/y/95547/Average-Weather-în-Cernavod%C4%83-Romania-Year-Round)

There is a slight variation in monthly and annual averages of air temperature year-on-year, following the same annual trend. The multi-year average of air temperature is around 11°C, higher than in the rest of the country.

January is the coldest month of the year, being the only one with a negative monthly average. The pronounced variations in monthly mean temperatures are characteristic of the transitional seasons of spring and autumn.

The warm season lasts for 3.5 months, from May 27 to September 12, with an average daily high temperature above 27°C. The hottest month of the year in Cernavodă is July, with an average high of 30.6°C and an average low of 16.7°C. The cold season lasts for 3.4 months, from November 24 to March 4, with an average daily high temperature below 8°C. The coldest month of the year in Cernavodă is January, with an average low of -3.89°C and an average high of 3.33°C). *(https://weatherspark.com/y/95547/Average-Weather-în-Cernavod%C4%83-Romania-Year-Round)*

Tab. 47 The average monthly temperatures in Cernavodă

Temperature	**Jan.**	**Febr.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Maximum	3.33	5.56	11.11	17.22	23.33	27.22	30.00	29.44	24.44	17.78	10.56	5.00
Average	-0.56	1.11	5.56	11.11	17.22	21.11	23.33	22.78	18.33	12.22	6.11	1.11
Minimum	-3.89	-2.78	1.11	5.56	11.11	15.00	16.67	16.11	12.22	6.67	1.67	-2.78

During the winter period, negative temperatures occur with a frequency of about 13%, with temperatures below -10°C having a frequency of 0.4%. Temperatures ranging from 12°C to 14°C have a frequency of about 7% and can be found throughout the year, except in January. Temperatures above 20°C, which occur all year round except during the winter months, have a frequency of 23.7%. During the warm season, the number of days with an average air temperature greater than 30°C is only 0.3, representing 0.1%. [84]

Historical data [85] for average surface air temperatures from 1991 to 2022 are presented in the figure below.

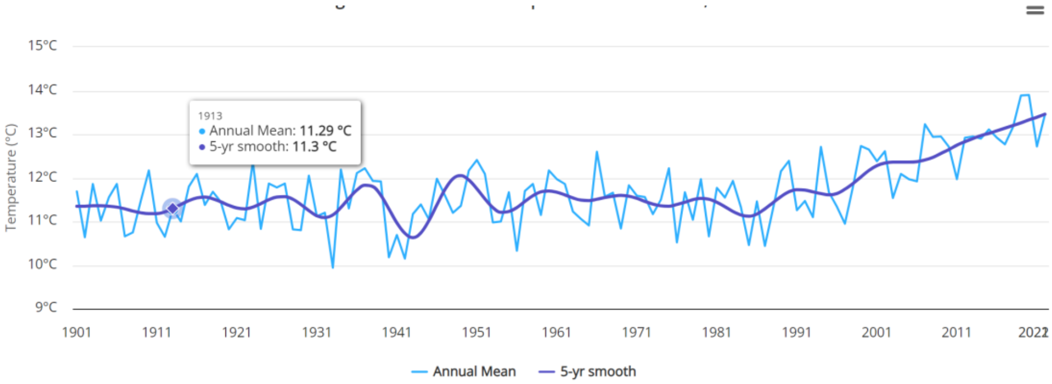


Fig. 46 – Observed annual average temperature for the period 1901-2020, Constanța, Romania

A rise in temperature trend has been observed since the 1990s.

The annual mean amplitude is the difference between the highest and lowest monthly average and indicates the degree of continentality of the thermal regime of a region. In Cernavodă, the annual mean amplitude is 23.2°C, with a small difference compared to the values recorded at the Fetești (23.8°C) and Medgidia (22.7°C) stations, where the moderating influence of the Black Sea is stronger). [86]

The following figures show the evolution of daily maximum and minimum temperatures recorded at the meteorological stations in the area, during the period 1945-2017.

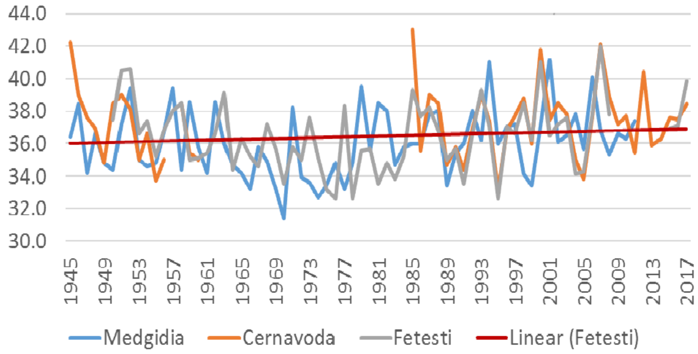


Fig. 47 Evolution of the annual daily maximum air temperature at three meteorological stations (1945-2017)

[84] Nuclear Security Report for the Intermediate Solid Radioactive Waste Storage Facility at Cernavodă NPP - Chapter 2., Doc.79-01320-RFS-DIDSR-CAP2/2022
[85] Romania - Climatology | Climate Change Knowledge Portal (worldbank.org)
[86] National Institute of Meteorology and Hydrology - Meteorological and dispersion study of pollutants in the area of Cernavodă NPP Unit 1

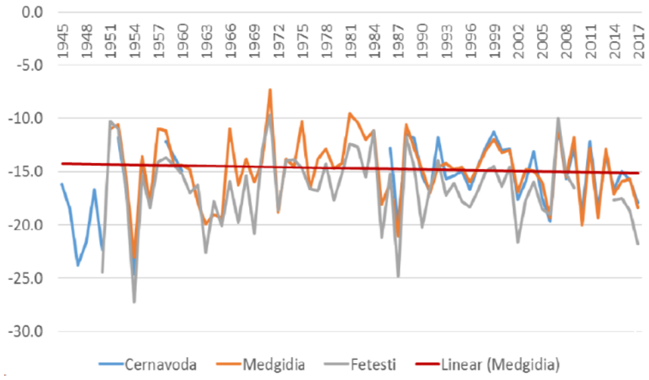


Fig. 48 Evolution of the annual daily minimum air temperature at three meteorological stations (1945-2017)

The absolute extremes of air temperature are the absolute maximums and minimums. The absolute amplitude, which represents the difference between the absolute maximum and the absolute minimum, is 66.8°C in Cernavodă.

The average diurnal amplitudes, which depend on the height of the sun and the length of the night, are greater in the warm season and smaller in the cold season. The average diurnal amplitude in Cernavodă is 10.0°C in July and 3.6°C in January.

Monthly and annual averages of daily extremes represent the averages of daily maximums and the averages of daily minimums. Meteorological studies have indicated the following:

- The monthly averages of daily maximums are positive throughout the year.
- The monthly averages of daily minimums are negative from December to February.
- The monthly averages of daily maximums and minimums are similar to those recorded at nearby meteorological stations, with differences being insignificant (< 1.5°C).[87]

The maximum and minimum temperatures and their probabilities of occurrence were evaluated according to the methodology "International Atomic Energy Agency-Phenomenes Meteoroloqiques Extremes et Choix de Sites de Centrales Nucleaires Collection Securite No. NS-G-3.4", by processing the series of values recorded at the Fetești and Medgidia stations from 1945 and 1946 to 1986, statistically extended to 2001, and updated with the data and information available as of 2018 from the ANM report.[88]

[87] Institute of Meteorology, Hydrology and Water Management - Update of the meteorological and pollutant dispersion study in the Cernavodă NPP area - October 2000
[88] Nuclear Security Report for the Intermediate Solid Radioactive Waste Storage Facility at Cernavodă NPP - Chapter 2, Doc.79-01320-RFS-DIDSR-CAP2/2022

Tab. 48 Extreme temperatures with various probabilities of occurrence (°C)

a. Absolute maximum air temperature with various probabilities of occurrence (^{0}C)								
Meteorological station	Return period (years)	1000	100	50	20	10	5	2
	Probability of occurrence (%)	0.1	1	2	5	10	20	50
Feteşti Medgidia	Theoretically evaluated values according to the distribution function(°C)	46.5 53.5	42.7 47.1	41.5 45.1	40.0 42.5	38.8 40.4	37.5 30.3	35.6 35.1
b. Absolute minimum air temperature with various probabilities of occurrence (^{0}C)								
Meteorological station	Return period (years)	1000	100	50	20	10	5	2
	Probability of occurrence (%)	0.1	1	2	5	10	20	50
Feteşti Medgidia	Theoretically evaluated values according to the distribution function(°C)	-35.1 -35.7	-28.2 -28.1	-26.1 -25.8	-23.3 -22.7	-21.1 -20.3	-18.4 -17.8	-15.4 -14.0

Running the application available on the RO-ADAPT public portal *(http://www.roadapt.ro/geoportal-harta-interactiva.php)* provided results indicating:

- change of up to +7°C in the average maximumtemperature for August during the period 2023-2100 (reference 1971-2000) – in the RCP4.5 scenario, and up to +9.9°C in the pessimistic RCP8.5 scenario.
- an increase of up to 7.9°C in the average minimum temperature for January during the period 2023-2100 (reference 1971-2000) – in the RCP4.5 scenario, and an increase of up to 9.2°C in the pessimistic RCP8.5 scenario.

- ***Liquid Precipitation***

The absolute maximum amount of precipitation fallen in 24 hours was 155.5 mm in Cernavodă (July 2017), 118.4 mm in Feteşti (July 1994), and 84.6 mm in Medgidia (August 1974).

The absolute maximum amount of precipitation fallen in one hour was 47.3 mm in Cernavodă (2010), 97.2 mm in Feteşti (1994), and 84.2 mm in Medgidia (1974).[89]

[89] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

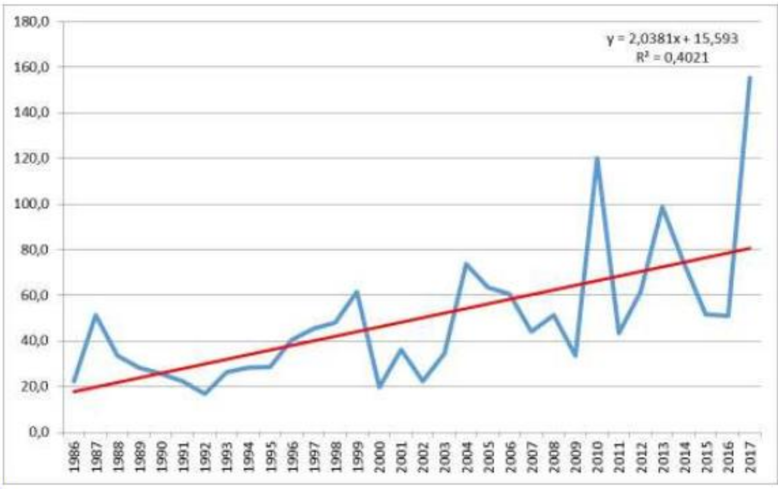


Fig. 49 The evolution of the maximum amount of precipitation in 24 hours, annual value, at the Cernavodă meteorological station (1986-2017)

To calculate the probabilities and return periods of precipitation amounts in 24 hours, the maximum observed value in a year of precipitation amount in 24 hours was calculated for the Cernavodă NPP area as the maximum value among the values recorded at the three stations, thus covering observed data for the period 1945-2017.[90]

The maximum amount of precipitation in 24 hours with different probabilities and return periods, respectively, in the Cernavodă area is presented in the following table.

Tab. 49 Maximum amount ofprecipitation in 24 hours with different probabilities and return periods respectively, in Cernavodă area

Probabilities (%)	20	10	5	2	1	0,5
Return periods (years)	5	10	20	50	100	200
Maximum amount of precipitation (mm)	67.82	82.46	99.35	126.66	152.21	183.1

The maximum amount of precipitation in 24 hours (annual value) at the Cernavodă station shows tendency of increasing during the period 1986-2017, highlighting the increase in precipitation intensity.

It was noticed that the maximum precipitation value recorded in 24 hours in Cernavodă of 155.5 mm corresponds to an anticipated value of about 152 mm for a return period of 100 years.

The projected changes regarding monthly precipitation in Cernavodă for the period 2080-2099 according to RCP8.5, compared with the reference period 1988-2005, are represented in Fig. 50. A decrease in monthly precipitation is recorded in the range of 0.5-12 mm (the 50th percentile value).[91]

[90] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

[91] RCP8.5-A scenario af comparatively high greenhouse gas emisiins. Climate change.Riahi, K, Rao, S, Krey, V, Cho, C, Chirkov, V, Fischer, Gm Kindermann, G, Nakicenovic, N, Rafaj, P, 2011

Fig. 50 Projected changes in monthly precipitation in Cernavodă for the period 2080-2099 according to RCP8.5[92]

Regarding extreme precipitation events, the projections for Cernavodă show minimal changes in the amount of rainfall during these extreme precipitation events, as presented in Fig. 51. The indicator shows how much of the total precipitation in a certain area comes primarily from extreme precipitation events, as opposed to evenly distributed events. The higher the number, the fewer extreme precipitation events. Therefore, the lower the number, the more evenly distributed the precipitation is, and the most significant rainfall events are not as exceptional overall. According to the figure, during the period 2080-2099, rainfall will be distributed approximately evenly in Cernavodă.[22]

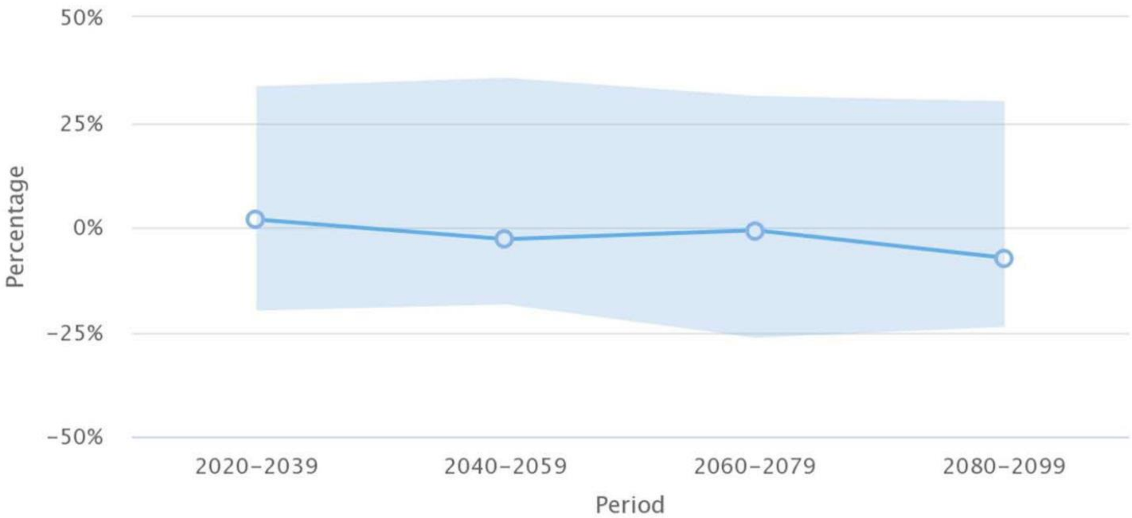


Fig. 51 Projected changes in precipitation on days with higher precipitation amounts in Cernavodă for the period 2088-2099 according to RCP8.5 (compared to the reference period 1986-2005)[23]

[92] https://climateknowledgeportal.worldbank.org/country/romania

- ***Solid Precipitation (Snow)***

When designing the structures of the Cernavodă NPP, the action of snow on the central structures was established for a reference weight value of the snow layer gz = 100 kgf/m^2, corresponding to a return period of 50 years set for zone D, where the locality of Cernavodă is classified according to STAS 10101/21-1978 and in accordance with STAS 10101/21-1992.

The absolute maximum thickness of the snow layer (cm) was 90 cm in Cernavodă (February-March 1954), 96 cm in Feteşti (January 1966), and 11 cm in Medgidia (November 1981).

Based on available observation data, the maximum thickness of the snow layer was calculated with a probability of 0.5%, which for the area of interest is 159.58 cm. For calculating the probabilities and return periods of the snow layer thickness, the maximum observed value in a year was calculated for the area covering Cernavodă, as the maximum value among the values recorded at the three stations in the NPP area, thus covering the observed data for the period 1945-2017.[93]

Tab. 50 The maximum thickness of the snow layer (in cm) with different probabilities and return periods respectively, in the Cernavodă area (with historical data covering the period 1945-2017, from the meteorological stations Cernavodă, Feteşti, Medgidia)

Probabilities (%)	20	10	5	2	1	0,5
Return periods (years)	5	10	20	50	100	200
Maximum thickness of snow (cm)	33.65	46.66	62.92	91.70	121.14	159.58

It is noticed that the recorded value in 1954 in Cernavodă corresponds to an anticipated value of approximately 91.70 cm for a return period of 50 years.

3.6.3 Extreme Meteorological Phenomena

- ***Drought***

Drought is a meteorological phenomenon primarily characterized by a pronounced lack of precipitation. The causes that can lead to drought are of various natures: atmospheric, hydrological, pedological, etc.

There is a tendency of desertification in the Danube basin; according to the Hellman criterion based on recorded data, it results that the highest average annual number of days without precipitation during dry intervals in southern Dobrogea exceeds even 135 days; the studied region, due to the duration and intensity of droughts, is part of zone I-a of aridity - the area with the most severe drought in the country. The Palmer Drought Severity Index calculated for the Danube basin suggests a tendency towards desertification throughout the Danube basin for the summer months (June, July, August), year-on-year, under current climate conditions (period 1900-2015), with the tendency towards aridization being stronger and more significant in the central Danube basin.

[93] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

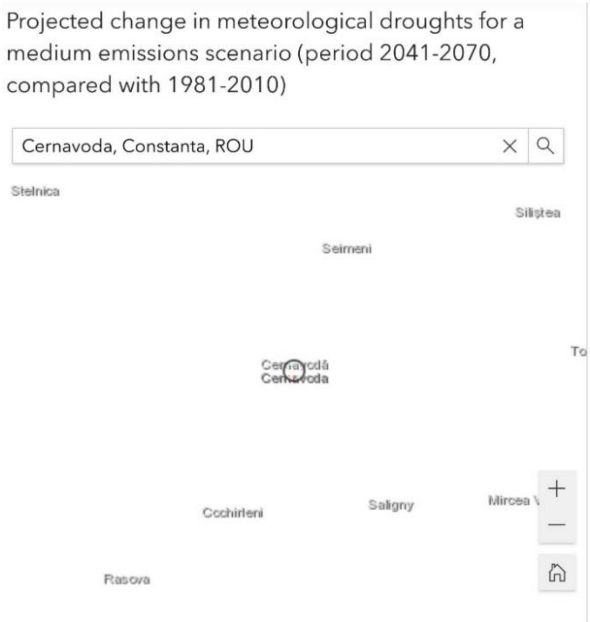
The highest average annual number of days without precipitation during dry intervals in the area was approximately 135 days in Cernavodă and Medgidia, and 120 days in Fetești.

The maximum annual number of drought days with various probabilities of occurrence is given in the following table.

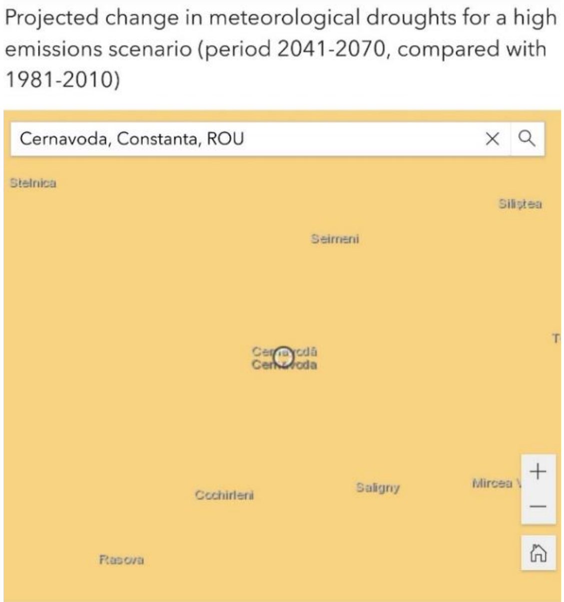
Tab. 51 Maximum number of drought days with various probabilities of occurrence

Meteo station	Cold season					Warm season				
	ASSURANCE (%)					ASSURANCE (%)				
Cernavodă	64	57	49	32	-	72	64	53	44	-
Medgidia	100	86	78	54	-	80	71	58	49	-
Fetești	58	52	44	38	-	86	76	63	53	-

Projected changes in the frequency of meteorological droughts for two emission scenarios are presented in the figure below.



The projected change in meteorological droughts for a scenario with moderate emissions (period 2041-2070, compared to 1981-2010)



The projected change in meteorological droughts for a scenario with high emissions (period 2041-2070, compared to 1981-2010)

The projected change in meteorological droughts for a scenario with moderate emissions (period 2041-2070, compared to 1981-2010))

-1.5 to -1

-1 to -0.5

-0.5 to 0.5

0.5 to 1

1 to 1.5

1.5 to 2

2 to 2.5

> 2.5

Fig. 52 Drought - Projected changes in the frequency of meteorological droughts for two emission scenarios[94]

[94] https://discomap.eea.europa.eu/climate/

- ***Blizzard***

Blizzard is a hazard resulting from the combination of snowfall with snow transport due to wind. The maximum number of days with blizzards is 6 at the Cernavodă station, 9 at the Medgidia station, and 6 at the Fetești station.

The definition of the blizzard phenomenon includes two aspects: on one hand, it involves the ground-level snow transport (below 1.80 m), and on the other hand, it involves snow transport at altitude or actual blizzard (above 1.80 m).[25]

The monthly and annual average number of days with blizzards is presented in Tab. 52, while Tab. 53 presents the absolute maximum number of days with blizzards, both monthly and annually.

Tab. 52 The monthly and annual average number of days with blizzards (1961 – 2017)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Cernavodă	0.8	0.3	0.1								0.1	0.4	1.7
Feteşti	1.2	1.0	0.4	0.0							0.2	0.6	3.4
Medgidia	0.4	0.0	0.2								0.1	0.2	0.9

Tab. 53 The absolute maximum number of days with blizzards, both monthly and annually (1961-2017)

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Cernavodă	Number of days	3	2	3								1	4	6
	Year of occurence	2000 2004 2005	1996 2010	1993								1993 2001	1996	1996
Feteşti	Number of days	9	5	4	1							3	4	9
	Year of occurence	1966	1967 1969	1993	2003							1981	1961	1966
Medgidia	Number of days	5	1	2								2	5	6
	Year of occurence	1966	1996 2015	1962 1987 1993								1975	1961	1962

- ***Hail***

Analyses of the frequency of hail episodes and hailstone diameter have highlighted that in the southeastern region of Romania, both variables generally remain below the values of other regions in the country (Tab. 54).

Tab. 54 Absolute maximum number of days with hail, both monthly and annually

Station	Indicator	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual**
Cernavodă	Number of days		1	2	1	1	2	1		1	1	1		2
	Year of occurence		1948	1995	1992	1953 1954 1987 2001 2004	1949	1958 1991 1993 2009 2012		1952 1996	1989	1947		1947 1992 1995 1996 2009
Feteşti	Number of days	1	1	1	1	3	1	1	2	1	1			6
	Year of occurence	1971	1988	1958 1970	1951 1970 1972 1973 1974 1989; 1998 2001 2007	1987	1956 1975 1977 1980 1982 1985 1989 1994	1954 1963 1968 1975 1976 1978 1979 1994 1997 2002	1975	1952 1988	1975			1975
Medgidia	Number of days				1	2	1	2	1	1	1	1	1	5
	Year of occurence				1966 1974 1983 1989 1993 1995 2008	2008	1969 1975 1977 1983 1987 1988 1989 1991 1992 2002 2013 2015	1976 1993 2002 2010 2011	1971 1974 1980 1982 1993 2003	2005	1993	2010	1980	1993

Source: ANM (National Metereology Administration) – Meteorological study on the Cernavodă NPP site, 2019

The average duration of a hail episode, calculated from available data for the period 2001-2017 at the Cernavodă station, is 14 minutes, with a maximum value of 60 minutes and a minimum of 2 minutes.

The maximum diameter value of hailstones, recorded during the operational period, is 20 mm at the Cernavodă station, 24 mm at the Medgidia station, and 24 mm at the Fetești station.

The maximum speed value of hailstones, recorded during the operation period, is 15.7 m/s at the Cernavodă station, 18.1 m/s at the Medgidia station, and 15.7 m/s at the Fetești station.[95] The average speed value of hailstones, recorded during the operation period, is 6.8 m/s at the Cernavodă

[95] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

station, 8.1 m/s at the Medgidia station, and 7.4 m/s at the Fetești station. The hailstone speed was calculated based on its diameter.[96]

The potential damages that can be caused by a hailstorm are generally proportional to the size of the hailstone. Additionally, the hardness of the hailstone, its shape, and orientation during its fall trajectory are also taken into consideration. The latter is influenced by the speed and direction of the wind during the event.

When hail falls in open fields and damages cannot be measured, the intensity of the phenomenon is linked to the size of the hailstones rather than the damages they could have caused. However, when damages are not obvious, the lowest category is assigned. The same criterion is used when damages cannot be quantified; for example, a hailstorm with hailstones the size of a chicken egg may cause damages falling within the category H6-H8. If damages cannot be quantified, the hailstorm is classified into the nearest lower category (H5) according to the grading in the following table.

Tab. 55 The international TORRO scale regarding hail intensity [97]

	Intensity	**Diameter (mm)[1)]**	**Damages**
H0	Hard Hail	5÷9	No noticeable damages
H1	Potential Damage	10÷15	Slight general damage to plants, crops
H2	Significant	16÷20	Significant damage to fruits, crops, vegetation
H3	Severe	21÷30	Severe damage to fruits and crops, damage to glass and plastic structures, paint and wood scored
H4		31÷40	Significant damage to glass structures, damage to cars
H5	Destructive	41÷50	Destruction of glass structures, damage to tiled roofs, significant risk of injury
H6		51÷60	Damage to brick walls
H7	Very destructive	61÷75	Severe damage to roofs, significant risk of significant injuries
H8		76÷90	Severe damage to aircraft structures
H9	Superstorms	91÷100	Severe damage to infrastructure, significant risk of severe or fatal injuries to persons in open fields
H10		> 110	Severe damage to infrastructure, significant risk of severe or fatal injuries to persons in open fields

Note: Approximate range of values; other factors, difficult to directly quantify from hail measurements conducted in Romania (e.g., hailstones per unit area, wind speed), may also affect severity.

According to the Walter-Lieth type climodiagram [98] represented in Fig. 53, the dry period occurs from mid-June to September (yellow zone), while the blue areas indicate the wet periods.

[96] Pruppacher, H.R. și Klett, J.D. – Microphysics of Cloud and Precipitation. 2nd edition, 1997
[97] Webb, J.D.C., Elsom, D.M., & Meaden, G.T – Sever hailstorms în Britain and Ireland, a climatological survey and hazard assessment. Atmospheric Research, 2009
[98] https://climatecharts.net/

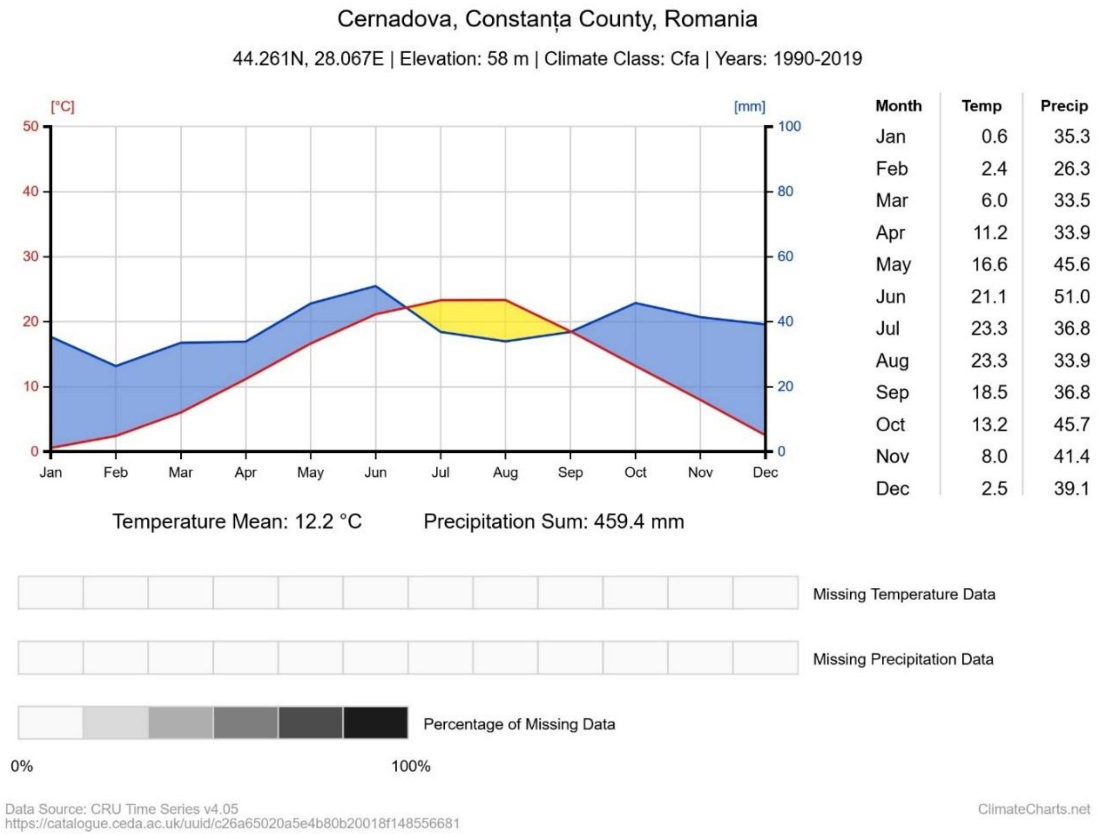


Fig. 53 Walter-Lieth type climodiagram for 1990-2019 (multiannual monthly averages)

- ***Lightning***

The frequency of this phenomenon is expressed through the average annual and monthly number of days with thunderstorms and the absolute maximum number of days with thunderstorms on a monthly and annual basis. These are specific to the warm season of the year. The highest average monthly number of days with thunderstorms is recorded in June. It is 5.6 in Cernavodă, 7.8 in Fetești, and 7.9 in Medgidia.[99] The average annual number is 21.8 days in Cernavodă, 29.5 days in Fetești, and 30.6 days in Medgidia.[100] The frequencies of this phenomenon are expressed by the average/absolute maximum number of days with thunderstorms on a monthly and annual basis (Tab. 56/Tab. 57).

Tab. 56 The average monthly and annual number of days with thunderstorms (1961 - 2017)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	ANNUAL
Cernavodă	0.1	0.1	0.3	1.5	3.8	5.6	5.2	2.6	1.6	0.4	0.0	0.0	21.8
Fetești	0.1	0.1	0.2	1.9	5.2	7.8	6.8	4.8	2.1	0.4	0.1	0.1	29.5
Medgidia	0.1	0.1	0.3	1.7	5.5	7.9	7.3	4.5	2.1	0.7	0.4	0.1	30.6

[99] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018
[100] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

Tab. 57 The absolute maximum number of days with thunderstorms, both monthly and annually

Station		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	ANNUAL
Cernavodă	Number of days	1	2	4	5	8	12	11	9	8	3	1	10	35
	Year of occurence	2000 2007 2010 2014	2009	2006	2005	2008	1953 1997 1998	1997 2010	2004	1996	2005	1952	1954	1954
Fetești	Number of days	2	2	4	7	14	14	15	13	10	2	1	1	54
	Year of occurence	1971	1985	1979	2006	1975	1979 1997	1983	2002	1968	1955 1960 1964 1973 1982 1998 2005 2007	1957 1980 1981 1997	1980 1995 1997	1979
Medgidia	Number of days	2	2	4	6	14	3	7	3	7	5	4	1	51
	Year of occurence	1953 2001	1973	2006	1995	2010	1982 1989 1997	2010	1975	1996	1960	2010	1973 1980 1990 1997	2010

- ***Tornadoes***

Tornadoes are phenomena characteristic of spatial scales (a few kilometers) and temporal scales (minutes to tens of minutes) that are difficult to observe in a classic meteorological network.

The spatial distribution of tornadoes in Romania (Fig. 54) shows that they are more frequent in the eastern part of the country, with a maximum located in the southeastern area of approximately 2 tornadoes per 105 km^2 in 5 years. The Cernavodă NPP site falls within the range of approximately 1.5-2.25 tornadoes per 105 km^2/5 years. Tornado occurrences are more frequent during the months of April to September, with the majority occurring in the months of May to July, between 09:00–21:00, peaking between 15:00-17:00. Such phenomena were recorded in Făcăieni – Ialomița in August 2002 (F3 on the Fujita scale), in Ciobanu (near Medgidia) in May 2005, and in the locality of Dragalina – Călărași in April 2019.[101]

Until now, tornadoes have been recorded in the area of interest, but classifying their maximum intensities on the Fujita scale (Tab. 58) is very difficult.

Most observations, upon which studies have been based so far, have been made by observers who happened to be at the scene during tornado occurrences.[102]

Both the very strong winds and the projectiles carried by them during tornadoes could damage the structures and components of the Cernavodă NPP.[103]

[101] Antonescu, B, & Bell, A, Torbadoes în Romania. Monrhley Wether Review, 143(3), 689-701, 2015

[102] 79/82-01551-AR-022 Services for the analysis of historical recorded data and forecasts necessary for the systematic characterization of external hazards of natural origin applicable to the Cernavodă NPP site - Meteorology, ANM, November 2018

[103] Cernavodă NPP, Security Report, 2019 - Chapter 2 "Site Characteristics", rev. RFS Cernavodă U2, 2020

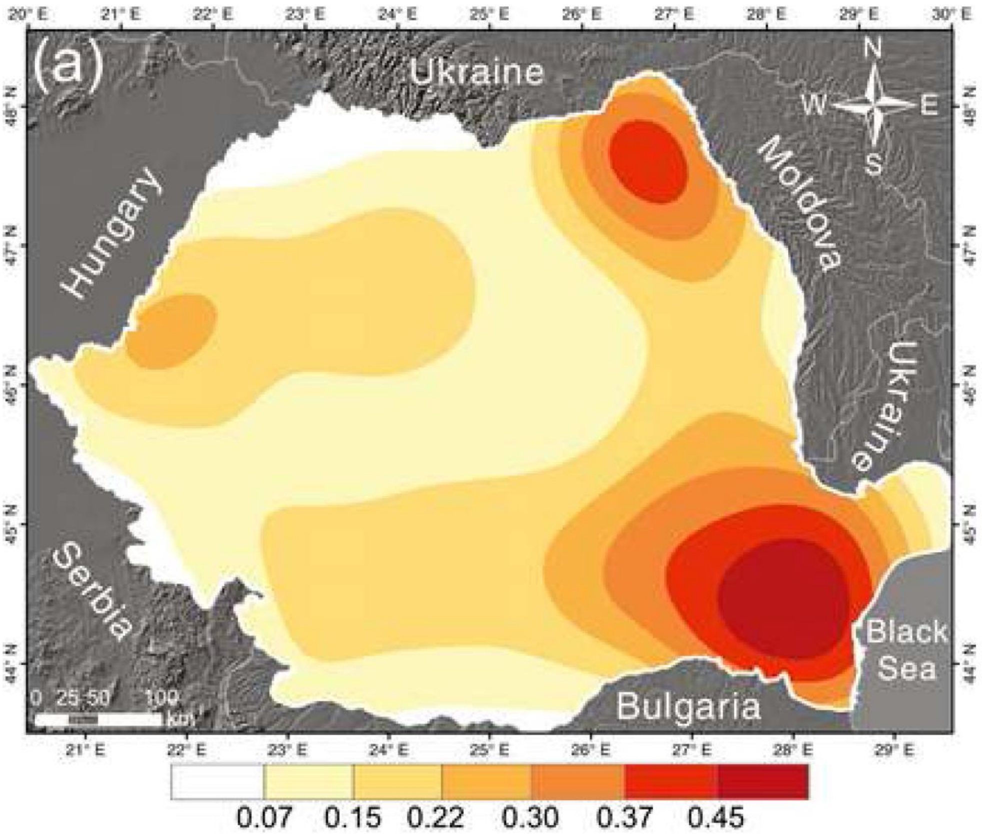


Fig. 54 Spatial distribution of tornadoes in Romania *(B. Antonescu and A. Bell, 2015)*

Tab. 58 The Fujita scale of tornado intensity and their associated effects in Europe

Fujita Scale	Wind speed (km/h)	Effects on medium houses (made of brick) in Europe
F0	64÷116	almost no damage
F1	117÷180	minor and medium damage to the roof
F2	181÷253	significant damage to the roof/roof torn off the house
F3	254÷332	roof torn off/walls collapsed
F4	333÷418	almost all walls collapsed
F5	419÷512	house destroyed

- ***Other Weather Phenomena***

Dust Transport - This phenomenon consists of the lifting of dust and sand from the earth's surface into the atmosphere under the action of the wind. The dust and sand remain suspended for a duration of time that depends on the size of the dust or sand particles and the wind speed. In the area of the site, the frequency of this phenomenon is very low. In Fetești and Medgidia, there were recorded 1.5 days per year with such phenomena.

Fog is a relatively frequent phenomenon in the areas bordering the Danube River. In Cernavodă, the average annual number of foggy days is around 47, with a maximum of 87. During the year, fog is most frequent in the cold season. *(Tab. 59, position a).*

Rime is a weather phenomenon specific to winter days. In Cernavodă, the average annual number of days with rime is 5.9, with a maximum of 17. During the year, rime is most frequent in December and January *(Tab. 59, position b).*

Glaze Ice is also frequent in winter. In Cernavodă, the average annual number of days with glaze ice is 5.5, with an annual maximum of 14 days *(Tab. 59, position c).*

Tab. 59 Weather Phenomena in Cernavoda

Cernavodă meteo station	MONTHS												ANNUAL
	I	II	III	IV	V	VI	VII	VII	IX	X	XI	XII	
a) number of foggy days													
medium	9,2	4,9	2,6	2,9	2,4	0,8	0,7	1,4	2,1	4,4	6,9	9,1	47,4
Maximum	18	9	8	7	7	1	2	4	7	10	14	14	87
b) number of days with rime													
medium	2,5	0,8	0,1	-	-	-	-	-	-	-	0,3	2,2	5,9
Maximum	13	2	1	-	-	-	-	-	-	-	2	7	17
c) number of days with glaze ice													
medium	2,1	0,1	0,3	-	-	-	-	-	-	-	0,9	2,1	5,5
Maximum	14	2	2	-	-	-	-	-	-	-	8	9	14
d) number of days with blizzard													
medium	0,4	0,6	0,6	-	-	-	-	-	-	-	0,1	0,7	2,2
Maximum	2	4	4	-	-	-	-	-	-	-	1	3	9
e) number of days with hail													
medium	-	-	0,1	0,1	0,1	0,4	0,1	-	-	-	0,1	-	0,9
Maximum	-	-	2	1	1	1	1	-	-	-	1	-	2

The analysis of project vulnerability to climate change is presented in Chapter 5. *Description of the significant environmental effects of the project.*

3.7 Material Assets

The Cernavodă Nuclear Power Plant is located in Constanţa County, approximately 2 km southeast of the town of Cernavodă, about 1.5 km northeast of the first race of the Danube-Black Sea navigable canal, ***on the site area resulted from the excavations of the former Ilie Barza limestone quarry, at 44°20' north latitude and 28°01' east longitude***. The NPP site is bordered to the northeast by the Valea Cişmelei and to the southwest by DJ 223.

The location of the Cernavodă NPP complies with the provisions of Authorization No. I/665 from September 30, 1978, issued by the State Committee for Nuclear Energy for the siting of the facility.

The lands associated with the Cernavodă NPP site are used only with the approval of the National Commission for the Control of Nuclear Activities (CNCAN) and Cernavodă NPP, as they are located in the exclusion zone defined in accordance with "NSR-01 Fundamental Radiological Safety Standards". ***Within the Cernavodă Nuclear Power Plant site, only constructions related to the operation of the nuclear power plant are allowed.***

Cernavoda NPP is not registered as having patrimonial, architectural, or landscape value.

Within the perimeter of the two sub-projects, there are no buried patrimonial assets that are included on the list of historical monuments or in the National Archaeological Record.

In the proximity of Cernavodă NPP, there are no cultural heritage assets of national importance in the National Archaeological Record (RAN) of the National Heritage Institute of Romania. The closest archaeological sites of registered value are the Roman settlement at Ștefan cel Mare - Dealul Bodgaproste (RAN Code 62342.02) - located about 0.8 km south of Cernavoda NPP, and the archaeological site at Cernavodă (RAN No. 60785.26) - located about 1.5 km west.

In accordance with the legal provisions in force, for the realization of the works aimed at the two sub-projects, namely the Refurbishing of Unit 1 of Cernavodă NPP (RT-U1) and the Extension of DICA with MACSTOR 400 modules (DICA-MACSTOR 400), **no materials or natural resources will be exploited from within or from the immediate vicinity of the natural areas included in the European ecological network Natura 2000.**

Provision of materials for both sub-projects will be carried out gradually, in construction phases, so that they are implemented and the long-term storage of materials on the Cernavodă NPP site to be avoided.

The refurbishing activities for the Subproject Refurbishing of Unit 1 of Cernavodă NPP (RT-U1) consist of replacement, repair, and modernization works and ***will be carried out inside Unit 1***.

Regarding the allocation of the land for the purpose of extending the current area of the DICA repository, **the land allows for this extension since the nature of the foundation rock in the extended area is part of the same good foundation zone**. According to the geological study issued by GEOTEC in 2000, the presence of Barremian limestone as a rocky base represented the premise for choosing this location at its western extremity, in front of reactor 5, where the base rock is found at a depth of 2 – 6 meters, sufficiently high to allow the making of foundation under good technical-economic conditions.

The resources used for the implementation of the project are presented in subchapter *1.6.6 Natural resources, raw materials, and energy required for the realization of the project*.

It is anticipated that there will be no negative effects on material assets through the realization of the works for the two sub-projects RT-U1 and the Extension of DICA Macstor 400.

3.8 The Landscape

The Cernavodă NPP is located in a transition zone from floodplain to low-altitude plateau, dominated by agricultural land, with natural areas and anthropized zones representing a modest percentage. During the operation of the nuclear units, no changes have been recorded regarding the landscape in the area.

In the project site area, the landscape and visual environment are characteristic of industrial sites, with the presence of dispersal stacks, production halls, and social headquarters of Cernavodă NPP (office buildings, workshops, and laboratories with ground and first floors), etc.

3.9 Radiological aspects

3.9.1 The evolution of the performance indicators of Units U1 and U2 of Cernavoda NPP, during 1997÷2022

Unit 1 at Cernavoda NPP reached its first criticality on April 16, 1996 and declared its commercial operation on December 2, 1996. During 1997 – 2022, Unit 1 operated with an average capacity factor of 90.38%, the annual net production of electricity being 4606578÷5661651 MWh.[104]

Unit 2 reached the first criticality on May 6, 2007 and declared its commercial operation on November 1, 2007. During 2007 – 2022, Unit 2 operated with an average capacity factor of 94.2%, the annual net production of electricity being 4950649÷5622376 MWh. [104]

The evolution of the performance indicators of units U1 and U2 of Cernavoda NPP, during 1997 - 2022, is presented in Tab. 60.

Tab. 60 The evolution of the performance indicators of units U1 and U2 of Cernavoda NPP [105]

Year	U1			U2		
	Net power production (MWh)	**Capacity factor (%)**	**Number of operating hours**	**Net power production (MWh)**	**Capacity factor (%)**	**Number of operating hours**
1997	4968837	87.27	7753	–	–	–
1998	4918951	86.19	7585	–	–	–
1999	4813027	84.51	7390	–	–	–
2000	5053354	88.29	7792	–	–	–
2001	5049871	88.25	7719	–	–	–
2002	5106225	89.37	7854	–	–	–
2003	4905663	79.51	7026	–	–	–
2004	5142305	89.71	7892	–	–	–
2005	5114677	90.08	7904	–	–	–
2006	5177957	91.37	8201	–	–	–
2007	5518346	97.6	8539	887239.5	93.23	1363
2008	4805476	84.83	7414	5528108	96.92	8669
2009	5661651	100.1	8710	5158248	90.6	8067
2010	5167231	91.53	7982	5537520	97.24	8551
2011	5633142	99.67	8694	5177835	91.07	8052
2012	4948204	87.16	7652	5615317	98.47	8702
2013	5622015	99.4	8681	5073743	89.15	7906
2014	5164376	91.14	8033	5589304	98.5	8689
2015	5504930	96.92	8613	5204743	92.23	8179
2016	4765824	83.78	7490	5622376	99.09	8784
2017	5485440	97.14	8637	5094710	89.72	7963
2018	4928499	87.31	7919	5530839	97.43	8658
2019	5292668	93.86	8600	5075542	89.18	7909
2020	4963253	87.29	7665	5611815	98.32	8737
2021	5450512	96.19	8588	4950649	87.02	7742
2022	4606578	81.42	-	5615458	98.60	-

[104] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2021, Doc. IR-96200-056 Rev. 0

[105] Cernavoda NPP, Environmental Progress Report, 2022

Fig. 55 graphically presents the amounts of electricity supplied to the national grid by the two units from Cernavoda NPP, in the time frame starting from their commissioning until present.

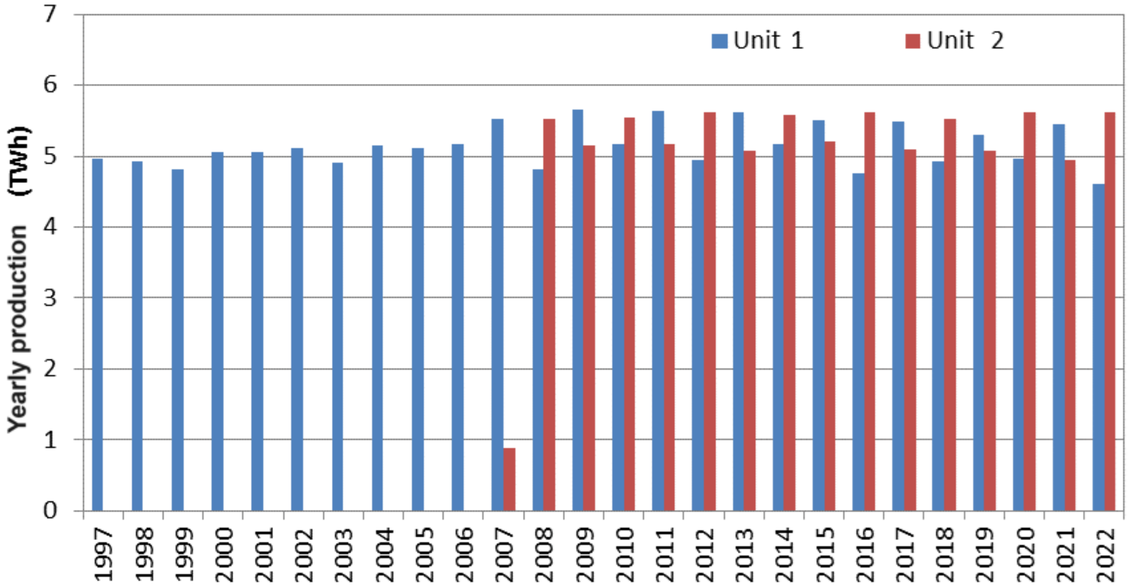


Fig. 55 The evolution of net power production at the U1 and U2 units of Cernavodă NPP

Fig. 56 shows graphically the values of the capacity factors for the two units at Cernavoda NPP, recorded throughout their operating period.

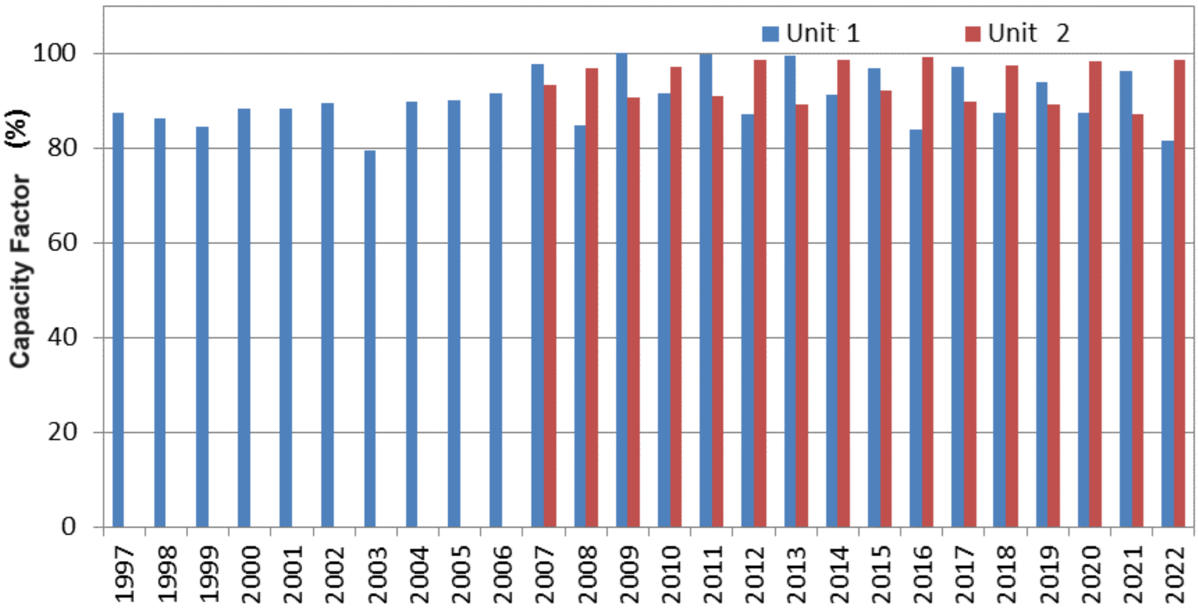


Fig. 56 The evolution of the capacity factors at units U1 and U2 of Cernavoda NPP

The values of productions and capacity factors are correlated with the operating performance of the NPP units, taking into account planned or unplanned NPP shutdown periods.

The current state of the environment in the area of influence of Cernavoda NPP includes the contribution of the two nuclear units in operation and their support facilities.

3.9.2 Results of radioactive effluents monitoring

The control of radioactive emissions, the monitoring of environmental radioactivity and the management of radioactive waste is carried out by the Radioprotection Department through the Radioprotection Technical Service, which develops the appropriate programs, monitors compliance with their provisions and reports emission values and monitoring results.

The following tables and figures show the results of monitoring gaseous and liquid radioactive effluents generated by the operation of Cernavoda NPP Unit 1, in relation to the derived emission limits and to the results provided by Unit 2 – similar to Unit 1 but entered into operation 11 years after U1.

3.9.2.1 Results of the gaseous radioactive effluents monitoring

Derived emission limits in force for gaseous effluents

Based on the dose constraints established by CNCAN for each of the nuclear installations at the Cernavoda NPP site, Derived Emission Limits (DEL) were calculated by the plant operator, which were approved by the regulatory body.

The following table shows annual DELs approved by CNCAN for the radioactive gaseous effluents resulting from each of the two nuclear units in operation at Cernavoda NPP.

Tab. 61 Derived annual emission limits for radioactive gaseous effluents applicable for each of the two nuclear units in operation at Cernavoda NPP [106]

Radionuclide	DEL (GBq/an)	Radionuclide	DEL (GBq/an)
H-3	3.96E+06	Sb-125	4.29E-01
C-14	5.28E+03	Te-132	4.78E-01
I-131	8.14E-03	Cs-134	3.16E-02
I-132	5.35E+02	Cs-137	1.47E-02
I-133	1.24E+01	Ba-140	2.89E-01
I-134	2.57E+03	Ce-141	7.93E-01
I-135	1.60E+02	Ce-144	7.36E-02
Cr-51	1.78E+01	Eu-152	7.34E-02
Mn-54	7.27E-01	Gd-153	1.69E+00
Fe-59	1.48E-01	Eu-154	9.03E-02
Co-58	6.08E-01	Hf-181	1.84E-01
Co-60	6.90E-02	Ar-41	1.08E+04
Zn-65	7.14E-02	Kr-85	4.63E+04
Sr-89	1.45E-01	Kr-85m	8.72E+04
Sr-90+	1.43E-02	Kr-87	1.59E+04
Zr-95+	6.54E-01	Kr-88	4.64E+03
Nb-95	4.99E-01	Xe-131m	1.66E+06
Mo-99	4.55E+00	Xe-133	4.06E+05

[106] Cernavoda NPP, *Derived release limits for Cernavoda NPP*, Doc. IR-96002-027, rev 1 & 79/82-00580-DBA-0008 rev.0/2023

Ru-103	8.70E-01	Xe-133m	4.79E+05
Ru-106+	5.80E-02	Xe-135	5.70E+04
Ag-110m	2.12E-01	Xe-135m	3.32E+04
Sb-122	1.52E+00	Xe-138	3.75E+03
Sb-124	2.25E-01		

In order to optimize the control of radioactive discharges and to guarantee their level as low as possible and balanced during the year, the follow-up of discharges is done at smaller time intervals, for which intermediate objectives regarding emissions are established - respectively quarterly derived limits, monthly and weekly:

- Quarterly DELs: 35% of annual DELs
- Monthly DELs: 15% of annual DELs
- Weekly DELs: 6% of annual DELs.

Results of the Gaseous Effluent Monitoring Program for Units 1 and 2

The types of analyzes performed for the gaseous effluents emitted from each of the units in operation at Cernavoda NPP are presented in Tab. 62.

Tab. 62 Analyzes of gaseous effluents

Sample type	**Analysis**	**Frequency**	**M.U.**
Particle filter	γ, β global	daily	Bq/m^3
Activated charcoal filter	Iodine - gamma spectrometry	daily	Bq/m^3
Water vapor collectors	Tritium – LSC	daily	Bq/l
CO_2 Bubbler	C-14 – LSC	daily	Bq/l
In-stream detection	Noble gases – Counter with scintillation detector and GM detector	daily	BqMeV/zi

To ensure optimal control, gas emissions are normally reported at weekly intervals. To determine the total radioactivity discharge of the plant, the discharges as %DEL for all radionuclides during the reporting period are summed.

The Official Weekly Gaseous Effluent Discharge Report contains the % DEL discharged for the previous week and the % DEL per year cumulative up to the end of the previous week.

The quarterly report includes information on the amount of daily releases, the fourth quarterly report being the annual report.

Next, the results of the "Gaseous effluent monitoring program for Units 1 and 2", regarding the values of radioactive gaseous effluent emissions in the period 1996 ÷ 2022, are presented.

Tab. 63 Annual emissions of radioactive gaseous effluents from Unit 1 during 1996 ÷ 2022 and annual DEL values (valid for each nuclear unit separately)[107]

Radionuclides \ Year	H-3 (oxide) [kBq]	C-14 (gas) [kBq]	Noble gases [kBqMeV]	I-131 [kBq]	I-133 [kBq]
1996	1.37E+09	5.76E+07	6.03E+10	0	
1997	2.55E+10	1.77E+08	6.17E+10	7.06E+03	
1998	5.08E+10	2.90E+08	1.75E+10	7.55E+02	
1999	8.53E+10	1.70E+08	2.13E+10	0	
2000	2.08E+11	2.32E+08	6.95E+09	0	
2001	1.80E+11	1.64E+08	2.72E+10	1.42E+03	
2002	2.86E+11	1.24E+08	0	0	
2003	1.71E+11	1.18E+08	8.42E+08	0	0
2004	1.98E+11	1.92E+08	2.28E+10	0	0
2005	2.46E+11	1.07E+08	9.33E+09	0	0
2006	3.50E+11	2.85E+08	1.71E+10	0	0
2007	2.50E+11	2.31E+08	6.33E+09	5.46E+02	0
DEL (1996-2007)	**5.25E+13**	**1.10E+11**	**2.16E+13**	**3.43E+08**	**-**
2008	2.74E+11	3.30E+08	0	1.26E+02	0
2009	4.51E+11	2.71E+08	4.27E+08	0	1.11E+03
2010	2.49E+11	2.17E+08	2.99E+08	0	0
2011	1.40E+11	1.07E+08	4.62E+08	0	0
2012	3.01E+11	6.92E+07	1.71E+09	0	0
2013	2.35E+11	1.09E+08	9.00E+08	0	0
2014	3.05E+11	8.20E+07	7.89E+08	0	0
2015	1.44E+11	1.12E+08	1.75E+09	0	0
2016	1.75E+11	9.32E+07	8.85E+08	0	0
2017	1.35E+11	8.64E+07	2.22E+08	0	0
2018	1.52E+11	1.11E+08	9.86E+07	0	0
2019	1.83E+11	1.41E+08	0	0	0
2020	1.83E+11	1.56E+08	0	0	0
2021	2.35E+11	1.69E+08	0	0	0
2022	2.38E+11	1.71E+08	0	0	0
DEL (2008-present)	**3.96E+12**	**5.28E+09**	**5.39E+10**	**8.14E+03**	**1.24E+07**

Emissions of radioactive isotopes of ***iodine*** recorded values above the detection limits of the gaseous effluent monitoring system only at Unit 1 and only until the year 2009, with all values falling within the DEL (the most restrictive set in 2008) for I-131, being 4 orders of magnitude below the DEL for I-133. In the interval 2010 ÷ 2022, monitoring results for these isotopes continued to be below detection limits.

The results of monitoring the emissions of H-3, C-14, noble gases during 2017÷2022 show that, similarly to the situation during 2007 ÷2016 analyzed in the last environmental balance study, for all averaging intervals, the measured emission values are with at least an order of magnitude smaller than the associated derivative limits.

[107] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Doc. IR- 96200-057

To illustrate the statement above, Fig. 57 shows the evolution of H-3 emissions into the atmosphere, for Units 1 and 2, during their operation period. The same data is presented in Fig. 58 in the form of fractions of the DEL, calculated by reporting the emissions to the DEL in force corresponding to the monitored period.

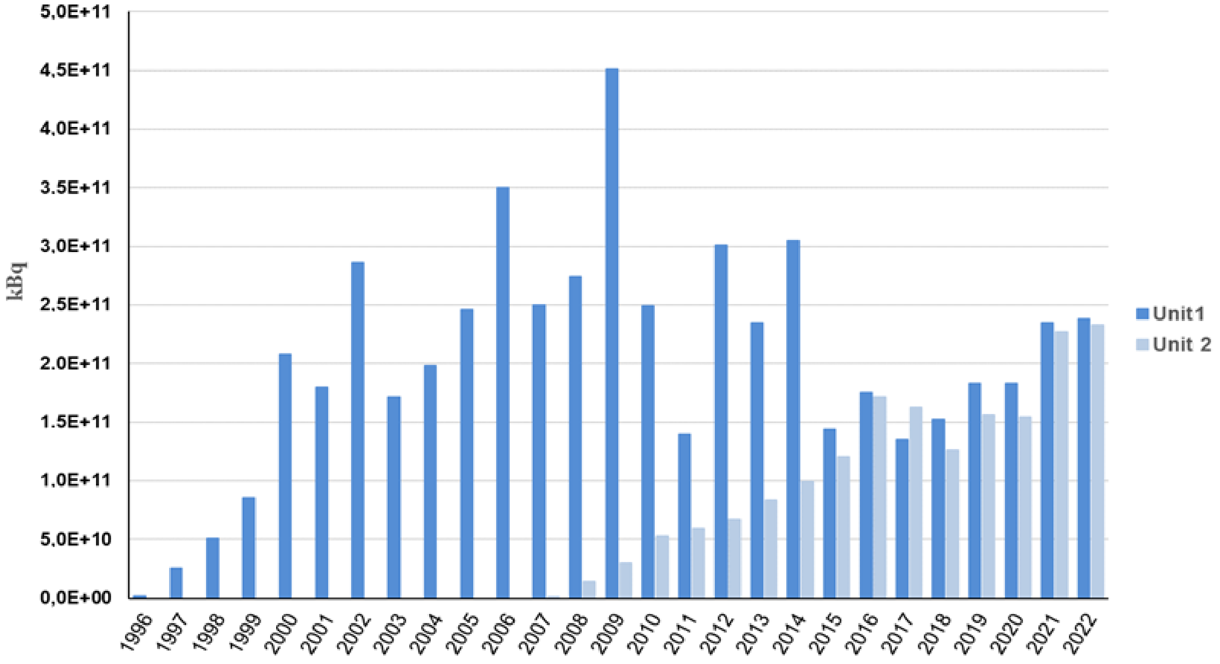


Fig. 57 The evolution of annual emissions of tritium (oxide) into the atmosphere from the nuclear power units 1 and 2 of Cernavoda NPP, during 1996 ÷ 2022

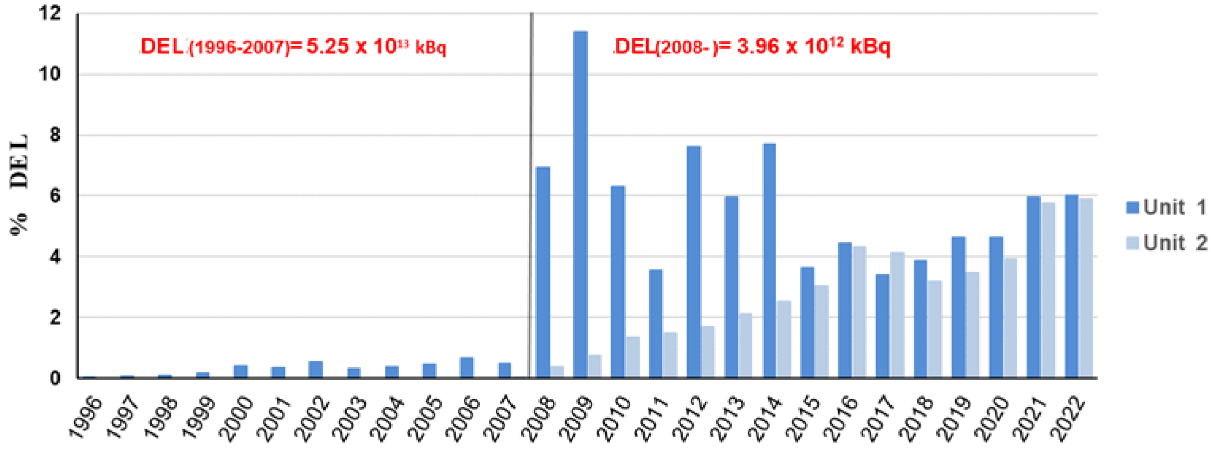


Fig. 58 The evolution of annual emissions of tritium (oxide) into the atmosphere, during 1996 ÷ 2022 - expressed as a percentage of the derived limits

It can be observed that over the entire operating interval of Unit 1, the annual emissions of tritium into the atmosphere, in the form of tritiated water vapor, were significantly below the derived limits approved by CNCAN.

The maximum value of annual tritium (oxide) emissions, recorded in 2008 for the gaseous effluent from Unit 1, represents 11.40% of the more restrictive derived limit applicable starting from that year.

The similar evolution in the interval 2015-2022 of the annual emissions of tritium (oxidized form) in the gaseous effluents released by the two units indicates a correlation of the emissions with the management of heavy water in the reactor systems and with the operation and maintenance of the emission control systems tritiated water in the atmosphere (condensation and vapor recovery).

For the year 2022, Fig. 59 shows the monthly emissions of tritium into the atmosphere, as a result of the release of gaseous effluents from Units 1 and 2. The same monitoring results are also presented in Fig. 60, in the form of fractions of the annual derived limit corresponding to each unit.

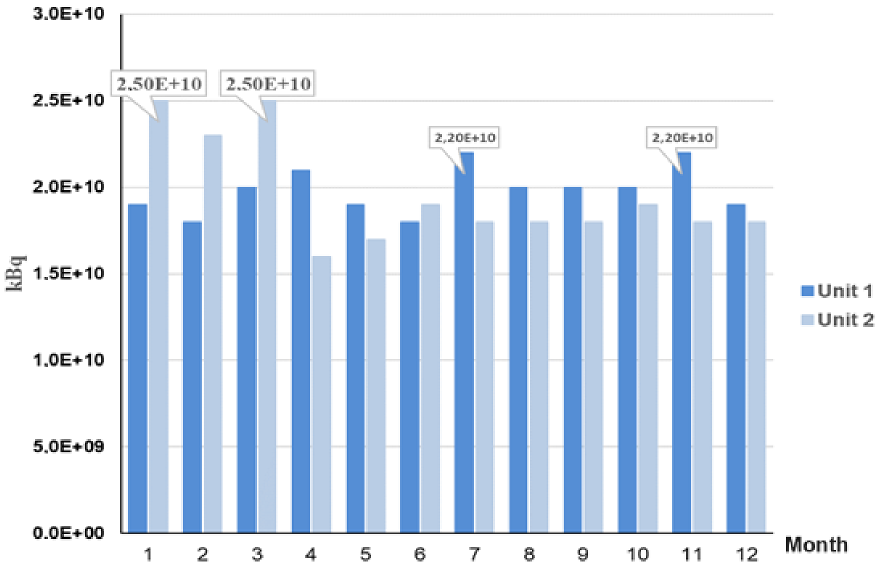


Fig. 59 The monthly emissions of tritium (oxide) into the atmosphere from the U1 and U2 nuclear power units of Cernavoda NPP, in 2022[108]

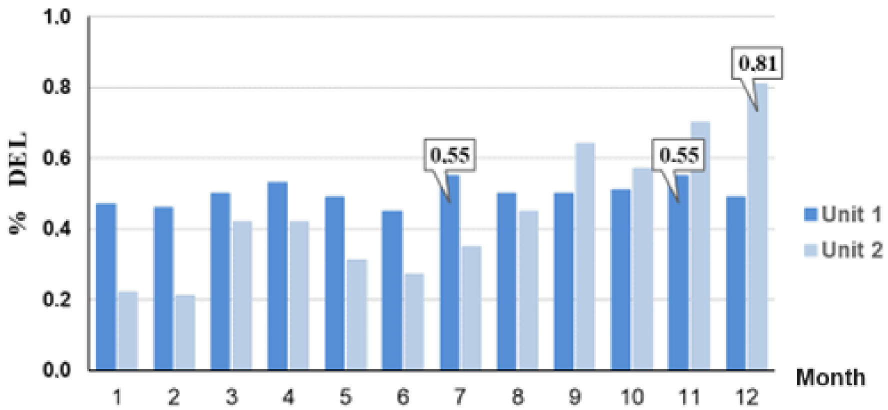


Fig. 60 The monthly emissions of tritium (oxide) into the atmosphere from the U1 and U2 nuclear power units of Cernavoda NPP, in 2022 – expressed as a percentage of the derived emission limits [108]

[108] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Doc. IR- 96200-057

As can be seen from the figures above, the monitoring results from the year 2022 indicate a quasi-constant level of monthly tritium emissions from the U1 unit and in the same range of values as the emissions from the U2 unit - commissioned 11 years after U1 unit.

The monthly tritium emissions in 2022 remain significantly below the corresponding derived emission limits (15% of the annual DEL), being in the same range of values as those recorded in 2016, the reference year of the most recent environmental balance study.

Fig. 61 shows the values of annual C-14 emissions, via gaseous effluents, from Cernavoda NPP units in operation, and Fig. 62 shows the same monitoring data, by relating them to the corresponding derived emission limits.

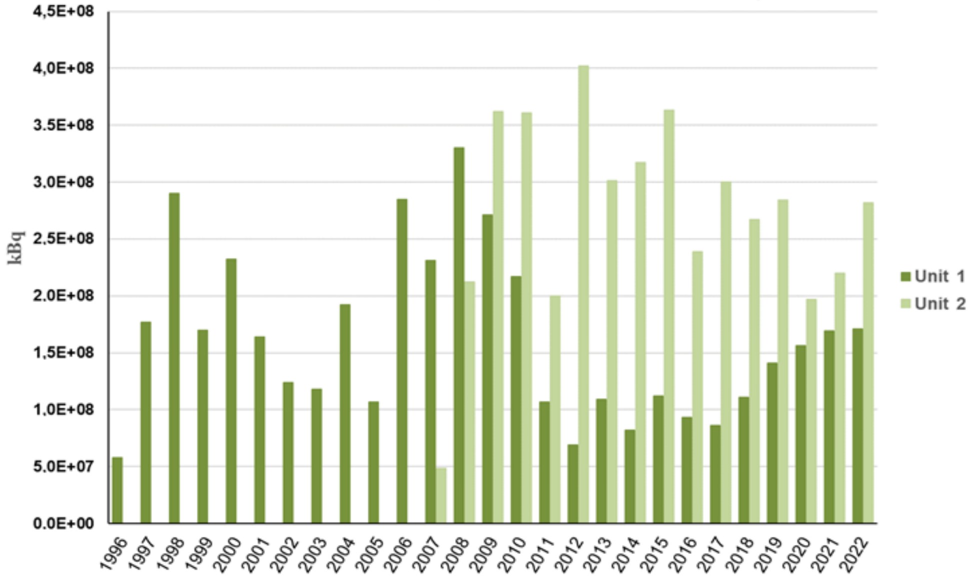


***Fig. 61 The evolution of the annual emissions of C-14 into the atmosphere from the nuclear power units 1 and 2 of Cernavoda NPP, in the interval 1996 ÷ 2022*[109]**

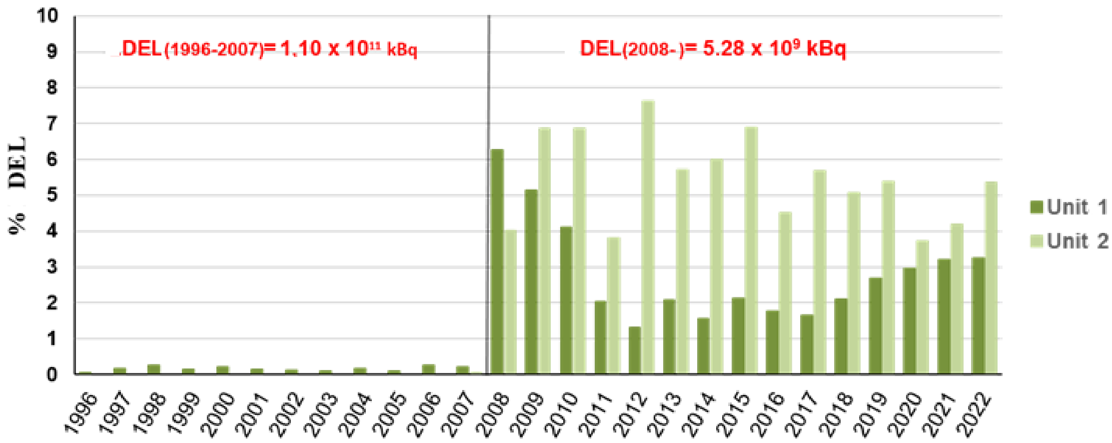


***Fig. 62 Evolution of annual emissions of C-14 in the atmosphere, in the interval 1996 ÷ 2022 - expressed as a percentage of the derived emission limits*[109]**

[109] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Cod IR-96200-057

During the entire period of operation of Unit 1, the annual emissions of C-14 into the atmosphere were below the derived limits approved by CNCAN. The annual emissions of C-14 from the Unit 1 were below 10% of the most restrictive value of the derived limits established for this radionuclide, being in the same range of variation as the emissions generated from Unit 2.

For the year 2022, Fig. 63 shows the monthly emissions of C-14 into the atmosphere, as a result of the releases of gaseous effluents from Units 1 and 2. The same monitoring results are also shown in Fig. 64, in the form of fractions of the annual derived limit corresponding to each unit.

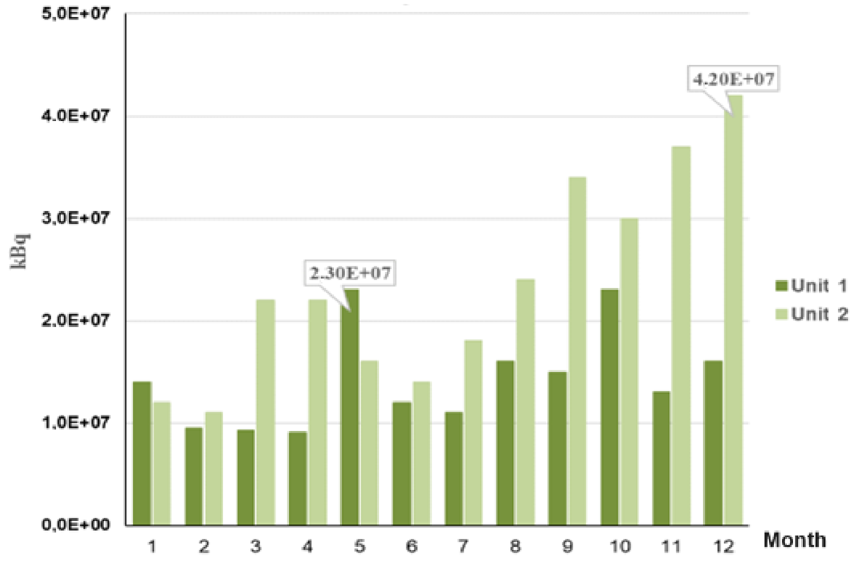


Fig. 63 The monthly emissions of C-14 in the atmosphere from the nuclear power units 1 and 2 of Cernavoda NPP, in the year 2022[110]

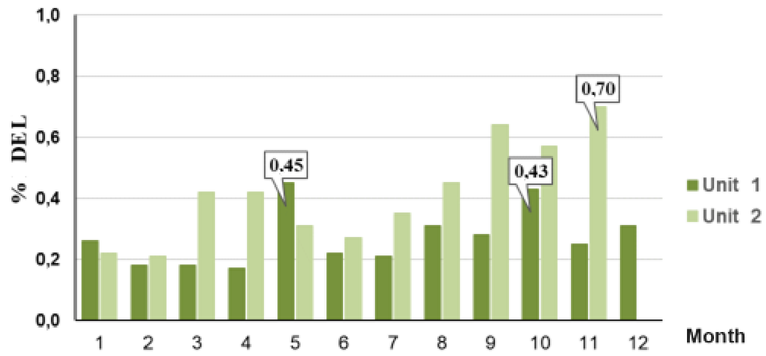


Fig. 64 The monthly emissions of C-14 into the atmosphere from the U1 and U2 of Cernavoda NPP, in 2022 – expressed as a percentage of the derived emission limits [110]

The monitoring results from the year 2022 indicate that the monthly C-14 emissions from Unit 1 remain below 1% of the annual derived emission limit and in the same range of values as the emissions from the Unit 2 – entered into operation 11 years after U1.

[110] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Doc. IR-96200-057

Fig. 65 shows the monitoring results of the annual emissions of noble gases, via gaseous effluents, from the Cernavoda NPP units in operation, and Fig. 66 shows the same monitoring data, by reporting them to the corresponding derived limits.

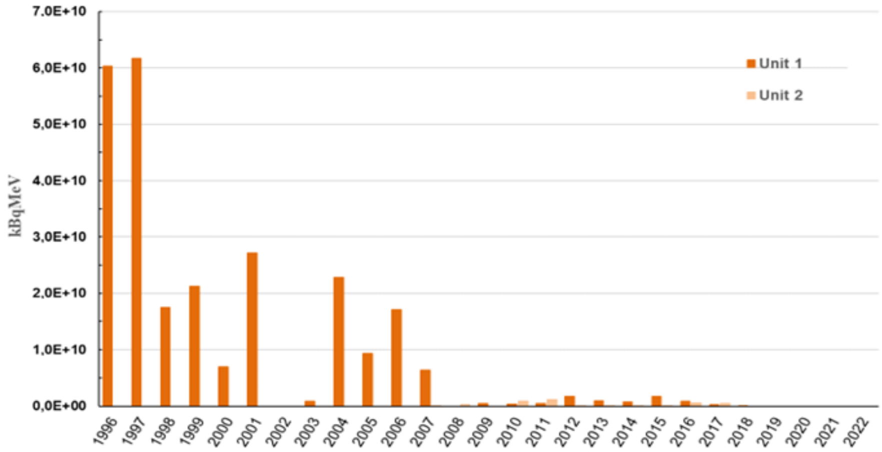


Fig. 65 The evolution of the annual emissions of noble gases into the atmosphere from the nuclear power Units 1 and 2 of Cernavoda NPP, in the interval 1996÷2022[111]

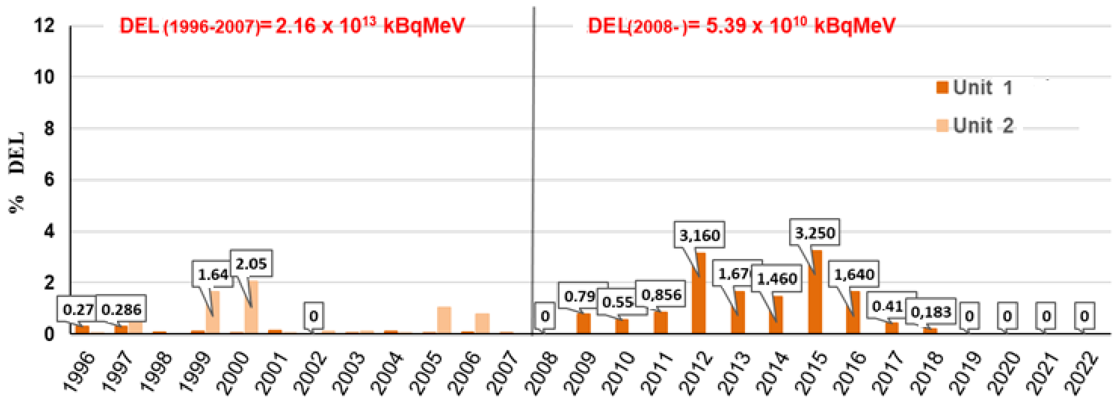


Fig. 66 The evolution of the annual emissions of noble gases in the atmosphere – expressed as a percentage of the derived limits [111]

During the entire operation period of Unit 1, the annual emissions of *noble gases* were at least an order of magnitude below the applicable derived limits, and starting from 2019 the emissions of noble gases were constantly below the detection limits of the monitoring system for gaseous effluents.

For the purposes of this impact analysis, Cernavoda NPP has drawn up a *Report on the monitoring of liquid and gaseous radioactive effluents from the Cernavoda NPP site, in Quarter I - 2023.* **Regarding the emissions of gaseous effluents, the report states that for Unit 1, the total emissions of gaseous effluents in the first quarter of 2023 (the period January 1 - March 31) is equivalent to an effective dose for a representative person from the population of 0.918 microSv. This value represents 0.92% of the approved dose constraint for Unit 1**. Similarly, the report states that, for **Unit 2**, the total emissions of gaseous effluents in the first quarter of 2023 (period 1

[111] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Doc. IR-96200-057

January – 31 March) is equivalent to a dose effective of 0.992 microSv for a representative person in the population. This value represents 0.99% of the approved dose constraint for Unit 2.

3.9.2.2 Results of the liquid radioactive effluents monitoring

Derived emission limits in force for liquid effluents

According to the regulatory acts, before discharge into the environment, the concentration of beta activity and the global range of potentially radioactively contaminated wastewater must fall within the limits imposed by the Liquid and Gaseous Radioactive Effluent Monitoring Program at Cernavoda NPP.

The radioactivity parameters of the liquid effluents are determined in the Dosimetry Laboratory of the NPP, by analyzing the samples from the Liquid Effluent Monitor (LEM).

The following table presents the Derived Emission Limits approved by CNCAN for the nuclear power units in operation of Cernavoda NPP, calculated according to the emission path of liquid effluents.

Tab. 64 Derived Emission Limits approved by CNCAN for each of the nuclear units (U1, U2) in operation at Cernavoda NPP[112]

DEL for Emissions of liquid effluents in CDMN		DEL for Emissions of liquid effluents in the Danube	
Radionuclide	**DEL (GBq/an)**	**Radionuclide**	**DEL (GBq/an)**
H-3	1.97E+06	H-3	4.92E+07
C-14	8.94E-01	C-14	4.28E+01
I-131	9.07E-01	I-131	2.39E+01
I-132	8.53E+01	I-132	1.28E+03
I-133	1.92E+01	I-133	1.17E+02
I-134	2.45E+02	I-134	1.40E+03
I-135	2.58E+01	I-135	4.21E+02
Cr-51	2.87E+02	Cr-51	1.14E+03
Mn-54	2.22E+00	Mn-54	5.11E+01
Fe-59	2.19E+00	Fe-59	4.48E+01
Co-58	3.87E+00	Co-58	2.47E+01
Co-60	1.54E-01	Co-60	4.77E+00
Zn-65	5.33E-01	Zn-65	2.47E+01
Sr-89	3.67E+00	Sr-89	9.81E+01
Sr-90+	9.66E-02	Sr-90+	3.98E+00
Zr-95+	3.95E+00	Zr-95+	2.98E+01
Nb-95	1.41E+01	Nb-95	9.42E+01
Mo-99	4.82E+01	Mo-99	8.84E+02
Ru-103	1.75E+01	Ru-103	3.98E+01
Ru-106+	1.52E+00	Ru-106+	4.21E+01
Ag-110m	9.37E-01	Ag-110m	4.21E+01
Sb-122	1.33E+01	Sb-122	3.11E+02
Sb-124	3.31E+00	Sb-124	1.28E+02

[112] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Doc. IR-96200-057

DEL for Emissions of liquid effluents in CDMN		DEL for Emissions of liquid effluents in the Danube	
Radionuclide	**DEL (GBq/an)**	**Radionuclide**	**DEL (GBq/an)**
Sb-125	1.49E+00	Sb-125	7.16E+01
Te-132	3.06E+00	Te-132	1.10E+02
Cs-134	4.68E-02	Cs-134	1.99E+00
Cs-137	4.78E-02	Cs-137	2.24E+00
Ba-140	4.64E+00	Ba-140	5.11E+01
Ce-141	1.67E+01	Ce-141	2.65E+02
Ce-144	1.93E+00	Ce-144	5.51E+01
Eu-152	1.49E-01	Eu-152	5.51E+00
Gd-153	1.97E+01	Gd-153	1.79E+02
Eu-154	2.02E-01	Eu-154	7.16E+00
Hf-181	1.11E+01	Hf-181	3.25E+02

In addition to the annual discharge limits, in order to track and optimize the control of radioactive discharges, operational limits were calculated, in the form of DELs for shorter periods of time, as follows:

- Quarterly DEL: 35% of annual DEL;
- Monthly DEL: 15% of annual DEL.

If these short-term limits are exceeded, Cernavoda NPP has the obligation to notify CNCAN, to establish the reasons that led to the increase in evacuations and to institute corrective measures to reduce radioactive emissions.

For the discharge of liquid effluents into the Danube - Black Sea Canal, additional measures are implemented, so that the concentration of radioactivity in the water in the canal respects the limits established by the legislation in force for drinking water. Administrative and monitoring measures ensure compliance with the legal requirements regarding the radioactivity of drinking water (H-3 concentration, gross-alpha activity and gross-beta activity). The plan of measures for limiting the concentration of radioactivity in the discharged water is presented to the authorities to obtain authorizations for switching the discharge route.

If, in one year, liquid effluents are discharged both in the Danube-Black Sea Canal and in the Danube, *there is the additional condition that the sum of the doses received by a person from the critical group during that year, following these discharges, shall not exceed 25 μSv.*

As for rainwater (meteor), from the site of DICA's concrete modules, they are retained in collection chambers equipped with isolation valves and level indicators, from where samples are taken as soon as their filling is signaled. The samples are analyzed at the Dosimetry Laboratory in order to detect possible radioactive contamination. If the results of the laboratory analyzes indicate that the conditions authorized for discharge are met, the meteoric waters are discharged by gravity into the Cișmelei Valley through the sewerage system. Otherwise, the meteoric water is collected in barrels/cisterns, after which it is transferred to the active drainage system of the nuclear-electric units.

Radioactive emissions in water

Tab. 65 shows, broken down by the Danube and CDMN discharge routes, respectively, the evolution of the annual emissions of liquid effluents from the nuclear units in operation at Cernavoda NPP, determined within the framework of the liquid effluent monitoring program.

Tab. 65 Annual emissions of radioactive liquid effluents from Cernavoda NPP_Unit 1 [113]

Isotope	Discharge route	U1_ Activity discharged through liquid effluents (kBq/an)									
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
H-3	D C	7.88E+08 0.00E+00	1.12E+10 4.21E+08	6.17E+10 1.41E+08	1.40E+10 5.29E+09	4.13E+10 2.15E+09	5.21E+10 0.00E+00	7.05E+10 1.42E+10	1.02E+11	1.71E+11	1.09E+11
Cr-51	D C	3.91E+03 0.00E+00	6.95E+04 1.09E+03	1.13E+03 -	6.62E+04 6.79E+04	9.17E+04 1.05E+03	5.57E+03 0.00E+00	7.19E+04 2.56E+04	1.23E+10	2.41E+10	5.56E+09
Mn-54	D C	- -	- -	4.26E+02 0.00E+00	1.71E+03 0.00E+00	- -	- -	- -	5.62E+03	2.02E+05	1.36E+05
Fe-59	D C	9.09E+02 0.00E+00	- -	- -	4.86E+03 0.00E+00	- -	- -	- -	0.00E+00	1.36E+04	4.33E+03
Co-58	D C	- -	- -	- -	- -	- -	- -	- -	-	-	-
Co-60	D C	- -	8.76E+03 0.00E+00	- -	5.88E+03 0.00E+00	2.15E+04 0.00E+00	5.57E+03 0.00E+00	1.45E+04 1.46E+03	-	-	-
Zn-65	D C	2.53E+03 0.00E+00	1.24E+03 0.00E+00	- -	- -	- -	- -	- -	7.70E+02	2.60E+03	2.99E+02
Zr-95+	D C	- -	4.29E+05 1.44E+04	2.86E+05 -	1.04E+06 1.63E+05	2.36E+05 3.26E+04	5.61E+04 0.00E+00	6.10E+04 2.90E+03	-	0.00E+00	0.00E+00
Nb-95	D C	- -	7.05E+05 3.50E+04	7.45E+05 0.00E+00	1.97E+06 2.99E+05	6.06E+05 6.72E+04	1.47E+05 0.00E+00	1.34E+05 8.77E+03	-		-
Ru-103	D C	2.25E+03 0.00E+00	2.57E+03 0.00E+00	1.34E+03 0.00E+00	- -	- -	- -	- -	-		-
Sb-124	D C	1.71E+03 0.00E+00	5.22E+05 5.44E+04	3.81E+05 0.00E+00	1.59E+04 3.28E+02	2.67E+04 5.37E+02	9.66E+03 0.00E+00	1.52E+04 2.07E+03	-	0.00E+00	-
Sb-125	D C	- -	- -	1.11E+04 0.00E+00	- -	2.40E+02 0.00E+00	- -	- -	-	6.67E+02	-
I-131	D C	2.60E+04 -	5.22E+06 2.81E+04	5.96E+05 0.00E+00	4.42E+03 6.00E+03	- -	- -	- -	7.51E+03	5.30E+04	1.31E+05
Cs-134	D C	- -	4.51E+03 0.00E+00	6.53E+02 0.00E+00	4.80E+02 0.00E+00	- -	- -	- -	1.73E+03	2.55E+04	4.31E+04
Cs-137	D C	- -	3.17E+04 3.17E+03	1.44E+04 0.00E+00	1.62E+04 0.00E+00	3.70E+03 0.00E+00	8.64E+02 0.00E+00	3.00E+02 0.00E+00	-	-	-
Ce-141	D C	1.53E+03 0.00E+00	1.05E+03 0.00E+00	- -	- -	- -	- -	- -	-	-	-
Ce-144	D C	- -	1.77E+04 0.00E+00	1.65E+04 0.00E+00	3.00E+04 5.59E+03	1.93E+03 0.00E+00	- -	1.49E+03 0.00E+00	2.87E+05	1.18E+06	2.68E+05
Gd-153	D C	- -	- -	- -	- -	6.00E+03 0.00E+00	1.14E+03 0.00E+00	5.85E+02 0.00E+00	2.31E+06	3.39E+04	0.00E+00

D Effluent discharges in the Danube; C Effluent discharges in the Danube - Black Sea Canal

[113] Cernavoda NPP, Environmental balance level I, 2018

Tab. 65. Annual emissions of radioactive liquid effluents from Cernavoda NPP_Unit 1- cont'd (period 2006 – 2016)

Isotope	Discharge route	U1_ Activity discharged through liquid effluents (kBq/an)										
		2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
H-3	D	1.54E+11	1.54E+11	2.45E+11	7.46E+10	7.87E+10	1.38E+11	7.39E+10	8.37E+10	7.76E+10	1.84E+11	1.88E+11
	C	-	7.33E+07	-	1.06E+09	3.90E+08	-	-	-	1.35E+08	-	-
Cr-51	D	6.37E+04	2.10E+04	9.90E+03	8.93E+03	6.75E+02	3.68E+03	6.73E+03	9.89E+03	3.70E+04	5.64E+04	1.98E+04
	C	-		-	0.00E+00	5.12E+02	-	-	-	-	-	-
C-14	D	-	-	-	1.51E+07	3.15E+06	8.72E+06	8.24E+04	-	-		-
	C	-	-	-	7.54E+04	-	-	-	-	-		-
Mn-54	D	2.28E+02	8.11E+01	-	-	-	-	-	-	-	-	-
	C			-	-	-	-	-	-	-	-	-
Fe-59	D	-	-	6.44E+02	-	-	2.93E+02	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-
Co-58	D	-	-	-	-	-	-	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-
Co-60	D	3.90E+04	9.64E+03	1.37E+04	2.15E+04	7.55E+03	8.92E+03	9.34E+02	2.35E+02	3.12E+04	1.03E+04	1.16E+04
	C	-	-	-	1.44E+03	5.19E+01	-	-	-	-	-	-
Zn-65	D	-	-	-	-	-	-	-	-	-	-	1.84E+03
	C	-	-	-	-	-	-	-	-	-	-	-
Zr-95+	D	2.11E+05	4.32E+04	1.39E+04	1.18E+04	7.27E+03	1.62E+04	1.24E+04	6.62E+03	1.22E+04	9.37E+03	9.30E+03
	C	-	-	-	2.37E+03	3.32E+02	-	-	-	-	-	-
Nb-95	D	3.82E+05	7.98E+04	4.63E+04	3.61E+04	2.30E+04	4.23E+04	3.20E+04	1.37E+05	4.80E+04	2.71E+04	2.85E+04
	C	-	-	-	6.10E+03	7.28E+02	-	-	-	-	-	-
Ru-103	D	1.26E+02	1.96E+02	9.37E+02	2.07E+02	-	-	-	3.40E+02	1.77E+03	3.41E+02	1.94E+02
	C	-	-	-	0.00E+00	-	-	-	-	-	-	-
Sb-124	D	2.17E+05	2.96E+03	5.29E+04	2.72E+03	4.92E+02	8.04E+02	-	2.09E+02	3.48E+05	2.55E+03	4.69E+03
	C	-	-	-	0.00E+00	0.00E+00	-	-	-	-	-	-
Sb-125	D	7.52E+02	-		-	-	-	2.08E+02	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-
I-131	D	-	7.10E+03	1.83E+05	2.61E+05	4.13E+03	1.97E+03	3.52E+04	-	1.52E+05	9.06E+01	-
	C	-	-	-	0.00E+00	0.00E+00	-	-	-	-	-	-
Cs-134	D	-	-	1.86E+03	-	-	1.04E+02	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-
Cs-137	D	1.35E+03	4.54E+03	3.33E+04	1.84E+04	1.33E+04	1.98E+04	1.79E+03	1.03E+03	1.81E+04	5.38E+03	2.12E+03
	C	-	-	-	9.86E+02	3.95E+01	-	-	-	-		-
Ce-141	D	-	5.39E+01	1.42E+02	-	-	-	-	-	-	-	2.07E+02
	C	-	-	-	-	-	-	-	-	-	-	-
Ce-144	D	5.06E+03	1.39E+02	1.77E+02	-	-	3.25E+02	1.47E+02	-	2.22E+02	-	9.11E+01
	C	-	-	-	-	-	-	-	-	-	-	-
Gd-153	D	-	5.30E+02	1.59E+02	-	5.12E+02	-	-	-	-	-	1.29E+02
	C	-	-	-	-	0.00E+00	-	-	-	-	-	-

Isotope	Discharge route	U1_ Activity discharged through liquid effluents (kBq/an)										
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sb-122	D	-	-	7.60E+03	2.32E+03	6.57E+02	-	-	-	1.76E+05	2.40E+02	1.95E+03
	C	-	-	-	0.00E+00	0.00E+00	-	-	-	-	-	-
Te-132	D			-	2.78E+03	-	-	-	-	1.68E+02	-	-
	C			-	0.00E+00	-	-	-	-	-	-	-
Mo-99	D	-	-	6.48E+02	7.66E+02	1.59E+01	-	2.34E+02	-	1.89E+03	-	-
	C	-	-	-	0.00E+00	0.00E+00	-	-	-	-	-	-
I-133	D	-	-	1.56E+03	5.52E+03	-	-	-	-	-	-	-
	C	-	-	-	0.00E+00	-	-	-	-	-	-	-
Hf-181	D	-	-	-	1.27E+02	-	-	1.29E+02	1.72E+02	-	-	-
	C	-	-	-	0.00E+00	-	-	-	-	-	-	-
Ag-110m	D	-	-	9.37E+02	1.45E+03	-	1.15E+03	2.75E+03	4.32E+03	1.60E+04	7.79E+03	-
	C	-	-	-	0.00E+00	-	-	-	-	-	-	-

D- Effluent discharges in the Danube; C- Effluent discharges in the Danube - Black Sea Canal

Tab. 65. Annual emissions of radioactive liquid effluents from Cernavoda NPP_Unit 1- cont'd (period 2017 – 2022), according to the NPP Monitoring Reports

Isotope	Discharge route	U1_ Activity discharged through liquid effluents (kBq/an)					
		2017	2018	2019	2020	2021	2022
H-3	D	1.04E+11	1.40E+11	8.54E+10	1.34E+11	1.31E+11	2.28E+11
	C	-		-			
Cr-51	D	8.18E+03	1.77E+04	3.88E+04	4.71E+04	2.11E+06	1.80E+04
	C	-	-	-			
C-14	D	-	-	-		-	-
	C	-	-	-		-	-
Mn-54	D	-	5.35E+01	2.76E+02	2.27E+02	-	1.24E+02
	C	-	-	-		-	-
Fe-59	D	-	-	-		-	-
	C	-	-	-		-	-
Co-58	D	-	-	-		-	-
	C	-	-	-		-	-
Co-60	D	5.57E+03	3.48E+03	7.34E+03	4.28E+03	5.38E+03	1.37E+04
	C	-	-	-			-
Zn-65	D	-	-	-		-	-
	C	-	-	-		-	-
Zr-95+	D	1.63E+03	8.59E+03	6.06E+03	1.27E+04	7.50E+03	4.71E+03
	C	-	-	-			-
Nb-95	D	8.31E+03	2.79E+04	1.74E+04	4.42E+04	1.45E+05	6.59E+04
	C	-	-	-			
Ru-103	D	-	2.48E+02	4.78E+01	3.62E+02	1.33E+01	-
	C	-	-	-			-
Sb-124	D	9.83E+03	1.05E+05	7.87E+03	8.54E+05	9.81E+02	1.72E+03
	C	-	-	-	-	-	-
Sb-125	D	-	9.63E+03	-	-	-	-
	C	-	-	-	-	-	-
I-131	D	-	2.73E+04	-	-	-	-
	C	-	-	-			-
Cs-134	D	-	-	-		-	-
	C	-	-	-		-	-
Cs-137	D	3.06E+02	-	6.09E+02	3.52E+02	-	-
	C	-	-	-		-	-

Isotope	Discharge route	U1_ Activity discharged through liquid effluents (kBq/an)					
		2017	2018	2019	2020	2021	2022
Ce-141	D C	2.93E+01 -	- -	- -		- -	- -
Ce-144	D C	1.22E+02 -	- -	- -		- -	- -
Gd-153	D C	3.37E+01 -	- -	5.77E+02 -	4.33E+02	3.89E+03 -	9.99E+03 -
Sb-122	D C	2.84E+03 -	7.67E+03 -	2.99E+02 -	4.13E+05	5.20E+02 -	8.17E+01 -
Te-132	D C	- -	1.47E+02 -	- -		- -	- -
Mo-99	D C	- -	6.63E+02 -	- -		- -	- -
I-133	D C	- -	- -	- -		- -	- -
Hf-181	D C	- -	- -	- -		- -	- -
Ag-110m	D C	7.96E+02 -	1.60E+03 -	3.68E+03 -	7.86E+03	1.12E+03 -	1.64E+03 -
Ba-140	D C	4.64E+06 -	- -	- -		- -	- -
Eu-152	D C	1.49E+05 -	- -	- -		- -	- -
Eu-154	D C	2.02E+05 -	- -	- -	 -	- -	- -

D Effluent discharges in the Danube; C Effluent discharges in the Danube - Black Sea Canal

Among the detected radionuclides, tritium (the oxidized form) represents the major component of radioactivity in the liquid effluent emissions from Cernavoda NPP, so that when calculating the derived emission limits for each unit, it was allocated a fraction of 97% of the dose constraint associated with the path of liquid effluent emission (0.025 mSv/year), which represents 24.25% of the total dose constraint corresponding to the respective unit. Fig. 67 show the evolution of annual emissions for this radionuclide, broken down by nuclear units and by the two water discharge routes. Fig. 68 illustrate the evolution of the annual liquid tritium emissions from units 1 and 2 of Cernavoda NPP expressed as a percentage of the Derived Emission Limits.

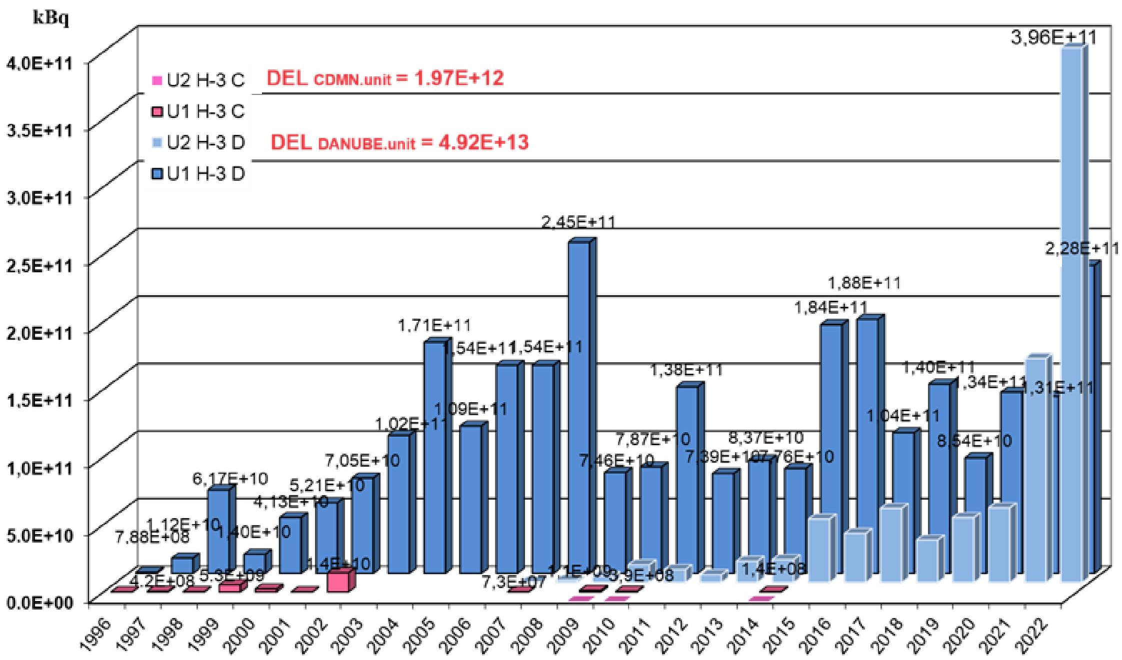


Fig. 67 The evolution of the annual liquid tritium emissions from the units 1 and 2 nuclear power units from the Cernavoda NPP, for each discharge route - Danube, respectively the Danube - Black Sea Canal

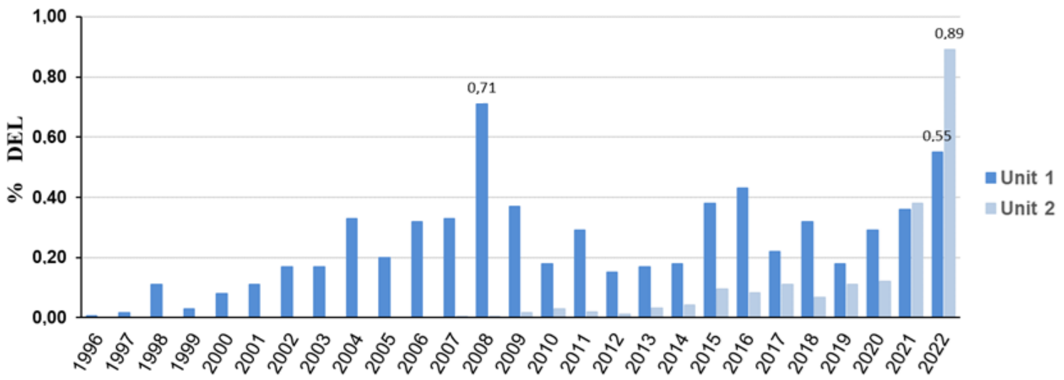


Fig. 68 Percentage of annual liquid tritium emissions from Unit 1 in relation to Derived Emission Limits

Note: starting from January 2008, the new Derived Emission Limits approved by CNCAN and calculated in accordance with the Norms regarding the limitation of releases of radioactive effluents into the environment were implemented.

During the entire period of operation of the nuclear power plants Units 1 and 2 of Cernavoda NPP, the annual emissions of tritium through liquid radioactive effluents determined for each individual unit were below the approved Derived Emission Limits.

The evolution of tritium emissions is a typical one for a CANDU-type nuclear unit, also reflecting the effect of the environmental impact reduction measures implemented at Cernavoda NPP.

It is found that, during the entire period of operation, the annual liquid emissions of tritium were constantly below 1% of the approved Derived Discharged Limits.

Weekly, the radioactivity monitoring results are centralized and compared with the administrative limits of Cernavoda NPP and with the assumed environmental objectives.

During the entire period of commercial operation, the discharges of radioactive liquid effluents were lower than the Derived Emission Limits approved by CNCAN. Throughout this period, there were registered only 2 slight exceeding of the administrative limits, more restrictive, that Cernavoda NPP establishes as an additional measure to control emissions.

Fig. 69 shows the levels of monthly tritium emissions for the liquid effluents released into the environment from Units 1 and 2, and Fig. 70 shows the percentage fractions corresponding to monthly tritium emissions, calculated by reference to the annual DELs.

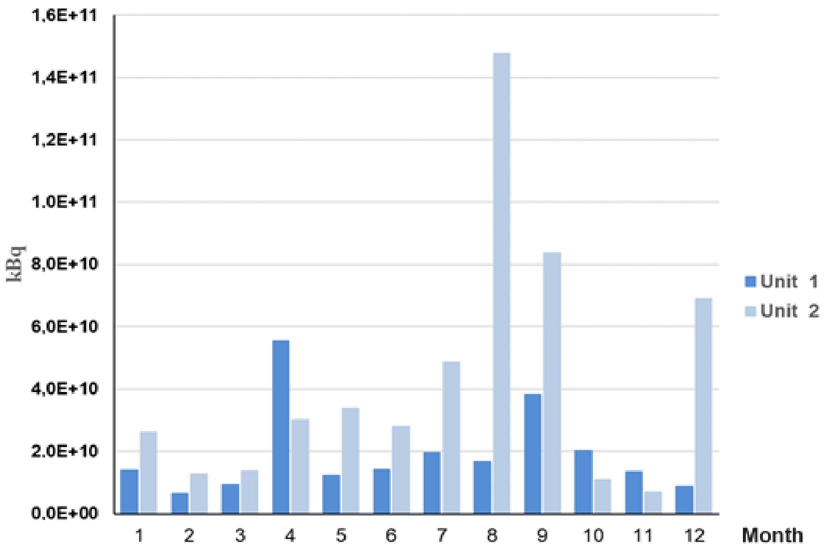


Fig. 69 Monthly emissions of tritium in liquid effluents from nuclear power units 1 and 2 of Cernavoda NPP, in 2022

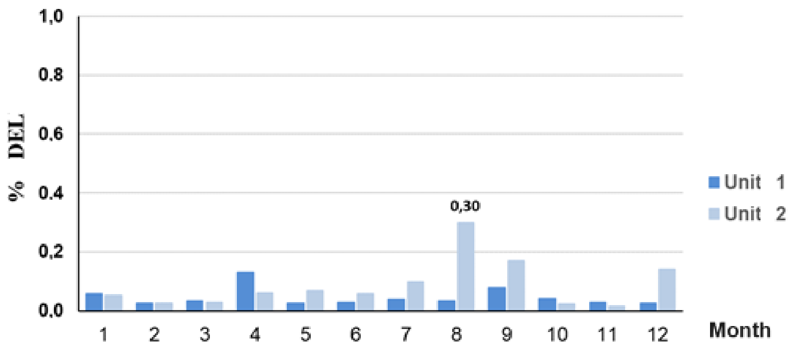


Fig. 70 The monthly emissions of tritium in the liquid effluents from the nuclear power units 1 and 2 of Cernavoda NPP, in the year 2022 – expressed as a percentage of the derived limits

The monitoring results from 2022 indicate a quasi-constant level of monthly tritium emissions from Unit 1, which are in the same range of values as the emissions from the Unit 2 - put into operation 11 years after Unit 1.

Water from the condenser cooling water channel - results provided by the Cernavoda NPP monitoring through its own laboratory

Within the routine monitoring program of Cernavoda NPP, the following are provided: the weekly sampling of integrated water samples from the condenser cooling water channel (CCW *Condenser Cooling Water*) and the analysis of these samples on a weekly basis. For this purpose, weekly samples are taken from a tank in which a sample of the condenser cooling water is continuously collected, after mixing it with the liquid effluents discharged from the management system of potentially radioactive liquid.

Following the gamma-spectrometry analyses, there were detected only natural radionuclides in the water sample.

Fig. 71 and Fig. 72 show the results of determinations of gross-beta activity concentration and tritium concentration in water samples taken from the condenser cooling water channel.

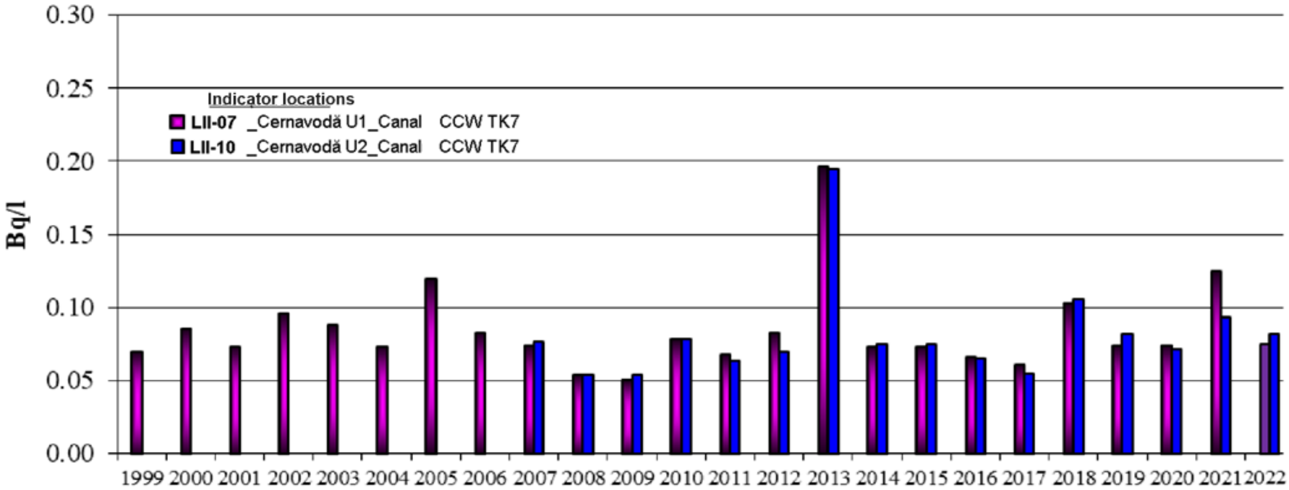


Fig. 71 The evolution of the annual averages determined by Cernavoda NPP for the gross-beta activity from the water samples from the condenser cooling water channel

The annual averages were in the same range of values as those determined for gross-beta activity from the samples of surface water.

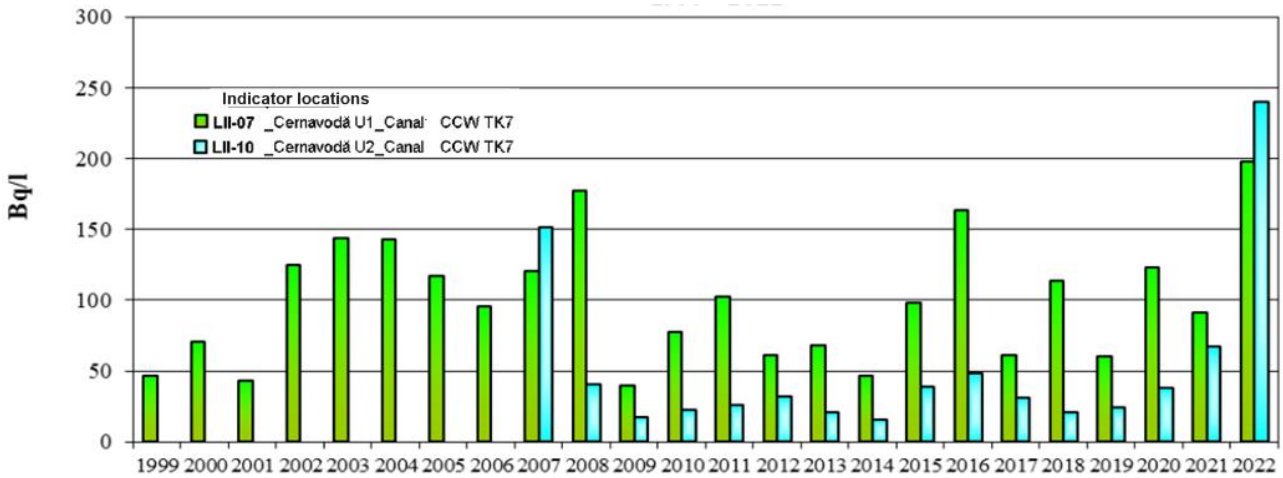


Fig. 72 The evolution of the average annual tritium concentrations determined in the water samples from the condenser cooling water channel for each unit in operation at Cernavoda NPP

According to Fig. 72 the annual averages of the activity concentration of tritium in the condenser cooling water discharge channel are relatively low, comparable to the level of 100 Bq/l corresponding to the limit of the drinking water quality parameter regarding tritium, according to Law 301 of November 27, 2015. However, as can be seen in Fig. 69, the monthly emissions of tritium can vary during the same year in an interval of up to an order of magnitude, which means that the values of tritium concentrations in the cooling water discharge channel condenser, during the discharges of effluents, can be significantly higher than the average annual value, which necessitates the rigorous management of the discharges in order to ensure compliance with potability levels in the receiving watercourses - downstream of Cernavodă NPP.

3.9.3 Results of environmental radioactivity monitoring

The routine environmental monitoring program carried out at Cernavoda NPP

The following table summarizes the sample types, analysis methods and sampling and analysis frequencies provided in the routine environmental monitoring program for the Cernavoda NPP.

Tab. 66 Types of samples, analysis methods and sampling frequencies, within the environmental radioactivity monitoring program at Cernavoda NPP

Sample type	Sampling frequency	Analysis type	No. of sampling points	Analysis frequency
Particles in the air	continuously	Gross-β analyses γ spectrometry	12	monthly - discharges < MDA
				weekly - MDA < discharges < 6 % DEL
				daily - discharges > 6 % DEL
Iodine in the air	continuously	γ spectrometry	12	quarterly - discharges < MDA
				weekly - MDA < discharges < 6 % DEL
				daily - discharges > 6 % DEL
Tritium in air	continuously	LSC - tritium	12	monthly - discharges < MDA
				weekly - MDA < discharges < 6 % DEL
				daily - discharges > 6 % DEL
C-14 in the air	continuously	LSC - C-14	3	monthly - discharges < MDA
				weekly - MDA < discharges < 6 % DEL
				daily - discharges > 6 % DEL
TLD (ambient gamma radiation)	continuously	integrated exposure	62	quarterly - discharges < MDA
				monthly - discharges > 6 % DEL
Surface water	weekly	Gross-β analyses	4	monthly
		γ spectrometry		
		LSC - tritium		
Water (CCW Channel)	continuously /weeklyl	Gross-β analyses	2	weekly
		γ spectrometry		
		Tritium		
Meteoric rainwater	depending on weather conditions	Gross-β analyses	3	Depending on the period in which the sampling is made
		γ spectrometry		
		Tritium		
Infiltration water	montly	Gross-β analyses	7	montly

Sample type	Sampling frequency	Analysis type	No. of sampling points	Analysis frequency
		γ spectrometry tritium		
Deep undergroundwater	montly	Gross-β analyses γ spectrometry tritium	2	montly
Drinking water	montly	Gross-β analyses γ spectrometry tritium	5	montly
Soil	biannual	Gross-β analyses γ spectrometry tritium	7	biannual
Sediment	biannual	Gross-β analyses γ spectrometry tritium	2	biannual
Milk	weekly	Gross-β analyses γ spectrometry tritium C-14	1	weekly (gamma spectrometry and H-3) monthly (global beta and C-14)
Atmospheric deposits	continuously/ monthly	Gross-β analyses γ spectrometry tritium	5	montly
Fish	biannual	Gross-β analyses γ spectrometry tritium C-14	5	biannual
Meat	biannual	Gross-β analyses γ spectrometry tritium C-14	3	biannual
Vegetables	annual	Gross-β analyses γ spectrometry tritium C-14	3	anual
Fruits	annual	Gross-β analyses γ spectrometry tritium C-14	4	annual
Spontaneous vegetation	monthly, May - October	Gross-β analyses γ spectrometry tritium C-14	4	lunar
Eggs	annual	Gross-β analyses γ spectrometry tritium C-14	2	annual
Grains	annual – wheat biannual - corn	Gross-β analyses γ spectrometry tritium C-14	2	annual – wheat biannual - corn

Radioactivity levels – concentrations in the receiving environment

In the following, the results regarding the radioactivity of the environment in the Cernavoda NPP area, obtained from:

- the routine monitoring program carried out by Cernavoda NPP
- The National Network for Monitoring the Radioactivity of the Environment (RNSRM)
- the campaign carried out between 04 and 07/06/2023, within the framework of this study
- additional investigations carried out by third-party laboratories, within other projects of Cernavoda NPP.

3.9.3.1 The radioactivity of the Danube water - results provided by RNSRM

The environmental radioactivity monitoring program in the area of influence of Cernavoda NPP includes the analysis of the radioactivity of the Danube water at the Cernavoda River Station, Cochirleni, Capidava, Fetesti, Seimeni.

The following figures show the evolution of the gross-beta activity (annual average and maximum – immediate measurement) of the surface water samples taken from the Danube at: Cernavoda River Station, Cochirleni, Capidava and Fetesti in the period 2010 – 2021 and the monthly averages measured in 2021.

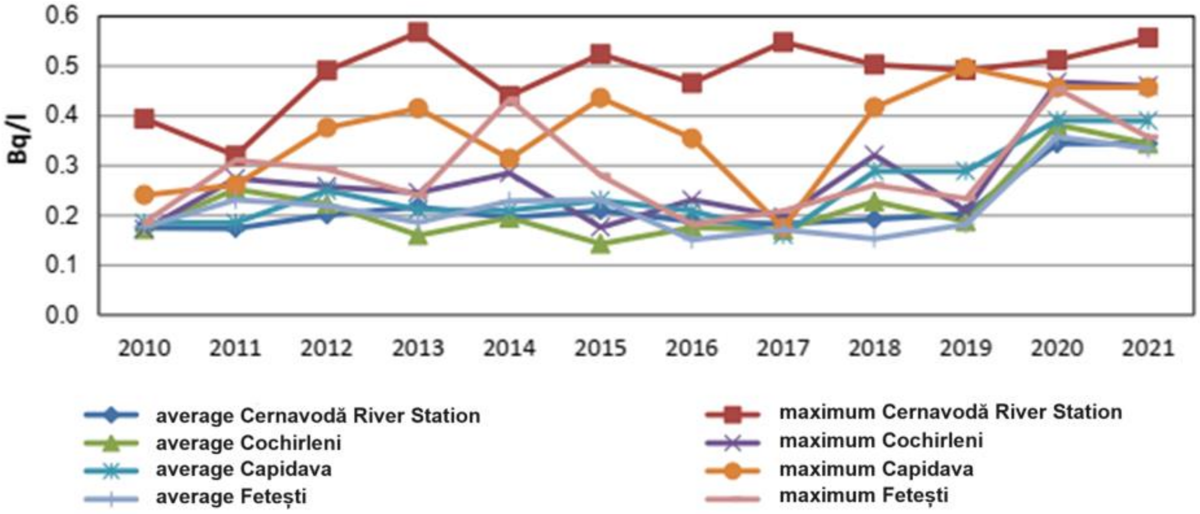


Fig. 73 Annual averages and maximums of the gross-beta activity of surface water in the Danube - immediate measurements, according to the State of the Environment Report for 2021 published by EPA Constanta

All the values determined in the period 2010 - 2021, both the average and the maximum, were below the warning limit of 2 Bq/l for the immediate gross-beta activity in water, established by MO no. 1978/2010 *regarding the approval of the Regulation on the organization and operation of the National Environmental Radioactivity Surveillance Network.*

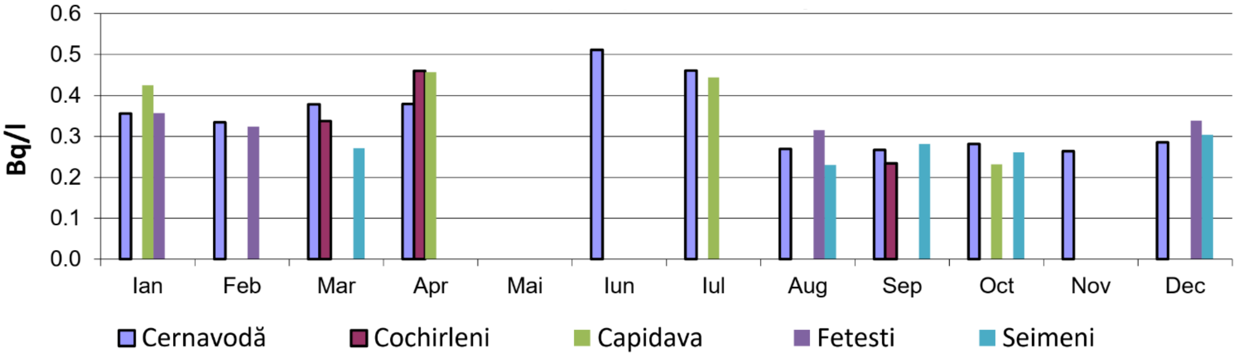


Fig. 74   2021 monthly averages of the gross-beta activity concentration of surface water in the Danube - immediate measurements, according to the State of the Environment Report for 2021 published by EPA Constanta

The following figure shows the evolution of the activity concentration of tritium in surface water samples from the Danube River, in the area of influence of Cernavoda NPP.

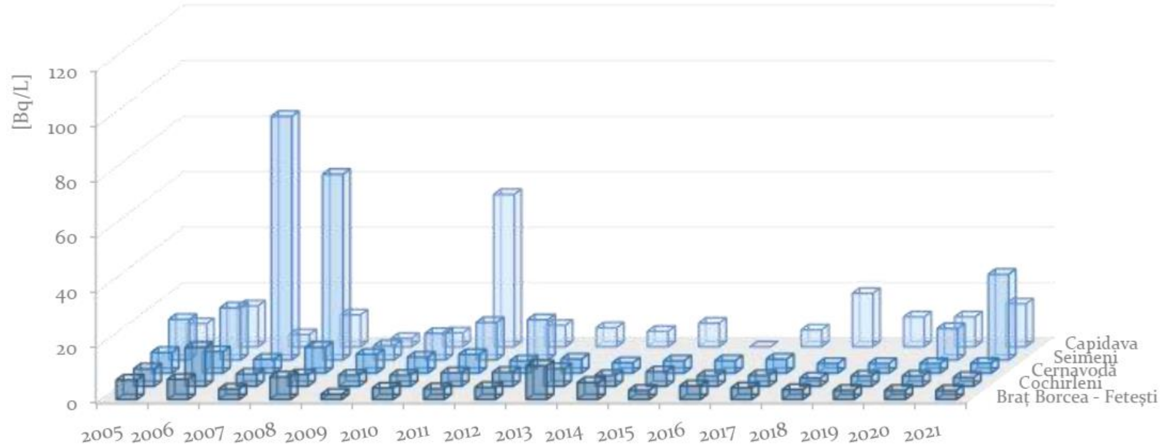


Fig. 75 The variation of the volumetric activity of tritium in water samples from the Danube, in the Cernavoda area, according to the State of the Environment Report for 2021 published by NEPA

It can be seen that the values of the global beta activity concentration and the tritium activity concentration are lower than the limit values of the corresponding parameters specified in Law 301 of November 27, 2015 (regarding the establishment of requirements for the protection of public health with regard to radioactive substances in drinking water), which proves that the emissions of radioactive liquid effluents from Cernavoda NPP do not affect the possibility of using water from the Danube for treatment in drinking purposes.

3.9.3.2 The radioactivity of the Danube water - results of Cernavoda NPP monitoring

The environmental radioactivity monitoring program around Cernavoda NPP includes the monthly sampling and analysis of surface water samples from locations LII-05 – Danube Black Sea Canal, LII-06 – Danube (Seimeni Channel) and SSS-02 – Danube Cernavoda (location of reference).

Fig. 76 shows the gross-beta activity concentration values (annual averages) recorded during the plant's operating period.

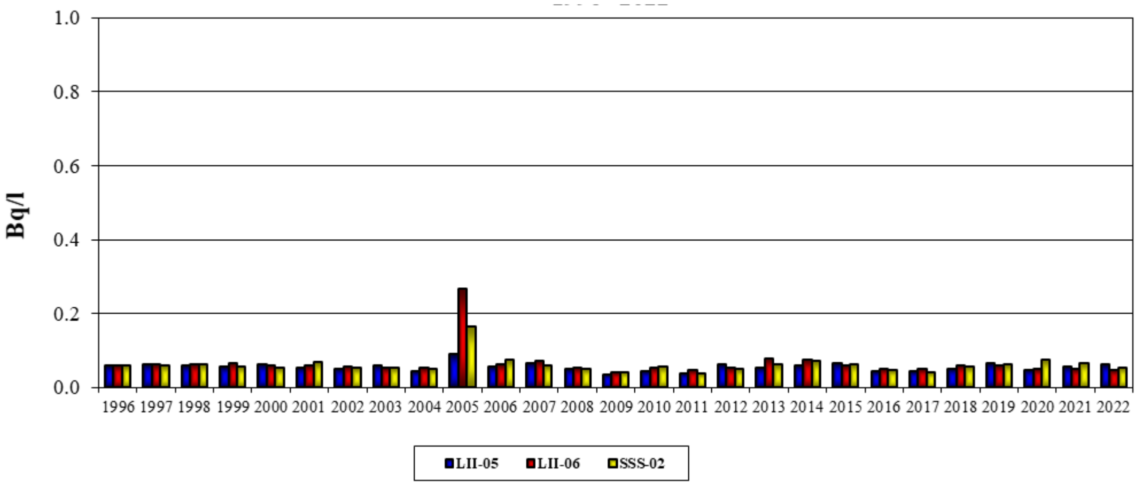


Fig. 76 The variation of the concentration of gross-beta activity in surface water samples analyzed by the radiological environmental monitoring program at Cernavoda NPP, in the period 1996 ÷ 2022

As in the case of the monitoring data presented by RNSRM, it is found that the average annual values of the gross-beta activity concentration reported by Cernavoda NPP for the period 1996-2022 were below the threshold of 2 Bq/l.

The results obtained from the gamma spectrometry analysis of surface water samples did not reveal artificial radionuclides emitting gamma radiation.

Fig. 77 shows the distribution of the average annual values of the activity concentration of tritium in the surface water samples analyzed according to the radiological environmental monitoring program at Cernavoda NPP.

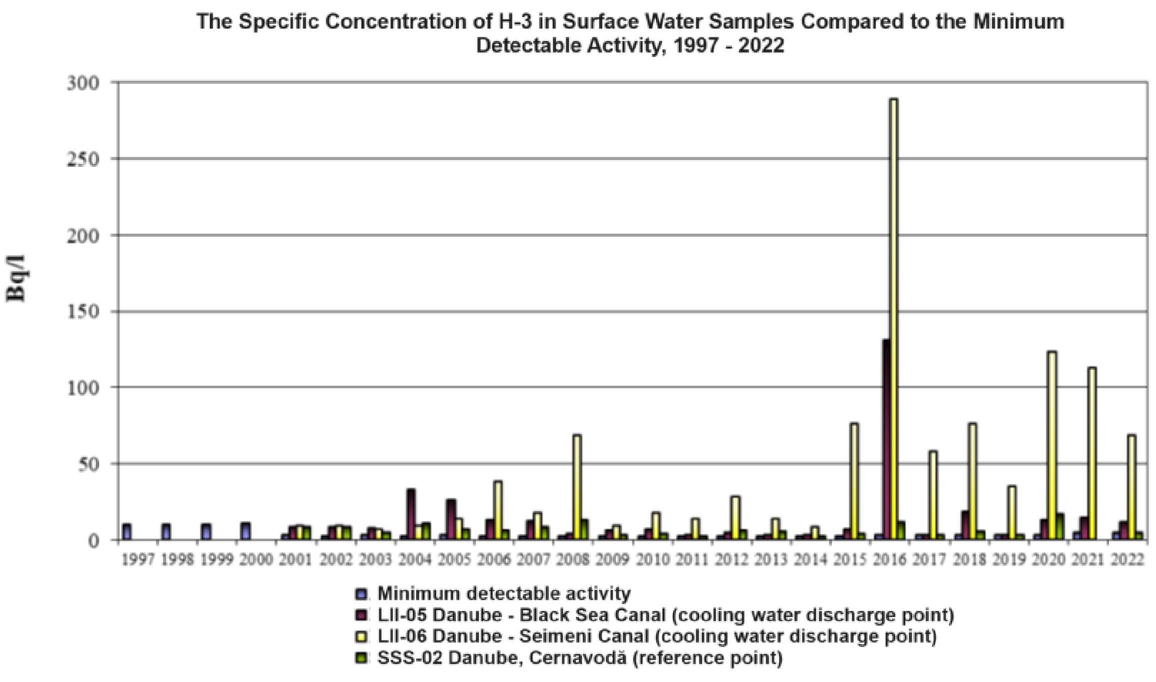


Fig. 77 The variation of the activity concentration of tritium in the surface water samples analyzed by the radiological environmental monitoring program at Cernavoda NPP, during 1996 ÷ 2022

In 2022, the average activity concentration of tritium in the surface water monitored at Cernavoda NPP was 73 Bq/l, while the maximum value recorded was 337 Bq/l, and the minimum detectable concentration was 4 Bq/l it. For the SAS-02 location – Valea Cismelei canal, the average value of the tritium activity concentration in 2022 was 5.1 Bq/l, with a monthly maximum of 5.9 Bq/l and a minimum of 4.2 Bq/l.

3.9.3.3 The radioactivity of the Danube water - results of RATEN ICN monitoring

For the purposes of this report, RATEN ICN Pitesti sampled, during the period 04-07-06-2023, surface water samples from the locations: Seimeni Discharge - Danube km 295 (N 44.380334°, E 28.04267°) and Danube upstream Saligny bridge (N 44.340017 °, E 28.019427°), on which it performed analyzes to determine: the activity concentration of tritium and the activity concentration of radionuclides emitting gamma radiation. The results of these analyzes are presented in the following table.

Tab. 67 The results of the analyzes carried out by RATEN ICN Pitesti on surface water samples sampled from the Danube in 2023

Sample name		Surface water – Seimeni discharge, Danube km 295	Surface water – Upstream of Cernavodă Bridge (Saligny Bridge)
The coordinates of the sampling location		N 44.380334°, E 28.04267°	N 44.340017°, E 28.019427°
Measurement report H-3		792/17.10.2023	793/17.10.2023
Concentration H-3 (Bq/kg)		533.4 ± 53.3	SLD
CMD H-3 (Bq/kg)		1.9	2
Gamma spectrometry measurement report		812/23.10.2023	813/23.10.2023
Activity concentration (Bq/l)	K-40	SLD	0.790 ± 0.090
	Cs-137	SLD	0.015 ± 0.003
	Tl-208	SLD	0.022 ± 0.003
	Bi-212	SLD	0.074 ± 0.023
	Pb-212	SLD	0.061 ± 0.007
	Bi-214	SLD	0.043 ± 0.007
	Pb-214	SLD	0.046 ± 0.006
	Ra-224	SLD	0.070 ± 0.013
	Ac-228	SLD	0.064 ± 0.010
CMD on the date of measurement for gamma-emitting radionuclides with T1/2 greater than 30 days, for which LDEs (Bq/l) are calculated	Mn-54	0.006	0.006
	Co-58	0.014	0.01
	Fe-59	0.056	0.03
	Co-60	0.007	0.006
	Zn-65	0.018	0.017
	Zr-95	0.028	0.02
	Ru-103	0.028	0.015
	Ru-106	0.055	0.056
	Ag-110m	0.007	0.008
	Sb-124	0.015	0.010
	Sb-125	0.013	0.014
	Cs-134	0.005	0.007
	Cs-137	0.006	0.008
	Ce-141	0.041	0.018
	Ce-144	0.023	0.021

	Eu-152	0.007	0.007
	Gd-153	0.010	0.009
	Eu-154	0.005	0.005
	Hf-181	0.025	0.013

CMD – Minimum detectable concentration

SLD – below the detection limit

From the table above, it can be seen that tritium is the only anthropogenic radionuclide generated in the plant and that was detected in the water from the monitoring location located on the Danube downstream of the confluence with the spillway (similar to location LII-06 of the monitoring of the plant). For each sample, the values of the minimum detectable concentrations of radionuclides emitting gamma radiation from the list of radionuclides for which derived emission limits are established were calculated and are presented in the table. None of these radionuclides were detected in the analyzed samples, which is in agreement with the results of the plant's monitoring program. The value recorded for the activity concentration of tritium is compatible with the range of variation of the corresponding results obtained in the environmental radioactivity monitoring program at Cernavoda NPP. Thus, for the year 2022, the monitoring report of Cernavodă NPP on the radioactivity of environmental factors (IR-96200-057) shows that for Unit 1, the average concentration of tritium in the CCW water samples (condenser cooling water discharge channel) was 198 Bq/l (maximum of 1080 Bq/l and minimum of 14 Bq/l), and for Unit 2, the average value was 240 Bq/l (maximum of 1720 Bq/l and minimum of 12 Bq/l).

Tab. 68 The results of the analyzes carried out by RATEN ICN Pitesti on the sediment samples taken from the Danube River bed in 2023

Sample name		Sediment – Seimenii Mari km 292	Sediment – Saligny Bridge
The coordinates of the sampling location		N 44.39687°, E 28.070204°	N 44.340017°, E 28.019427
Actinide measurement report		836/25.10.2023	837/25.10.2023
Pu-239/240	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	6.4	5.2
Pu-238	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	3.9	3.5
Am-241	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	5.4	5.7
Cm-244/Cm243	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	5.4	5.7
Cm-242	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	6.4	6.9
U-238	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	3.5	3.9
U-235	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	2.1	4.5

U-234	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	7	2.3
Gamma spectrometry measurement report		826/23.10.2023	827/23.10.2023
Activity concentration (Bq/kg)	K-40	587.7 ± 62	553.7 ± 59.2
	Cs-137	5.3 ± 0.7	9.7 ± 1.2
	Tl-208	12.8 ± 1.5	16.3 ± 1.8
	Bi-212	37.6 ± 6.9	62.5 ± 9.1
	Pb-212	34.5 ± 3.7	44.9 ± 4.6
	Bi-214	26.8 ± 3.0	27.6 ± 3.1
	Pb-214	28.3 ± 3.1	27.9 ± 3.0
	Ra-224	26.1 ± 4.4	47.8 ± 6.5
	Ac-228	34.8 ± 3.7	49.0 ± 5.1
	U-235	1.3 ± 0.5	1.2 ± 0.6
CMD at the measurement date for gamma-emitting radionuclides with T1/2 greater than 30 days, for which LDEs are calculated (Bq/kg)	Mn-54	1.3	1.8
	Co-58	1.2	2.6
	Fe-59	2.5	7.3
	Co-60	1.4	1.7
	Zn-65	3.4	4.7
	Zr-95	2.3	5.1
	Ru-103	1.1	3.7
	Ru-106	11.4	15.4
	Ag-110m	1.5	2.3
	Sb-124	1.1	2.6
	Sb-125	2.9	3.7
	Cs-134	1.4	1.8
	Cs-137	1.4	2.1
	Ce-141	1.2	4.6
	Ce-144	4.6	6.1
	Eu-152	1.8	2
	Gd-153	1.9	2.6
	Eu-154	1.2	1.4
	Hf-181	1.2	1.2

As part of the additional monitoring of surface water radioactivity carried out by RATEN ICN in 2023, two shore sediment samples were also taken from the locations: Saligny Bridge (the right bank of the Danube river, upstream from the confluence with the Danube - Black Sea canal) and Seimeni fluvial kilometer 292 (the right bank of the Danube river, approximately 3 km downstream from the confluence with the spillway of the plant). The results of the analyzes carried out on the sediment samples (alpha-emitting radionuclides and gamma-emitting radionuclides) are presented in Tab. 68. Based on them, it can be concluded that there is no contamination of the shore sediment with artificial radionuclides specific to the Cernavoda NPP, the presence of Cs-137 in both sediment samples being explained by the alluvial character of the analyzed material, which makes this radionuclide present in most of the collection area in the lower Danube basin, as a result of the Chernobyl accident, to be carried away by soil erosion and to manifest its presence in the sediment.

3.9.3.4 Groundwater and drinking water - results provided by the monitoring carried out by Cernavoda NPP through its own laboratory

During the operation period of the plant, the routine radiological monitoring program of the environment carried out by the Environmental Control Laboratory of Cernavoda NPP, included the following types of relevant determinations to highlight the impact on groundwater and drinking water:

Tab. 69 Types of relevant determinations for highlighting the impact on groundwater and drinking water carried out by Cernavoda NPP

Sample type	Investigation points	Type of analysis	Sampling and analysis frequency
Drinking water	Drinking water from the available supply sources in the investigation points: SSS-03 Saligny, SSS-15 Faclia and SSS-16 Seimeni and AII-03 Cernavoda	- gross-β analyses - γ spectrometry - tritium	Monthly
Infiltration water	The wells drilled at the NPP site in the DIDSR areas (SSS-08, SSS-26 and SSS-27) and DICA (SAI-01, SAI-02, SSS-24_P3, SSS-25_P4)	- gross-β analyses - γ spectrometry - tritium	Monthly
Deep underground water	Drillings with a depth of more than 500 m, inside the exclusion zone (SAF-01, SAF-02)	- gross-β analyses - γ spectrometry - tritium	Monthly

Fig. 78 and Fig. 79 show the values of the annual averages of the gross-beta activity concentration, respectively of the tritium activity concentration in the infiltration water samples analyzed within the radiological environmental monitoring program at Cernavoda NPP, during 2004 ÷ 2022.

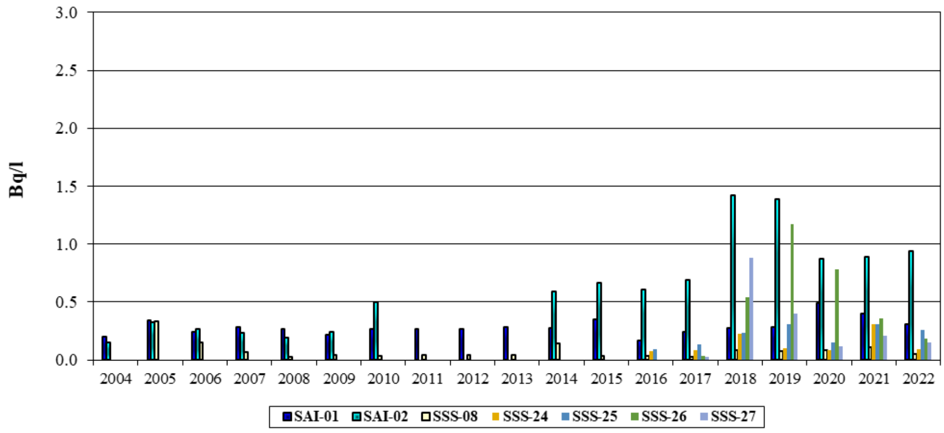


Fig. 78 The annual averages of the gross-beta activity concentration in the infiltration water samples analyzed within the radiological environmental monitoring program at Cernavoda NPP, during 2004 ÷ 2022

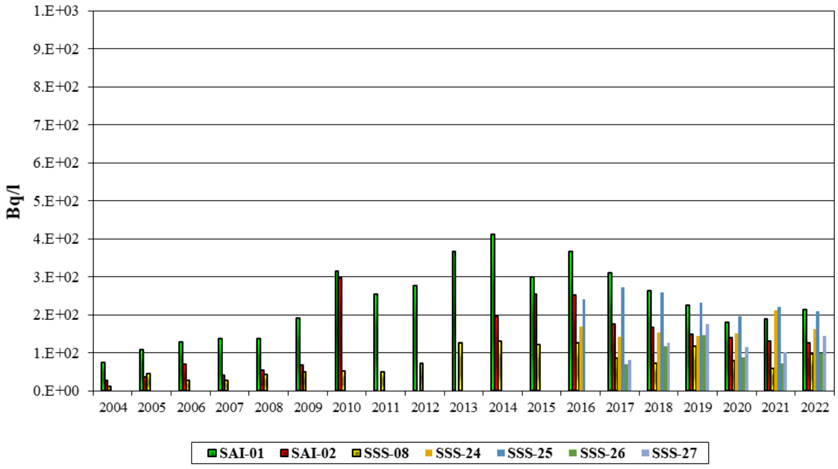


Fig. 79 The annual averages of the activity concentration of tritium in the infiltration water samples analyzed in the framework of the radiological environmental monitoring program at Cernavoda NPP, during 2004 ÷ 2022

It can be observed that between 2008 and 2014 there was a slight tendency to increase the average annual values of the concentration of tritium activity in the infiltration water samples, especially for the SAI-01 and SAI-02 locations (observation wells in the vicinity of DICA), followed by a decrease and finally stabilization of the annual average values in the following period (2015 – 2022).

Fig. 80 shows the values of the annual averages of the gross-beta activity concentration, respectively of the tritium activity concentration in deep water samples analyzed within the radiological environmental monitoring program at Cernavoda NPP, in the period 2004 ÷ 2022.

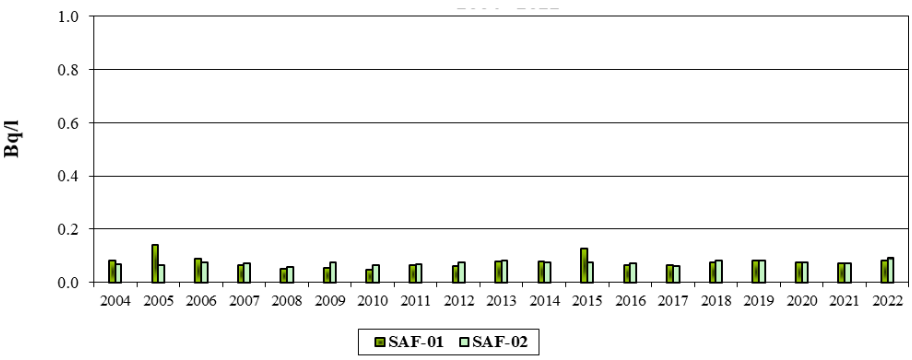


Fig. 80 Annual averages of gross-beta activity concentration in deep water samples analyzed in the framework of the radiological environmental monitoring program at Cernavoda NPP, during 2004 ÷ 2022

It can be noticed that the annual average values of the gross-beta activity concentration in deep water were kept at a constant level during the reporting period. Also, in the report on the environmental radioactivity monitoring, it is shown that, for the deep water samples, the gamma spectrometry analyzes did not reveal the presence of artificial radionuclides specific to the CANDU reactor, and the analyzes for determining the activity concentration of tritium were below detection limit. **Based on these results, it can be concluded that the deep waters in the area of influence of the plant are not radiologically affected by the activities on the Cernavoda NPP platform**.

Fig. 81 and Fig. 82 show the values of the annual averages of the gross-beta activity concentration in the drinking water samples analyzed within the radiological environmental monitoring program at Cernavoda NPP, during 2007 ÷ 2021, respectively in 2022.

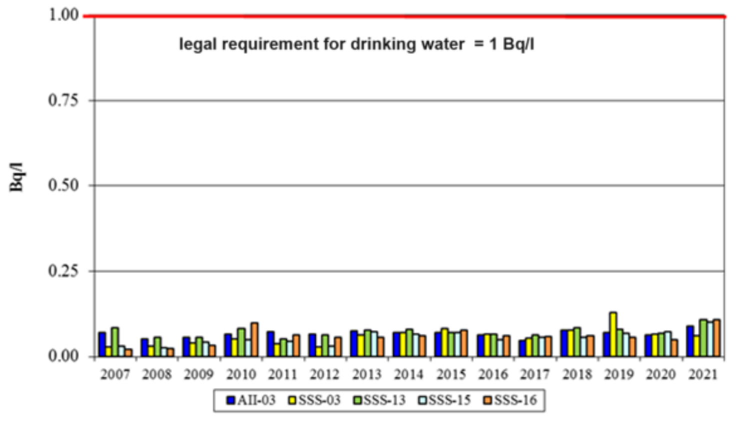


Fig. 81 Annual averages of gross-beta activity concentration in drinking water samples analyzed in the framework of the radiological environmental monitoring program at Cernavoda NPP, during 2007 ÷ 2021

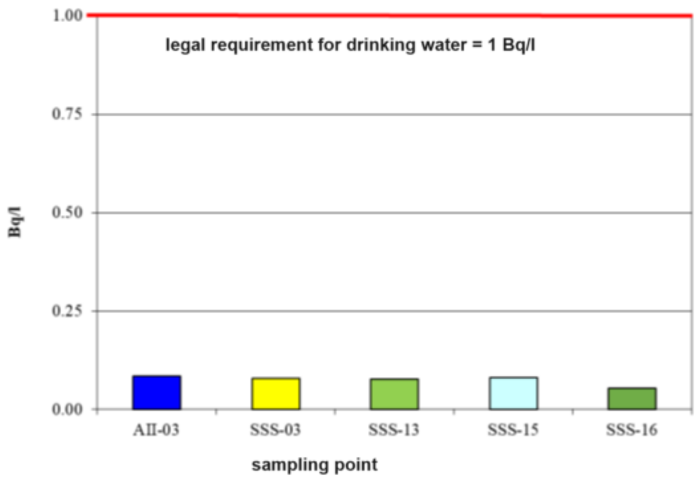


Fig. 82 Annual averages of gross-beta activity concentration in drinking water samples analyzed in the framework of the radiological environmental monitoring program at Cernavoda NPP, in 2022

Fig. 83 shows the annual averages of the activity concentration of tritium in the drinking water samples analyzed during 2007 ÷ 2002.

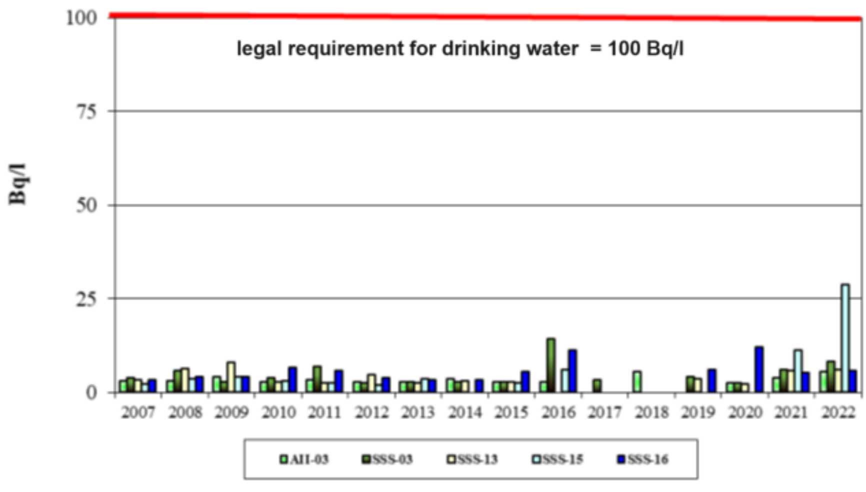


Fig. 83 Annual averages of tritium activity concentration in drinking water samples analyzed in the framework of the radiological environmental monitoring program at Cernavoda NPP, during 2007 ÷ 2022

The results presented above show that, during the monitoring period, the quality parameters related to the radioactive content of drinking water were within the legal limits for all monitored sources.

3.9.3.5 Undergroundwater and drinking water - results provided by additional monitoring activites

During 2020 - 2021, drinking water and deep groundwater were characterized from a radiological point of view, as part of an additional monitoring activitiy carried out in order to analyze the impact on the environment as a result of the implementation of the CTRF project. As part of this monitoring activity, water samples were taken from the LCM locations (the drinking water supply network of the city of Cernavoda) and on-site wells. The results of the analyzes carried out by the laboratories of ICSI Rm. Valcea and RATEN ICN Pitesti are presented in the table below.

Tab. 70 The results of the analyzes carried out by ICSI Rm. Valcea and RATEN ICN Pitesti on drinking water samples taken during 2020-2021

Measured parameter	**Drinking water LCM**	**Ground water on-site drilling**
Activity concentration H-3 (Bq/l)	< 0.4	< 0.4
Activity concentration C-14 (Bq/g C)	0.204 ± 0.016	0.026 ± 0.006
Gross-beta activity concentration (Bq/l)	<0.03	0.06 ± 0.03
Activity concentration gamma emitting radionuclides (Bq/l)	SLD	SLD
Activity concentration Pu-239/240 (mBq/l)	< 0.7	< 0.8
Activity concentration Pu-238 (mBq/l)	< 0.7	< 0.8
Activity concentration Am-241 (mBq/l)	< 0.9	< 0.8
Activity concentration U-238 (mBq/l)	13.5 ± 2	8.9 ± 1.6
Activity concentration U-235 (mBq/l)	< 0.7	< 0.7
Activity concentration U-234 (mBq/l)	23.9 ± 2.9	6.8 ± 1.3

The radiological monitoring of drinking water sources in the area of influence of the plant was continued in 2023 through a set of analyzes carried out by RATEN ICN Pitesti. The results of this monitoring activity are presented in the next table.

Tab. 71 The results of the analyzes carried out by RATEN ICN Pitesti on drinking water samples, in 2023

Sample name		Drinking water - Faclia well	Drinking water – NPP Environmental Control Laboratory
The coordinates of the sampling location		N 44.278112°, E 28.104226°	N 44.336046°, E 28.037491°
Measurement report H-3		794/17.10.2023	795/17.10.2023
Concentration H-3 (Bq/kg)		SLD	SLD
CMD H-3 (Bq/kg)		1.9	1.9
Gamma spectrometry measurement report		814/23.10.2023	815/23.10.2023
Activity concentration (Bq/l)	Radionuclide		
	K-40	SLD	SLD
	Cs-137	SLD	SLD
	Tl-208	SLD	SLD
	Bi-212	SLD	SLD
	Pb-212	SLD	SLD

Sample name		Drinking water - Faclia well	Drinking water – NPP Environmental Control Laboratory
	Bi-214	SLD	SLD
	Pb-214	SLD	SLD
	Ra-224	SLD	SLD
	Ac-228	SLD	SLD
CMD at the date of measurement for gamma-emitting radionuclides with T1/2 greater than 30 days, for which LDEs are calculated (Bq/l)	Mn-54	0.031	0.031
	Co-58	0.054	0.055
	Fe-59	0.183	0.177
	Co-60	0.035	0.025
	Zn-65	0.083	0.084
	Zr-95	0.105	0.105
	Ru-103	0.086	0.089
	Ru-106	0.269	0.271
	Ag-110m	0.035	0.033
	Sb-124	0.055	0.056
	Sb-125	0.064	0.063
	Cs-134	0.026	0.026
	Cs-137	0.031	0.030
	Ce-141	0.115	0.116
	Ce-144	0.111	0.111
	Eu-152	0.034	0.035
	Gd-153	0.045	0.045
	Eu-154	0.024	0.025
	Hf-181	0.080	0.081

CMD – Minimum detectable concentration
SLD – below the detection limit

Based on the results presented above, it can be stated that the sources of drinking water, including deep groundwater in the area of influence of Cernavoda NPP are not affected by the plant's activities, they fall within the legal limits from the point of view of the relevant quality indicators to the radioactive content.

3.9.3.6 Soil – results provided by the monitoring carried out by Cernavoda NPP through its own laboratory

Between 1996 ÷ 2022, soil samples from 7 sampling locations were analyzed in the Environmental Control Laboratory of Cernavoda NPP, of which five locations were added to the monitoring program starting 2004 (see the table below).

Tab. 72 Soil radioactivity investigation points - according to the approved monitoring program of Cernavoda NPP

Investigation point	Location type	Year of inclusion in the monitoring program	Current sampling/analysis frequencies
LDI-01 Mircea Voda Irrigated land	Location Indicator	1996	Biannual/Biannual
LDI-02 Seimeni Irrigated land	Location Indicator	1996	Biannual/Biannual
SSL-01 Cernavoda NPP DICA_soil sampling	Location Indicator	2004	Biannual/Biannual

Investigation point	Location type	Year of inclusion in the monitoring program	Current sampling/analysis frequencies
SSS-10 Cernavoda NPP U1 protected perimeter	Location Indicator	2004	Biannual/Biannual
SSS-11 Cernavoda Grape farm	Location Indicator	2004	Biannual/Biannual
SSS-13 Cernavoda Environmental Control Laboratory	Location Indicator	2004	Biannual/Biannual
SSS-12 Topalu	Reference Location	2004	Biannual/Biannual

In 2022, 14 soil samples from the 7 sampling locations were analyzed, in which natural gamma-emitting radionuclides were detected (K-40, Ac-228, Bi-212, Bi-214, Pb-212 and Pb-214 , U-235, Th 228, Ra-224) as well as the artificial radionuclide Cs-137 with an average specific activity of 3.31 Bq/kg. It should be noted that Cs 137 was constantly detected in all soil samples taken during the Preoperational Program, after 1986 (the Chernobyl accident). After the deposition period, in May 1986, a general trend of decreasing concentrations was observed up to values of the order of Bq/kg.[114]

The following graph shows the variation of average concentrations of Cs-137 in soil samples. The pre-operational value represents the average for the period 1984 - 1993 recorded for the monitoring points Cernavoda, Saligny, Faclia.

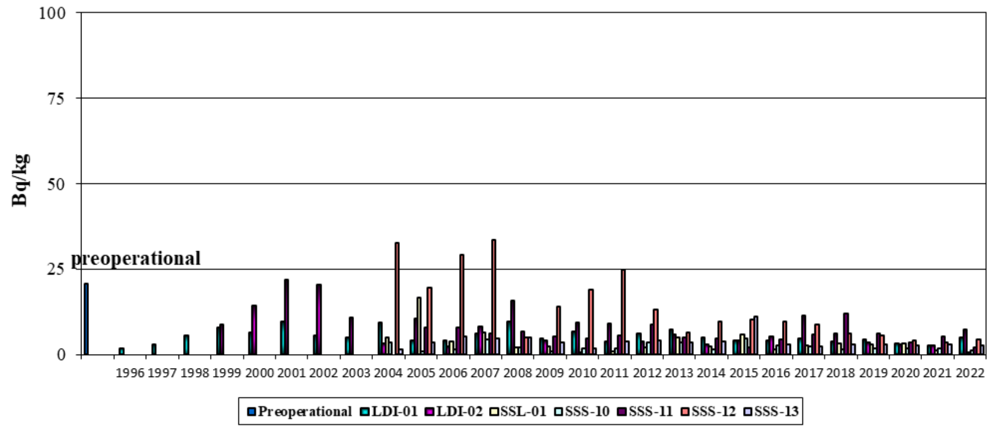


Fig. 84 The evolution of the average concentrations of Cs-137 in the soil samples investigated by the Environmental Control Laboratory of Cernavoda NPP, in relation to the levels in the pre-operational stage

The activity concentration values of Cs-137 in the analyzed soil samples are comparable to the average value recorded in the pre-operational program. Since the deposits of Cs-137 that resulted from the Chernobyl accident were uneven, and the migration of this radionuclide into the soil is strongly influenced by the type of soil and its use, the activity concentration values of Cs-137 in the

[114] Cernavoda NPP, Results of environmental factors and radioactivity level monitoring in Cernavoda area, during 1996 – 2022, Doc. IR-96200-057 Rev. 0

monitored locations they had a fluctuating character over time, with an obvious tendency to decrease as a result of the decay of the radionuclide and its dilution due to the migration process.

The following figure shows the evolution of the annual averages of the gross-beta activity in the soil, according to the results obtained through the analyzes carried out by the Environmental Control Laboratory of Cernavoda NPP.

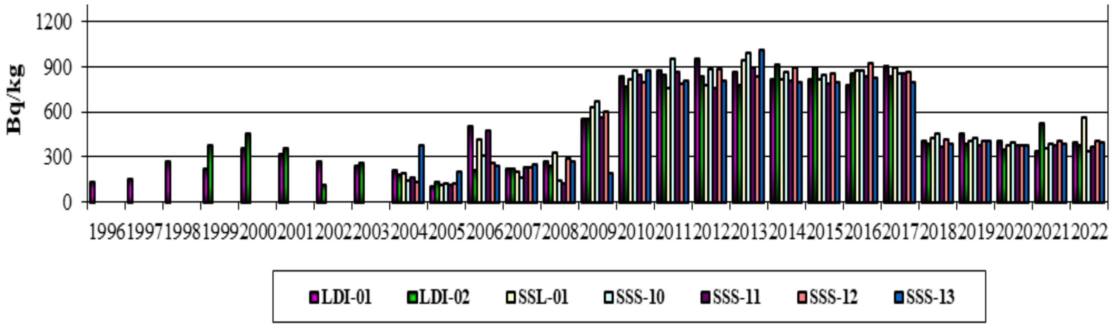


Fig. 85 Evolution of gross-beta activity - annual averages - in soil samples analyzed by the Environmental Control Laboratory of Cernavoda NPP

It is found **that the evolution of the gross-beta activity in the indicator locations follows the variation of the gross-beta activity for the reference point, with a tendency to maintain** in the range of 800 – 1000 Bq/kg in the period 2010 – 2017 and then **at 300 – 600 Bq/kg in the period 2018 – 2022.** The discontinuity of the reported values regarding the concentration of gross-beta activity in the soil samples, at the level of 2018, manifested otherwise also in the pre-operational stage (see the results of the years 1987 and 1988 in relation with the rest of the period), can be explained through a change in the data processing method in the analysis stage, possibly as a result of the change in the radionuclide in relation to which the gross-beta activity was reported. Maintaining a constant and quasi-unity ratio between the concentration of gross-beta activity in the samples from the indicator locations and that from the reference location shows that during the monitored period there was no change in the level of soil radioactivity (the activity of beta-emitting radionuclides with energy higher than 200 keV) as a result of the activities on the Cernavoda NPP platform. Moreover, values comparable to those obtained in the environmental monitoring program from 2018 to 2022 were also reported in the additional study of radiological characterization of environmental factors carried out for the purpose of analyzing the environmental impact of the construction project of the tritium removal facility from Cernavoda NPP, study in which, following the measurements carried out by ICSI Rm. Valcea, values of the concentration of gross-beta activity in the soil were reported in the range of 500 – 600 Bq/kg.

Fig. 86 shows the evolution of the annual average concentrations of tritium in the soil samples analyzed by the Environmental Control Laboratory of Cernavoda NPP in the interval 2005 ÷ 2022.

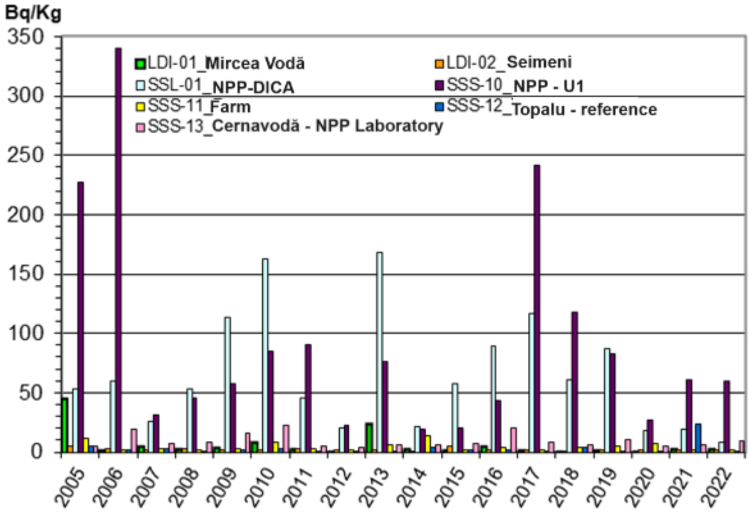


Fig. 86 The evolution of the average annual activities of tritium in the soil samples investigated by the Environmental Control Laboratory of Cernavoda NPP in the interval 2005 ÷ 2022

The highest activities of tritium in the soil were determined for the indicator locations in the protected perimeter of U1 (SSS-10) and the DICA area (SSL-01), indicator locations located in the vicinity of tritium emission sources in the atmosphere - **points located on the platform Cernavoda NPP**. The distribution of the specific activities of tritium in the soil indicates tritium emissions into the atmosphere as the main source for tritium in the soil, mainly through atmospheric deposition and downwash phenomena. Also, **no trend of constant increase in tritium concentration in the soil can be found in any of the investigation points**.

3.9.3.7 Soil – results provided by RNSRM

The multi-annual variation of the annual averages and maximums of the gross-beta activity of uncultivated soil samples, recorded at SSRM Constanta and SSRM Cernavoda within the Standard Environmental Radioactivity Monitoring Program, is presented in Fig. 87. Sampling was carried out with weekly frequency, and gross-beta measurement was done five days after collection.

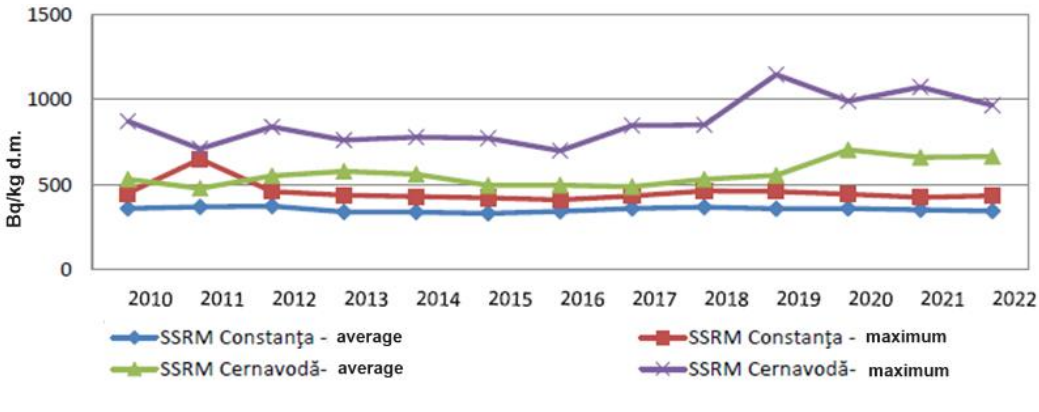


Fig. 87 The multiannual variation of the gross-beta activity of uncultivated soil, according to the County Report on the state of the environment for the year 2022, published by EPA Constanta

As part of the special monitoring programs coordinated by APM Constanta, determinations of gross-beta activity and gamma spectrometry analyzes were carried out for samples of uncultivated soil and arable soil from sampling points arranged in the zone of influence of Cernavoda NPP.

In the analyzed samples, radionuclides from the natural radioactive series, K-40 and the artificial radionuclide Cs-137, whose presence in the soil is due to the Chernobyl accident, were identified. The ranges of variation of K-40 and Cs-137 concentrations in the soil in the area of influence of the Cernavoda NPP are presented synthetically in Fig. 88.

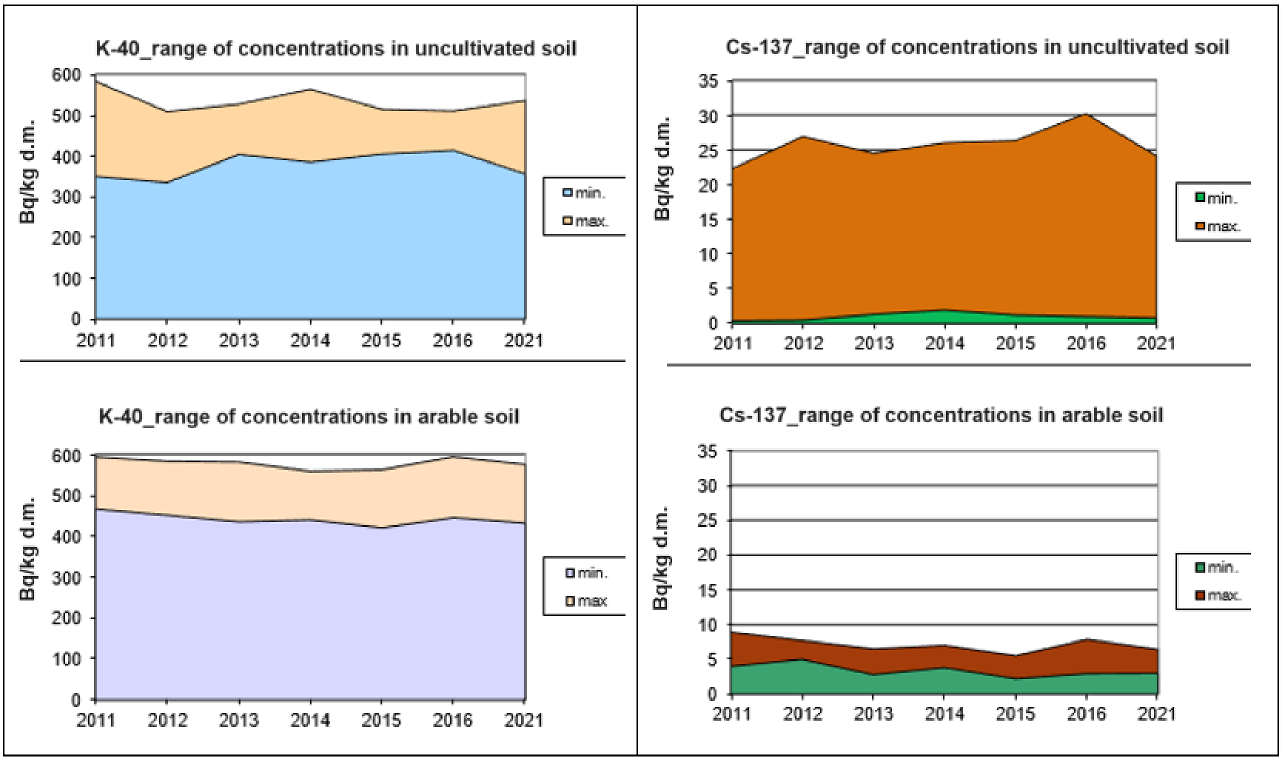


Fig. 88 The ranges of variation of the concentrations of radionuclides K-40 and Cs-137 in the soil in the area of influence of Cernavoda NPP - synthesis of public data from the annual reports on the state of the environment drawn up by EPA Constanta for the years 2011÷2016, 2021 (Bq/kg d.s.)

3.9.3.8 Soil – results provided by additional monitoring activities

As part of the additional monitoring activites carried out in 2023 by RATEN ICN, soil samples were taken at two depths (0-10 cm and 20-30 cm) from a location located in the vicinity of DICA and from a location located in the vicinity of Ostrov town (Constanta county). The selection of the two locations was made so that the additional radiological characterization would include results regarding the radioactivity present in the soil in the vicinity of the facilities that are the subject of this assessment (Unit 1 and DICA), but at the same time to respond to a request from the Bulgarian authorities regarding the presentation of data concerning the impact of Cernavoda NPP activities on the population of this country. The analyzes carried out by RATEN ICN, on the samples taken, included: determination of the activity concentration of tritium in free water extracted from the soil, determination of the activity concentration of alpha-emitting radionuclides (isotopes of U, Pu, Am and Cm) and determination of the activity concentration of gamma-emitting radionuclides. The results of these determinations are presented in the following table.

Tab. 73 The results of the radiological characterization of the soil samples taken by RATEN ICN in 2023

Sample name		DICA Soil 0-10 cm	DICA Soil 20-30 cm	Ostrov Soil 0-10 cm	Ostrov Soil 20-30 cm
The coordinates of the sampling location		N 44.323457°, E 28.053836°	N 44.323457°, E 28.053836°	N 44.104891°, E 27.390626°	N 44.104891°, E 27.390626°
Measurement report H-3		796/17.10.2023	797/17.10.2023	798/17.10.2023	799/17.10.2023
Concentration H-3 (Bq/kg fw)		516.2 ± 51.6	240.7 ± 24.1	SLD	SLD
CMD H-3 (Bq/kg fw)		1.7	1.7	5.2	5.2
Actinide measurement report		828/25.10.2023	829/25.10.2023	830/25.10.2023	831/25.10.2023
Pu-239/240	Concentration (mBq/g)	SLD	SLD	SLD	SLD
	CMD (mBq/g)	4.1	7.2	3.5	5.1
Pu-238	Concentration (mBq/g)	SLD	SLD	SLD	SLD
	CMD (mBq/g)	4.5	4.5	3.9	2.8
Am-241	Concentration (mBq/g)	SLD	SLD	SLD	SLD
	CMD (mBq/g)	7.8	7.8	4.5	3.4
Cm-244/Cm243	Concentration (mBq/g)	SLD	SLD	SLD	SLD
	CMD (mBq/g)	7.8	7.8	4.5	3.4
Cm-242	Concentration (mBq/g)	SLD	SLD	SLD	SLD
	CMD (mBq/g)	9.3	9.3	5.4	4
U-238	Concentration (mBq/g)	15.2 ± 2.9	27.1 ± 4.9	23.9 ± 3.7	29.4 ± 4.2
	CMD (mBq/g)	2	3.2	2.1	2
U-235	Concentration (mBq/g)	2.3 ± 1.1	5.9 ± 2.2	2.4 ± 1.1	SLD
	CMD (mBq/g)	1.2	1.9	1.2	1.4
U-234	Concentration (mBq/g)	21.3 ± 3.4	21.4 ± 4.3	20.6 ± 3.4	24.7 ± 3.8
	CMD (mBq/g)	1.2	1.9	1.2	1.4
Gamma spectrometry measurement report		816/23.10.2023	817/23.10.2023	818/23.10.2023	819/23.10.2023
Activity concentration (Bq/kg)	K-40	529.2 ± 55.4	537.5 ± 56.6	657 ± 69.1	666.5 ± 70.5
	Cs-137	SLD	SLD	8.5 ± 1.0	8.7 ± 1.1
	Tl-208	9.8 ± 1.1	9.0 ± 1.0	15.0 ± 1.6	15.0 ± 1.7
	Bi-212	29.2 ± 3.8	30.2 ± 4.8	45.7 ± 6.8	41.0 ± 7.4
	Pb-212	24.7 ± 2.6	22.8 ± 2.4	41.0 ± 4.2	42.4 ± 4.4
	Bi-214	23.5 ± 2.5	20.5 ± 2.3	26.5 ± 2.9	24.4 ± 3.1
	Pb-214	23.4 ± 2.4	19.1 ± 2.0	27.9 ± 2.9	28.7 ± 3.2
	Ra-224	SLD	21.9 ± 3.5	33.2 ± 4.8	37.3 ± 5.7
	Ac-228	29.1 ± 3.0	28.6 ± 3.0	41.4 ± 4.3	46.6 ± 4.9
	U-235	1.5 ± 0.3	1.5 ± 0.4	1.7 ± 0.5	2.0 ± 1.0
CMD at the measurement date for gamma-emitting radionuclides with $T_{1/2}$ greater	Mn-54	0.7	1.1	1.3	1.7
	Co-58	1	1.5	1.9	2.5
	Fe-59	2.6	4.1	5.2	6.9
	Co-60	0.7	0.9	1.3	1.6
	Zn-65	1.8	2.9	3.5	4.7
	Zr-95	1.9	3	3.7	4.9

Sample name		DICA Soil 0-10 cm	DICA Soil 20-30 cm	Ostrov Soil 0-10 cm	Ostrov Soil 20-30 cm
than 30 days, for which LDEs are calculated (Bq/kg)	Ru-103	1.3	2	2.5	3.4
	Ru-106	5.8	9.3	11.7	15.4
	Ag-110m	0.7	1.2	1.8	2.4
	Sb-124	0.9	1.5	1.9	2.5
	Sb-125	1.4	2.3	2.9	3.7
	Cs-134	0.7	1.1	1.3	1.8
	Cs-137	0.7	1.2	1.4	1.9
	Ce-141	1.6	2.5	3.3	4.5
	Ce-144	2.4	3.9	4.9	6.4
	Eu-152	0.8	1.3	1.6	2.1
	Gd-153	1	1.6	2.1	2.7
	Eu-154	0.6	0.9	1.2	1.5
	Hf-181	1.3	2	2.6	3.5

CMD – Minimum detectable concentration
SLD – below the detection limit

The results presented above show that there is no radioactive contamination in the soil at the DICA location, with radionuclides emitting alpha or gamma radiation specific to the plant, and the presence of tritium in the free water in the soil, at the higher concentration levels, is explainable, this being in accordance with the values of the activity concentration of tritium from the water vapor present in the air in the vicinity of the plant. At the same time, the results of soil radioactivity monitoring carried out by RATEN ICN in the Ostrov location show that there is no radiological impact on the soil in this location, as a result of the plant's activities. Since the Ostrov location is located, near the border with Bulgaria, at the closest point to the Cernavoda NPP, by extrapolation we can conclude that the soil on the territory of Bulgaria is not affected from a radiological point of view as a result of the normal operation of the Cernavoda NPP.

3.9.3.9 Air – results provided by the monitoring activities carried out by Cernavoda NPP through its own laboratory

The radiological monitoring of air quality in the zone of influence of Cernavoda NPP was carried out through continuous sampling in 13 locations located as follows: four locations at distances greater than 10 km from the plant, three locations at distances between 5 and 10 km, three locations between 1 and 5 km and three locations inside the exclusion zone. The results regarding the monitoring of gross-beta activity in the air, during 1996 – 2022, are presented in Fig. 89 ÷ Fig. 92.

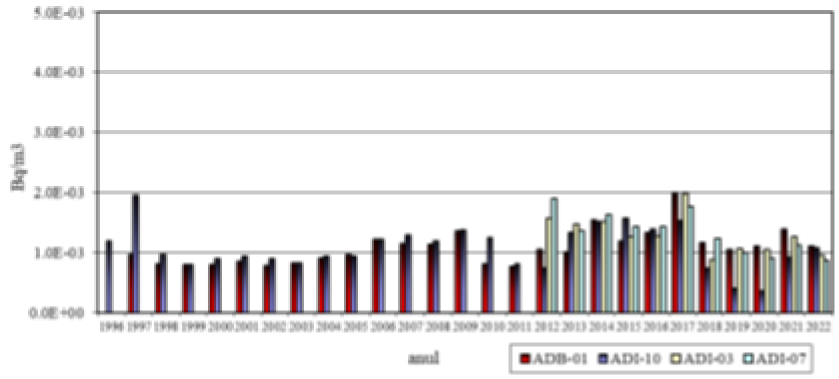


Fig. 89 Annual averages of gross-beta activity concentration in air at locations greater than 10 km from the plant

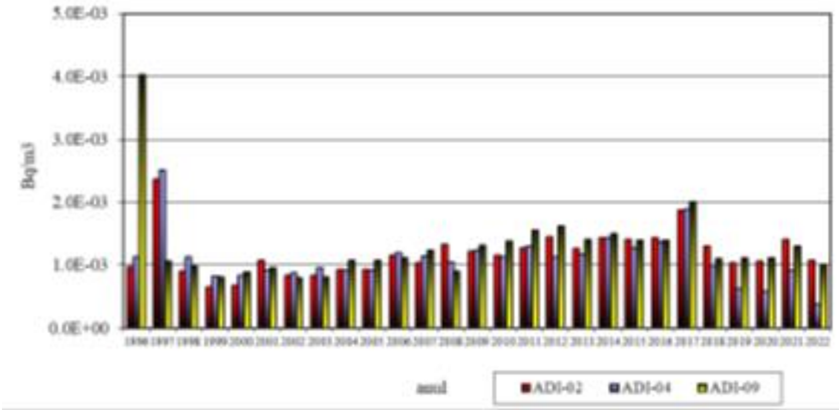


Fig. 90 Annual averages of gross-beta activity concentration in air at locations located at distances between 5 and 10 km from the plant

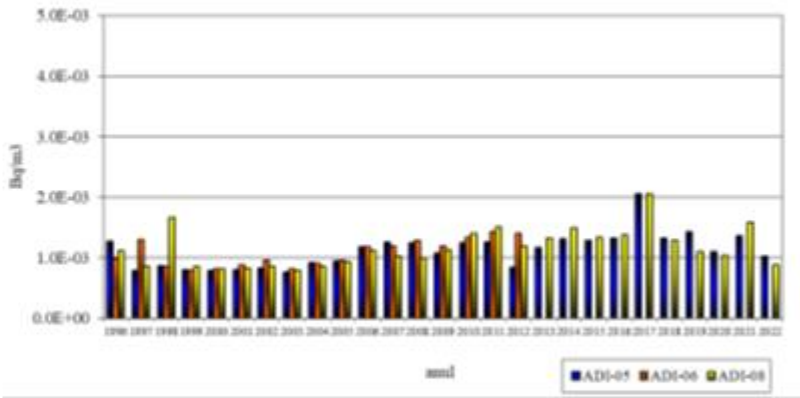


Fig. 91 Annual averages of gross-beta activity concentration in air at locations located at distances between 1 and 5 km from the plant

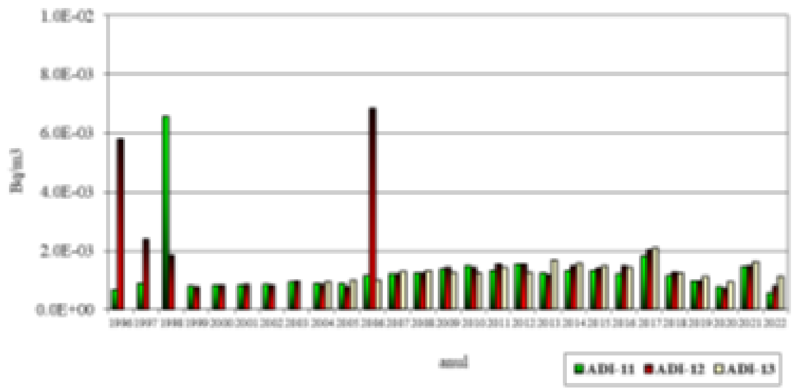


Fig. 92 Annual averages of gross-beta activity concentration in air at locations located at in the exclusion zone of the plant

Analyzing the above results, as well as the evolution of the monthly values of gross-beta activity concentrations reported in 2022 (see Fig. 93), through the environmental radioactivity monitoring program, it can be concluded that, under normal operating conditions, the emissions of gaseous effluents from the power plant do not lead to the contamination of the air with radioactive particles in the area of influence of Cernavoda NPP (the time variation profile of the results for all indicator locations is similar to that corresponding to the reference location, within the limits of fluctuations due to measurement uncertainty). For some locations on the site, in certain periods in the past (1996-1998, 2008) higher values of the parameter related to the concentration of beta-global activity in the air were recorded, which, however, are justified by the works executed in the vicinity of the respective monitoring locations, which led to the generation of high concentrations of dust in the air.

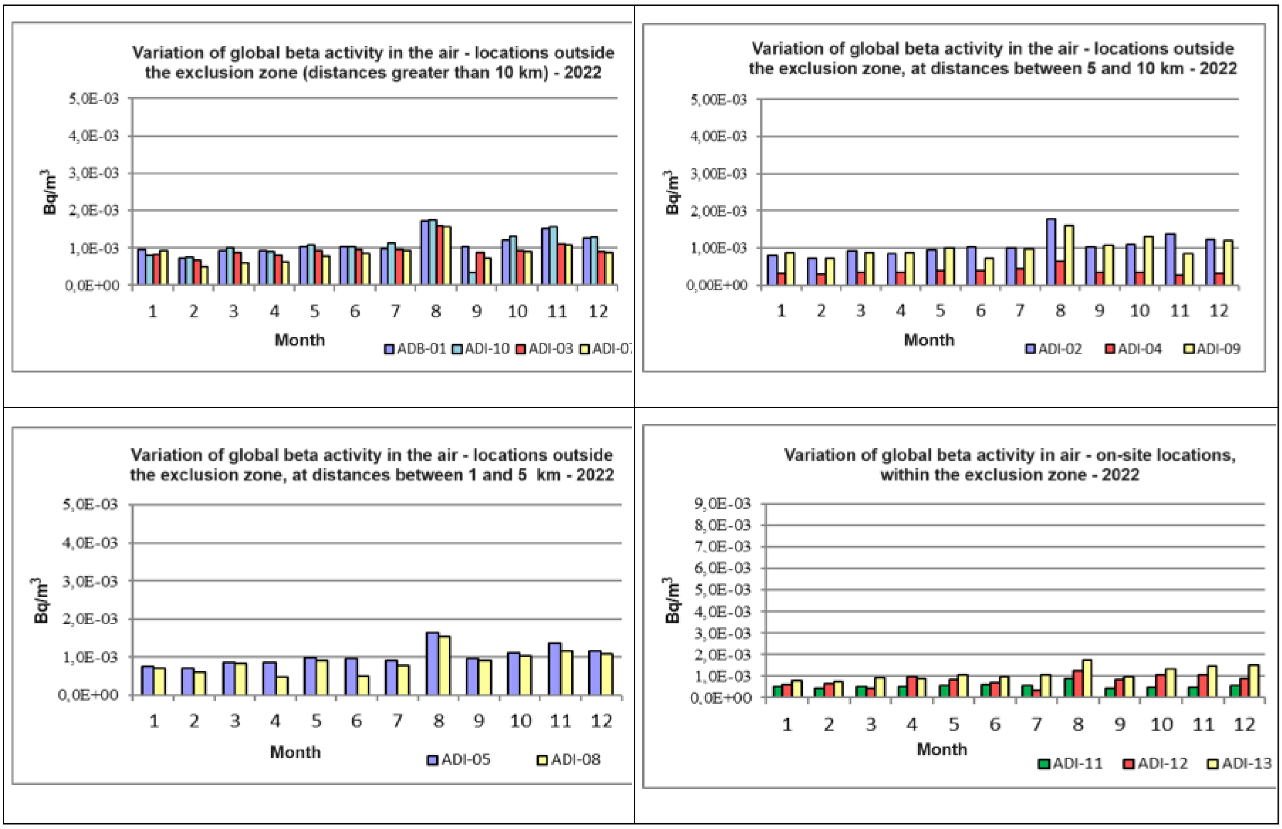
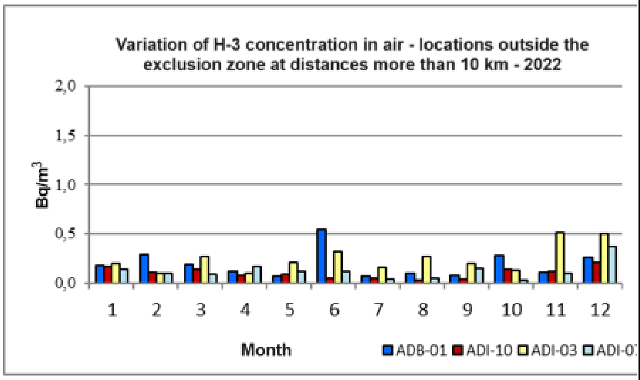
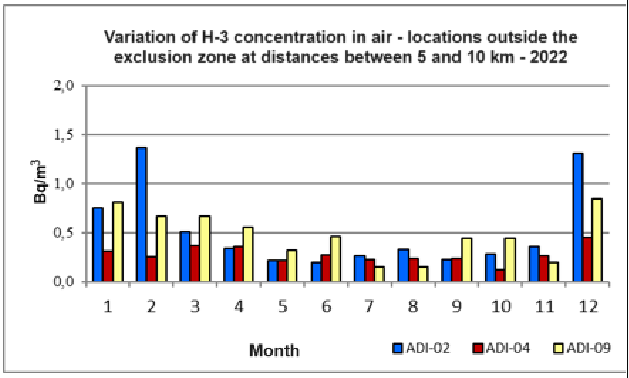
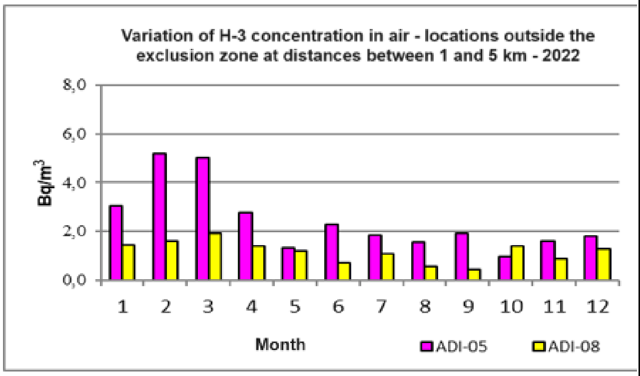


Fig. 93 The evolution of the concentration of gross-beta activity in the air, according to the results of the environmental radioactivity monitoring program for the year 2022

The thirteen monitoring locatios are also used for sampling to determine the activity concentration of tritium in air. The annual averages of the tritium activity concentration values in the air, recorded in the period 1997 ÷ 2022 in the locations of the environmental radioactivity monitoring program at Cernavoda NPP, are presented in Fig. 94– Fig. 97. Also,







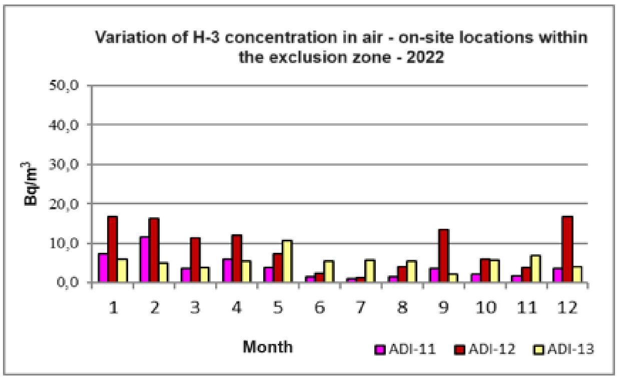


Fig. ***98*** shows the evolution of the monthly values of the tritium concentration in the air, recorded in 2022.

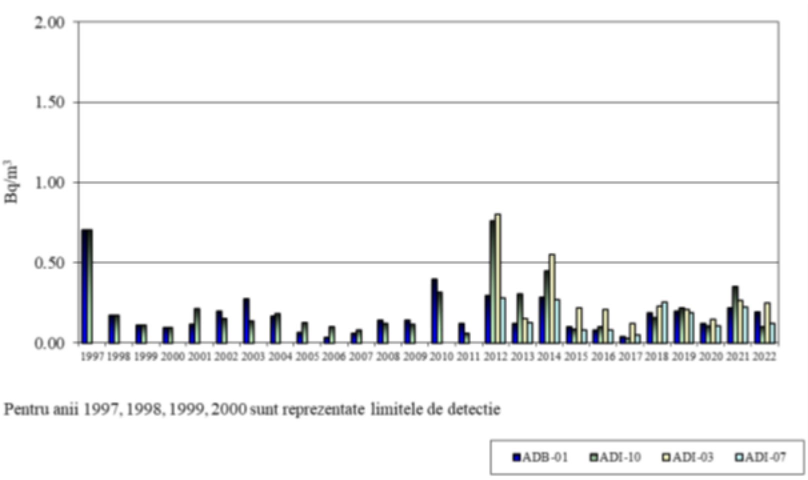


Fig. 94 Annual averages of tritium activity concentration in the air, in the interval 1996 - 2022, for monitoring locations located at distances greater than 10 km from the plant

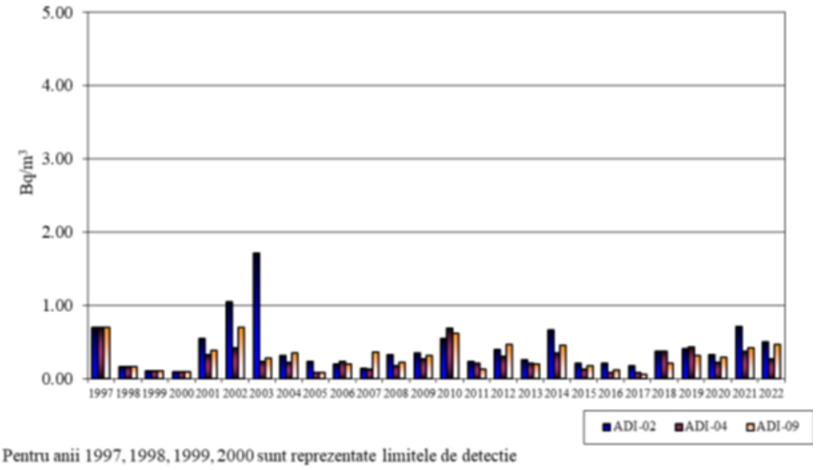


Fig. 95 Annual averages of tritium activity concentration in the air, in the interval 1996 - 2022, for monitoring locations located at distances between 5 and 10 km from the plant

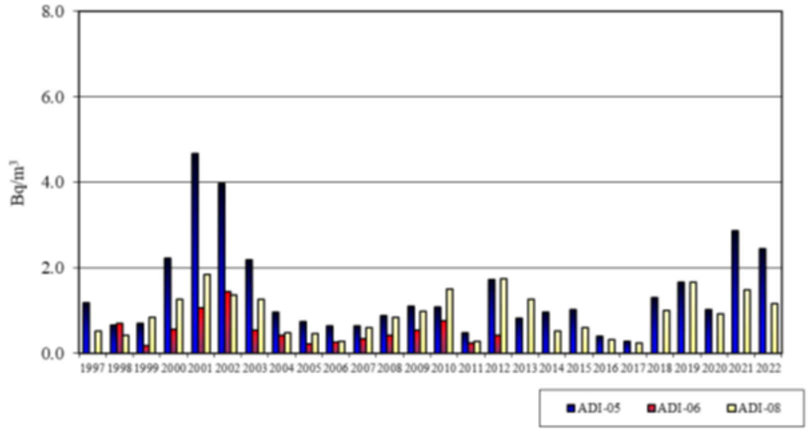


Fig. 96 Annual averages of tritium activity concentration in the air, in the interval 1996 - 2022, for monitoring locations located at distances between 1 and 5 km from the plant

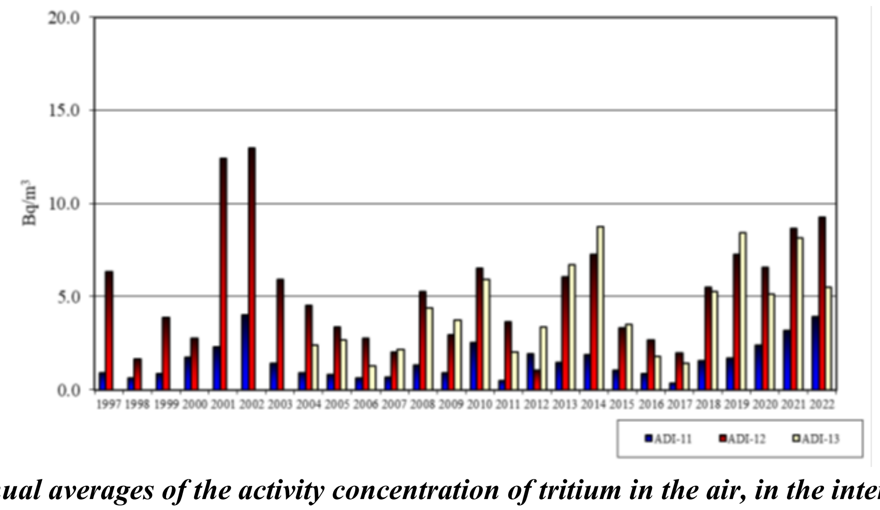


Fig. 97 The annual averages of the activity concentration of tritium in the air, in the interval 1996 - 2022, for the monitoring locations located inside the exclusion zone of Cernavoda NPP

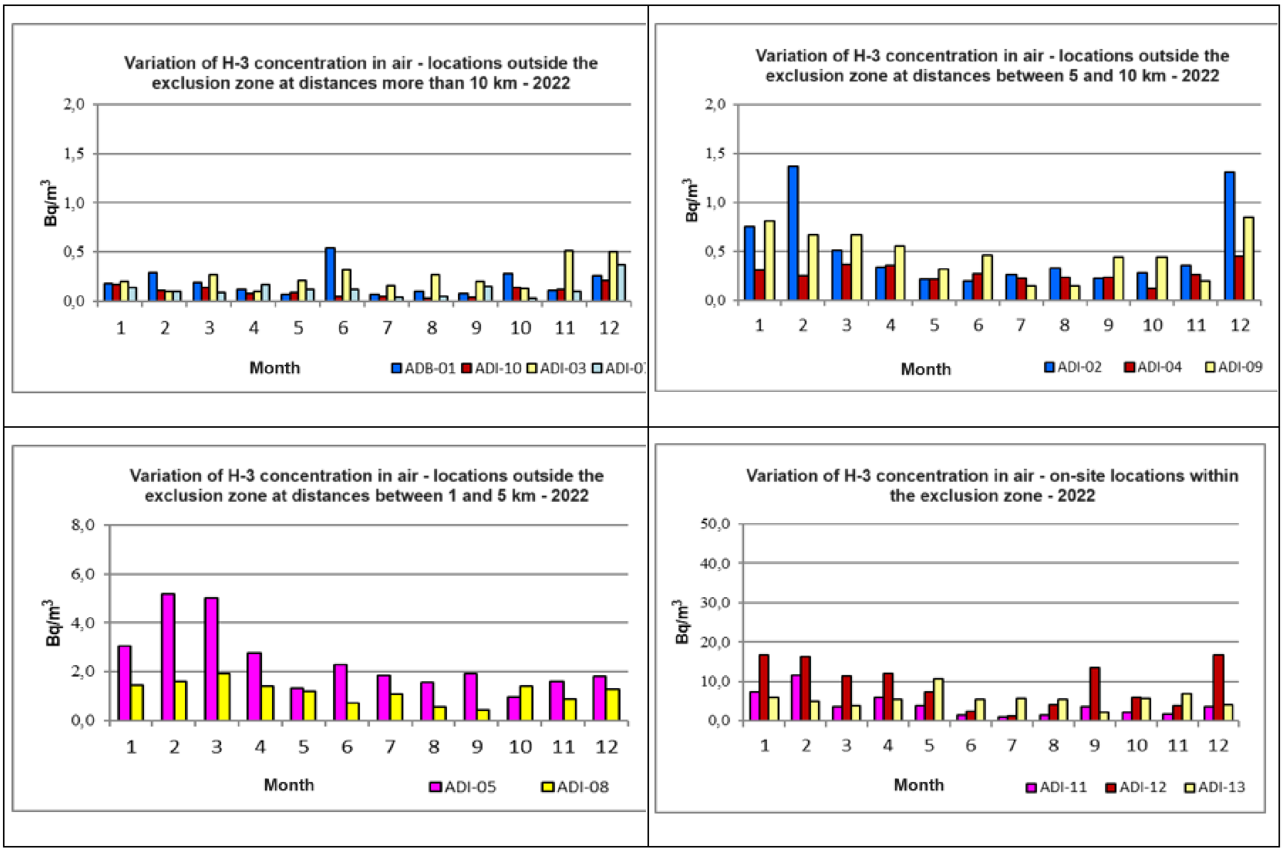


Fig. 98 The monthly values of the activity concentration of tritium in the air, recorded in 2022, for the monitoring locations in the area of influence of Cernavoda NPP

The above results indicate a correlation between the tritium activity concentration values with the distance from the source, in agreement with the pollutant dispersion model. However, if, conservatively, the highest value of the activity concentration of tritium recorded by the environmental monitoring program in locations outside the exclusion zone (< 5 Bq/m^3) would be used for the calculation of the reference person's exposure, an annual dose of less than 1 microSv would be obtained, which is insignificant relative to the approved dose constraint for the plant.

3.9.3.10 Air - results provided by additional monitoring activities

The additional monitoring activities carried out by RATEN ICN Pitesti, in 2023, included the collection of an aerosol sample from a location in the vicinity of DICA, as well as the collection of a particle filter from the gaseous effluent monitoring system from Unit 1, made available by the personnel of the technical - radiation protection service of the plant. The analyzes carried out on the two samples consisted in the determination of the content of alpha-emitting radionuclides and the determination of the content of gamma-emitting radionuclides, with reporting the results in the form of activity concentrations in the air (see the table below).

Tab. 74 The results of the radiological characterization of the aerosol samples taken by RATEN ICN in 2023

Sample name		Aerosol filter ventilation stack Unit 1	Aerosol filter NPP- DICA site
The coordinates of the sampling location		N/A	N 44.323457°, E 28.053836°
Actinide measurement report		834/25.10.2023	835/25.10.2023
Pu-239/240	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.3	1.7
Pu-238	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.1	0.5
Am-241	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.1	0.5
Cm-244/Cm243	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.1	0.5
Cm-242	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.1	0.6
U-238	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.2	0.9
U-235	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.1	0.6
U-234	Concentration (mBq/m^3)	SLD	SLD
	CMD (mBq/ m^3)	0.1	0.9
Gamma spectrometry measurement report		822/23.10.2023	823/23.10.2023
CMD on the date of measurement for gamma-emitting radionuclides with $T_{1/2}$ greater than 30 days, for which LDEs are calculated (Bq/m3)	Mn-54	0.001	0.01
	Co-58	0.001	0.01
	Fe-59	0.003	0.024
	Co-60	0.001	0.007
	Zn-65	0.003	0.026
	Zr-95	0.002	0.018
	Ru-103	0.001	0.009
	Ru-106	0.01	0.08
	Ag-110m	0.001	0.009
	Sb-124	0.001	0.009
	Sb-125	0.003	0.02
	Cs-134	0.001	0.01
	Cs-137	0.001	0.01
	Ce-141	0.001	0.008
	Ce-144	0.003	0.026
	Eu-152	0.001	0.01
	Gd-153	0.001	0.01
	Eu-154	0.001	0.007
	Hf-181	0.001	0.008

CMD – Minimum detectable concentration
SLD – below the detection limit

The data in Tab. 74 support the conclusion formulated on the basis of the results of the self-monitoring activities carried out by Cernavoda NPP, in terms of disproving the presence of air contamination with radioactive particles, under normal operating conditions of the plant.

In addition, compared to the determinations mentioned above, RATEN ICN carried out sampling of water vapor from the air from the DICA and Ostrov locations (the same locations where soil and spontaneous vegetation samples were taken), in order to determine the activity concentration of tritium. The results of this monitoring are presented in the following table.

Tab. 75 Tritium activity concentration in air water vapor samples taken by RATEN ICN in 2023

Sample name	Condensate of water vapor in the air - DICA	Condensate of water vapor in the air - Ostrov
The coordinates of the sampling location	N 44.323457°, E 28.053836°	N 44.104891°, E 27.390626°
Measurement report H-3	802/17.10.2023	803/17.10.2023
Concentrations H-3 (Bq/mc)	17.1 ± 2.6	SLD
CMD H-3 (Bq/mc)	0.1	0.1

The activity concentration of tritium in the air, determined for the DICA location, falls within the variation range of the values recorded by the environmental radioactivity monitoring program, for the locations inside the exclusion zone. It can also be noted that at the Ostrov location, the activity concentration of tritium in the air was below the detection limit, which was assessed at 0.1 Bq/m^3, taking into account the conditions in which the determination was made. Thus, it can be concluded that in this location, there is no detectable increase in the concentration of tritium in the air as a result of the dispersion of the gaseous effluents emitted by Cernavoda NPP under normal operating conditions. By extrapolation, it can be stated that there is no radiological impact on the people on the territory of Bulgaria as a result of the emissions of gaseous radioactive effluents from the Cernavoda NPP, under normal operating conditions.

3.9.3.11 Spontaneous vegetation - results provided by the monitoring activites carried out by Cernavoda NPP through its own laboratory

As part of the environmental radioactivity monitoring program at Cernavoda NPP, the monitoring of the level of radioactivity in spontaneous vegetation samples began in 2003, and since 2009, this has been carried out systematically, through monthly sampling (between May and October) of samples from four locations: SSL-01 – DICA, SSS-10 – Protected U1 Perimeter, SSS-13 – LCM, SSS-12 – Topalu (reference location). The samples taken were processed to determine the activity concentration of: gross-beta, gamma-emitting radionuclides, tritium and C-14.

Fig. 99 shows the evolution of the average annual values of the concentration of beta-global activity in the samples of spontaneous vegetation taken during 2004 ÷ 2022. Analyzing these data, in relation to those presented in Fig. 85 (relating to the gross-beta activity of the samples of soil) a similar profile of the distribution of values is noted, which confirms the hypothesis of a possible change in the data reporting method after 2017.

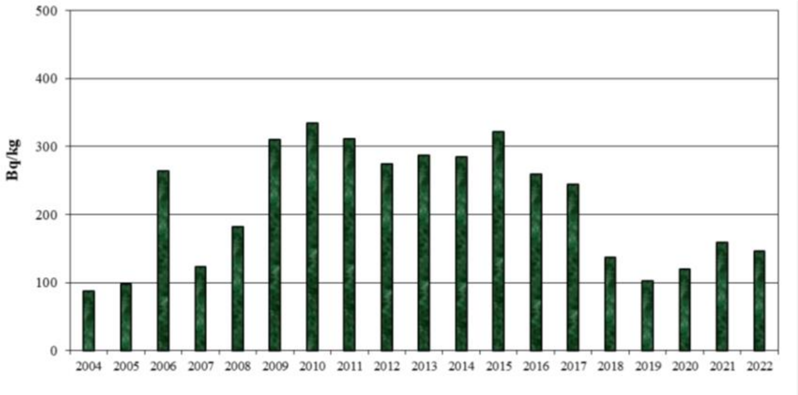


Fig. 99 Average annual values of gross-beta activity concentration in spontaneous vegetation samples taken during 2004 ÷ 2022

Fig. 100 shows the results of monitoring the gross-beta activity concentration in 2022. It can be seen that the values recorded in the indicator locations are similar to those recorded in the reference location (within the measurement uncertainty and the natural variability of this parameter).

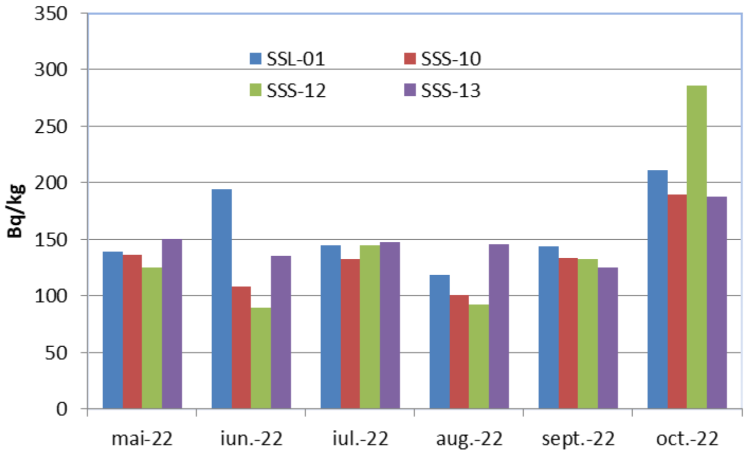


Fig. 100 Values of the concentration of gross-beta activity in spontaneous vegetation samples during 2022

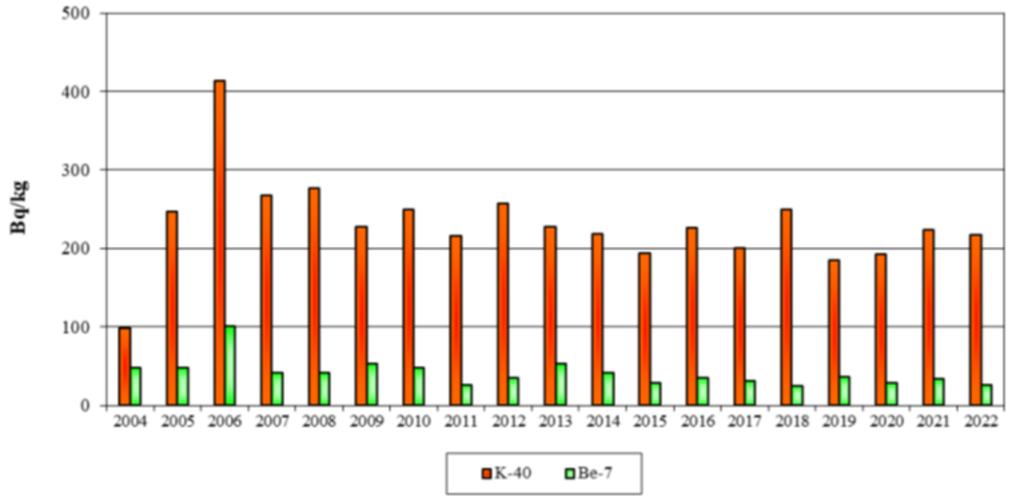


Fig. 101 Annual means of activity concentration of K-40 and Be-7 in spontaneous vegetation samples, during 2004 ÷ 2022

Following the gamma spectrometry analysis, artificial radionuclides, gamma radiation emitters, were not detected in the vegetation samples. The gamma-emitting radionuclides highlighted in the samples were K-40 (primordial radionuclide) and Be-7 (cosmogenic radionuclide), whose activity concentrations, averaged annually, are shown in Fig. 101.

Fig. 102 and Fig. 103 show the annual averages of tritium activity concentrations, determined in spontaneous vegetation samples taken during the period 2004 ÷ 2022.

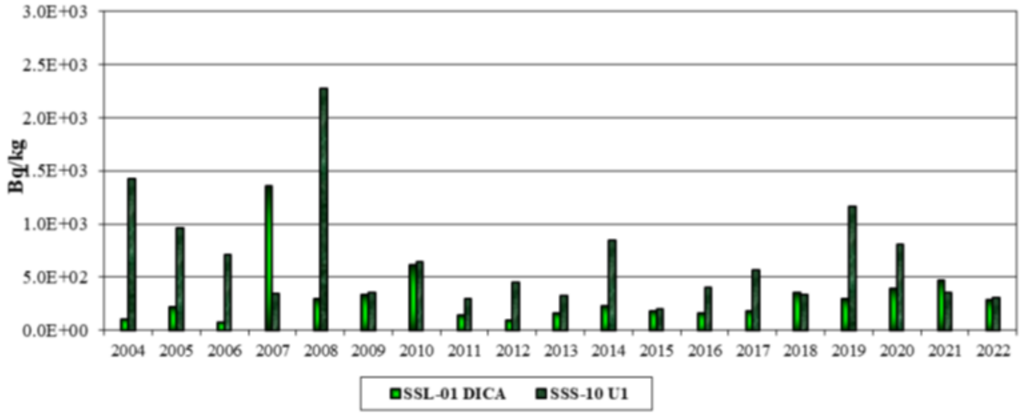


Fig. 102 Annual averages of tritium activity concentration in spontaneous vegetation samples during the interval 2004 ÷ 2022, for the locations on the Cernavoda NPP site

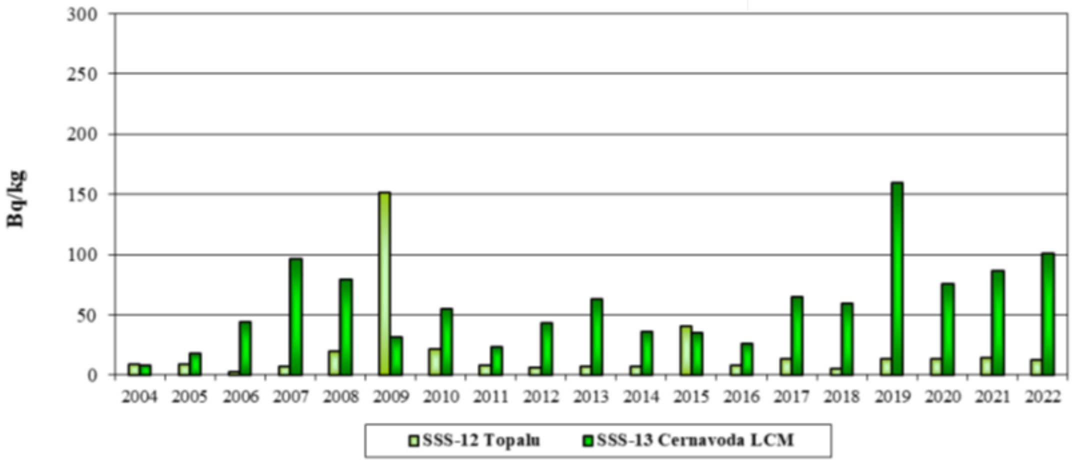


Fig. 103 Annual averages of tritium activity concentration in spontaneous vegetation samples during the period 2004 ÷ 2022, for locations outside the exclusion zone of the plant

The values of the tritium activity concentration in the spontaneous vegetation samples taken and analyzed in 2022 are shown in Fig. 104. It can be seen that for each of the locations from the vicinity of the plant, including the SSS-13 (located less than 2.5 km from Unit 1) the reported values of tritium activity concentration throughout the monitoring period are higher by one to two orders of magnitude than the values at the reference location, but follow the same pattern of variation, with higher values in the spring and autumn periods (periods with more abundant precipitation). This evolution of the activity concentration is most probably due to the variation of the specific water content of the plants depending on their development cycle and the availability of soil water. Tritium activity concentration values would be much less fluctuating if the activity concentration was calculated by reference to the amount of free water extracted from the sample and subjected to analysis. However, for the purpose of dose assessments, in the case of vegetable products, the relevant activity concentration of tritium is related to the amount of fresh product (in the state in which it is consumed).

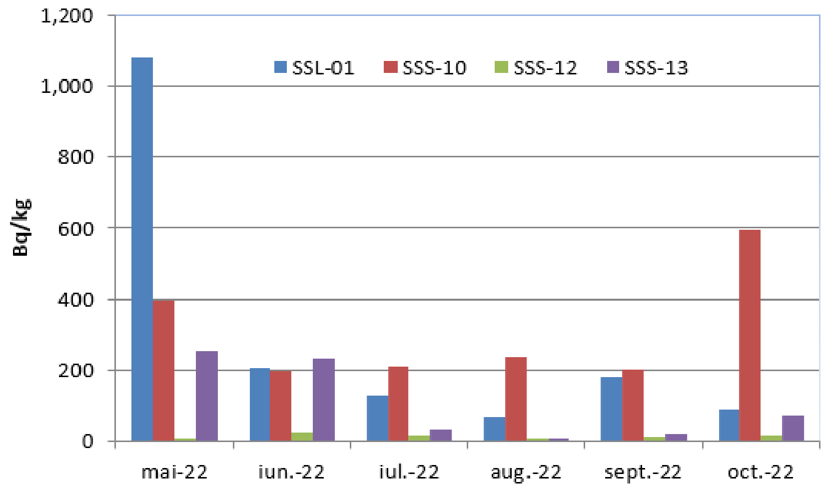


Fig. 104 Tritium activity concentration values in spontaneous vegetation samples in 2022

Carbon-14, whose activity concentration was determined, during 2004 ÷ 2020, by reference to the amount of carbon in the sample, had a distribution profile of the annual average values quasi-constant, as can be seen in Fig. 105.

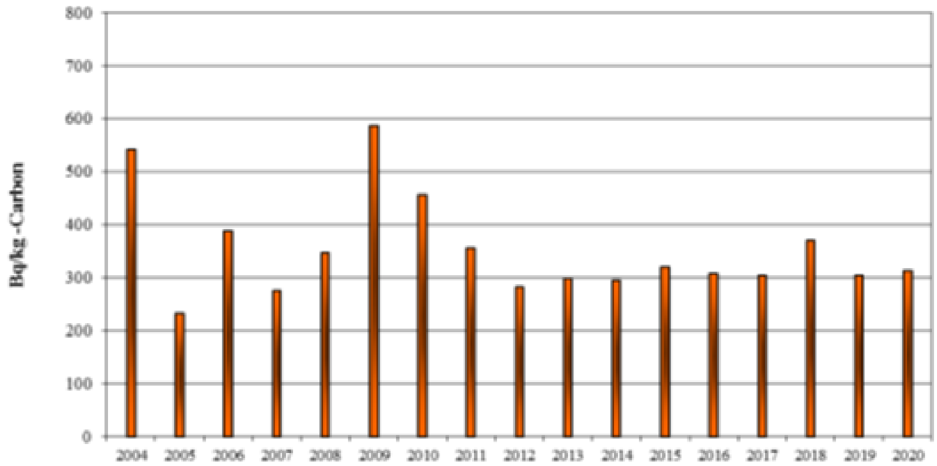


Fig. 105 Annual averages of C-14 activity concentration in spontaneous vegetation samples during the period 2004 ÷ 2020

Fig. 106 shows the activity concentration values of C-14 in spontaneous vegetation samples taken during the year 2022. This time the concentration was calculated by reference to the mass of the sample taken for analysis, the values thus obtained being approximately one order of magnitude lower than those obtained by referring to the carbon content. Analyzing the relative distribution of the values obtained in the indicator locations, in relation to those obtained in the reference location (at a distance greater than 20 km from the plant) it can be stated that for none of these locations we can detect any systematic increase in activity concentration of C-14, which means that the releases of

C-14 into the atmosphere, resulting from the activity of the Cernavoda NPP, are not in a position to change, in a detectable way, the levels of this radionuclide in the environmental compartments, not even at a local level.

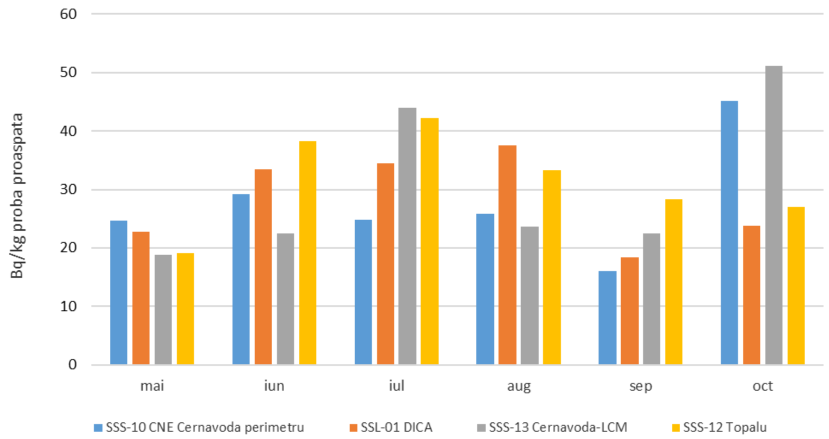


Fig. 106 C-14 activity concentration values in spontaneous vegetation samples in 2022

3.9.3.12 Spontaneous vegetation - results provided by additional monitoring activities

The 2023 study, carried out by RATEN ICN Pitesti, regarding the monitoring of the radioactivity of environmental factors in the vicinity of Cernavoda NPP also included the sampling of two samples of spontaneous vegetation from the locations: DICA and Ostrov, in order to determine the activity concentrations of: tritium, alpha-emitting radionuclides and gamma-emitting radionuclides (see Tab. 76).

Tab. 76 The results of the radiological characterization of spontaneous vegetation samples taken by RATEN ICN in 2023

Sample name		DICA vegetation	Ostrov vegetation
Coordinates of the sampling location		N 44.323457°, E 28.053836°	N 44.104891°, E 27.390626°
Measurement report H-3		800/17.10.2023	801/17.10.2023
Concentration H-3 (Bq/kg fw)		1477.0 ± 147.7	SLD
CMD H-3 (Bq/kg fw)		2	5
Actinide measurement report		832/25.10.2023	833/25.10.2023
Pu-239/240	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	0.3	0.4
Pu-238	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	0.3	0.3
Am-241	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	0.3	0.3
Cm-244/Cm243	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	0.3	0.3
Cm-242	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	0.4	0.3

Sample name		DICA vegetation	Ostrov vegetation
U-238	Concentration (mBq/g)	1.7 ± 0.5	3.0 ± 0.6
	CMD (mBq/g)	0.4	0.4
U-235	Concentration (mBq/g)	SLD	SLD
	CMD (mBq/g)	0.3	0.3
U-234	Concentration (mBq/g)	2.7 ± 0.6	3.4 ± 0.7
	CMD (mBq/g)	0.3	0.3
Gamma spectrometry measurement report		820/23.10.2023	821/23.10.2023
Activity concentration (Bq/kg dw)	Be-7	86.6 ± 9.1	78 ± 8.2
	K-40	392.2 ± 42.6	454.9 ± 49.4
	Cs-137	1.1 ± 0.2	6.7 ± 0.8
	Tl-208	SLD	SLD
	Bi-212	SLD	SLD
	Pb-212	SLD	SLD
	Bi-214	SLD	SLD
	Pb-214	SLD	SLD
	Ra-224	SLD	SLD
	Ac-228	SLD	SLD
	U-235	SLD	SLD
CMD on the date of measurement for gamma-emitting radionuclides with $T_{1/2}$ greater than 30 days, for which LDEs are calculated (Bq/kg dw)	Mn-54	0.4	0.4
	Co-58	0.4	0.4
	Fe-59	1.2	1.2
	Co-60	0.5	0.6
	Zn-65	1.2	1.3
	Zr-95	0.8	0.8
	Ru-103	0.4	0.4
	Ru-106	3.2	3.7
	Ag-110m	0.4	0.7
	Sb-124	0.4	0.4
	Sb-125	0.8	1.0
	Cs-134	0.3	0.4
	Cs-137	0.5	0.5
	Ce-141	0.3	0.4
	Ce-144	1.1	1.4
	Eu-152	0.4	0.5
	Gd-153	0.5	0.6
	Eu-154	0.3	0.4
	Hf-181	0.3	0.4

The results obtained during this additional monitoring confirm that tritium is the only one of the radionuclides released into the environment by Cernavoda NPP, with a sufficiently high emission rate so that its accumulation in environmental factors is possible at the local level. Thus, in the case of the spontaneous vegetation sampled from the Cernavoda NPP platform, the tritium concentration level in the free water in the plants is similar to that in the water vapor in the air and comparable to that in the free water in the soil, indicating a local balance of the tritium concentration in environmental factors. On the other hand, for the spontaneous vegetation sample taken from the Ostrov location (near the border with Bulgaria), the results of the monitoring carried out by RATEN

ICN show that it cannot highlight the presence of any artificial radionuclide (with the exception of Cs-137 from Chernobyl), which means that, at this distance, the releases of radioactive effluents from Cernavoda NPP does not produce any detectable change in the radioactive content of the vegetation.

Conclusions regarding the current radiological state of the environment

The analyzes to determine the activity concentration of radionuclides emitting gamma radiation did not reveal the presence of specific anthropogenic radionuclides at the Cernavoda NPP in: surface waters, underground waters, drinking water, soil, air, and spontaneous vegetation in the area of influence of the Cernavoda NPP, the only gamma-emitting radionuclides highlighted in some samples being the natural radionuclides and Cs 137, present in the environment as a result of the Chernobyl accident. The results obtained within the environmental monitoring program at Cernavoda NPP, as well as previous studies regarding the impact of activities on the Cernavoda NPP platform on the environment, showed that the only radionuclide coming from the operation of the plant, which can be detected outside its location, is tritium, and the area where its concentration in environmental factors can have values above the background level has a maximum radius of 10 km. Thus, it can be stated that, under normal operating conditions of the plant, the emissions of radioactive effluents from Cernavoda NPP do not produce any detectable change in the level of radioactivity of the environmental compartments in locations situated on the border with Bulgaria and, consequently, neither within the territory of this country.

3.9.4 The Human Factor

3.9.4.1 Dose calculation for the representative person in the population

Based on the analysis of the results of the environmental radioactivity monitoring at the Cernavodă NPP, for the environmental factor "air", it appears that the only radionuclides for which an additional dose to the population can be taken into consideration, due to radioactive emissions from the plant, are H-3 and C-14.

For these radionuclides, the annual doses that may be received by representative members of the population have been estimated according to the methodology for the calculation of Derived Emission Limits (DELs) for the Cernavodă NPP [79/82-00580-DBA-0008].

Doses have been calculated following two methods, as described below:

- based on gaseous and liquid emissions from the two nuclear units (applied to H-3 and C-14;
- based on concentrations measured in environmental samples by the routine environmental radioactivity monitoring programme at the Cernavodă NPP (applied only for H-3, as C-14 is not detectable in environmental samples taken outside the NPP exclusion zone).

Method 1 - dose calculation from gaseous and liquid emissions of U1 and U2

This method is based on the DEL calculation methodology [79/82-00580-DBA-0008]. The method uses the overall transfer parameters "f_i" (maximum annual unit effective doses), determined for members of each critical group and for each route, according to the DEL calculation methodology.

As such, it is a conservative method, leading to overestimation of dose values.

The dose calculation is based on the following formula:

$D_i = f_{ik} * 10^6 * (E_{ik} * 1000/8760/3600)$, where:

- D_i (µSv/an) = annual dose of radionuclide "i"
- f_{ik} (Sv*s/Bq/an) = the maximum annual effective dose to one person in the population due to a continuous release at a rate of one Bq/s of radionuclide i by the exhaust route k;
- E_{ik} (kBq/an) = annual emission of radionuclide "i" on exhaust route "k".

The f_{ik} parameter values were calculated by Cernavodă NPP and approved by CNCAN [79/82-00580-DBA-0008].

Dose conversion factors for exposure routes originating from gaseous emissions are given in the following table.

Tab. 77 Dose conversion factors for exposure routes originating from gaseous emissions

	f_i (Sv/year per Bq/s)		
	Inhalation	Ingestion	Total
adult (H-3)	1.96E-13	1.47E-13	3.44E-13
child (H-3)	2.50E-13	1.68E-13	4.18E-13
adult (C-14)	8.72E-12	7.42E-11	8.29E-11
child (C-14)	6.09E-12	8.35E-11	8.95E-11

Similarly, the following table presents the conversion factors established for exposure assessment for exposure routes originating from liquid effluents.

Tab. 78 Conversion factors established for exposure assessment for exposure routes originating from liquid effluents

	f_i (Sv/year per Bq/s)		
	Cernavodă	Constanța	Seimeni
H-3 adult	1.77E-13	2.35E-13	8.51E-15
C-14 adult	7.90E-10	7.55E-12	1.65E-11
H-3 child	3.83E-13	3.57E-13	1.53E-14
C-14 child	6.93E-12	7.81E-12	3.05E-13

The emission values used in the calculation are the total annual emission values for each nuclear unit and exhaust route presented in the report IR-96200-057: "Results of the monitoring of environmental factors and radioactivity levels in the Cernavodă area, between 1996-2022", revision 0. The period analysed is 2012 - 2022 (see Tab. 79 - Tab. 88)

For gaseous discharges [79/82-00580-DBA-0008] the following persons were considered as representative of the population: adults and children living in Cernavodă.

For liquid discharges, the following representative persons from the population were considered:

- Cernavodă - adult, child respectively (discharge route: Danube-Black Sea Canal);
- Constanța - adult, child respectively (discharge route: Danube-Black Sea Canal);
- Seimenii Mari - adult, child respectively (discharge route: Danube).

In terms of routes of exposure, only inhalation, ingestion of food and immersion in water are relevant for H-3 (transfer parameters from atmosphere or water, to soil or sediment and immersion in the atmosphere are zero, so the external dose and the dose received by immersion in the atmosphere are zero).

For C-14, the only relevant routes of exposure are inhalation and ingestion of food.

Immersion in water was considered only for Seimenii Mari, as swimming is not practised in the Danube-Black Sea Canal (for Cernavodă and Constanța).

Constanța was only taken into account with the dose from water ingestion (as about 40% of its population is supplied with drinking water from the Canal.

Method 2 - dose calculation from measured concentrations in environmental samples

This method is similar to method 1, in that it uses the same transfer parameters as in 79/82-00580-DBA-0008 in the calculation, but the exposure calculation is based on activity concentrations measured in environmental samples from different environmental compartments and uses only conversion factors that relate the intake doses via different exposure routes to the activity concentrations in the corresponding environmental compartments.

The method is less conservative than the first and closer to estimating actual effective doses because it eliminates the more conservative assumptions used to determine transfer parameters linking concentrations in environmental compartments to radioactive releases from sources.

Actual doses due to tritium emissions are calculated using the following equations [IR-96200-057]:

$$D[Sv/a] = C[Bq/m^3] \cdot I[m^3/a] \cdot FC \cdot DCF_i[Sv/Bq]$$

where:

C H-3 activity concentration in air (Bq/m^3)

I inhalation rate (m^3/a)

FC occupational factor (fraction of the number of days in the year that the person is exposed)

DCF_I dose conversion factor for inhalation

$$D[Sv/a] = C[Bq/kg] \cdot I_f[kg/a] \cdot DCF[Sv/Bq]$$

where:

C(Bq/kg) the concentration of H-3 in the food sample

I_f (kg/an) the consumption rate of the food in question

DCF(Sv/Bq) dose conversion factor for ingestion

In the calculations, the values of the transfer parameters presented in the tables of the document "Derived emission limits for the Cernavodă NPP" 79/82-00580-DBA-0008 rev.0, 2023 were used directly. The values of the constants *I*, *FC* and DCF_I are those given in “*Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities CAN/CSA-N288.1-M87*” and “*Safety Series No. 115, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA 1996*”.

Using this method, the annual effective doses of tritium (hereafter referred to simply as "effective doses") that may be received by each member of the critical groups defined for Cernavodă (adults and children between 0 and 1 year(s)) were calculated for each year from 2010 to 2020.

Doses have not been estimated for the critical groups of Constanţa and Seimenii Mari, because they are located at a greater distance from the plant than the city of Cernavodă and are characterized by source-atmosphere transfer parameters (atmospheric dispersion factors) with lower values, while gaseous discharges are those with a major contribution to doses.

The relevant routes of exposure for residents of Cernavodă for tritium are inhalation and ingestion of food (as described in Method 1).

The tritium activity concentration values in the environmental compartments used in dose calculations are represented by:

- for the inhalation exposure route (environmental compartment "air") - annual average concentration values measured at the ADI-08 monitoring site in Cernavodă
- for food ingestion exposure routes (environmental compartments: "fruit", "'vegetables'", "fish", "eggs", "milk", "chiken", "pork", "beef") - averages between sampling locations for annual average concentration values calculated for each food sampling location and each food category.

The following table shows the annual averages of H-3 activity concentration in representative samples for the environmental compartments affected by releases of radioactive effluents considered in the effective dose assessment.

Tab. 79 Annual averages of H-3 activity concentration in representative samples for affected environmental compartments

Year	**Vegetables (Bq/kg)**	**Fruit (Bq/kg)**	**Cereal (Bq/kg)**	**Meat (Bq/kg)**	**Milk (Bq/l)**	**Eggs (Bq/kg)**	**Fish (Bq/kg)**	**Water (Bq/l)**	**Air (Bq/m^3)**
2012	6.96	17.5	1.57	4.64	5.83	5.53	5.36	3.22	1.73
2013	4.56	15.35	6.82	2.47	5.64	13.83	5.08	3.03	1.26
2014	11.59	12.63	2.09	3.53	7.7	23.68	5.89	3.29	1.49
2015	4.82	3.51	1.43	3.8	7.88	<1.13	4.27	3.34	0.6
2016	5.88	13.29	0.66	3.28	11.4	5.5	5.26	8.69	0.32
2017	4.51	6.43	0.73	12.58	11.7	53.1	5.53	3.33	0.24
2018	8.48	8.01	0.46	4.79	6.83	5.63	3.23	5.63	0.99
2019	9.57	12.75	1.72	2.09	9.88	16.78	4.06	4.66	1.66
2020	6.73	31.22	0.91	3.21	9.39	11.87	8.33	4.89	0.93
2021	13.3	19.55	2.81	3.50	14.84	11.14	6.91	6.51	1.47
2022	9.01	10.05	1.29	5.74	12.21	24.15	13.40	10.91	1.16

Presentation of radioactive emission data for the last 10 years of operation of the Cernavodă NPP, highlighting the contribution of tritium and C-14 to the dose to a representative member of the population

The following table shows the annual emissions of H-3 and C-14 in the radioactive gaseous effluents released from the Cernavodă NPP and the annual DRL values (established for each nuclear unit).

Tab. 80 Annual emissions of H-3 and C-14 in radioactive gaseous effluents released from Cernavodă NPP and annual DEL values

Year	**H-3 (oxide) [kBq]**		**C-14 (gas) [kBq]**	
	Unit 1	**Unit 2**	**Unit 1**	**Unit 2**
2012	3.01E+11	6.73E+10	6.92E+07	4.02E+08
2013	2.35E+11	8.36E+10	1.09E+08	3.01E+08
2014	3.05E+11	9.95E+10	8.20E+07	3.17E+08
2015	1.44E+11	1.20E+11	1.12E+08	3.63E+08
2016	1.75E+11	1.71E+11	9.32E+07	2.39E+08
2017	1.34E+11	1.63E+11	8.64E+07	3.00E+08
2018	1.52E+11	1.26E+11	1.11E+08	2.67E+08
2019	1.83E+11	1.56E+11	1.41E+08	2.84E+08
2020	1.83E+11	1.54E+11	1.56E+08	1.97E+08
2021	2.35E+11	2.27E+11	1.69E+08	2.20E+08
2022	2.38E+11	2.33E+11	1.71E+08	2.82E+08
DEL	**3.96E+12 kBq/unit**		**5.28E+09 kBq/unit**	

As far as liquid effluent emissions are concerned, the activities emitted annually are recorded by taking into account their release route (cooling water discharge chanel - Seimeni, or Danube-Black Sea Canal). The following table shows the annual activities of H-3 and C-14 released through liquid effluents by the Cernavodă NPP, in the period 2012 - 2022.

Tab. 81 Annual activity for H-3 and C-14 released in liquid effluents from the Cernavodă NPP from 2012 to 2022

Year	**H-3 [kBq]**		**C-14 [kBq]**	
	Seimeni	**CDMN**	**Seimeni**	**CDMN**
2012	1.98E+12	-	1.14E+05	-
2013	9.95E+10	-	-	-
2014	9.46E+10	2.18E+08	-	-
2015	2.31E+11	-	-	-
2016	2.24E+11	-	-	-
2017	1.59E+11	-	-	-

Year	H-3 [kBq]		C-14 [kBq]	
	Seimeni	CDMN	Seimeni	CDMN
2018	1.72E+11	-	-	-
2019	1.34E+11	-	-	-
2020	1.89E+11	-	-	-
2021	2.97E+11	-	-	-
2022	6.24E+11	-	-	-
DEL	**4.92E+13**	**1.97E+12**	**4.28E+07**	**8.94E+05**

Applying Method 1, based on the derived emission limit model, the annual effective doses for each radionuclide (hereafter referred to as "maximum doses") that may be received by a member of the population were calculated for each release route and each exposure route for the years 2012 to 2022. The results of these estimates, with respect to exposure due to H-3 releases in gaseous effluents, are presented in Tab. 82.

Tab. 82 Annual effective doses for H-3 in gaseous effluents

Year	Maximum effective dose (µSv)					
	inhalation - adult	inhalation - child	ingestion - adult	ingestion - child	total - adult	total - child
2012	2.29	2.92	1.72	1.96	4.01	4.88
2013	1.98	2.52	1.49	1.69	3.47	4.22
2014	2.52	3.20	1.89	2.15	4.40	5.35
2015	1.64	2.09	1.23	1.40	2.87	3.49
2016	2.15	2.74	1.61	1.84	3.77	4.58
2017	1.85	2.35	1.39	1.58	3.23	3.93
2018	1.73	2.20	1.30	1.48	3.03	3.68
2019	2.11	2.69	1.58	1.80	3.69	4.49
2020	2.10	2.67	1.57	1.79	3.67	4.46
2021	2.88	3.66	2.16	2.46	5.03	6.12
2022	2.93	3.73	2.20	2.51	5.13	6.24
Dose constraint for H-3 in gaseous effluents = *52.5* µSv (per nuclear unit, as authorised by CNCAN)						

Similarly, Tab. 83, shows the maximum annual dose values due to C-14 releases in gaseous effluents from the Cernavodă NPP for the period 2012 - 2022.

Tab. 83 Annual effective doses for C-14 in gaseous effluents

Year	Maximum effective dose (µSv)					
	inhalation - adult	inhalation - child	ingestion - adult	ingestion - child	total - adult	total - child
2012	0.13	0.09	1.11	1.25	1.24	1.34
2013	0.11	0.08	0.96	1.08	1.08	1.16
2014	0.11	0.08	0.94	1.06	1.05	1.13
2015	0.13	0.09	1.12	1.26	1.25	1.35
2016	0.09	0.06	0.78	0.88	0.87	0.94
2017	0.11	0.07	0.91	1.02	1.01	1.10
2018	0.10	0.07	0.89	1.00	0.99	1.07
2019	0.12	0.08	1.00	1.12	1.12	1.21
2020	0.10	0.07	0.83	0.93	0.93	1.00
2021	0.11	0.08	0.91	1.03	1.02	1.10
2022	0.13	0.09	1.07	1.20	1.19	1.29
Dose constraint for C-14 in gaseous effluents = *15.0* µSv (per nuclear unit, as authorised by CNCAN)						

Effective dose values were estimated only for years in which measurable radionuclide activity concentrations were recorded in effluent monitoring samples.

The following table shows the estimated maximum effective doses to members of the public as a result of H-3 releases in liquid effluents from the Cernavodă NPP.

Tab. 84 Annual effective doses for H-3 in liquid effluents

Year	Maximum effective dose (µSv)					
	adult			child		
	Cernavodă	Constanța	Seimeni	Cernavodă	Constanța	Seimeni
2012	-	-	0.533	-	-	0.960
2013	-	-	0.027	-	-	0.048
2014	0.001	0.002	0.026	0.003	0.002	0.046
2015	-	-	0.062	-	-	0.112
2016	-	-	0.061	-	-	0.109
2017	-	-	0.043	-	-	0.077
2018	-	-	0.046	-	-	0.083
2019	-	-	0.036	-	-	0.065
2020	-	-	0.051	-	-	0.092
2021			0.080			0.144
2022			0.168			0.303
Dose constraint for H-3 in liquid effluents = 24.25 µSv ((per nuclear unit, as authorised by CNCAN)						

Similarly, the maximum effective dose to members of the public due to C-14 releases in liquid effluents from the Cernavodă NPP was estimated (Tab. 85).

Tab. 85 Annual effective doses for C-14 in liquid effluents

Year	Maximum effective dose (µSv)					
	adult			child		
	Cernavodă	Constanța	Seimeni	Cernavodă	Constanța	Seimeni
2012	-	-	5.98E-05	-	-	1.16E-06
2013	-	-	-	-	-	-
2014	-	-	-	-	-	-
2015	-	-	-	-	-	-
2016	-	-	-	-	-	-
2017	-	-	-	-	-	-
2018	-	-	-	-	-	-
2019	-	-	-	-	-	-
2020	-	-	-	-	-	-
2021	-	-	-	-	-	-
2022	-	-	-	-	-	-
Dose constraint for C-14 in liquid effluents = 22.7 nSv per nuclear unit, as authorised by CNCAN)						

By summing up the contributions to the maximum effective dose of exposures due to releases of liquid and gaseous effluents, the maximum effective dose was estimated for each representative population category considered in the calculation model used. The following table shows the results of these estimates for H-3.

Tab. 86 Estimated results for the maximum effective dose of exposures due to H-3 releases in liquid and gaseous effluents

Year	Maximum effective dose (µSv)					
	adult			child		
	Cernavodă	Constanța	Seimeni	Cernavodă	Constanța	Seimeni
2012	4.012	-	0.533	4.878	-	0.960
2013	3.471	-	0.027	4.220	-	0.048
2014	4.408	0.002	0.026	5.361	0.002	0.046
2015	2.876	-	0.062	3.497	-	0.112
2016	3.769	-	0.061	4.583	-	0.109
2017	3.236	-	0.043	3.934	-	0.077
2018	3.029	-	0.046	3.682	-	0.083
2019	3.693	-	0.036	4.490	-	0.065
2020	3.671	-	0.051	4.464	-	0.092
2021	5.033	-	0.080	6.120	-	0.144
2022	5.131	-	0.168	6.239	-	0.303

Similarly, the maximum effective dose due to C-14 emitted as liquid and gaseous effluents by the Cernavodă NPP in the period 2012 -2022 was calculated (Tab. 87).

Tab. 87 Calculated results for the maximum effective dose due to C-14 emitted as liquid and gaseous effluents by the Cernavodă NPP in the period 2012 -2022

Year	Maximum effective dose (µSv)					
	adult			child		
	Cernavodă	Constanța	Seimeni	Cernavodă	Constanța	Seimeni
2012	1.238	-	-	1.338	-	1.16E-06
2013	1.078	-	-	1.164	-	-
2014	1.049	-	-	1.133	-	-
2015	1.248	-	-	1.349	-	-
2016	0.873	-	-	0.943	-	-
2017	1.016	-	-	1.097	-	-
2018	0.993	-	-	1.073	-	-
2019	1.117	-	-	1.207	-	-
2020	0.928	-	-	1.002	-	-
2021	1.022	-	-	1.105	-	-
2022	1.191	-	-	1.286	-	-

Note: In Tab. 84 – Tab. 87 the boxes marked with a "-" sign indicate that a maximum effective dose was not estimated because in that year there were no discharges of radioactive effluents into the Danube-Black Sea Canal discharge route, or it was not possible to quantify the activity discharged (in the case of radionuclide C-14), as it was below the detection limit (see Tab. 81).

Applying the ***calculation method 2*** described above, the effective dose values (in excess of background) were estimated for a representative member of the population (resident in Cernavodă) as a result of exposure to H-3 from liquid and gaseous effluents released into the environment by the Cernavodă NPP (Tab. 88).

Tab. 88 Additional effective doses calculated by method 2 for excess over natural background

Year	Additional effective dose (µSv)		
	inhalation	ingestion	total
2012	0.29	0.11	0.40
2013	0.21	0.09	0.30
2014	0.25	0.13	0.38
2015	0.10	0.07	0.17
2016	0.05	0.16	0.21
2017	0.04	0.08	0.12
2018	0.17	0.12	0.29
2019	0.28	0.12	0.40
2020	0.16	0.15	0.31
2021	0.25	0.19	0.44
2022	0.19	0.22	0.42

The analysis of the results presented above shows that the additional effective doses calculated by method 2 are systematically lower than those calculated by method 1, due to the lower degree of conservatism of this method. ***Even in the case of maximum effective doses (assessed by method 1) their level is well below the dose constraints associated with radionuclides and their release routes established in the licensing process.***

During refurbishment activities, as discussed in section 1.8.1.3, gaseous emissions of tritium may increase by up to an order of magnitude over those recorded during routine plant operation, but even in this situation the effective dose to a representative member of the population will be less than 52.5 microSv/year, representing the fraction of the dose constraint allocated to tritium exposure from gaseous effluents released from a plant unit.

3.9.4.2 Population and human health

In accordance with the legal regulations in force - Law 111/1996 on the safe conduct, regulation, licensing and control of nuclear activities, republished, with subsequent amendments and additions and NSN-01 Nuclear Safety Rules for the siting of nuclear power plants, the Cernavodă NPP has established[115]:

- ***a 1 km exclusion zone around operating reactors*** – area in which measures are taken to exclude the location of permanent residences for the population and the carrying out of social and economic activities not directly related to the operation of the nuclear objectives of the Cernavodă NPP;
- ***a reduced population zone of 3 km radius around operating reactors*** – in which measures are taken to restrict the location of permanent residences for the population and the conduct of social and economic activities.

The following figure illustrates the spatial distribution of the population within a 30 km radius around the Cernavodă NPP.

[115] Final Nuclear Safety Report Unit 1 - Summary, February 2023

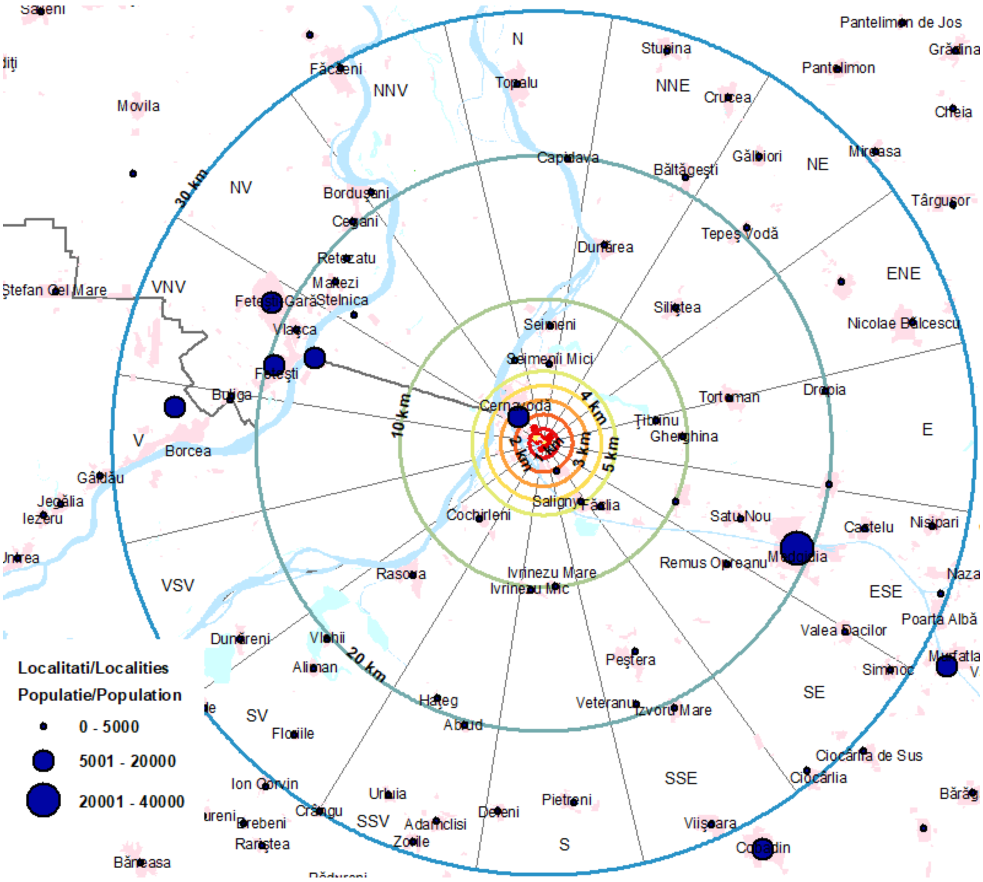


Fig. 107 Population distribution in the 30 km zone around Cernavodă NPP
(Source: Data produced by ANCPI, www.geoportal.gov.ro)

The following table shows the number of inhabitants in the most populated localities up to 30 km from the Cernavodă NPP.

Tab. 89 Number of inhabitants in the main towns on a 30 km radius from Cernavodă NPP (https://www.citypopulaţion.de/en/romania/)

Town	Number of residents in 2021
Medgidia	34612
Cernavodă	15088
Feteşti	27465

Since 1989, the National Institute of Public Health has been developing the ***Surveillance Study on the health status of populations living in the vicinity of major nuclear sites in Romania***. According to the methodology, a series of health indicators are analysed annually, namely ***demographic data, incidence of specific cancers and mortality related to these populations***. The results of these studies reveal the following:

- ***Health and environment report for 2021:***

– The dynamic analysis of the population in the period 2010 - 2020 revealed a predominance of children and young people (0 - 24 years) and a lower proportion of people aged over 60. A relatively even distribution of the population aged 20 - 44 years was also observed, with a predominance still of the younger population aged 20 - 44 year.

– Both the ***incidence of solid malignancies*** and the ***incidence of leukaemias and lymphomas in the area of influence (30 km) of the Cernavodă NPP were lower than the respective incidences reported for Romania in the period 1999 - 2020***.

– As in the case of neoplasm incidence, both ***overall mortality and specific mortality from neoplasms were below the same indicators by country throughout the study period***.

- ***Health and environment report for 2022:***

– ***In 2021***, there were 93842 residents in the Cernavodă NPP surveillance area. The population structure by age groups for the Cernavodă area compared to the population structure at national level shows a higher proportion of children and young people up to 40 years of age in the supervised area compared to the population structure for the whole country. This situation is reversed for the population in the age groups over 45 years.

– ***The incidence values of new cases of solid tumours*** and ***malignant diseases of the blood and blood-forming organs (leukaemia/lymphoma), the specific mortality values*** for these diseases ***and the overall mortality values were below the national reference values***:

Tab. 90 Incidence and mortality by types of cancers in the Cernavodă NPP supervised area in 2021

Indicator	MU	Supervised area of Cernavoda NPP	Romania
incidence of solid tumours	cases /100000 inhabitants	135.33	215.89
incidence of leukemia/lymphoma	cases /100000 inhabitants	8.52	18.65
solid tumour mortality	cases /100000 inhabitants	62.87	200.66
leukemia/lymphoma mortality	cases /100000 inhabitants	3.19	9.45
general mortality	cases /1000 inhabitants	7.17	15.17

4. DESCRIPTION OF THE RELEVANT ENVIRONMENTAL FACTORS SUSCEPTIBLE TO BE AFFECTED BY THE PROJECT

Taking into consideration the activities provided in Chapter I, in the stage of the Project implementation (construction and refurbishment), and respectively operation, it is possible that there are periods of time when there are vulnerabilities of some environmental factors, such as:

- ***In the stage of project implementation***, the environmental factors which are likely to be affected by the Project are related to the radioactive emissions and the radioactive waste generation.

Given that the Unit 1 refurbishment sub-project will carry out extensive intervention work on the active circuits of the plant, with the replacement of important components in the reactor active area, it is anticipated (based on the experience of other similar projects) that there will be a slight increase in tritium emissions in the form of gaseous and liquid radioactive effluents, compared to the emissions recorded during the operating period prior to the refurbishment.. These will be managed within the approved limits through rigorous application of the plant's procedures for limiting and reducing radioactive emissions to the environment.

At the same time, the refurbishment works will result in significant volumes of solid radioactive waste to be managed under the radioactive waste management programme, using existing facilities (DIDSR) and/or those to be developed for the purpose of the project (the new DIDR U5).

As regards the biodiversity, the works involved in the refurbishment stage remains are similar to usual major construction-assembly projects, **the impact on biodiversity**, in the context of the highly anthropised platform of the NPP, **remains insignificant**.

As regards the socio-human factor, *The population health impact assessment study -May 2024* - elaborated by the National Institute of Public Health, indicates the followings:

- Protection measures have been planned to reduce the impact on the environment and the health of the population. Compliance with these measures and with the technical conditions concerning equipment and the safe operation of installations in a monitored system will lead to minimising the impact on the environment and the health of the population. ***The quality of life and living standards of the local community will not be negatively affected by the implementation of the project under normal operating conditions***.
- As long as the project and the recommendations in the expert opinions/studies are respected, the activities to be carried out within the framework of this investment ***will not adversely affect the health of the population in the area, through the application of the measures provided for***. It is considered that the investment objective can have a positive socio-economic and administrative impact in the area and that any negative impact on the health of the population can be avoided by complying with the conditions listed.

- ***During the operation phase*** no vulnerabilities to environmental factors are expected as the resulting emissions are similar to those from the current operation of the U1 and U2 units, and DICA, and that they will be within the limits set by the regulatory acts issued by the Ministry of the Environment, Water and Forests and by the operating authorizations issued by CNCAN - for all nuclear objectives on the site.

Transboundary: As a result of the environmental assessment, the transboundary impact on Bulgaria's environment and population is assessed to be insignificant at 25 km and 40 km, as the refurbished U1 + U2 + extended DICA operation has the same impacts as in the current, regulated operation.

The conclusions of the Safety Report on Major Accident Involving Dangerous Substances prepared for the RT-U1 and DICA-MACSTOR 400 extension project are presented in Chapters 5 and 8 and the results of the assessments can be found in Annex 6 - RS_SEVESO.

The risk assessment based on nuclear safety analyses, the potential health effects on the population resulting from a radiological/nuclear accident failure, are presented in subchapter 8.2.

5. DESCRIPTION OF THE SIGNIFICANT EFFECTS THE PROJECT MAY HAVE ON THE ENVIRONMENT

Since the design of the nuclear power plant with CANDU-type reactors in Cernavodă, the main focus has been on the possible positive or negative effects on the ecosystems within the defined ecotope[116] area around this facility, as well as on safety measures and the prevention of potential pollution accidents.

This matter could extend beyond the country's borders, and therefore, this study evaluates the project's effects in a transboundary context in accordance with the provisions of the Espoo Convention (adopted in February 1991).

The main concerns in the operation of nuclear power plants are primarily related ***to nuclear security, generated radioactive waste storage***, as well ***as ensuring the necessary nuclear fuel*** for energy production.

On the other hand, nuclear energy generates electricity without GHG emissions. The reduction of GHG emissions is manifested by producing a significant amount of energy that supplies the National Energy System (SEN) without generating GHG. The importance of this effect is demonstrated by calculating the GHG emissions from a unit that produces the same equivalent amount of energy using fossil fuels.

By the end of 2022, the operation of the nuclear units at Cernavodă NPP provided 215 TWh of electricity to the SEN, avoiding the emission of 174263 kt $CO_{2\ equivalent}$ that would have resulted from the operation of a thermal power plant with a capacity of more than 300 MW producing the same amount of electricity by burning lignite.

During the extended operation period of Unit 1, 181 TWhe will be generated for the national energy system (U1) (at a capacity factor of 98%), avoiding the emission of 146757 kt $CO_{2\ equiv.}$ – which would have resulted from coal burning in a thermal power plant to produce the same amount of energy.

Given the complexity of the project, the elaborator analyzed both the positive and negative effects during the implementation and operational phases of the two sub-projects, RT-U1 and DICA-MACSTOR 400, as well as for the overall project. The analysis is presented in Tab. 91.

[116] **Ecotope -** A particular type of habitat in a region, https://hortiweb.ro/dictionar-general-de-botanica-e

Tab. 91 Effects of the RT-U1 Project and DICA-MACSTOR 400 on the environment

Environmental Factor /Natural Elements	**Project Effects**				**Proposed Measures**
	During Implementation		**During Operation**		
	Positive effects	**Negative effects**	**Positive effects**	**Negative effects**	
1	2	3	4	5	6
		The Project RT-U1 and DICA-MACSTOR 400			
Air	–	**- Insignificant** emissions of particles and combustion gases from la: - Earthworks and construction - Machinery and vehicles	- Supply of electrical energy to the National Energy System (SEN) for another operating cycle of U1, ***without GHG emissions and other combustion gases***	**Insignificant** It falls within the regulated limits.	***During implementation***: - measures to limit emissions during transportation and excavation activities - planning internal transportation - covering materials during transportation - use of high-performance vehicles/ equipment ***During implementation***: - Following the refurbishment of U1, the frequency of CTP use will decrease due to the chosen constructive alternative. - Diesel groups will be tested successively to ensure that the values of the specific pollutant concentration in the surrounding environment are not exceeded.
Water	Reduced cooling water consumption from the Danube.	***Insignificant*** Insignificant suspension from excavations and other earthworks due to rain.	- Extension of the water supply and drainage system on the Cernavodă NPP site, due to the new objectives planned under the RT-U1 subproject, with the addition of control sections for the quality of water generated on-site.	**Insignificant** It falls within the regulated limits.	***During implementation***: - Cooling water for the U1 reactor condenser is no longer needed during the refurbishment period. - Local on-site systems are in place to direct and collect any rainwater runoff, and their discharge follows the existing on-site control and discharge flow. ***During operation***: - Additional measures and conditions for monitoring the phreatic aquifer will be implemented, as stipulated in the Water

Environmental Factor /Natural Elements	Project Effects				Proposed Measures
	During Implementation		During Operation		
	Positive effects	Negative effects	Positive effects	Negative effects	
1	2	3	4	5	6
					Management Permit issued for the project: - Additional observation boreholes in the DICA-MACSTOR 400 area -New boreholes in the area of the new DIDR-U5
Noise and vibrations	-	***Insignificant*** The work area is located approx.. 2 km away from the receptors in the residential area	NA	NA	–
Soil	The extension of DICA is carried out: - on the Cernavodă NPP site, authorized for nuclear activities. - in an area with "good bedrock".	***Insignificant*** Portions around the new DIDR-U5 temporarily affected.	- Optimizing the occupied land by increasing the capacity for intermediary storage of the spent nuclear fuel, according to the chosen alternative. - The selected alternative allows the use of the same facilities for the operation of DICA after extension.	-	***During implementation***: - After the completion of the works, the land will be rehabilitated through scarification and grassing. ***During operation***: - Additional measures and conditions for monitoring the phreatic aquifer will be stipulated in the Water Management Permit issued for the project and will also cover soil quality control in the extended DICA and the new DIDR-U5 areas.
Generation of Waste					
- radioactive solide - radioactive LILW-SL	Provide intermediate storage spaces for low and medium-	-	- The new DIDR-U5 will also allow for the disposal of low and medium activity waste	-	***During implementation***: - Ensuring the internal transfer of radioactive waste according to the procedures of Cernavodă NPP

Environmental Factor /Natural Elements	Project Effects				Proposed Measures
	During Implementation		During Operation		
	Positive effects	Negative effects	Positive effects	Negative effects	
1	2	3	4	5	6
- radioactive LILW-LL	level radioactive waste resulting from the refurbishment by setting up the new DIDR-U5.		resulting from the refurbished U1 operation, with authorization from CNCAN and the Ministry of Environment.		***During operation***: - DIDR-U5 will serve as an intermediary storage facility until the DFDSMA is completed (for LILW-SL waste), and the DGR (for LILW-LL waste).
Generation of radioactive waste: spent nuclear fuel during the shutdown of U1 (transfer from the Spent Fuel Pool to the Interim Spent Fuel Storage Facility) and during the operation of U2	The BCU from Unit U1 ensures the wet storage of the entire quantity of spent nuclear fuel discharged from reactor U1.	–	The increase of the intermediary storage capacity in safe conditions for dry spent nuclear fuel, which provides intermediary storage for two nuclear units, each with 2 operating cycles.	It falls within the regulated limits.	***During implementation/operation***: Pre-storage in DICA and final storage in DGR - under controlled conditions (Fig. 108). Monitoring in accordance with CNCAN approval in the cylinder's atmosphere: - engineering barriers - air treatment inside the storage cylinder (suspension filter + activated carbon for I-131, and water analyzed for potential tritium presence)
Non-radioactive	Recovery of recoverable waste, by authorized operators.	Insignificant	Recovery by authorized operators of recoverable waste resulting from the operation of the project	Insignificant	***During implementation/operation***: Separate storage of recyclable waste, which is fully recovered. Waste is collected and stored in separate containers and handed over to authorized operators for recovery.
Hazardous non-radioactive	-	-	Disposal by authorized operators	Insignificant (e.g., exhausted resins from STA, expired reagents, etc.)	***During implementation/operation***: Storage in controlled conditions and in specially designated areas: - Transport within the nuclear power plant (NPP) premises using suitable industrial transport means/outside the

Environmental Factor /Natural Elements	Project Effects				Proposed Measures
	During Implementation		During Operation		
	Positive effects	Negative effects	Positive effects	Negative effects	
1	2	3	4	5	6
					premises, using authorized operators' means of transport.
Household	-	Insignificant	Disposal by authorized operators	Insignificant	***During implementation/operation***: Storage in separate containers and periodically collected by authorized operators for disposal at authorized facilities.
Climate and climate change	-	-	Avoiding GHG emissions through the production of "green" energy.	Insignificant	***During implementation***: Production of 181 TWhe at Unit 1 (estimated at a capacity factor of 98%) without GHG emissions, during the extended operational period (2030-2060), as a result of the project's implementation
Population: -health -living conditions (comfort) -socio-human factor	Opportunities for new jobs, number of people employed during the execution period.	Unit 1 is no longer supplying energy. During the refurbishment, the amount of energy supplied by the nuclear power plant (NPP) to the National Energy System is halved.	- Centralized heating of the population of Cernavodă town, using residual heat from Unit 1 and Unit 2 - Opportunities for jobs, with 1700 people employed during the operational period of the refurbished Unit 1 together with Unit 2. - Unit 1 contributes with around 10% to the national electricity production.	Without significant effects in normal operation.	***During implementation/operation***: - For the project: implementation of a surveillance and monitoring program for liquid and gaseous radioactive effluents - for DICA - installation of additional protective shields of adequate thickness for the duration of the workers' presence if the dose rate limit of 25μSv/h is exceeded at the accessible external surface of modules.

Environmental Factor /Natural Elements	**Project Effects**				**Proposed Measures**
	During Implementation		**During Operation**		
	Positive effects	**Negative effects**	**Positive effects**	**Negative effects**	
1	2	3	4	5	6
Biodiversity (fauna, flora, aquatic environment)	-	Insignificant - Disturbances to nesting birds at less than 0.8-1 km) - Vegetation - transportation	Compliance with legal requirements in the field, according to the regulatory act.	Insignificant	***During implementation/operation***: Monitoring measures are provided in Chapter 7.
Utilization of natural resources: - Uranium from mining operations in Romania	NA	NA	Producing the nuclear fuel bundles in the country is a substantial advantage and contributes to maintaining an integrated nuclear fuel cycle The energy resulting from the operation of the project contributes to supplying the National Energy System with 181 TWhe after refurbishment.	Use of uranium from limited natural resources.	

Environmental Factor /Natural Elements	**Project Effects**				**Proposed Measures**
	During Implementation		**During Operation**		
	Positive effects	**Negative effects**	**Positive effects**	**Negative effects**	
1	2	3	4	5	6
- Water	Insignificant	Insignificant	- Water is a strategic resource for safety and national security (as per Article 1, para. 1^1 d of Water Law no. 107/1996, with subsequent amendments and additions) and it is to generate approx..20% of the national electricity (together with Unit 2). The abstracted water flows will not exceed the current regulated flows for operation.	Insignificant Use of water from renewable surface resources, Danube-Black Sea Canal-Race I.	- Quantitative and qualitative monitoring of water volumes extracted according to Cernavodă NPP’s internal procedures and in compliance with the Environmental Authorization and Water Management Authorizations.

From a radiological impact perspective on the environment, ***the activities carried out during the implementation period of the decommissioning project*** will take place in compliance with the requirements established in the authorizations specific to this phase, and at the end of the activities, any radioactive contamination on the site of the former nuclear installations will be reduced to at a level that would allow release from its authorization regime.

The EIA Directive stipulates that public and private projects that may have significant effects on the environment are subject to an environmental assessment before approval is granted. As a result, the decommissioning project will be approved by the competent environmental authority by issuing the Environmental Agreement for decommissioning.

Closure and decommissioning activities will start and be carried out strictly after obtaining the legal approvals/authorizations.

The necessary conditions to be met for the closure/decommissioning of the nuclear facilities as well as those necessary to restore the initial state of the land will be established within the environmental impact assessment procedure for this type of project, following the analysis of a technical documentation that will comply with the requirements in the norms, practice, as well as national and international legislation and will be specified in the environmental agreement issued for this type of project.

The technical documentation will also include the monitoring plan for the environmental components.

5.1 Potential impact associated with the use of natural resources from the perspective of sustainable development

- **Natural resources needed for the implementation of the project** include: soil, water, river stone, sand, and wood.

Regarding the **soil**, the project will be developed on land within the industrial platform of the Nuclear Power Plant, <u>designated exclusively for constructions related to the operation of nuclear activities.</u>

With regard to the allocation of the land area for the purpose of extending the current DICA storage area, the land allows for this addition as the nature of the bedrock on the extended area is still part of the good bedrock zone. According to the geological study issued by GEOTEC in 2000, the presence of Barremian limestone as bedrock was the reason for the choice of this site at its western extremity, in front of reactor 5, where the bedrock is located at a depth of 2 - 6 m, high enough to allow the foundations to be laid in good technical and economic conditions. [117]

The land area to be occupied by the constructions is not within any protected natural area, is not registered as an archaeological site, and does not have direct economic value for the population (such as agriculture, animal husbandry, etc.).

[117] Study on the geological, geotechnical and hydrogeological characteristics of the DICA site for the approval of the foundation area, Geotec SA, December 2000

Water will be sourced from the same local water supply systems of the holder, and the water requirement during the implementation of the two subprojects will comply with the authorized water flow rates during the operation of all facilities on the site.

The necessary mineral resources are extracted from authorized/regulated mining operations, ensuring environmental protection and compliance with mineral resource exploitation norms.

- **The natural resources required for the project operation** are: water—for technological requirements, and uranium for nuclear fuel (UO_2 fuel bundles).

The refurbishment process of Unit 1 will not alter the reactor's power (706.5 MWe), and consequently, the consumption of nuclear fuel will be similar to that of the first operating cycle.

In a report of the Ministry of Environment (1993) on the State of the Environment in Romania, it was indicated that the existing uranium resources "cover" the operation of the 5 planned nuclear units for a period of 20 years. Therefore, ***in terms of natural capital***, Cernavodă NPP having two operational units, ***the operation of the refurbished Unit 1 does not pose a significant issue regarding uranium resources***.

Romania is the only country in the European Union that operates CANDU-type nuclear units and has the capacity to manufacture CANDU nuclear fuel.

According to Romania's ***Strategy for maintaining the integrated nuclear cycle***, SNN shareholders approved through AGA Resolution No. 5/25.04.2018, the "*Strategy for diversifying sources of supply with raw materials necessary for nuclear fuel production*". This includes a gradual transition from purchasing uranium dioxide (UO_2) to purchasing technical uranium concentrate (U_3O_8). Among the measures included is the identification of a solution to ensure the capacity for processing/refining technical uranium concentrate (U_3O_8), ***which is the raw material used to produce sinterable uranium dioxide powder (UO_2) required for the fabrication of nuclear fuel bundles***.

Nuclearelectrica S.A. completed the acquisition of the uranium concentrate processing line from the National Uranium Company S.A- Feldioara Branch on December 28, 2022.

Therefore, the acquisition of the technical uranium concentrate processing line (E plant) by SNN from the National Uranium Company and the production within SNN of uranium dioxide, which will be used by the FCN Pitești Branch (a subsidiary of SNN) for nuclear fuel fabrication, **contributes to maintaining the integrated nuclear cycle**.

The strategic decision to acquire a portion of the Feldioara assets necessary for raw material processing aimed at ensuring integrated production capabilities within SNN. This decision also aimed to guarantee the production of nuclear fuel bundles and optimize operations at FCN Pitești and Cernavodă NPP in the context of expanding the nuclear power plant's capacity and maintaining the national nuclear fuel cycle. The transaction was cost-effective and reduced dependency on a single supplier.

Through judicious planning and optimizing the quantities of raw materials required for the project, the minimization of natural resource use will be ensured.

5.2 Assessment of the potential impact on environmental factors generated by pollutant emissions, noise and vibration, radioactivity and generated waste

The size of the project must be considered in the existing environmental context, and **taking into account its potential significant effects on the environment**.

As a result, in order to identify whether the project RT-U1 and DICA-MACSTOR 400 extension has significant effects on the environment, the EIA developer has analysed whether the project ***by its nature, size and location*** is likely to have significant effects on environmental factors:

- population and human health,
- biodiversity;
- land, soil, water, air, climate;
- material assets, cultural heritage and landscape;
- interaction between the above factors.

According to the *General Guidance applicable to the stages of the environmental impact assessment procedure,* the **overall impact significance** is the result of multiplying the **amplitude (magnitude)** of the impact *(low, medium, high)* by the **sensitivity of the receptor** *(low, medium, high)*.

The significance/importance of the impact can be *minor (insignificant), moderate and major (significant).*

The spatial extent of the impact may be *local, regional, national or transfrontier.*

Sub-chapter 5.2.11 presents the environmental impact assessment matrixes for the project RT-U1 and DICA-MACSTOR 400.

5.2.1 Environmental factor WATER

Tab. 91 shows the main effects - negative and positive - on water - as a natural resource, by implementing and operating the RT-U1 and DICA-MACSTOR 400 Extension project.

Subproject RT-U1

During the implementation stage (*preparation phase, execution phase*), **the effects on the Danube River and on groundwater in the area are insignificant**. The entrainment of suspensions resulting from demolition, excavation and transport of materials will be mitigated/eliminated by wetting granular materials during the works and by covering loads during transport.

The temporary decommissioning of the U1 reactor during the actual refurbishment phase will halve the cooling water flow requirements for the condenser of Unit 1, which will halve the thermal pollution of the Danube River, as insignificant as it is today.

A potential risk of pollution of natural water (the channel in the Cișmelei Valley) is significantly mitigated by ongoing activities of monitoring the quality of rainwater collected from the platform and automatic routing of possibly contaminated water to the radioactive liquid waste management system.

As for the domestic wastewater from the 11000 NPP employees, **the effect on the environment is insignificant** because the wastewater is collected by the separate sewage system and routed to the urban sewage network of Cernavodă, and finally it undergoes the wastewater treatment process before being discharged into the Danube River.

Examining Tab. 91, it is assessed that, overall, the effects on water during the subproject implementation phase are minor, and during the operation phase the risk of rainwater pollution and the risk of leakage from the reactor operating system is nullified by the preventive safety measures adopted.

The analysis carried out on the effects of the RT-U1 sub-project found that it does not generate a significant effect on water.

Subproject DICA-MACSTOR 400

Tab. 91 shows the effects - negative and positive - of the DICA-MACSTOR 400 sub-project on the environmental factor "water".

Both during execution and during operation, there is a risk of affecting water quality in places where it appears as free level, with suspensions carried by rain or wind, during excavation, earthworks or from the storage platform. The effects are temporary and insignificant.

During operation, there is a risk of radionuclides propagation into aquifer through accidental leakage due to the non-tightness of the cylinders. ***As a result, additional measures are planned in the sub-project to control water quality and water levels in the aquifer, by extending the phreatic aquifer protection zone.***

The implementation of the DICA-MACSTOR 400 subproject does not generate significant effects on the environmental factor water.

At the same time, the RT-U1 and DICA-MACSTOR 400 extension Project has no impact on water bodies, aspect communicated by ANAR by address No. 22588/ET/08.10.2021 following the analysis of the documentation submitted by the project owner.

The Assessment of the impact that the project may have on the environmental factor WATER, in accordance with the methodology of the General Guide applicable to the stages of the environmental impact assessment procedure - Annex 1 to Ord. 269/2020 is presented in Tab. 105, Tab. 106 și Tab. 107. The conclusions of the assessment are:

The non-radiological impact during the implementation and operation of the RT-U1 and DICA-MACSTOR 400 project, as a result of domestic, technological and rainwater discharges***, is insignificant positive, as a result of controlled discharges according to internal procedures.***

The radiological impact during the implementation and operation of the RT-U1 and DICA-MACSTOR 400 project, due to discharges of radioactive liquid effluents and those resulting from washing/decontamination, ***is minor negative and respectively insignificant negative, due to a possible slight increase in the levels of releases of radioactive liquid effluents during the***

refurbishment, followed by their return to values similar to those prior to the implementation of the refurbishment, once Unit 1 returns to commercial operation.

5.2.2 Environmental factor AIR

Non-radiological impact

In order to make an integrated assessment as rigorous as possible of the impact of the activity of the objective in the context of the existing pollution background, the following scenarios for modelling the dispersion of non-radioactive pollutants into the atmosphere were proposed in this study:

- **For the construction phase** of the proposed project objectives, a scenario was developed using a conservative approach, in the sense that a worst-case scenario was imagined in terms of air pollutant emissions associated with the activities carried out during this phase, while considering the overlap of these emissions. In this sense, both the earth handling operations/the existing concrete/stone/rock removal, loading and off-site transport operations associated with the construction of a MACSTOR 400 module within DICA and those associated with the realisation of the necessary infrastructure for the refurbishment of Unit 1 (buildings, platforms, parking lot) were considered as being carried out simultaneously. Any situation other than the one analysed would involve lower pollutant emissions and therefore a lower impact on air quality. This scenario has been referred to as - *the "**Construction Site**" **Scenario***
- **For the operational phase,** based on the information provided by the beneficiary, the following relevant scenarios have been compiled in terms of the possible grouping of emission sources and the achievement of maximum impact on ambient air quality:
    - *"Backup" scenario* - operation of the start-up power plant (with two boilers) together with two Stand by Diesel Generators (SDG) of Unit 1 and one Stand by Diesel Generator (SDG) of Unit 2
    - *"Breakdown" scenario* - operation of the start-up power plant (with two boilers) together with an Emergency Power System (EPS) of Unit 1 and an Emergency Power System (EPS) of Unit 2;
    - *“Test - backup U1" scenario* - testing the operation of a Stand-by Diesel Generators (SDG) of Unit 1;
    - *“Test - backup U2" scenario* - testing the operation of a Stand-by Diesel Generators (SDG) of Unit 2;
    - *“Test – breakdown" scenario* - testing the operation of an Emergency Power System (EPS);
    - *“Test - CTP" scenario* - testing the operation of the start-up boiler plant (both boilers simultaneously);
    - *“Test - CTP 1 boiler" scenario* - testing the operation of the start-up boiler plant (one boiler);
    - *“Test – SPAI” scenario* - testing the operation of the fire water system (SPAI) motor pump
    - *“Test - GDM 1” scenario* - testing the operation of a Mobile Diesel Group (GDM)
    - *“Test - DICA**"** scenario* - testing of the operation of the diesel generator related to the Burning Fuel Storage (DICA)
    - *“Test - CCAU" scenario* - testing the operation of the generator of the On-Site Emergency Control Centre (CCUA);
    - *“Test-all-sources" scenario* - testing the operation of all installations simultaneously.

Given that in any of the scenarios listed above for the **operational phase**, the number of possible annual hours of operation of the facilities is small, the analysis of the long-term (one year) average impact is not relevant. Therefore, for the operational phase only **short-term impacts** have been analysed for pollutants for which short-term legal limit values for ambient air concentrations are set (NO_2, CO, SO_2, PM_{10}).

For the **construction phase**, both short-term and long-term impacts were assessed for the following pollutants NO_2, NO_x, CO, SO_2, PM_{10}, $PM_{2,5}$, Ni and benzo(a)pyrene.

A conservative approach has been taken to highlight the maximum possible impact. To this end, the dispersion of the estimated hourly emissions in the atmosphere was modelled continuously over a year in order to be able to analyse the possible short-term effect on the environment under any meteorological conditions encountered during a year.

For modelling the dispersion of pollutants generated by non-radioactive atmospheric emission sources at the Cernavodă NPP site, the AERMOD model was used, taking into account the sources and their associated emissions presented in paragraph1.8.2.3.

Dispersion calculations were performed on a grid of receptors with dimensions of 5 km x 5 km and 100 m grid spacing, covering the Cernavodă NPP site, the city of Cernavodă and the town of Ștefan cel Mare.

Modelling was carried out under complex field conditions, taking into account building effects and the photochemical reaction scheme of the dispersion model.

The modelling results are presented graphically in the form of dispersion maps, showing the isopleths curves for all pollutants and for all scenarios for which dispersion modelling has been performed, for all relevant averaging ranges, overlaid on the geographical map of the area. Dispersion maps are presented in:

- Annex 6 AIR QUALITY B – Spatial distributions of concentrations of non-radioactive pollutants for the construction phase
- Annex 6 AIR QUALITY C – Spatial distributions of concentrations of non-radioactive pollutants for the operating stage

The following tables show the maximum values of the modelled concentrations in the inhabited areas of the analysed area for the construction and operation phases.

Tab. 92 Maximum ambient air pollutant concentrations in inhabited areas obtained for the construction phase

Pollutant	**Mediation period**	**Maximum concentration - Cernavodă**	**Maximum concentration - Stefan cel Mare**	**Limit value - LV**
		µg/m³		
NO_2	1 hour	144.13	60.61	200
NO_2	1 year	0.0072	0.0009	40
NO_x	1 year	0.0107	0.0014	30
SO_2	1 hour	1.10	0.53	350
SO_2	24 hours	0.0458	0.0222	125
SO_2	1 year	8.6E-05	1E-05	20
CO	8 hours	33.95	17.45	10000

Pollutant	Mediation period	Maximum concentration - Cernavodă	Maximum concentration - Stefan cel Mare	Limit value - LV
		μg/m³		
PM_{10}	24 hours	3.89	1.73	50
PM_{10}	1 year	0.0059	0.0008	40
$PM_{2.5}$	1 year	0.0032	0.0004	25
Ni	1 year	2.86E-07	4E-08	0.02
Benzo(a)pyrene	1 year	1.24E-07	2E-08	0.001

Tab. 93 Maximum ambient air pollutant concentrations in inhabited areas obtained for the operation stage

Scenario	Pollutant	Mediation period	Maximum concentration - Cernavodă	Maximum concentration - Stephen the Great	Limit value - LV
			(μg/m³)		
"Backup"	NO_2	1 hour	222.44	130.37	200
"Breakdown"	NO_2	1 hour	333.27	142.63	200
"Test - backup U1"	NO_2	1 hour	98.30	62.08	200
"Test - backup U1"	NO_2	1 hour	113.89	55.86	200
"Test - breakdown"	NO_2	1 hour	182.42	104.94	200
"Test - CTP"	NO_2	1 hour	16.38	32.81	200
"Test - CTP 1 boiler"	NO_2	1 hour	13.32	22.82	200
"Test - SPAI"	NO_2	1 hour	72.00	66.38	200
"Test - GDM 1"	NO_2	1 hour	99.27	92.86	200
"Test - DICA"	NO_2	1 hour	20.22	5.06	200
"TEST - CCAU"	NO_2	1 hour	38.20	19.01	200
"Test - all sources"	NO_2	1 hour	803.36	350.61	200
"Backup"	CO	8 hours	67.59	27.40	10000
"Breakdown"	CO	8 hours	30.77	10.52	10000
"Test - backup U1"	CO	8 hours	19.49	9.33	10000
"Test - backup U1"	CO	8 hours	29.62	10.10	10000
"Test - breakdown"	CO	8 hours	10.48	4.76	10000
"Test - CTP"	CO	8 hours	9.78	7.19	10000
"Test - CTP 1 boiler"	CO	8 hours	5.62	4.28	10000
"Test - SPAI"	CO	8 hours	8.31	5.23	10000
"Test - GDM 1"	CO	8 hours	46.33	11.25	10000
"Test - DICA"	CO	8 hours	1.52	0.20	10000
"TEST - CCAU"	CO	8 hours	3.78	0.96	10000
"Test - all sources"	CO	8 hours	268.68	79.20	10000
"Backup"	PM_{10}	24 hours	8.15	4.03	50
"Breakdown"	PM_{10}	24 hours	3.93	2.54	50
"Test - backup U1"	PM_{10}	24 hours	1.93	0.75	50
"Test - backup U1"	PM_{10}	24 hours	3.53	0.82	50
"Test - breakdown"	PM_{10}	24 hours	1.02	0.43	50
"Test - CTP"	PM_{10}	24 hours	3.57	2.41	50

Scenario	Pollutant	Mediation period	Maximum concentration - Cernavodă	Maximum concentration - Stephen the Great	Limit value - LV
			($\mu g/m^3$)		
"Test - CTP 1 boiler"	PM_{10}	24 hours	2.05	1.43	50
"Test - SPAI"	PM_{10}	24 hours	0.65	0.48	50
"Test - GDM 1"	PM_{10}	24 hours	3.60	0.94	50
"Test - DICA"	PM_{10}	24 hours	0.12	0.02	50
"TEST - CCAU"	PM_{10}	24 hours	0.29	0.08	50
"Test - all sources"	PM_{10}	24 hours	21.38	8.19	50
"Backup"	SO_2	1 hour	226.19	350.60	350
"Breakdown"	SO_2	1 hour	226.13	350.58	350
"Test - backup U1"	SO_2	1 hour	0.12	0.08	350
"Test - backup U1"	SO_2	1 hour	0.20	0.15	350
"Test - breakdown"	SO_2	1 hour	0.25	0.06	350
"Test - CTP"	SO_2	1 hour	226.13	350.58	350
"Test - CTP 1 boiler"	SO_2	1 hour	129.90	207.56	350
"Test - SPAI"	SO_2	1 hour	0.08	0.06	350
"Test - GDM 1"	SO_2	1 hour	0.27	0.13	350
"Test - DICA"	SO_2	1 hour	0.01	0.00	350
"TEST - CCAU"	SO_2	1 hour	0.02	0.01	350
"Test - all sources"	SO_2	1 hour	226.25	350.61	350
"Backup"	SO_2	24 hours	43.34	29.23	125
"Breakdown"	SO_2	24 hours	43.30	29.22	125
"Test - backup U1"	SO_2	24 hours	0.03	0.01	125
"Test - backup U1"	SO_2	24 hours	0.06	0.01	125
"Test - breakdown"	SO_2	24 hours	0.02	0.01	125
"Test - CTP"	SO_2	24 hours	43.30	29.22	125
"Test - CTP 1 boiler"	SO_2	24 hours	24.84	17.37	125
"Test - SPAI"	SO_2	24 hours	0.01	0.01	125
"Test - GDM 1"	SO_2	24 hours	0.06	0.01	125
"Test - DICA"	SO_2	24 hours	0.00	0.00	125
"TEST - CCAU"	SO_2	24 hours	0.00	0.00	125
"Test - all sources"	SO_2	24 hours	43.39	29.25	125

Following the analysis of the results of the mathematical modelling of air quality impacts, the following conclusions can be drawn:

Construction phase

- In the construction phase for all pollutants, in inhabited areas, the concentration values are below the applicable limit values, target values or critical levels for any averaging time
- By aggregating the impact due to the construction phase with local background concentration levels, no exceedances of limit values, target values or critical levels will occur within inhabited areas.

Operation stage

- For nitrogen dioxide (NO_2) exceedances of hourly limit values may occur in inhabited areas for the scenarios: "Breakdown", "Backup" and "Test - all sources".
- For sulphur dioxide (SO_2) exceedances of hourly limit values may be recorded in inhabited areas for the scenarios: “Backup”, “Breakdown”, 'test – CTP”, “Test - all sources”. The most important contribution to these exceedances comes from the start-up power plants (in cases where both boilers are operated together).

  We note that while the tests have a well-established schedule, the CTP works occasionally, only in very low temperature situations –less frequent in recent years or if the restart of a unit cannot be done with the energy provided by the other nuclear unit in operation.
- For the other pollutants (CO, PM_{10}) the maximum value of the modelled concentrations is below the associated limit value in any scenario or averaging time considered.
- For all pollutants the maximum values achieved in inhabited areas for a single installation test scenarios are below the limit value
- In order not to exceed the limit values for pollutants in inhabited areas, it is recommended to perform the testing operations for each installation separately (only one installation in operation at a given time).

The production of energy (electrical and thermal) by burning fossil fuels generates, in addition to greenhouse gases, emissions of specific pollutants (acidifying pollutants, particles), which are avoided in the case of operating a nuclear power plant.

The Assessment of the non-radiological impact that the project may have on the environmental factor AIR, in accordance with the methodology of the General Guide applicable to the stages of the environmental impact assessment procedure - Annex 1 to Ord. 269/2020 is presented in Tab. 105, Tab. 106 și Tab. 107. The conclusions of the assessment are:

The non-radiological impact on air during the implementation of RT-U1 and DICA-MACSTOR 400 project, caused by emissions of combustion gases and dust from equipment/engines as well as dust emissions from construction activities and temporary storage of waste, construction materials, is ***minor negative,*** and ***during the project operation*** - the estimated impact is ***insignificant negative/positive*** as the nuclear process avoids emissions of acidifying pollutants and dust resulting from fossil fuel combustion.

Radiological Impact

The Assessment of the radiological impact that the project may have on the environmental factor AIR, in accordance with the methodology of the General Guide applicable to the stages of the environmental impact assessment procedure - Annex 1 to Ord. 269/2020 is presented in Tab. 105, Tab. 106 și Tab. 107. The conclusions of the assessment are:

The radiological impact on air during the implementation of the RT-U1 and DICA-MACSTOR 400 project is minor negative, and insignificant negative during the operation of the project, due to a possible slight increase in radioactive gaseous effluent emission levels during the refurbishment, followed by their return to values similar to those before the implementation of the refurbishment.

5.2.3 WASTE

Tab. 91 shows the effects of waste generation at the Cernavodă NPP during the refurbishment of U1 and the extension of the DICA storage facility with MACSTOR 400 modules.

Radioactive waste

In the case of the refurbishment of Unit 1, as in the case of the operation of nuclear units, radioactive waste management is a permanent concern of the operator.

The management of radioactive waste generated during the refurbishment of Unit 1 has been analysed, based on international experience and taking into account the technical solutions to be adopted during the pre-disposal stage, in the framework of the study *KHNP, Feasability Study on Management of Radwaste Generated during Unit 1 Refurbishment and Operation of Unit 1,2 in Cernavodă NPP – Environmental Issues Report*.

Low and intermediate level radioactive waste from the refurbishment activities and from the operation of the Cernavodă NPP units ***will be permanently disposed of, according to their classification, in DFDSMA and DGR respectively***, in accordance with the National Medium and Long Term Strategy for the Safe Management of Spent Nuclear Fuel and Radioactive Waste, approved by GD 102/2022.

Low and intermediate level radioactive waste containing short-lived radionuclides (LILW-SL), after treatment and conditioning by the licence holder, will be disposed of in the DFDSMA site **-** the repository to be built in the exclusion zone of the Cernavodă NPP, subject to approval by the competent authorities. The first stage of DFDSMA is intended to be completed in 2028, with 8 cells to be built in this first phase.

Low and intermediate level radioactive waste containing long-lived radionuclides (LILW-LL), which include spent ion exchange resins from systems not in contact with nuclear fuel (plus some resins in contact with nuclear fuel, depending on operating time and irradiation history), filters, reactivity control rods and other components, as well as radioactive waste from the refurbishment process, mostly consisting of reactor metal components (including pressure tubes, Calandria tubes etc.), ***will be stored long-term, on-site, in the new DIDR-U5 and will be permanently stored in a deep geological repository (DGR) when it becomes available***.

The following figure shows the radioactive waste streams from the Cernavodă NPP, with their final destinations, DFDSMA and DGR.

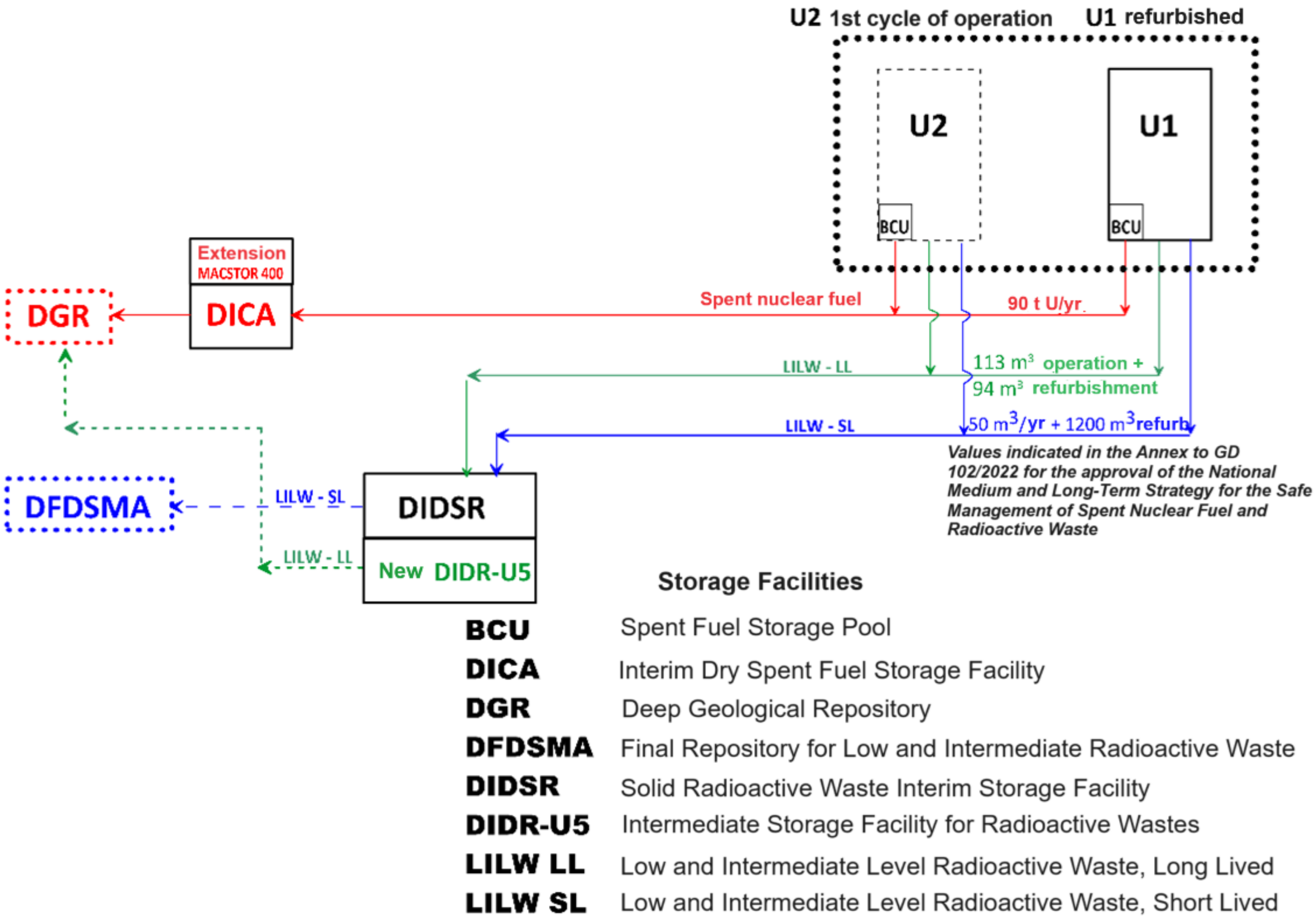


Fig. 108 Flow of radioactive waste (low and intermediate level active) and spent nuclear fuel resulting from Cernavodă NPP activities, until completion of the planned final disposal solution

The inventory of radioactive waste generated in the refurbishment process and its management plan are presented in detail in chapter 1.8.1.

In the operational, post-refurbishment phase of Unit U1, both the inventory and the radioactive waste management will be similar to the situation in the first operating cycle.

The minimization of impact and safe management during operation and maintenance of Units 1 and 2 in commercial operation at the Cernavodă NPP is achieved through the radioactive waste management practices LILW-SL, LILW-LL and SNF described in paragraphs 3.5, 3.6, and 3.7 respectively of the National Medium and Long Term Strategy for the Safe Management (SNGS) of Spent Nuclear Fuel and Radioactive Waste, approved by GD No 102/2022.

According to SNGS, the volumes/quantities of radioactive waste estimated to be generated from the operation and refurbishment of the nuclear units U1 and U2 of the Cernavodă NPP are:

- ***LILW-SL***:100 m^3/year - unconditioned volume generated from the operation and maintenance of U1 and U2 units currently in commercial operation, and 1200 m^3 - volume resulting from the refurbishment of a CANDU unit (paragraph 3.5 of the Annex to the strategy)
  This means that each nuclear unit generates 50 m^3/year LILW-SL from operation and maintenance, plus 1200 m^3 from refurbishment.
- ***LILW-LL***: 852 m^3 – volume of unconditioned waste during the operation and refurbishment of the four nuclear units (paragraph 3.6.1. of the Annex to the strategy). The volumes of waste estimated to be generated by units U1 and U2 are 226 m^3 from operation and 188 m^3 from refurbishment respectively (Table 8 - Section 2 of the Annex to the Strategy).
  This means that for each of the units U1 and U2 113 m^3 LILW-LL waste will be generated from operation and 94 m^3 from refurbishment.
- ***SNF***: the operation of units U1 and U2 at the Cernavodă NPP generates most of the spent nuclear fuel in Romania, at an average rate of about 180 t U per year (paragraph 3.7 of the annex to the strategy), i.e. about 90 t U/year.unit.

It is noted that the DFDSMA will ensure the final disposal of treated and conditioned LILW-SL waste and the DGR will ensure the final disposal of treated and conditioned LILW-LL radioactive waste, presumably spent nuclear fuel (SNF) that will be generated as a result of the operation of both units U1 and U2 - currently in commercial operation, as well as future units U3 and U4.

Non-radioactive waste

The main negative environmental effects of non-radioactive waste are that it takes up unproductive space, is unsightly and risks becoming a source of soil, vegetation, water and air pollution if not properly managed.

During the project period, the following categories of non-radioactive waste are generated: waste from construction materials, absorbent materials, polishing materials, filters and protective clothing; packaging waste; municipal and assimilable waste. The impact of their generation is minimised by applying specific procedures for separate collection, temporary storage in specially designated areas/containers on the Cernavodă NPP site and recovery/disposal by authorised operators.

During the operation of the refurbished U1, the types of waste and quantities generated will be similar to those of the first operating cycle.

Thus, it is estimated that the operation of the two nuclear units, refurbished U1 and U2, will generate, as it currently does, between 60 and 799 tonnes/year of recoverable waste, of which between 70 and 629 tonnes are iron and copper waste, 15 - 25 tonnes of paper and cardboard waste, 0 - 25 tonnes of wood waste and 20 - 116 tonnes of waste oil - mainly from transformers. This waste is recovered in its entirety by authorised operators on a contract basis. Thus, the recycling of recoverable waste is an action that falls under the requirements of the SNEC - Recycle (R8) and Recovery (R9) principles.

Non-recyclable waste is hazardous waste, meaning annual quantities between 18 - 153 tonnes, of which ion exchange resins represent up to 26%. Hazardous waste containing organic substances represents 27.4% of the total hazardous waste (153 tonnes - maximum). Hazardous waste is collected and temporarily stored under controlled conditions and handed over to authorised operators for disposal.

Household waste has no significant impact on the environment when managed in accordance with the regulations in force. It is estimated that during the future operation of the two nuclear units about. 2 l of household waste/man/day for both Cernavodă NPP personnel and contractors. This waste is stored in specially arranged places, in containers regularly handed over to authorised operators for transport to the centralised landfill for municipal waste.

5.2.4 Environmental factor SOIL

Non-radiological impact

The sources of non-radiological pollution of the soil and subsoil during the project implementation phase are represented by:

- execution of topsoil stripping works, excavations, etc.;
- machinery traffic on unpaved surfaces;
- accidental spillage of petroleum products from machinery used on site;
- improper storage of construction materials;
- improper waste management.

The areas disturbed for the preparation and implementation of the project are limited.

Transport in the industrial perimeter will be carried out exclusively on the routes planned for this purpose.

Petroleum products (diesel, mineral oils) could leak onto the site from vehicle and machinery engines.

In the case of improper storage of construction materials and/or waste directly on the ground, it could occur a deterioration of the soil/subsoil quality.

These are ***potential*** sources of soil and subsoil pollution, ***the possible occurrence of pollution can only be of an accidental nature***, resulting from non-compliance with the conditions laid down in the construction project, regarding the handling and/or storage of construction materials, waste, in areas other than those provided for this purpose.

During the realization of the RT-U1 and DICA MACSTOR - 400 Project, in order to ensure an adequate management for the management of waste during the construction works, the legal provisions relating to the management of waste and the management of the chemical substances used will be obeid within the construction site on site, as well as the specific procedures of Cernavoda NPP.

Subproject RT-U1

During the preparation period of the RT-U1 sub-project the impact on soil is manifested by the development/realisation of the supporting infrastructure for the refurbishment, including the development of the new DIDR-U5. It is estimated that at this phase **the impact on soil is minor negative/positive** given that most of the platforms are already concreted and the new DIDR-U5 is being installed in an existing building on the site.

As regards the specific activities during ***the refurbishment phase***, the impact is ***minor***, given that the activities are mainly carried out in the reactor building and the transfer of radioactive waste from U1 to the new DIDR-U5, respectively to the DICA-MACSTOR 200/400, is carried out with appropriate equipment, on the routes specifically allocated for these transfers.

Subproject DICA-MACSTOR 400

Regarding the execution activities of the MACSTOR 400 modules, the impact on the soil is:

- ***minor negative as a result of land occupation*** with modules by extending the surface with 16000 m^2 compared to the current DICA
- ***positive*** as the intermediate storage of the spent fuel resulting from the operation of the nuclear units will be done ***on the NPP platform - site allocated by CNCAN exclusively for the development and carrying out of nuclear-specific activities***, combined with the fact that the ***land for the extension of DICA represents a "good bedrock"*** for this type of activities.

By the profile and character of the activities ***during the period of operation***, possible soil, subsoil and groundwater pollution in the site area could only occur in situations such as:

- pollution by accidental spills of chemicals (e.g. petroleum products) directly on soil
- non-compliance with the conditions for storage and removal of waste from the site.

By the profile and character of the activities during the operation of the project, possible interactions on soil could be caused only by some accidental situations with consequences in local soil pollution.

In addition, ***during the project operation, the impact associated with the generation of non-radioactive waste is insignificant*** as it is temporarily stored in specially designed areas on the Cernavodă NPP platform and handed to authorized operators for recovery/disposal.

The Assessment of the impact that the project may have on the environmental factor SOIL, in accordance with the methodology of the General Guide applicable to the stages of the environmental impact assessment procedure - Annex 1 to Ord. 269/2020 is presented in Tab. 105, Tab. 106 și Tab. 107. The conclusions of the assessment are:

The non-radiological impact on soil during the realization of the RT-U1 and DICA-MACSTOR 400 project, as a result of land occupation by: *execution of new constructions and MACSTOR modules, temporary storage of non-radioactive waste from construction/excavation, recyclable/non-recyclable waste* ***is minor negative/positive. The positive nature*** of the impact results from the fact that the project is executed on the site designated by CNCAN exclusively for the development of nuclear objectives, and the extension of the DICA is in the area with "good bedrock".

The non-radiological impact on the soil during RT-U1 and DICA-MACSTOR 400 project operation is ***insignificant***, as a result of the application of the internal procedures of Cernavoda NPP on the management of the generated waste and of the monitoring conditions imposed by MMAP/ANAR/ABADL.

Radiological impact

The Assessment of the impact that the project may have on the environmental factor SOIL, in accordance with the methodology of the General Guide applicable to the stages of the environmental impact assessment procedure - Annex 1 to Ord. 269/2020 is presented in Tab. 105, Tab. 106 și Tab. 107. The conclusions of the assessment are:

The radiological impact on soil during the implementation of the RT-U1 and DICA-MACSTOR 400 project, respectively ***during project operation***, is ***minor negative***, ***respectively insignificant negative***, since, under normal operating conditions, both during the implementation of the RT-U1 and DICA-MACSTOR 400, and during the operation of the refurbished Unit 1, radioactive contamination could occur, at very low levels and only in the vicinity of the plant, as a result of the transfer of radioactive pollutants (tritium in the form of tritiated water) from the air to soil.

5.2.5 The environmental factor BIODIVERSITY

During the assessment of the impact of the analyzed project on biodiversity, account was taken of the particularities of the location ***inside the Cernavoda NPP industrial platform, land allocated by CNCAN exclusively for the development and carrying out of nuclear-specific activities***; although modestly represented, the biodiversity environmental factor retains elements of connection with the proximal environmental matrix. In our approach, we sought to highlight the functional elements and the ways to maintain them despite the expansion of the industrial-type perimeters, so that the location does not generate effects of discontinuity (*gep affect*).

Our approach focused on the regulatory stages completed under the coordination of the Ministry of Environment, Water and Forests - representing the central environmental protection authority with attributions in the regulation of this project - which published the **Decision of the scoping stage no. 1/23.02.2022 by which it is proposed to start the** ***environmental impact assessment procedure, without the need for adequate assessment*** *and assessment of the impact on water bodies*. (Annex 3).

From a temporal point of view, the manifestation of the impact on biodiversity experienced a significant historical expansion, given the fact that ***the Cernavoda NPP site is located on the site of a former limestone quarry***, so the duration of the manifestation of the effects remains extended over several decades.

During the documentation and evaluation, respectively at the time of formulating the conclusions, ***the results of the BIOTA programs (2009-2012, 2013-2016), the conclusions of the appropriate assessment study for U3 and U4 and the results of the ongoing environmental monitoring program were also taken into account by Cernavoda NPP which did not show a significant impact on biodiversity.***

The non-radiological impact is manifested through the actual footprint of the project, given by the occupation of the land. It should be noted that the target areas remain in the NPP perimeter, having the destination and function of an industrial type area, dedicated to the activities associated with the NPP. The structure of these habitats, as shown in subchapter. 3.4 (Fig. 31 – Fig. 34), remains a modestly expressed one, dominant being ubiquitous, ruderal, invasive and/or pioneer species; the simplification of the biocenosis is due to the initial changes in the components of the flora and fauna, which occurred from the time of the first constructive stages of the NPP.

Thus, the loss of biodiversity, as a result of the occupation of the land by building the structures belonging to RT-U1 and DICA-MACSTOR 400, is quantified as the loss (in equivalent) of up to 8-12 pairs of nesting songbird species (e.g. codroș – *Phoenicurus ochruros*, warbler – *Troglodytes troglodytes,* great tit – *Parus major*; blackbird – *Turdus merula*). The presence of such species was routinely observed including in free areas (green spaces) with simplified morphology at the level of some perimeters belonging to the NPP.

However, the disturbance wave of the population effects will die off immediately after the completion of the construction stage, as a result of the implementation of the impact mitigation measures aimed at increasing the support capacity of the proximal habitats, so as to regain the potential to maintain some flora and fauna populations fauna inside the NPP perimeters (including songbird species that maintain a high and medium tolerance to the impact generated by the anthropogenic factor.

In the given context, the reverberation of the disturbance wave will not propagate significantly in the territory, it will fade over a distance that will not exceed 3 diameters of the territories occupied by such species (below 1.4 - 1.5 km), so the manifestation in a cross-border context remains **insignificant**.

Associated with the impact generated during the construction stage, there are effects mainly due to noise, but also dust generation. If in the case of noise generation, fauna species are affected (again, this is the case of songbird species that can no longer effectively delimit their territory through song), in the case of dust generation, flora species are affected as a result of reducing the photosynthetic capacity through dust deposition.

Both impact situations retain a limited, reduced relevance (assessed as **insignificant**) in the context given by the ecotope at the level of the target area, with an expression that does not exceed 300 - 800m (in a prudent, conservative assessment, up to 1km).

Subproject RT-U1

The direct impact on biodiversity manifests insignificantly on the area that does not exceed the limits of the exclusion zone (0.8 -1 km), in the construction stage and in the operation stage. During the construction stage, there may be disturbances to the nesting of songbirds. The foliar photosynthetic capacity is estimated to be reduced to the existing vegetation insignificantly during the execution.

The indirect impact caused by transport inside and outside the NPP premises is insignificant, judging by the experience of the previous years of operation. The structures of the access roads to the NPP and the external roads are in satisfactory condition. Incidents with birds or mammals (foxes, jackals, etc.) are very unlikely.

Under current operating conditions, the designed constructions and installations ensure the quality of the environment. Contamination of flora and fauna in the area of influence has not been noticed in the current operation of U1 and U2 since commissioning until now.

Subproject DICA-MACSTOR 400

Effects similar to those of subproject RT-U1 are estimated.

The assessment of the impact that the project may have on the BIODIVERSITY environmental factor, in accordance with the methodology of the General Guide applicable to the stages of the environmental impact assessment procedure - Annex 1 to Ord. 269/2020 is presented in Tab. 105, Tab. 106 and Tab. 107. The conclusions of the assessment are:

The impact on biodiversity (aquatic environment, flora, fauna) during the execution period of the RT-U1 and DICA-MACSTOR 400 project is insignificant.

The impact on biodiversity (aquatic environment, flora, fauna) during the operational period of the RT-U1 and DICA-MACSTOR 400 project is insignificant.

5.2.6 NOISE and VIBRATION

The evaluation of an impact for a project starts from the analysis of the current state of the site related to the project in relation to its surroundings, combined with the identification of all sources that can contribute to the definition of that impact.

Considering the activities specific to the project phases, as well as the development schedule of these activities, we appreciate that for this project the noise and vibration emission assessment is important to be carried out for **the current state and for the project site phase** (The phase of setting up and execution of the infrastructure and constructions supporting the project)**.**

Thus, based on our experience, **we estimate that the noise levels** in the U1 Shutdown Phase, retubing, tests and the Operation Phase of the refurbished U1, when Unit 2 is also operating - **will be similar to the results of the current state of the environment in terms of noise emission.**

However, the impact assessment was carried out for all the described phases, the results of modeling the noise levels generated specific to each phase can be found in Tab. 94 and in boards 1 - 6 in Annex 6 NOISE.

With regard to the analysis of the noise related to the project, the existence of an activity schedule requires the assessment of noise and vibration levels in the planned phases, in order to assess compliance with the legal provisions, or if appropriate to implement appropriate corrective measures.

Accordingly, the noise and vibration impact assessments referred to the following phases:

- The project implementation stage
  - The phase of setting up and execution of the infrastructure and constructions supporting the project, which includes the set-up of DIDR-U5, constructions within the framework of DICA – MACSTOR 200/400 modules, construction of buildings, necessary RT-U1 support buildings; (2024 – 2026)

    In operation on site there are U1, U2 and DICA MACSTOR 200.
  - Shutdown Phase U1, retubing, tests, which includes: DIDR-U5 in operation, DICA MACSTOR in operation, U1 is shut down for retubing, U2 in operation, constructions at DICA MACSTOR 400. (2027 – 2029)
- Operation stage of refurbished U1 and DICA-MACSTOR 400: In this phase the MACSTOR 400 module building activity is carried out and U2 is also operating (in the second operating cycle of Unit 1, starting in 2030).

The construction site activities related to the period of setting up and realizing the infrastructure as well as the planned objectives for the RT-U1 project and DICA MACSTOR 400 expansion are activities that generate additional noise and vibrations, through the internal traffic of the means of transport and through the use of their specific devices.

Since the renovation activity involves the creation and set-up of the infrastructure as well as the set-up of spaces with buildings located in different areas on the site of the power plant, in the acoustic modeling of the territory, it was chosen for groupings of buildings within appropriate site areas, based on the neighborhood criterion.

Each construction site area was modeled [118] as a surface-type noise source, to which an emission resulting from the acoustic powers of the work equipment required for the construction phase hes been assigned, with the necessary corrections related to the working time of each within the established reference period, as well as to the type of activities in different phases of the construction site.

Another element that must be taken into account is the approximate working time of each device within the established reference duration, also correlated with the type of activities in different phases of the construction site (for example, a bulldozer only works in the stage of making the foundation).

In a conservative approach, the evaluation of the noise distribution (noise map) was carried out as if the mini-construction sites were simultaneously in operation. With this approach it is obvious

[118] Law 121 of July 3, 2019, regarding the assessment and management of ambient noise

that if the mini-construction sites are active simultaneously and the noise levels are within the legal limits, then the conclusion is also valid if their activity is non-simultaneous.

The equipment specific to the works on the site, in its various stages, are: bulldozer, crawler excavator, tower crane, welding generator, bench with circular saw, loader, machine for pressure application of concrete and mortar, mixer for concrete and mortar, truck, compressor. For the information necessary to assign their acoustic characteristics, GD no. 1756/2006 and the British standard BS 5228 – 1:2009 + A1:2014 Part 1 were consulted.

Another source of noise related to the construction site phase is the traffic related to the supply of materials needed for each mini-site: heavy trucks, concrete mixers.

The road traffic noise within the territory of the plant, on the established access roads, was calculated by assigning to each section of road, 6 passes/hour for such vehicles, with travel speeds of 20 km/h.

Tab. 94 : Noise levels (L_{eq}) for the current status and project phases of RT-U1 and DICA-MACSTOR 400

Reference point	**Noise levels dB(A)**			
	Current state (Board 1)	**Constructio n phase** (Board 2)	**Refurbishment phase** (Board 3)	**Final phase (post refurbishment)** (Board 4)
1	44.8	59.6	42.5	41.8
2	29.7	55.9	48.2	47.5
3	47.7	48.4	48.7	47.7
4	62.1	62.1	61.4	62.1
5	62.0	62.0	51.4	62.0
6	55.6	55.6	52.4	55.7
7	33.1	52.3	41.5	40.2

All noise levels (Leq), evaluated, fall within the limits imposed by SR 10009-2017, being lower than the limit of 65 dB(A)

Higher noise levels characterize the area to the east, but these are also below the value of 65 dB(A). However, at a distance of about 50 m from the boundary of the enclosure, the noise levels are below 60 dB(A), and at more than 200 m they are below 55 dB(A), which means a insignificant impact on the conservation objectives in the protected natural areas Natura2000 sites in the vicinity of the project.

The results of modeling the noise levels for the planning and execution Phase of the infrastructure and constructions supporting the project can be found in Board 2: *Distribution of noise levels for the complementary constructions phase* in Annex 6 NOISE.

The results of modeling the noise levels for the Shutdown Phase U1, retubing, tests are illustrated in *Board 3: The distribution of noise levels for the refurbishment phase U1, and those for the Operating Phase of the refurbished U1 and DICA-MACSTOR 400* are shown in *Board 4 : The distribution of noise levels for the final situation (U1 refurbishment and DICA extension project).*

The impact on the population generated by the acoustic emissions during the performace of the RT-U1 and DICA-MACSTOR 400 project is insignificantly negative, as a result of the large distance between the receivers and the source.

Evaluation of the impact of noise on the conservation objectives of the protected natural areas Natura 2000 sites in the vicinity of the project

Globally, the adverse effect of noise on protected natural areas is proven by the fact that, together with other pollutants, it has contributed to the disappearance of more than 20% of species compared to 1900 and to the decline of the populations of many of the remaining ones.

The difficulty of adopting limits to protect living things derives from the fact that depending on the species the sensitivities to noise are different, both in sound pressure level and in the perceived frequency range. Therefore, the restrictions cannot invoke the observance of certain limits, but refer to the wording "as little noise as possible". Studies on the noise reactions of different species are carried out by quantifying over time the variation in the number of individuals of a certain species, exposed to the noise levels generated by certain sources (traffic, industry, etc.) in the area in the vicinity of these sources.

An example taken from a study (California) citing an acceptable limit of 60 dB(A) for the noisiest time of the day [119] relates to the protective value of an endangered nightingale-like species.

The impact on fauna generated by acoustic emissions during the RT-U1 and DICA-MACSTOR 400 project is insignificant negative (due to the long distance between the receiver and the source).

Vibration assessment

In Germany, DIN 4150 norms establish limit values so that the integrity of constructions is not affected (Tab. 95) - the descriptor parameter is ppv (peak particle velocity).

Tab. 95 Limits ppv according to frequencies (DIN 4150-3: 2016-12)

Line	Building type	Frequency range			Horizontal vibrations. on the paving of the top floor
		1 – 10 Hz	10 – 50 Hz	50 – 100 Hz	
1	Buildings with industrial use, or other similarly structured buildings	20	20 – 40	40 – 50	40
2	Residential buildings	5	5 – 15	15 – 20	15
3	Buildings sensitive to vibrations (e.g. protected monuments)	3	3 – 8	8 – 10	8

In the Romanian legislation, references to the limits regarding the ppv parameter in the case of vibrations transmitted through the ground can be found in the Technical Regulations regarding the Measurement of the speed of movement of seismic waves - annex to the NSPM for the Storage, Transport and Use of Explosive Materials, ed. 1997, in which the correlation between the degree of seismic intensity (MSK scale – Medvedev, Sponheuer, Karnik - 1964) according to STAS 3684/71,

[119] Guillaume Dutilleux, Anaïs Fontaine, Bruit routier et faune sauvage, Juillet 2015

the speed of oscillations of soil particles and the effects on structures, in the case of movements produced by blasting works, is also presented (Tab. 96).

Tab. 96 The speed of soil particle oscillations and the effects on structures according to Romanian legislation

Degree of seismicity STAS 3685-71	**The effect on structures**	**Oscillation speed ppv (mm/s)**	
		Allowed value	**Limit value**
IV	Possible damage to rural constructions, pipelines under pressure, oil and gas wells, mine wells, very fragile structures.	5	10
V	The painting layer is exfoliated. Small and narrow cracks appear in the plaster in rural and urban constructions. Possible minor damage to industrial buildings.	11	20
VI	There are cracks in the coating in the partition walls and the detachment of some pieces of plaster in industrial constructions.	21	40
VII	Fractures occur in the resistance elements in rural type constructions, fractures in masonry with detachment of large pieces of coating in urban type constructions and cracks in coating with detachment of pieces in industrial type constructions. steep slopes. Possible damage to pipe joints. Damage to mounted machines.	41	80
VIII	Major fractures occur in the resistance elements of rural and urban constructions. Cracks occur in the resistance elements of industrial constructions.	81	160

In Great Britain the standard BS 7385: Part 2 1993, Guide on limit values of transient vibrations relative to cosmetic damage provides the following, ppv peak velocity in [mm/s]:

Tab. 97 Transient vibration limit values relative to cosmetic damage, according to the Standard BS 7385: Part 2 1993

Item no.	The type of building	ppv [mm/s]
1	Reinforced or framed structures	50 for frequencies ≥ 4 Hz
2	Unreinforced or framed structures, light Ordinary residential or commercial buildings	15 – 20, growing, for frequencies from 4 Hz to 50 Hz 20 – 50, growing, for frequencies from15 Hz to 50 Hz and above

In the previous environmental assessment developed for Cernavoda NPP (BM - 2018) it was found that the effect of vibrations generated by current activities on the site is insignificant. As a result, the present study analyzed the effect of vibrations generated in the planning and execution phase of the infrastructure and constructions supporting the project (construction site phase).

A category of ***vibration sources*** that must be considered is ***construction machinery*** during their work. Some are equipment characterized by important masses, whose activity involves the development of large forces, interacting with the ground generating shocks and vibrations that are transmitted to a distance through the elastic environment represented by the ground.

The second ***significant source of vibrations is the heavy internal traffic of the transport of the necessary construction materials, including concrete mixers.*** The movement of these heavy vehicles on a road with inherent unevenness is the cause of the vibrations generated by the transport.

The soil is an elastic-plastic environment characterized by a certain damping constant. The wave is defined by the frequency and one of the following parameters: particle displacement, particle velocity, particle acceleration. By propagating in the surrounding elastic medium, the energy of the wave is distributed over increasingly larger wave surfaces, so that at a given point, at a given distance, the amplitude, velocity, and acceleration decrease due to geometric considerations. The friction induced in the movement of the particles of the propagation medium and the transformation of a part of the wave energy into heat is the cause of the damping that characterizes the propagation environment.

The negative effects of vibrations starting from different values of the descriptor parameter manifested the following effects:

- at the workplace – exposure of the worker (for example, working with the pickhammer) to doses above the admissible limit, established by the labor protection norms;
- on industrial and commercial buildings, residential buildings, constructions characterized by weak resistance (for example, historical monuments) and consist in the production of damages of various degrees (from cosmetic damage to the destruction of the building);
- influencing the comfort of residents of residential buildings exposed to vibrations above certain limits.

A useful unit used in characterizing vibratory motion is the maximum velocity of the oscillating particle at a given point. It is denoted by the symbol ***ppv*** (*peak particle velocity*).

Through specific measurements the *ppv* parameter can be evaluated. In the field, there are some methods of forecasting the values of the vibration parameters depending on the type of activity considering the equipment used for it. A method considered suitable to use in the present case is the one presented in the Guide "Transportation and Construction Vibration". Guidance Manual"[120].

Starting from the value (ppv_0) at a certain reference distance (d_0) the value (ppv_d) at the desired distance (d) is calculated

The index n is dependent on the type of ground through which the wave propagates.

$$\boldsymbol{ppv_d} = \boldsymbol{ppv}_0 * \left(\frac{\boldsymbol{d}_0}{\boldsymbol{d}}\right)^{\boldsymbol{n}}$$

- $\boldsymbol{ppv_d}$ [mm/s] - the peak velocity of the particle at a distance $\boldsymbol{d}$ [m]
- $\boldsymbol{ppv_0}$ - the peak velocity of the particle at the reference distance of 7.62 m (25 ft); 1ft. = 0.3048 m
- $\boldsymbol{n}$ - attenuation index for the propagation of vibrations through the ground.

[120] Jim Andrews, David Buehler, Harjodh Gill, Aesley L. Bender Transportation and Construction Vibration . Guidance Manual. Caltrans, 2013

In a conservative approach, the value of n is taken to be 1.1. Higher values of n, corresponding to less rigid soils with lower transmissibility, lead to faster attenuation of ppv.

The following table lists the reference PPV_0 values at 7.62 m distance for some machines used in construction.

Tab. 98 Amplitudes of vibration speeds for some construction machines

Item no.	**Equipment**	**The peak velocity of the particle *(PPV_0)* [mm/s] at the reference distance (d_0 = 7.62 m)**
1	Vibro compactor cylinder	5.15
2	Large bulldozer	2.19
3	Drilling machine for caisson	2.19
4	Heavy truck, loaded	1.86
5	Pickhammer	0.86
6	Equipment used to remove bumps on a road	58.8

According to the above table, in the framework of the construction site works to be carried out within the NPP, among the site machines, the bulldozer is the most important source of vibrations, as amplitudes of their parameters. The table also contains the characteristic of the heavy truck as a source of vibrations on the roads used in the territory of the plant. Since the values of the vibration parameters (displacement, speed, acceleration) decisive in assessing the effects are the maximum, ***the bulldozer is important for the construction site, and the heavy vehicle for traffic***.

In the following table, for the specified sources, the distances from these machines are presented for which the ***ppv*** parameter has the values entered in column (1).

Tab. 99 The distances from the bulldozer and from a heavy vehicle, at which the speeds entered in column (1) are obtained

***PPV* [mm/s]**	**Distance to the bulldozer [m]**	**Distance from the heavy vehicle [m]**
(1)	**(2)**	**(3)**
5.0	3.70	3.21
4.0	4.54	3.92
3.0	5.89	5.10
2.0	8.52	7.4
1.0	16.00	13.85
0.5	30.00	26.00

Also, in the following figure there is the comparative representation, for the bulldozer and the heavy vehicle, of the variations of the peak velocity of the particle as a function of distance.

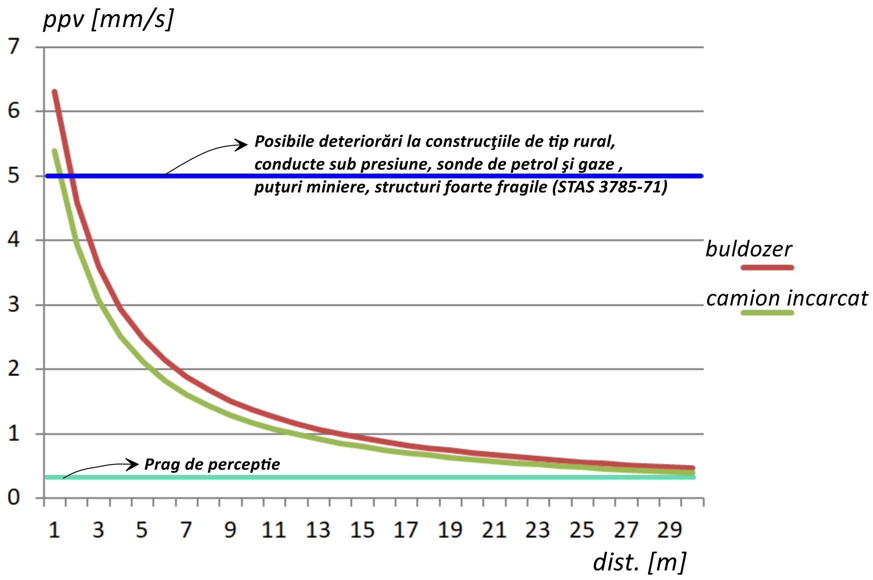


Fig. 109 Representation of the variation of the ppv parameter as a function of distance for a bulldozer and a loaded truck. (The vibration perception threshold is represented by the range 0.14 – 0.30 mm/s)

In the following figures (*Fig. 110 - a* and *b*) the distributions of equal level curves of ppv in the vicinity of a construction site are represented.

Each curve represents the geometric locus of the points at which the maximum ***ppv*** can reach the value marked on the drawing.

The red curves correspond to a value of ***ppv*** = 5 mm/s.

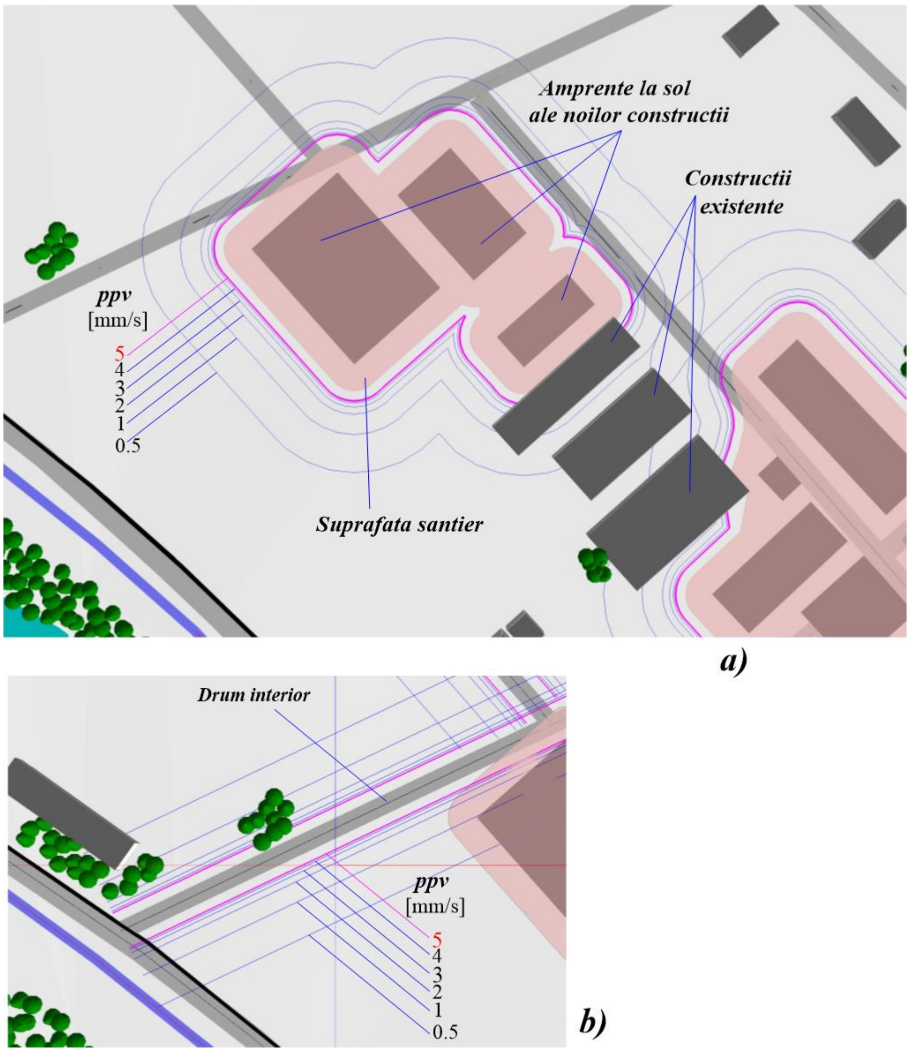


Fig. 110 Graphical representations of ppv distributions in the vicinity of a construction site (a) and in the vicinity of a heavy vehicle access road (b) – detail

The results of the vibration analysis for the phase of setting up and execution of infrastructure and constructions supporting the project can be found in Board 9: *The values of the maximum vibration levels - ppv [mm/s], which may appear in the vicinity of a site sector, generated by some specific activities and respectively in* Board 10*: The values of the maximum levels of vibrations – ppv [mm/s], which may appear in the vicinity of a road sector, generated by the movement of trucks loaded with construction materials, concrete mixers* from *Annex 6 NOISE.*

Vibration levels during the construction phase of the project are low and do not cause cosmetic damage to the facades, which represents an insignificant negative impact on the objectives on the site located in the vicinity of the project.

Cumulative impact with other approved/ongoing projects on the Cernavoda NPP site

The following presents the summary of the evaluations for the cumulative impact of the RT-U1 and DICA-MACSTOR400 project with other approved/ongoing projects at the Cernavoda NPP site, for the noise component. These projects are also implemented within the power plant, as there are no other objectives nearby that would generate noise to which the noise generated within the power plant can be added.

The analysis steps for the cumulative impact scenarios are found in the subchapter 5.2.12 - Tab. 114.

The results of the evaluation of the cumulative impact generated by the noise sources for each of the analyzed scenarios are presented in the following table:

Tab. 100 Noise levels (L_{eq}) for cumulative impact estimation for each of the three scenarios

Reference point	**Noise levels dB(A)**		
	Stage I_2024 - 2026 - MAINLY EXECUTION	Stage II_2027 – 2029 U1 SHUTDOWN, RETUBING, TESTS and CONSTRUCTIONS	Stage III_2032-2037 ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE
1	59.6	45.0	46.6
2	55.9	48.2	48.4
3	48.4	55.6	62.4
4	62.1	61.8	62.5
5	62.0	53.9	62.4
6	60.5	60.1	60.2
7	52.3	42.8	42.8

All evaluated noise levels (Leq) fall within the limits imposed by SR 10 009-2016, being below the limit of 65 dB(A).

The differences between the final state and the current one are due to the commissioning of U3 and U4, of CTRF as well as the planned activity of building MACSTOR 400 modules.

Higher noise levels characterize the area to the east, but these are also below the value of 65 dB(A). However, at about 50 m from the boundary of the enclosure, the noise levels are below 60 dB(A), and at more than 200 m they are below 55 dB(A), ***which means a insignificant impact on the conservation objectives of the protected natural areas Natura2000 sites in the vicinity of the project***.

Vibration levels are low and do not cause cosmetic damage to building facades.

The results of the noise assessment through acoustic mapping for the cumulative impact can be found in boards 6, 7 and 8 in Annex 6 NOISE.

The impact on the population generated by acoustic emissions and vibrations during the operation period of the RT-U1 and DICA-MACSTOR 400 project is insignificant, due to the long distance between the receivers and the source - similar to the current operation situation of the two nuclear units U1 and U2 on the site.

5.2.7 Impact on CLIMATE - the nature and amplitude of greenhouse gas emissions. The vulnerability of the project to climate change

Transforming the energy system to achieve net zero emissions, which requires the large integration of different renewable technologies, involves major technical, economic, social and political challenges.

The Sixth Assessment Report of the United Nations Intergovernmental Group for Climate Change (IPCC – AR6) shows that many of the scenarios assessed can achieve the objective of limiting the increase in global average annual temperature to 2°C compared to pre-industrial levels, without or limited exceeding (Fig. 111).

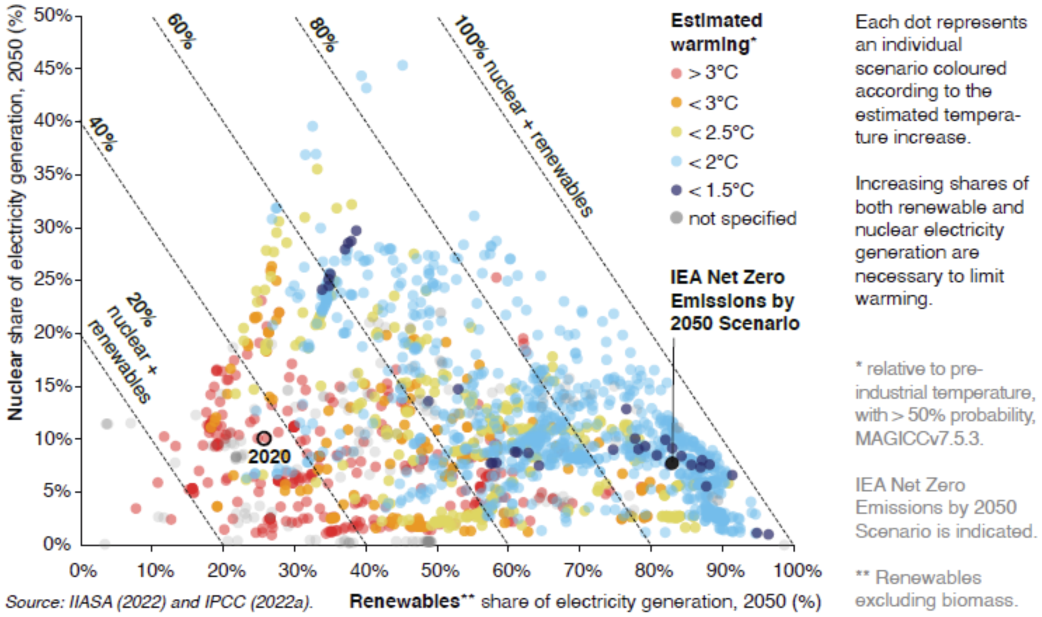


Fig. 111 Shares of nuclear and renewable energy in the electricity generation mix and corresponding climate warming across IPCC AR6 scenarios

The nuclear energy can provide various low-carbon energy products for power systems, including electricity and process heat for industry, desalination, district heating and hydrogen production. These low-carbon energy products can provide both additional electricity production and the ability to store energy to complement wind and solar energy production as means of mitigating climate change (IPCC, 2022a). [121]

The following figure shows the forecast for the evolution of global greenhouse gas emissions (CO_2 equivalent) in the "**Net zero emissions by 2050**" scenario. It is noted that by the year 2040 GHG emissions from the production of electricity and thermal energy will have to be zero, and this trend justifies the opportunity of refurbishment project.

[121] Climate Change and Nuclear Power 2022; Securing Clean Energy for Climate Resilience

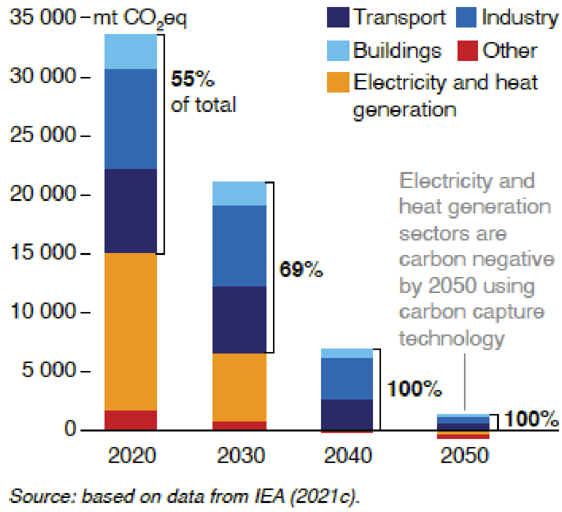


Fig. 112 Global energy sector emissions by sector and decade, 2020–2050 under the IEA Net Zero Emissions by 2050 Scenario[122]

Cernavoda NPP is part of the of nuclear power plants category which, in addition to electricity production, also provides approx. 42 GWh$_t$ of thermal energy annually for the heating system of the city of Cernavodă, ranking 15th in the world in the list of nuclear power plants that provide energy for district heating.

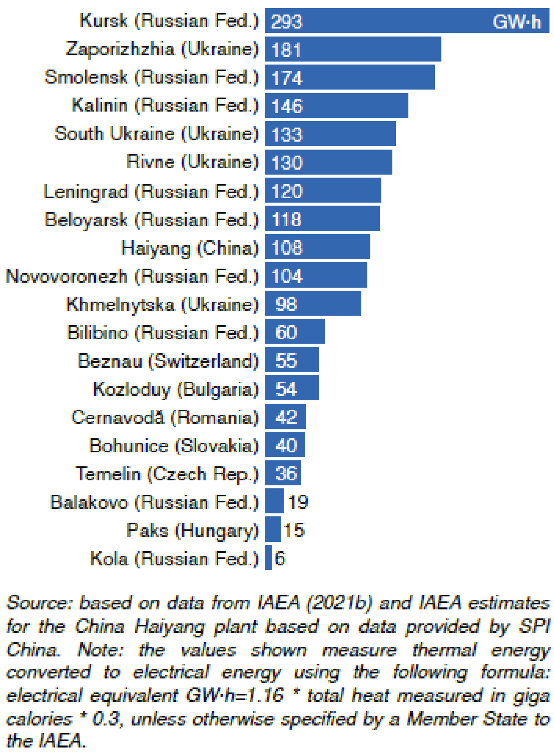


Fig. 113 Nuclear power plants that provide heating[123]

[122] IAEA, Climate Change and Nuclear Power 2022 Securing Clean Energy for Climate Resilience – Chapter 04 Climate resilient nuclear infrastructure: Mapping future climate, weather and water risks
[123] Climate Change and Nuclear Power 2022; Securing Clean Energy for Climate Resilience

5.2.7.1 GHG emissions

The following table shows the estimated GHG emissions and avoided GHG emissions by operating the refurbished U1 unit, in the second 30-year operating cycle.

Tab. 101 Estimated GHG emissions for refurbished U1 operation and avoided emissions compared to the fossil fuel - coal scenario

Period	Refurbished U1 energy production		Direct emissions kt CO_2 equiv.		Total emissions kt CO_2 equiv.		Avoided total emissions kt CO_2 equiv.
	Electric energy TWhe	Thermal energy TWht	Nuclear process	Coal burning	Nuclear process	Coal burning	
2030-2060	181	0.63	0	138039	2180	148937	**146757**
Annual	6.03	0.02	0	4601.3	73	4965	**4892**

The average emission factors indicated in the Fifth Assessment Report of the Intergovernmental Group on Climate Change - Working Group Volume III, Annex III Technology-specific costs and performance parameters - Table A.III.2. - Emissions of selected electricity supply technologies (gCO_2eq/kWh) were used for the assessment of GHG emissions. The average values of the emission factors were applied in the assumptions of the production on the same amount of energy by the nuclear process and respectively by burning coal, namely:

- for nuclear process: $EF_{direct\ emissions}$ = 0 gCO_{2eq}./kWh și $EF_{total\ emissions}$=12 $gCO_{2equiv.}$/kWh
- for coal burning: $EF_{direct\ emissions}$ =760 gCO_{2eq}./kWh și $EF_{total\ emissions}$ =820 $gCO_{2equiv.}$/kWh

Direct greenhouse gas (GHG) emissions are those from sources controlled or owned by the organization - in this case emissions associated with burning the fuel.

Total emissions include direct emissions and indirect emissions generated by the construction of the infrastructure and the supply chain.

The results are consistent with the information provided annually by SNN SA in the "Clean Label" prepared according to the provisions of ANRE Order no. 69/2009 for the approval of the Electricity Labeling Regulation (r1) amended and supplemented by ANRE Order no. 61/2016. Thus, in the period 2013-2022, the specific annual emissions of SNN SA were below the specific emission considered in the methodology (12 gCO_2equiv./kWh), which makes the annual GHG emissions avoided to present values close to the estimated ones.

Tab. 102 Annual GHG emissions associated with the operation of Unit 1 in the period 2018-2022 and emissions avoided compared to the situation of using fossil fuel – coal, calculated on the basis of the electricity label

Year	Electrical energy produced U1 (MWhe)	Specific emmissions ($kgCO_2$/MWh)	GHG emissions kt CO_2/year	Specific emmissions ($kgCO_2$/MWh)	GHG emissions kt CO_2/year	Avoided GHG emissions kt CO_2/year
		SNN SA		Coal burning		
2013	5622015	5.37	30.2	919.48[124]	5169.3	5169.3
2016	4765824	2.47	11.8	910.73[124]	4340.4	4340.4
2017	5485440	5.42	29.7	911.14	4998.0	4998.0
2018	4928499	4.66	23.0	915.60	4512.5	4512.5
2019	5292668	5.13	27.2	881.04	4663.1	4663.1
2020	4963253	4.44	22.0	851.74	4227.4	4227.4
2021	5450512	10.74	58.5	823.18	4486.8	4486.8
2022	4606578	7.50	34.5	812.87	3744.5	3744.5

Note: According to the Electricity Label, the primary source for the production of electricity at SNN SA is its own nuclear power, in a percentage of 96 - 99.3%.

From the GHG emissions point of view, after the implementation of the RT-U1 and DICA-MACSTOR 400 project, the estimated level of CO_2 emissions will remain within the limits provided for in Authorization no. 38/25.01.2023 on greenhouse gas emissions for the period 2021-2030, avoiding - as at present - the generation of approx. 5 million tons of CO_2 annually [125].

From the perspective of the aforementioned, extending the life of Unit U1 with one more operating cycle is part of the decarbonization measures.

The impact on the climate during the RT-U1 and DICA-MACSTOR 400 project implementation, as a result of GHG emissions from machines/engines***, is insignificantly negative, and during the operation period of the project the impact is positive due to the avoidance of GHG emissions by obtaining electricity through the nuclear process***

5.2.7.2 Vulnerability of the project to climate change. Adaptation measures

The 2022 IAEA Report for climate change and nuclear energy [126] presents the specific vulnerabilities of nuclear power plants arising from the risks associated with climate change.

For nuclear power plants located in Central and Western Europe (WCE Western&Central Europe), the geographical area in which Cernavoda NPP is included, the main vulnerabilities for plants located near a river are related to:

- increase in average temperature and high temperatures
- hydrological drought
- floods and intense rainfall
- strong winds - storms.

[124] ANRE, General Energy Market Directorate. Report on the results of monitoring the electricity market in December 2013 and December 2016 respectively
[125] https://www.nuclearelectrica.ro/ir/proiecte-de-investitii/
[126] IAEA, Climate Change and Nuclear Power 2022 Securing Clean Energy for Climate Resilience – Chapter 04 Climate resilient nuclear infrastructure: Mapping future climate, weather and water risks

The intensity, duration and number of dangerous phenomena can be amplified under the conditions of climate change.

External hazards, including those associated with climatic conditions, have been taken into consideration since the choice of the Cernavoda NPP site. Meteorological conditions and hydrological parameters are monitored on site, trends are analyzed and forecasts are updated to identify risks and establish measures to reduce the impact.

The analyzes indicated that the main risks for the Cernavoda NPP platform are those determined by:

- Flooding from external sources (high level of the Danube and/or intense local precipitation);
- Severe environmental conditions (strong wind/tornado, high/low temperature, phenomena specific to the winter season, ***extremely low water level in the Danube River***, etc.[127]

according to the aforementioned report.

- ***The danger of flooding from external sources*** - the results of the analyzes indicated the following sources as credible:
  - Overflows of the Danube River;
  - Rains of extreme intensity on the site of the plant and its surroundings.

For the water level in the Danube, the project base flood level was considered to be 14.13 mMB, with the probability of being reached once in 10000 years. The historical maximum level of the Danube water at Cernavodă was 11.72 mMB, recorded in May 2006, it falls within the anticipated value with a probability of return once every 100 years (11.93 mMB). The elevation of the plant site is 16.00 mMB, and the reference elevation for the buildings' floors is 16.30 mMB. Thus, the possibility of flooding the Cernavoda NPP site as a result of the extreme rise in the level of the Danube is improbable.

In case of torrential rains, the maximum historical intensity recorded on the site was 47.3 l/m^2/hour, and the rainwater collection system is sized for 97.2 l/m^2/hour. According to the analyzes carried out and validated by INCDDD Tulcea, a rain with an intensity 10 times higher than the value for which the collection system is dimensioned, can lead to a temporary accumulation of water on the site up to a level of about 20 cm, lower than the 30 cm provided by the reference level for the floors of the buildings.

- ***Increase in average temperature and high temperatures during summer***

According to the most pessimistic scenario, the maximum temperature could reach 49.5°C, under conditions of amplification of the frequency and duration of heat waves. In these conditions could occur:

- the increase in the water temperature in the race I of the CDMN (from where the reactor condensers cooling water is abstracted)
- biological instability of the water, with algal blooms and biological deposits on the contact surfaces of the installations
- modification of the heat transfer regime of the condensers cooling system.

[127] SNN SA –Cernavoda NPP, Presentation Memoir RT-U1 and DICA – MACSTOR 400, November 2021

In order to fight against the effects, Cernavoda NPP proceeds to:

- Monitoring of meteorological and hydrological parameters.
- Security analyzes and sensitivity studies carried out periodically to evaluate safe operating limits for systems where influences of elevated temperatures have been observed
- Water treatment to inhibit the growth of algae and other organisms
- Supplementing cooling capacity for the cooled water supply system, the emergency cooling system, the spent fuel pool sprinkler system, the ventilation and air conditioning systems inside the nuclear buildings. To cool the fuel, water will be used from the existing reserves on the Cernavoda NPP site, regulated by the Water Management Authorization, the emergency power supply system and the mobile Diesel units.[128]

Hydrological drought – according to estimates, the change in the number of drought events (SPI-3 < -1) can be between 0.5 – 1 in 30 years (subchapter 3.6.3), with the possibility of 69 consecutive days of dryness in a year[129]. The consequence is a decrease in the level and flow of surface water, which can affect the operation of the condenser cooling water pumps, with possible unplanned shutdown of the reactor.

In order to combat the effects of this phenomenon, the strategy is established for both units operating on the site, applicable in the event of an extreme decrease in the flow rates or available levels of cooling water, which is implemented through abnormal operation procedures. Preventive shutdown of the units is provided. The cooling of the nuclear fuel is ensured in this case with mobile equipment or from deep sources (aquifer not influenced by the seasonal variations of the surface water level). Emergency cooling pumps have been upgraded to operate at 1.45 mrBS levels and raw water pumps - at 1.55 mrBS.

- ***Phenomena specific to the winter season***

The freeze-thaw phenomenon, frost, ice accumulation can affect the proper functioning of equipment and systems of Cernavodă NPP exposed to the outside.

The cooling water intake can be damaged by the formation of partially frozen liquid.

Direct consequences can be on the ventilation systems that can be blocked by the layer of ice deposited on the ventilation and ventilation grilles.

Breaks and short-circuits of electric lines of Cernavoda NPP can occur.

Fighting the effects is done as follows:

- Nuclear buildings are equipped with heating systems that have as their source the heat produced by the reactor, the starting thermal plant or electricity. For parts of systems directly exposed to low temperatures it can be appreciated that thermal stress and embrittlement are covered by the conservatism required by the design codes used.
- Formation of the partially frozen liquid is prevented by injecting hot water into the distribution basin.
- There are specific procedures to address the abnormal situation that has occurred, including through Diesel groups - backup generator.

[128] SNN SA – Cernavoda NPP, Nuclear Security Report for the Intermediate Solid Radioactive Waste Storage Facility at Cernavodă - Chapter 2, Doc.79-01320-RFS-DIDSR-CAP2/2022

[129] IAEA, Climate Change and Nuclear Power 2022 Securing Clean Energy for Climate Resilience – Chapter 04 Climate resilient nuclear infrastructure: Mapping future climate, weather and water risks

- ***Strong wind, tornadoes, storms***

- ***Strong wind*** can cause the automatic disconnection of nuclear units, due to weather conditions that cause disturbances in the national energy system

Design reserves and qualifications for other types and combinations of nuclear structure loadings provide intrinsic and enhanced resistance to high winds.

The emergency plan provides for administrative measures to deal with cases where the wind may present a threat to the operation of the plant or the safety of personnel.

- ***Tornadoes*** are phenomena recorded in the region that can indirectly influence the operation of the NPP, mainly by making the power lines in the regional energy system unavailable. Tornadoes confirmed so far in the region have been low-intensity events - F0 and F1 on the Fujita scale, the strongest being classified as F3 in Făcăeni in May 2017 - which, even if they occur in the site's influence area, do not have the ability to to displace a sufficient volume of water to affect the cooling of the nuclear fuel. The assessment of safety margins for this hazard, including projectile generation, conservatively considered damage to river water pumping structures and unavailability of electrical power sources. In this case, deep wells or firemen's tanks can provide the water needed for cooling, and the mobile diesel groups the necessary electricity.

Taking into account the assessed risks and hazards, the vulnerability of the project to climate change is reduced, with specific climate change adaptation measures already taken for each type of risk.

5.2.8 Socio-economic effects

Subproject RT-U1

During the planned long-term shutdown for refurbishment – when Unit U1 will not generate energy, the National Energy System will no longer benefit from the electricity supply of approx. 5000 GWhe, amount that will have to be secured from other sources.

As shown in subchapter 1.7.8, jobs will be created as follows:

- Creation of direct jobs during the refurbishment: around 1700.
- For the operation of Unit 1, in the second operating cycle, the number of jobs increases from 11000 to 19000 persones.

Subproject DICA-MACSTOR 400

As a positive effect, the opportunity for new jobs is highlighted. For each built module to be executed, about. 30 people will be involved.

5.2.9 Impact on the health of the population as a result of the implementation of the RT-U1 and DICA-MACSTOR 400 project

This sub-chapter presents the assessment of the radiological and non-radiological impact on the health of the population, following the implementation of the project „*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*”, based on the Population Health Impact Assessment Study - May 2024 prepared by the National Institute of Public Health.

5.2.9.1 Radiological impact on the health of the population following the implementation of the RT-U1 and DICA-MACSTOR 400 project

In order to assess the environmental impact of the project „Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”, the National Institute of Public Health (NIPH) has developed the Population Health Impact Assessment Study - May 2024.

The analysis of the results of the environmental radioactivity monitoring at the Cernavodă NPP showed that the only radionuclides for which an additional dose to the population can be considered as a result of the radioactive emissions of the plant are ^{3}H and ^{14}C. For these radionuclides, the annual doses that may be received by representative members of the population have been estimated according to the methodology for calculating derived discharge limits for the Cernavodă NPP (IR-96002-027).

Doses for critical population groups (adults and children aged 0-1 years) were calculated by two methods: 1) based on gaseous and liquid emissions (discharges) from the two nuclear units (applied for ^{3}H and ^{14}C); 2) based on concentrations measured in environmental samples by the routine environmental radioactivity monitoring programme at the Cernavodă NPP (applied only for ^{3}H, as ^{14}C is not detectable in environmental samples taken outside the Cernavodă NPP exclusion zone).

In order to provide a context for the possible significance of these doses, the ***dose*** and ***risk (estimated) to a member of the critical groups living in the vicinity of the Cernavodă NPP*** were considered for analysis.

For conservative reasons, calculations of health effects were made using ***maximum doses***. In view of the final LAR (lifetime attributable risk) result, the ***ten-year average dose*** was used in the calculations. At the same time the ***minimum and maximum values*** were estimated for the two age groups in the three locations (Cernavodă, Seimeni, Constanța).

It should be pointed out that the risks for people living further away from the 30 km proximity zone of the Cernavodã NPP will be lower because the dose decreases as distance increases.

The following risk coefficients were used to calculate excess cancer mortality:

a) nominal detriment-adjusted risk coefficients from ICRP Publication 103 (Table A4.4)

b) risk coefficients corresponding to the "lifetime attributable risk" defined in BEIR VII, Chapter 12

The scenario used was for the general population, the risk was calculated as Lifetime excess cases of fatal cancer calculated per 100000 (one hundred thousand) persons:

Tab. 103 Lifetime excess cases of fatal cancer calculated per 100000 people

Excess cases of fatal cancer/100000		ICRP MODEL		BEIR VII MODEL	
		Adult	***Child (0-1 yrs)***	***Adult***	***Child (0-1 yrs)***
Cernavodă	*average*	2.17	2.57	1.84	2.19
	minimum	1.77	2.10	1.51	1.78
	maximum	2.79	3.32	2.37	2.82
Seimeni Mari	*average*	0.05	0.08	0.04	0.07
	minimum	0.01	0.02	0.01	0.02
	maximum	0.24	0.13	0.2	0.36
Constața		0.0009	-	0.0007	-

According to the hypothesis of the evolution of radioactive emissions from Unit 1 of the Cernavodă NPP during the refurbishment processes and during the commissioning period after refurbishment, the only radioactive emissions whose significant increase could be anticipated as a result of the activities during the refurbishment period are those of tritium, with a small probability, however, of exceeding the derived emission limits approved for Unit 1 during normal operation (the derived emission limits approved for Unit 1 are more than ten times higher than the recorded levels of emissions during operation). This assumption is supported by radioactive emissions data from the Point Lepreau Nuclear Generating Station (PLGS) and the Bruce A and Bruce B Nuclear Power Stations during a similar refurbishment process.

Based on the assumption that the annual emissions of tritium via liquid radioactive effluents will increase by an order of magnitude in the first year of the period during which the refurbishment work at Unit 1 will be carried out, an increase in the effective dose to people in Seimeni is observed, to values of 0.72 µSv for adults and 1.30 µSv for children, compared to the maximum dose values calculated during the operating period of 0.53 µSv for adults and 0.96 µSv for children.

Consequently, the lifetime attributable risk (LAR) values are not expected to change significantly during the project period compared to the normal operating situation.

To further contextualise the risk analyses, the results of ***the Survey Study on the health status of populations living in the vicinity of major nuclear sites in Romania***, a study developed by the National Institute of Public Health since 1989, were analysed. According to the methodology of this ecological study, a series of health indicators are analysed annually, namely ***demographic data, incidence of specific cancers and mortality related to these populations***. The data are collected and reported annually by the Territorial Radiation Hygiene Laboratories that have major nuclear sites in the counties, around which surveillance is carried out. Cancer incidence data were obtained for the following: all cancer sites combined; thyroid, lung and bronchus cancer; female breast; ovary; oesophagus; stomach; colon and rectum; bladder; brain and other nervous system; liver; and leukaemia and non-Hodgkin's lymphoma. These cancers were chosen because they are radiosensitive, and disease coding was based on the third edition of the International Classification of Diseases for Oncology (Percy et. All, 1990). The population size was obtained for localities within 30 km around the Cernavodă NPP (called the proximity area) and includes the resident population in this area.

The analysis of data on the incidence of cancers with specificity for exposure to ionizing radiation, as well as specific mortality from these cancers, was based on the calculation of crude rates and standardized rates, with standardization calculated on the basis of data reported in the Statistical Yearbooks. Indicators of the health status of the populations in the areas surveyed were derived from data collected from individual report cards, with new cancer cases being reported by GPs in the territory and by the County Oncology Cabinet. The health indicators relevant to this study, and which allowed a dynamic analysis of the last 10 years, were: standardised incidence reports of leukaemia/lymphoma and solid tumours and standardised specific mortality reports of leukaemia/lymphoma and solid tumours (new cases observed/new cases expected). The reference population was considered to be the population of Romania. Data for Romania on incidence and mortality by leukaemia/lymphoma and solid malignancies, as well as overall mortality data, were provided by the National Centre for Statistics and Informatics in Public Health. As a result, the small population size and rarity of some cancers limited the statistical power of this study's findings among the population living in the study area.

The results of this ecological study reveal ***that the standardized leukaemia/lymphoma and solid tumour incidence rates are subunit for the population in the vicinity of the Cernavodă NPP for the whole period analysed***. In other words, if the age-specific incidences had been applied to the reference population considered (the Romanian population), it would have been expected that a higher number of specific cancers would have occurred than the one recorded. Similarly, ***the standardised reports of specific mortality by leukaemia/lymphoma as well as the standardised reports of specific mortality by solid tumours for the population in the vicinity of the Cernavodă NPP are also subunit, for the whole period analysed***. These results indicate that, if the age-specific mortalities for the whole country were applied to the population in the analysed area, a higher number of specific deaths would be expected than the one recorded.

A similar analysis of the Pickering and Darlington NPPs area of influence in Canada revealed that although some increased cancer rates (thyroid, breast and kidney cancer) were recorded in the areas in the vicinity of the two plants, no clear pattern was found over the time periods analysed (1981 to 2004) for incidence and mortality indicators. All other health indicators were statistically significantly decreased in the study population, and overall the disease rates did not show a pattern suggesting that Pickering NPP and Darlington NPP had effects on population health, either during normal operation or during the period of similar refurbishment projects.

Thus, ***the health impact assessment study - prepared by INSP - indicates that there will be no significant impact on the health of the population in the vicinity of the Cernavodă NPP as a result of the implementation of the project.***

Potential health effects on the population resulting from a malfunction, radiological/nuclear accident etc. are presented in subchapter 8.2.

5.2.9.1 Non-radiological impact on the health of the population following the implementation of the RT-U1 and DICA-MACSTOR 400 project

Based on the assessment of non-radiological impacts on abiotic environmental factors, the population health impact study estimated that during both the project implementation and operation periods:

- there will be no significant impact on the health of the population in the area surrounding the Cernavodă NPP due to the air environmental factor;

- there will be no significant impact on the health of the population in the area surrounding the Cernavodă NPP due to the water environmental factor;

- there will be no significant impact on the health of the population in the area surrounding the Cernavodă NPP due to the soil environmental factor;

- from the analysis of the noise maps it is observed that exceedances of the 50/55 dB values could occur outside the NPP site only in certain phases (construction complementing the refurbishment) and in a rather limited area - but which could overlap with some existing constructions in the north-west neighbourhood.

Following the analysis carried out for the characterisation of the current state in the Cernavodă NPP area, it was found that the noise levels generated by the operation of the objectives on the site are within the limits set by SR 10009: 2017. Acoustics. Permissible limits of ambient noise levels.

- the socio-economic impact is positive – by creating jobs.

- provided that the project and the recommendations in the expert opinions/studies are complied with, the activities to be carried out within the framework of this investment objective will not adversely affect the health of the population in the area through the application of the measures provided.

The potential environmental impact in the event of a SEVESO accident is presented in subchapter 5.2.10.

5.2.10 Technologies and Substances Used – Environmental Impact in case of SEVESO Accidents

From the perspective of the Control of Major-Accident Hazards involving dangerous substances, the relevant subproject is RT-U1 (In the implementation of the subproject "Intermediate Dry Spent Fuel Storage Facility extension with MACSTORE-400 modules" and in the operation of DICA, no hazardous chemicals will be used)

Accidents involving hazardous substances that may occur at the Cernavodă NPP site can be grouped as follows:

1. Leaks and emissions of hazardous substances
2. Fires
3. Explosions.

The impact on the environment in the event of a Seveso accident is primarily determined by the hazard categories that characterize the substances that may be involved in an accident.

Thus, the dangerous substances falling under the scope of Law 59/2016 (Seveso) and posing a *health hazard* are hydrazine, morpholine, and chlorine in liquefied gas form.

Dangerous substances falling under the scope of Law 59/2016 (Seveso) and posing an *environmental hazard* are hydrazine, light liquid fuel (LLF), fire-resistant hydraulic fluid (FRF), liquefied chlorine gas, biocide ARQUAD MCB-50, and diluent WSX.

Dangerous substances falling under the scope of Law 59/2016 (Seveso) and presenting *physical hazards* are flammable liquids: diesel fuel, LLF, and flammable gases, while those presenting an explosion hazard are hydrogen, acetylene, oxygen, and argon-methane mixture P 10.

Leaks of volatile liquid substances and **vapors emissions** with high toxicity can cause toxic dispersions, affecting the environmental factors, air, water, and soil. There is also a risk of intoxication and/or injury of the personnel.

Fires are hazardous due to the thermal radiation, atmospheric pollution with combustion gases and smoke, as well as pollution of soil and groundwater with contaminated water resulting from extinguishing a fire in large quantities if it reaches unprotected areas. On-site, due to the protection of exposed areas through concreting, the collection and treatment system for potentially contaminated technological water and rainwater, the risk of pollution with contaminated water resulting from a possible fire is very low.

Thermal radiation can cause serious injury to operating and intervention personnel as well as damage to machinery and equipment, caused by exposure to fire and high temperatures, with the accident being amplified by the extension of the fire zone and the occurrence of explosions.

Smoke and combustion gases can cause intoxication of operating or intervention personnel caught in the fire zone without adequate protective equipment, this phenomenon being more severe in enclosed spaces where the possibilities of smoke and combustion gases evacuation are lower.

In the event of an **explosion**, serious injury to operating or intervention personnel caught in the blast and associated thermal radiation may occur. Significant damage to machinery and installations may also occur. The explosion may be followed by a violent fire of the flammable substances released due to the damage to the installations.

To assess the environmental impact in the event of a Seveso accident, scenarios analyzed for hydrazine, chlorine, and hydrogen have been selected (from the scenarios analyzed in the Safety Report), based on the following considerations:

1. Hydrazine (hydrazine hydrate) according to Regulation (EC) No. 1272/2008 presents the following hazard categories determining its inclusion under the scope of Law 59/2016:
   - Health Hazards, Acute Toxicity, Category 3 (H331: Toxic if inhaled, H311: Toxic in contact with skin)
   - Environmental Hazards, Short-term (acute) Hazard to the Aquatic Environment, Category 1 (H400: Very toxic to aquatic life) and Long-term (chronic) Hazard to the Aquatic Environment, Category 1 (H410: Very toxic to aquatic life with long-lasting effects).
2. Chlorine according to Regulation (EC) No. 1272/2008 presents the following hazard categories determining its inclusion under the scope of Law 59/2016:
   - Health Hazards, Acute Toxicity, Category 3 (H331: Toxic if inhaled)
   - Environmental Hazards, Short-term (acute) Hazard to the Aquatic Environment, Category 1 (H400: Very toxic to aquatic life)
   - Physical Hazards, Oxidizing Gas, Category 1 (H270: May cause or intensify fire; oxidizer)

3. Hydrogen according to Regulation (EC) No. 1272/2008 presents the following hazard categories determining its inclusion under the scope of Law 59/2016:
   - Physical Hazards, Flammable Gas, Category 1 (H220: Extremely flammable gas; may form explosive mixtures in air).
4. The most severe/adverse scenarios analyzed in the Safety Report.

Hydrazine is present on-site, in the SEIRU storage facility and in the following installations:

- The chemical water treatment facility required for the units and respective vehicular routes - Machine Room. At Unit 1 and Unit 2, in the Turbine Building at elevation 93, where a maximum of 2 barrels is stored (one sealed/full and one in use). The addition frequency is every 4-5 days, with quantities added of approximately 10 liters: approximately 0.4 tons in stock.
- Unit 0 (at CTP): The addition frequency in the cooling water circuits is 1-2 times per month, with the quantity added being approximately 5-8 liters. Stock is less than 0.2 tons

Following the PHA evaluation for the chemical water treatment facility required for the units, it resulted that the scenarios have an isolated or occasional probability and minor to moderate consequences.

It should also be mentioned that the main hazardous substance for which the Cernavodă NPP site falls under the scope of Law 59/2016 (Seveso) is hydrazine. The maximum quantity present on-site is 9 tons, relevant qualifying quantities being between 0.5 tons for Lower-tier requirements and 2 tons for Upper-tier requirements. The largest quantity of hydrazine is present in the SEIRU storage facility. The most severe and credible scenario is the spillage of the total quantity of hydrazine hydrate from a barrel outside the storage facility during its handling. The complete damage of the barrels within the storage facility due to falling structural elements as a result of an earthquake is unlikely, as the warehouse is of lightweight metal construction. The deterioration of barrels inside the warehouse – such as cracks or ruptures – may lead to leaks, which are collected in the retention bunds associated with the special pallets used for storage.

The SEIRU storage area is located on the left bank of the Danube - Black Sea Canal, about 1 km from the lock for barges/ships, towards the locality of Ștefan cel Mare.

It should also be noted that around nuclear units, the following are established:

- Exclusion zone with a radius of 1 km – where no activities other than those carried out within the Cernavodă NPP are allowed; measures are taken to exclude the placement of permanent residences for the population and the conduct of socio-economic activities not directly related to the operation of the nuclear facilities of the Cernavodă NPP.
- Zone with a low population density – with a radius from 1 to 3 km from the nuclear facility – where measures are taken to restrict the placement of permanent residences for the population and the conduct of socio-economic practices.

Chlorine is present on-site at the Water Treatment and Chlorination Station (permanently 2 cylinders in the installation: one connected and one reserve).

Considering the possible level of consequences in the event of an accident involving chlorine release, the distances at which the toxic cloud can have negative effects on human health have been calculated.

Scenario K.1. Mechanical shock during cylinder handling,

The scenario involves two situations:

1. Explosion of a chlorine cylinder with instant emission of 50 kg,
2. Cylinder fittings defects or their unsealing, valve cracking (defects are promptly remediated and chlorine leaks do not exceed 2 minutes).

Both scenarios have a low probability but can have major consequences if the toxic cloud reaches areas within the site with personnel present or inhabited areas, communication routes, etc.

From the modeling of scenario K.1.2, it resulted that for this scenario, not even the minimum dose of 1.486 [min x (ppm)n] (corresponding to the AEGL 1 threshold for a 10-minute exposure) was reached, the chlorine cloud formed disperses before the presentation of toxic effects.

Hydrogen is present on-site in the Technical Gas Storage Depot and in the following installations:

- Hydrogen Storage and Distribution System
- Technical Gas Distribution System for the Chemical Laboratory
- Machine room (Unit 1 and Unit 2)

The selected scenarios for hydrogen are as follows:

HYDROGEN STORAGE AND DISTRIBUTION SYSTEM:

Scenario A.1. Disconnection/ Rupture of the flexible hose during the hydrogen unloading operation from the tanker to the tank

The probability of this scenario is low because the unloading system is periodically checked by the supplier. However, the consequences can be major if the fire spreads to the tanker or storage tanks. The unloading procedure prescribes that the tanker unloading should face the outside of the site perimeter, so that a fire does not affect the storage tanks or fittings, reducing the potential for domino effects.

Scenario A.5. Catastrophic rupture of the hydrogen tank and Scenario A.9. Fire/explosion at the tank.

The consequences of these two scenarios are similar, potentially catastrophic with domino effects, thus the scenarios are treated under the same modeling. The probability of the scenarios is very low – low, as the site has military guard, the system is periodically inspected, and the unloadings are made according to the supplier's procedure.

Quantity of hydrogen in a tank: 0.0899 kg/Nm^3 * 2250 Nm^3 (la 45 bar) = 202.75 kg H_2.

Scenario A.6. Cracks in the hydrogen tank body

The probability of this scenario is very low – low because the tanks are periodically checked and tested by ISCIR. The consequences can be major, both in case of ignition of the formed hydrogen cloud, producing the flash fire phenomenon and personnel injury, as well as in case of jet fire ignition which has potential for domino effects.

Scenario A.10. Rupture/disconnection of hydrogen transportation pipes

The scenario involves the total rupture of the hydrogen transportation pipe on the route between the tank – Central Unit. The quantity of gas that can be released is the one existing in the pipe, the circuit being closed at both ends in case the turbine system is not supplied with hydrogen.

The amount of hydrogen in the pipe: 0.011 kg (calculated with a pipe length of 670 m, diameter 2", pressure 10.3 bar).

The probability of the scenario is very low – low, and the consequences are potentially major in case a fire breaks out following the leak and the flame reaches other process equipment.

Scenario A.11. Cracks in the hydrogen transportation pipes.

The scenario involves the formation of a crack with hydrogen emission until the pipeline route is emptied: tank – Central Unit. The quantity of gas that can be released is the one existing in the pipe, the circuit being closed at both ends in case the turbine system is not supplied with hydrogen. The amount of hydrogen in the pipe: 0.011 kg (calculated with a pipe length of 670 m, diameter 2", pressure 10.3 bar). The probability of the scenario is very low – low, and the consequences are potentially major in case a fire breaks out following the leak and the flame reaches other process equipment.

F. TECHNICAL GAS DISTRIBUTION SYSTEM FOR THE CHEMICAL LABORATORY

Scenario F.5. The explosion of a hydrogen cylinder

The scenario involves the explosion of a hydrogen cylinder at the cylinder storage for the technical gas distribution system for the chemical laboratory. The storage is adjacent to the hydrogen cylinder storage for the primary circuit. The probability is low but the consequences can be major, involving domino effects on other cylinders in the area.

H. MACHINE ROOM (Unit 1 and Unit 2):

Scenario H.6. Rupture/disconnection of hydrogen transportation pipelines.

The scenario involves the total rupture of the hydrogen transportation pipelines in the turbine room (Unit 1, respectively Unit 2). The quantity of gas that can be released is the one existing in the pipeline along the route tank – turbine room, the circuit being closed at both ends in case the turbine system is not supplied with hydrogen. The quantity of gas that can be released is the one existing in the pipe, the circuit being closed at both ends in case the turbine system is not supplied with hydrogen. The amount of hydrogen in the pipe: 0.011 kg (calculated with a pipe length of 670 m, diameter 2", pressure 10.3 bar). The probability of the scenario is very low – low, and the consequences are potentially major in case a fire breaks out following the leak and the flame reaches other process equipment.

Scenario H.11. Fire/explosion at the turbine cooling body due to the mixture between hydrogen and air.

The scenario involves the occurrence of leaks or cracks on the turbine body, the entry of air inside, the formation of an explosive mixture with the hydrogen in the system (81 kg, corresponding to 900 Nm^3 H_2) and the internal explosion. The probability of the scenario is very low, as the system condition is periodically checked, and in case of leaks or cracks on the turbine body due to internal pressure, normally hydrogen would be released into the atmosphere of the generator room. The consequences of such a scenario can be catastrophic, including through the occurrence of domino effects on the installations in the area. As a simplifying assumption, the turbine body was assimilated with a pressure vessel, with the same quantity of hydrogen and working conditions.

For the selected scenarios in the following table, the assessment of the impact on the environment in case of a SEVESO accident is presented.

Tab. 104 Environmental Impact Assessment in Case of SEVESO Accident

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
Subproject RTU1						
Construction Phase **Preparation + Implementation of Refurbishment project**	**Sc. J.1. Hydrazine barrel leakages (SEIRU depot)**	Leakage in the hydrazine depot area: - Toxic dispersion within the hall due to the evaporation of leaks; - Staff intoxication through the inhalation of toxic vapors.	Human factor (in-house staff and contracted personnel within the site and outside the site, operators, and population - reversible injuries) Environmental factor - air	Isolated	On-site: Radius of the area with irreversible injuries, average weather conditions, 59 m from the source, and adverse weather conditions 63 m from the source. Off- site: Radius of the area with reversible injuries 1810 m from the source, and in adverse weather conditions, 303 m from the source.	Major
	Sc. K.1.1. The explosion of a chlorine cylinder with an instantaneous emission of 50 kg	- Toxic dispersals; - Staff intoxication through the inhalation of toxic vapors.	Human factor (own and contracted personnel) Environmental factor - air	Isolated	On-site: Radius of the area with irreversible injuries, average weather conditions, 187 m from the source, and adverse weather conditions 154 m from the source. Reversible injuries zone 187 m from the source, average weather conditions, and in adverse weather conditions 154 m from the source	Catastrophic

Project: RTU1 + DICA MACSTOR 400	Scenario	Effects in case of SEVESO accident	Factors susceptible to be significantly affected	Impact Assessment		
				Probability of occurrence	Extension of impact	Significance of impact – Measure of consequences
	Hydrogen storage and distribution system					
	1.Sc. A.1.1. Disconnection/breaking of the flexible hose during the operation of unloading hydrogen from the tanker into the tank.	- Hydrogen leakage at the hydrogen unloading ramp; - Possibility of ignition of hydrogen leakage; - Possibility of formation of a flammable cloud; - Fires/explosions; - Personnel injuries; - Damages to the tanker and unloading equipment; - Potential Domino Effect; - Spread of fire to tanks if the fire is not controlled; - Environmental pollution with fire residues.	Human factor (own personnel and contracted personnel/tanker driver) Environmental factor - * Material goods	Improbable	On-site: Radius of the area with irreversible injuries, average and adverse weather conditions 69 m from the source. On-site: Radius of the area with reversible injuries 76 m from the source, in average and adverse weather conditions.	Major
	2.Sc. A.5 Catastrophic rupture of the hydrogen tank and A.9 Fire/explosion at the tank.	- Leakages in the hydrogen tank area; - Possibility of ignition of hydrogen leakage; - Possibility of formation of a flammable cloud;	Human factor (own personnel) Environmental factor - * Material goods	Improbable	On-site: Radius of the area with irreversible injuries, average and adverse weather conditions, 105 m from the source.	Catastrophic

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
		- Fires/explosions; - Potential Domino Effect; - Personnel injuries.			On-site: Radius of the area with reversible injuries, 218 m from the source, in average and adverse weather conditions.	
	3.Sc. A.6 Cracks in the body of the hydrogen tank	- Hydrogen leakages in the area of the hydrogen tanks; - Possibility of ignition of hydrogen leakage; - Possibility of formation of a flammable cloud; - Fires/explosions; - Potential Domino Effect; - Personnel injuries.	Human factor (on-site personnel and population outside the site, in adverse weather conditions - reversible injuries) Environmental factor - * Material goods	Improbable	On-site: Flash fire*** Radius of the area with irreversible injuries, average weather conditions, 69 m from the source, and in adverse weather conditions 411 m. Jet fire** 9 m in both weather conditions. On-site: Radius of the area with reversible injuries 107 m from the source for Flash fire in average weather conditions and 648 m in adverse weather conditions, and Jet fire 9 m in both weather conditions.	Major
	4. Sc. A.10. Rupture/ disconnection of hydrogen transportation pipes	- Leakages on the hydrogen transportation route; - Possibility of ignition of hydrogen leakage;	Human factor (own personnel) Environmental factor - *	Isolated	On-site: Radius of the area with irreversible injuries, average and adverse weather conditions: 15 m from the source.	Major

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
		- Possibility of formation of a flammable cloud; - Fires/explosions; - Potential Domino Effect; - Personnel injuries.			On-site: Radius of the area with reversible injuries: 16 m from the source in both weather conditions.	
	5. Sc. A.11. Cracks in the hydrogen transportation pipelines	- Leakages on the hydrogen transportation route; - Possibility of ignition of hydrogen leakage; - Possibility of formation of a flammable cloud; - Fires/explosions; - Potential Domino Effect; - Personnel injuries.	Human factor (own personnel) Environmental factor - *	Isolated	On-site: The radius of the area with irreversible injuries, under both average and adverse weather conditions, is 4 meters from the source. On-site: The radius of the area with reversible injuries is 5 meters from the source, under both average and adverse weather conditions.	Major
	Chemical Laboratory Gas Distribution Facility					
	Sc. F.5.1. Explosion of a Hydrogen Cylinder	- Fire/explosion - Propagation of projectiles from the cylinder body - Possibility of a domino effect causing	Human factor (own personnel) Environmental factor - * Material goods	Isolated	On-site: Radius of the area with irreversible injuries, under average and adverse weather conditions, is 17 meters from the source.	Major

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
		fire/explosion in other cylinders nearby - Effects of overpressure and projectiles - Potential domino effects on other cylinders in the depot			On-site: The reversible injuries zone is 36 meters from the source under both weather conditions.	
	MACHINE HALL (UNIT 2)					
	Sc. H.6. Rupture/Disconnection of hydrogen distribution pipelines	- Damage to installations and equipment - Formation of explosive atmosphere - Possibility of ignition of the flammable dispersion - Potential for fire spreading to other installations in the room - Potential for deflagration of the dispersion with explosive mass - Domino Effect - Personnel injury	Human factor (own personnel and contracted) Environmental factor - * Material goods	Isolated	On-site: The radius of the area with irreversible injuries, under both average and unfavorable weather conditions, is 15 meters from the source. On-site: The radius of the area with reversible injuries is 16 meters from the source under both average and unfavorable weather conditions.	Major

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
	Sc. H.11. Fire/explosion at turbine cooling body due to hydrogen/oxygen mixture	- Hydrogen and gaseous oxygen leaks with the formation of an explosive atmosphere; - Possibility of igniting the flammable dispersion; - Possibility of deflagration/detonation of the dispersion with explosive mass; - Personnel injury; - Damage to the cooling system and turbines; - Explosion of the turbine body, projection of metal parts, and potential - Domino effects on other installations; - Serious damage to the structure of the unit building.	Human factor (own personnel and contracted) Environmental factor - * Material goods	Isolated	On-site: The radius of the zone with irreversible injuries, under both average and unfavorable weather conditions, is 180 m from the source. On-site: The radius of the zone with reversible injuries, under both average and unfavorable weather conditions, is 382 m from the source.	Catastrophic
Operating Phase **Operation of Unit 1**	**Sc. J.1. Hydrazine barrel leakages (SEIRU storage)**	- Leakage in the hydrazine storage area ; - Toxic dispersions inside the hall as a	Human factor (own and contracted staff on site and off site economic operators and population - reversible injuries)	Isolated	On site: Irreversible injury zone radius , average weather conditions, 59 m from the source and non-	Major

Project: RTU1 + DICA MACSTOR 400	Scenario	Effects in case of SEVESO accident	Factors susceptible to be significantly affected	Impact Assessment		
				Probability of occurrence	Extension of impact	Significance of impact – Measure of consequences
Cycle 2 of operation		result of evaporation of spills; - Intoxication of personnel through inhalation of toxic vapours.	Environmental factor - air		effective weather conditions 63 m from the source. Off- site: reversible damage area 1810 m from source , and in adverse weather conditions 303 m from source	
	Sc. K.1.1. The explosion of a chlorine cylinder with instantaneous emission of 50 kg	- Toxic dispersions; - Intoxication of personnel by inhalation of toxic vapours.	Human factor (own and contracted staff) Environmental factor - air	Isolated	On site: Irreversible injury zone radius, average weather conditions, 187 m from source and unfavourable weather conditions 154 m from source Reversible injuries zone 187 m from the source, average weather conditions, and in adverse weather conditions 154 m from the source	Catastrophic

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
	Hydrogen storage and distribution system					
	1.Sc. A.1.1 Disconnection/breakage of the flexible hose during unloading of hydrogen from the tanker into the tank	- Leakages at the hydrogen offloading ramp; - Possibility of hydrogen leakage fire; - Possibility of formation of a flammable cloud; - Fires/explosions - Personal injury - Damage to tanker and unloading equipment; - Potential Domino Effect - Spread of fire to tanks if fire is not controlled; - Environmental pollution from fire debris;	Human factor (own and contracted staff/tanker driver) Environmental factor - * Material assets	Improbable	On site: Radius of the area with irreversible damage, average and unfavourable weather conditions 69 m from source On site: Area of reversible damage 76 m from source, in average and unfavourable weather conditions	Major
	2/Sc. A.5 Catastrophic rupture of the hydrogen tank	- Leakages in the area of hydrogen tanks; - Possibility of hydrogen leakage catching fire; - Possibility of formation of a flammable cloud; - Fires/explosions	Human factor (own staff) Environmental factor - * Material goods	Improbable	On site: Irreversible injury zone radius, average and unfavourable weather conditions, 105 m from source On site: Area of reversible damage 218 m from source, in	Catastrophic

Project: RTU1 + DICA MACSTOR 400	Scenario	Effects in case of SEVESO accident	Factors susceptible to be significantly affected	Impact Assessment		
				Probability of occurrence	Extension of impact	Significance of impact – Measure of consequences
		- Potential Domino effect - Personnel injury			average and unfavourable weather conditions	
	3.Sc. A.6 Cracks in the hydrogen tank body	- Leakages in the area of hydrogen tanks; - Possibility of hydrogen leakage catching fire; - Possibility of formation of a flammable cloud; - Fires/explosions - Potential Domino effect - Personnel injury	Human factor (own staff on site and population off site in bad weather conditions - reversible injuries) Environmental factor - * Material assets	Improbable	On site: Flash fire*** Irreversible damage area radius, average weather conditions, 69 m from source and in bad weather conditions 411 m and Jet fire** 9 m in both weather conditions. On site: Area of reversible damage 107 m from source Flash fire in average weather conditions and 648 m in bad weather conditions and Jet fire 9 m in both weather conditions.	Major
	4.Sc. A.10. Rupture/ disconnection of hydrogen transport pipelines	- Leakages on the hydrogen transport route; - Possibility of hydrogen leakage fire; - Possibility of formation of a flammable cloud; - Fires/explosions	Human factor (own staff) Environmental factor - *	Isolated	On site: Irreversible injury zone radius, average and adverse weather conditions, 15 m from source On site: Area of reversible damage 16 m from source in both weather conditions	Major

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
		- Potential Domino effect - Personnel injury				
	5.Sc. A.11. Cracks in hydrogen transport pipelines	- Leaks on the hydrogen transport route; - Possibility of hydrogen leakage fire; - Possibility of formation of a flammable cloud; - Fires/explosions - Potential Domino Effect - Personnel injury	Human factor (own staff) Environmental factor - *	Isolated	On site: Irreversible injury zone radius, average and adverse weather conditions, 4 m from source On site: Area of reversible damage 5 m from source in both weather conditions	Major
	Installation for the addition of hydrogen to the primary heat transport circuit					
	Sc. E.5.1 The explosion of a hydrogen cylinder	- Fire/explosion - Propagation of projectiles from the body of the cylinder; - Possibility of domino effect with fire/explosion to other cylinders in the area of racks - Overpressure and projectile effects	Human factor (own staff) Environmental factor - * Material goods	Isolated	On site; Radius of irreversible injury zone, average and adverse weather conditions, 17 m from source On site: reversible damage area 36 m from source in both weather conditions	Major

Project: RTU1 + DICA MACSTOR 400	Scenario	Effects in case of SEVESO accident	Factors susceptible to be significantly affected	Impact Assessment		
				Probability of occurrence	Extension of impact	Significance of impact – Measure of consequences
		- Possible domino effects to other cylinders in the warehouse				
	MACHINE HALL (UNIT 1 and 2)					
	Sc. H.6. Rupture/ Disconnection of hydrogen transportation pipelines	- Damage to installations and equipment - Formation of explosive atmosphere; - Possibility of ignition of flammable dispersion; - Possibility of fire spreading to other installations in the room; - Possibility of deflagration of explosive mass dispersion. - Domino effect - Personnel injury	**Human factor (own and contracted staff)** **Environmental factor - *** **Material goods**	Isolated	On site: radius of the area with irreversible damage, average and unfavourable weather conditions 15 m from the source On site: reversible damage area 16 m from source in both weather conditions	Major
	Sc. H.11. Fire/explosion in turbine cooling casing due to hydrogen/air mixture	- Hydrogen and oxygen gas leaks with explosive atmosphere formation;	**Human factor (own and contracted staff)** **Environmental factor - *** **Material goods**	Isolated	On site: radius of the area with irreversible damage, average and unfavourable weather conditions, 180 m from the source	Catastrophic

Project: RTU1 + DICA MACSTOR 400	**Scenario**	**Effects in case of SEVESO accident**	**Factors susceptible to be significantly affected**	**Impact Assessment**		
				Probability of occurrence	**Extension of impact**	**Significance of impact – Measure of consequences**
		- Possibility of ignition of flammable dispersion - Possibility of deflagration/detonation of dispersion with explosive mass. - Personal injury - Damage to cooling plant and turbines - Turbine casing explosion, projection of metal parts and possible Domino effects to other installations - Serious damage to the structure of the plant building.			On site: reversible damage area 382 m from source in both weather conditions	

* Due to its high volatility, hydrogen is unlikely to cause soil pollution or water pollution.

Hydrogen fires do not pollute the air significantly as no toxic combustion gases or smoke are produced.

** Jet fire - is a turbulent diffusion flame resulting from the burning of a fuel released continuously under pressure in a particular direction or directions. Jet fires can arise from the release of gases, intermittent liquid (two-phase) and liquids.

*** Flash fires - a rapid, non-explosive combustion that can occur in an environment where fuel and air have mixed in concentrations suitable for combustion.

5.2.11 Environmental Impact Assessment Matrix for the RT-U1 and DICA-MACSTOR 400 project implementation and operation stages

The following tables present the environmental impact assessment matrixes for the implementation and operational stages of each of the two sub-projects and for the RT-U1 and DICA-MACSTOR 400 project as a whole. The matrixes are prepared in accordance with the provisions of the *General Guidelines for the stages of the environmental impact assessment procedure*, based on the information in Chapters 1 and 3 and the impact assessments in Chapter 5.

In order to understand how the matrixes have been prepared, the following is a summary of the terms meanings used in the *General Guidelines for the stages of the environmental impact assessment procedure.*

The overall significance of Impact is characterised by its two components **- Amplitude (*Magnitude*) and Receptor Sensitivity.**

Magnitude of impact is ***small, medium, large*** in relation to:

- Effect intensity: ***low, medium, high***
- Type of effect: ***direct, indirect, secondary, cumulative***
- Extent of effect: ***local, regional, national, transfrontier***
- Nature of effect: ***negative, positive, both***
- Duration of effect: ***temporary, short-term, long-term***
- Reversibility of effect: ***reversible, irreversible***.

Receptor sensitivity is ***low, medium, high*** in relation to:

- Sensitivity of the receptor environment on which the effect is produced
- The capacity of the receptor environment *(physical factors - water, air, soil - biological factors - species or habitat - and social factors - specific group/community or material goods and socio-economic elements)* to adapt to the changes that the project may produce.

The assessment of the significance of the impact of the project was carried out in a consistent and objective manner in relation to the description of the positive and negative effects of the project on all the environmental components described in this chapter (i.e. Tab. 91), using "certified experts' assessments".

Tab. 105 Environmental Impact Assessment for the RT-U1 sub-project and for the DICA-MACSTOR 400 sub-project - Implementation Stage

Project Phase	Environmental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
RT-U1							
Implementation stage – (Infrastructure preparation + Refurbishment implementation)	**Air**	Emissions of non-radioactive pollutants: - combustion gases and dust from equipment/engines; - dust from construction activities, temporary storage of waste.	Intensity	Low	**SMALL**	**LOW**	**MINOR**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
		Gaseous radioactive effluents	Intensitaty	Low	**SMALL**	**LOW**	**MINOR**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
	Water	Non-radioactive domestic, technological and rainwater discharges + Reduction in cooling water consumption	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Positive			
			Duration	Short term			
			Reversibility	Reversible			
		Radioactive liquid effluents from washing/ decontamination	Intensitaty	Low	**SMALL**	**LOW**	**MINOR**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
	Soil, land	Land occupation by: - execution of new constructions - temporary storage of non-radioactive wastes from construction/excavation, recyclable/non-recyclable waste	Intensity	Low	**SMALL**	**LOW**	**MINOR**
			Type	Direct			
			Extension	Local			
			Nature	Positive/ Negative			
			Duration	Short term			
			Reversibility	Reversible			
		Transfer of radioactive pollutants from air	Intensity	Low	**SMALL**	**LOW**	**MINOR**
			Type	Direct			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Ireversible			
	Climate	GHG emissions from machinery/engines	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Indirect			
			Extension	N/A			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			

Project Phase	Environ mental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
	Biodiversity	**Aquatic environment:** Suspension loading of water bodies **Flora, Fauna:** Emissions of non-radioactive pollutants: - Combustion gases and dust from equipment/engines - dust from construction activities, temporary waste storage	Intensity Type Extension Nature Duration Reversibility	Low Direct Cumulative Local Negative Short term Reversible	**SMALL**	**LOW**	**Insignificant**
		Fauna: Noise emissions and vibration propagation from machinery/equipment	Intensity Type Extension Nature Duration Reversibility	Low Direct Local Negative Short term Reversible	**SMALL**	**LOW**	**Insignificant**
	Material Assets	Vibration propagation from machinery/equipment to buildings and infrastructure on site	Intensity Type Extension Nature Duration Reversibility	Low Direct Local Negative Short term Reversible	**SMALL**	**LOW**	**Insignificant**
	Cultural heritage	Acoustic emissions and vibration propagation - at heritage buildings, archaeological sites	Intensity Type Extension Nature Duration Reversibility	N/A N/A N/A N/A N/A N/A	N/A	N/A	**N/A**
	Landscape	The proposed objectives preserve the industrial aspect on the CNCAN designated site	Intensity Type Extension Nature Duration Reversibility	N/A N/A N/A N/A N/A N/A	N/A	N/A	**N/A**
DICA-MACSTOR 400							
Implementation stage – **Execution of MACSTOR 400 modules**	**Air**	Emissions of: - combustion gases and dust from equipment/engines - dust from construction activities of MACSTOR-400 modules	Intensity Type Extension Nature Duration Reversibility	Low Direct Cumulative Local Negative Short term Reversible	**SMALL**	**LOW**	**MINOR**
	Water	Rainwater	Intensity Type Extension Nature Duration Reversibility	Low Indirect Local Positive Long term Reversible	**SMALL**	**LOW**	**Insignificant**

Project Phase	Environmental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
	Soil, Land	**Land occupation with** modules, relocation of power poles, extension of fencing "good foundation rock"	Intensity	Low	**SMALL**	**LOW**	**MINOR**
			Type	Direct			
			Extension	Local			
			Nature	Negative/ Positive			
			Duration	Short term			
			Reversibility	Ireversible			
	Climate	GHG emissions from machinery/engines	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Indirect			
			Extension	N/A			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
	Biodiversity	**Aquatic environment:** Suspension loading of water bodies **Flora, Fauna:** Emissions of non-radioactive pollutants: - Combustion gases and dust from equipment/engines - dust from construction activities, temporary waste storage	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
		Fauna: Noise emissions and vibration propagation from machinery/equipment	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
	Material assets	Vibration propagation from machinery/equipment to buildings and infrastructure on site	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
	Cultural heritage	Acoustic emissions and vibration propagation - at heritage buildings, archaeological sites	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			
			Duration	N/A			
			Reversibility	N/A			
	Landscape	The proposed objectives preserve the industrial aspect on the CNCAN designated site	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			
			Duration	N/A			
			Reversibility	N/A			

Tab. 106 Environmental Impact Assessment for the implementation of the overall RT-U1 and DICA-MACSTOR 400 Project

Project Phase	Environmental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
RT-U1 + DICA MACSTOR 400							
Implementation stage – Preparation + Refurbishment implementation) + Execution of MACSTOR 400 modules	**Air**	Emissions of non-radioactive pollutants: - combustion gases and dust from equipment/engines; - dust from construction activities, temporary storage of waste.	Intensity Type Extension Nature Duration Reversibility	Low Direct Cumulative Local Negative Long term (DICA component) Reversible	**SMALL**	**LOW**	**MINOR**
		Gaseous radioactive effluents	Intensity Type Extension Nature Duration Reversibility	Low Direct Cumulative Local Negative Short term Reversible	**SMALL**	**LOW**	**MINOR**
	Water	Controlled non-radioactive wastewater discharges (domestic, technological and rainwater) + Reduction of technological water consumption	Intensity Type Extension Nature Duration Reversibility	Low Direct Cumulative Local Positive Long term (DICA component) Reversible	**SMALL**	**LOW**	**Insignificant**
		Radioactive liquid effluents from washing/ decontamination	Intensity Type Extension Nature Duration Reversibility	Low Direct Cumulative Local Negative Short term Reversible	**SMALL**	**LOW**	**MINOR**
	Soil, Land	Land occupation by: - new constructions + modules - temporary storage of non-radioactive construction waste/ excavation waste, recyclable / non-recyclable waste	Intensity Type Extension Nature Duration Reversibility	Medium Direct Local Negative/ Positive Long term Ireversible	**SMALL**	**LOW**	**MINOR**
		Transfer of radioactive pollutants from the air	Intensity Type Extension Nature Duration Reversibility	Low Direct Local Negative Short term Ireversible	**SMALL**	**LOW**	**MINOR**
	Climate	GHG emissions from machinery/engines	Intensity Type Extension Nature Duration	Low Indirect N/A Negative Short term	**SMALL**	**LOW**	**Insignificant**

Project Phase	Environ mental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
RT-U1 + DICA MACSTOR 400							
			Reversibility	Reversible			
	Biodiversity	**Aquatic environment:** suspension loads of water bodies **Flora, Fauna:** Emissions of: - combustion gases and dust from equipment/engines - dust from construction activities, temporary storage of waste	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negativ			
			Duration	Short term			
			Reversibility	Reversible			
		Fauna: Noise emissions and vibration propagation from machinery/equipment	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct			
			Extension	Local			
			Nature	Negative			
			Duration	Short term			
			Reversibility	Reversible			
	Material assets	Vibration propagation from machinery/equipment to buildings, infrastructure on site	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct			
			Extension	Local			
			Nature	Negative			
			Duration	Termen scurt			
			Reversibility	Reversibil			
	Cultural Heritage	Acoustic emissions and vibration propagation - at heritage buildings, archaeological sites	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			
			Duration	N/A			
			Reversibility	N/A			
	Landscape	The proposed objectives preserve the industrial aspect on the CNCAN designated site	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			
			Duration	N/A			
			Reversibility	N/A			

Tab. 107 Environmental Impact Assessment for the operation of the overall RT-U1 and DICA-MACSTOR 400 Project

Project Phase	Environ mental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
RT-U1 + DICA MACSTOR 400							
Operational stage **Refurbished U1** **+**	**Air**	Emissions of non-radioactive pollutants - combustion gases	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative/ Positive			
			Duration	Long term			
			Reversibility	Reversible			

Project Phase	Environmental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
RT-U1 + DICA MACSTOR 400							
DICA extended with MACSTOR 400 modules		Gaseous radioactive effluents	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative			
			Duration	Long term			
			Reversibility	Reversible			
	Water	Controlled discharges of non-radioactive wastewater (domestic, rainwater and cooling water)	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Positive			
			Duration	Long term			
			Reversibility	Reversible			
		Radioactive liquid effluents	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Direct Cumulative			
			Extension	Local			
			Nature	Negative			
			Duration	Long term			
			Reversibility	Reversible			
	Soil, Lands	Transfer of radioactive pollutants from air	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Indirect			
			Extension	Local			
			Nature	Negative			
			Duration	Long term			
			Reversibility	Ireversible			
	Climate	GHG-free energy production	Intensity	Medium	MEDIUM	MEDIUM	**POSITIVE**
			Type	Indirect Cumulative			
			Extension	Contributing to global impact			
			Nature	Positive			
			Duration	Long term			
			Reversibility	Reversible			
	Biodiversity	**Aquatic environment:** **-** Non-radioactive wastewater discharge - Radioactive liquid effluents **Flora, Fauna:** -Radioactive gaseous effluent emissions -Emissions of non-radioactive pollutants - combustion gases **Fauna:** Transfer along food chains	Intensity	Low	**SMALL**	**LOW**	**Insignificant**
			Type	Indirect			
			Extension	Local			
			Nature	Negative			
			Duration	Long term			
			Reversibility	Ireversible			
	Material Assets	Vibration propagation from machinery/equipment	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			

Project Phase	Environmental factor	Direct/indirect effects on environmental factors (receptors) through:	Magnitude			Senzitivity	Impact assessment Impact significance
RT-U1 + DICA MACSTOR 400							
		to buildings, infrastructure on site	Duration	N/A			
			Reversibility	N/A			
	Cultural Heritage	Acoustic emissions and vibration propagation - at heritage buildings, archaeological sites	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			
			Duration	N/A			
			Reversibility	N/A			
	Landscape	The proposed objectives preserve the industrial aspect on the CNCAN designated site	Intensity	N/A	N/A	N/A	**N/A**
			Type	N/A			
			Extension	N/A			
			Nature	N/A			
			Duration	N/A			
			Reversibility	N/A			

Tab. 108 Summary of impact significance due to project implementation and operation

Environmental factors	**Implementation** Stage		**Operation** Stage	
	Impact significance in terms of:		Impact significance in terms of:	
	non-radiological	**radiological**	**non-radiological**	**radiological**
WATER	Insignificant Positive	Minor Negative	Insignificant Positive	Insignificant Negative
AIR	Minor Negative	Minor Negative	Insignificant Positive/Negative	Insignificant Negative
SOIL	Minor Pozitive/ Negative	Minor Negative	Insignificant Negative	Insignificant Negative
CLIMATE	Insignificant Negative		Positive	
BIODIVERSITY	Insignificant Negative	Insignificant Negative	Insignificant Negative	Insignificant Negative
MATERIAL ASSETS	Insignificant Negative		N/A	
CULTURAL HERITAGE	N/A		N/A	
LANDSCAPE	N/A		N/A	

Note: *The insignificant negative impact, from a radiological point of view, is an impact that does not generate visible effects, the negative nature being given by the values detectable by measurement against the background of the area, due to current activities on the Cernavoda NPP platform.*

Human factor - the population health and socio-economic aspects

***From a radiological point of view - The Health Impact Assessment Study - prepared by the National Institute of Public Health (INSP) - indicates that there will be no significant impact on the population's health in the proximity area of Cernavoda NPP as a result of the implementation of the project**.*

Based on the assessment of ***non-radiological impact*** on abiotic environmental factors, the population’s health impact study estimated that during both the project implementation and operation periods:

- there will be no significant impact on the population's health in the area surrounding the Cernavodă NPP *due to AIR environmental factor*;

- there will be no significant impact on the population's health in the area surrounding the Cernavoda NPP *due to the environmental factor WATER*;

- there will be no significant impact on the population's health in the area surrounding the Cernavodă NPP *due to the environmental factor SOIL*;

- from the analysis of the noise maps, it can be observed that exceedances of 50/55 dB values could occur outside the NPP site, only in certain phases (complementary construction of the refurbishment) and in a rather limited area - but which could overlap with some existing constructions in the north-west neighbourhood.

Note: In accordance with *ORDER No. 994 of 9 August 2018 amending and supplementing the Norms of hygiene and public health on the living environment of the population, approved by Order of the Minister of Health No. 119/2014,* the limits of the values of noise levels refer to protected areas, i.e. those comprising ***sensitive receptors*** *(homes, schools, hospitals*) as defined by *Law 121/2019 on the assessment and management of environmental noise*.

There are no sensitive receptors in the vicinity of the Cernavoda NPP, as the existing buildings have other uses.

Following the analysis carried out for the characterisation of the current state in the Cernavoda NPP area, it was found that the noise levels generated by the operation of the objectives on the site are within the limits set by *SR 10009: 2017. Acoustics. Admissible limits of ambient noise levels*.

- the socio-economic impact is positive - by creating jobs.

- provided that the project and the recommendations in the expert opinions/studies are complied with, the activities to be carried out within the framework of this investment objective will not adversely affect the population's health in the area, through the application of the planned measures.

5.2.12 Cumulation of effects with those of other existing and/or approved projects whose areas of influence overlap totally or partialy with that of the assessed project, during both the construction and operation periods

5.2.12.1 Existing and/or approved projects on the Cernavoda NPP site

For the purpose of cumulative impact assessment, the project holder has provided the EIA developer with the list of projects approved by the environmental authorities/CNCAN and their timetables.

In the cumulative impact assessment, the EIA developer has also taken into account the current, on-site and environmentally regulated activities, such as the operation of unit U1 until it is shut down for refurbishment, the operation of unit U2, the operation of DICA, other activities supporting the operation.

Thus, the objective owner currently holds environmental agreements for two projects, namely:

- *Continuing construction works and completion of Units 3 and 4 at Cernavoda NPP, with CANDU 6-PHWR reactors (U3, U4)*
- *Construction works of the Cernavoda Tritium Removal Facility (CTRF)*

as well as development approval for

- *Works necessary to change the destination of the existing buildings on the site of Unit 5 from that for a nuclear power plant to that for other useful support objectives during the lifetime of Units 1 and 2 in operation and the future Units 3 and 4 of the Cernavodă NPP, in order to ensure their operation under nuclear safety conditions and fulfil all legal requirements (according to the Decision of the Scoping Stage No. 6983RP/08.11.2016 - U5-DEI 2016).*

The following table shows the time schedule of the above-mentioned projects and the operation of the objectives on the Cernavodă NPP site.

Tab. 109 Estimated time schedule for the implementation of the RT-U1 and DICA-MACSTOR 400 projects and existing and/or approved projects on the Cernavoda NPP site, in connection with current activities - 2023-2037

Project / Objective	2023	2024		2025		2026		2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	Legend
	sem II	sem I	sem II	sem I	sem II	sem I	sem II												
U2																			construction
U1 first cycle of operation																			operation
DIDR-U5		April 2024				April 2026	DIDR U5 in operation from July 2026 -												
RT-U1								shutdown, retubing		tests May-Sep 30/09/2029									
U1- post refurbishment											REBURBISHED U1 IN OPERATION								
DICA-MACSTOR 200	OPERATION with modules MACSTOR 200				DICA IN OPERATION with 17 modules type MACSTOR 200														
	construction M16 MACSTOR 200		construction M17 MACSTOR 200																
DICA-MACSTOR 400					from sem II 2025 - construction M18 ... 1.5 years/module MACSTOR 400														
								DICA IN OPERATION with MACSTOR 400 modules											
U5-DEI 2016 Works necessary to change the destination of the existing buildings on the site of Unit 5	execution of works for U5 until Dec. 2024																		
CTRF	construction + tests without tritium							tests with tritium March - Aug 2027	CTRF IN OPERATION starting Sep 2027										
U3, U4							construction and tests						U3 , U4 IN OPERATION						

NOTE: The period analysed for cumulative impact is 2023 – 2037, and the period 2032 - 2037 for Stage III is the peak period of activity on site, as all nuclear units, including U3 and U4, will be in operation from 2032. The year 2037 represents the time when Unit 2 will enter the refurbishment process.

5.2.12.2 Evaluation of the cumulative impact with the existing and/or approved projects on the Cernavoda NPP site

Analyzing the sequence of activities in the timetable of existing and/or approved projects and activities on the Cernavodă NPP site - presented in Tab. 109, the EIA developer established 3 stages corresponding to the ***relevant scenarios*** for the cumulative impact assessment:

- Stage I_2024 - 2026 MAINLY EXECUTION
- Stage II_2027 - 2029 SHUTDOWN RETUBING, TESTS and CONSTRUCTION
- Stage III_2032 - 2037 ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE.

The time periods for these milestones were chosen by the EIA developer according to the predominance of the types of activities to be carried out: construction, refurbishment and testing, operation.

The cumulative impact assessment is presented in tabular form for the relevant environmental factors, under non-radiological and radiological aspects, for each of the three stages/scenarios.

Tab. 110 Qualitative assessment of the impact on the environmental factor WATER, by cumulating with other projects and operational activities on the CERNAVODA NPP site

Cumulative impact scenario with other projects and activities on site	Description of the scenario	Evaluation/quantification of cumulative impact for non-radioactive pollutants	Remarks
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	Includes normal operating activities - U1 and U2 U1 refurbishment infrastructure construction works, MACSTOR 200/400 construction works and CTRF construction works	The impact is estimated to be insignificant, as a result of the surveillance procedures regulated by CNCAN.	No other types of effects are expected.
Stage II_2027 – 2029 **SHUTDOWN RETUBING,** **TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	Includes normal operating activities - U2	The impact is estimated to be insignificant, as a result of the surveillance procedures regulated by CNCAN.	The new DIDR-U5 will be equipped with observation boreholes for qualitative and quantitative monitoring of the groundwater aquifer in the area with the highest potential for contamination.
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction+ CTRF in operation	Includes normal operating activities - U1 2nd cycle + U2 + U3+ U4	The impact is estimated to be insignificant due to the operation under the conditions regulated by CNCAN and the Ministry of Environment.	An additional number of observation boreholes will be drilled in order to qualitatively and quantitatively monitor the groundwater aquifer in the DICA-MACSTOR 400 extension area. All monitoring programs for the discharges of non-radioactive effluents due to the operation of the 4 nuclear units on the site will be REVISED and COMPLETED, in accordance with the authorizations issued by CNCAN and the Ministry of Environment.

Tab. 111 Qualitative assessment of the impact on AIR QUALITY (non-radioactive pollutants) by cumulating with other projects and operational activities on the CERNAVODA NPP site

Cumulative impact scenario with other projects and activities on site	**Description of the scenario**	**Evaluation/quantification of cumulative impact for non-radioactive pollutants**	**Remarks**
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	Includes U1/U2 Start-up Thermal Power Plant or Diesel Unit testing activities that may overlap with infrastructure construction works for U1 refurbishemnt, MACSTOR 200/400 construction works and CTRF construction works.	The present study assessed the impact for the worst-case scenario for the U1 refurbishment infrastructure construction period cumulated with MACSTOR400 module construction works (with a theoretical impact higher than a MACSTOR 200). Scenarios have also been realized for CTP and Diesel groups testing activities at both units. The Environmental Impact Report for the CTRF also separately assessed the construction period impacts. Analyzing the results by aggregation leads to the following conclusions: -possibility of occurrence of exceedances of limits in Cernavodă in case of maximum hourly NO_2 concentrations -hourly or daily maximum values below the limits in the case of SO_2 -daily maximum values below limit for PM10 -as the emissions associated with these activities are short- lasting, it can be estimated that the annual mean background values of the area are insignificantly affected. ***The impact is estimated to be minor***.	The cumulative impact assessment considered the worst case scenario for each pollutant related to the testing of energy support equipment in case of start-up/emergency/failure (thermal power plant and diesel generators), taking into account the recommendation to test only one equipment at a given time. For NO_2 , the exceedance of the limit value for maximum hourly concentrations can only occur in the case of construction work overlapping with the testing of a Diesel unit from U1/U2. The exceedance of the limit value is recorded in a restricted area in the locality of Cernavodă in the immediate vicinity of the perimeter of the nuclear power plant.

Cumulative impact scenario with other projects and activities on site	**Description of the scenario**	**Evaluation/quantification of cumulative impact for non-radioactive pollutants**	**Remarks**
Stage II_2027 – 2029 **SHUTDOWN RETUBING,** **TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	U3 and U4 construction involves construction activities without large-scale operations related to the handling of dusty materials or the intensive use of a significant number of machines. Emissions associated with the construction of the MACSTOR 400 modules were estimated in this study, and the worst case scenario analyzed included the most intensive activities in terms of earth handling and machinery operation.	The EIA conclusions on the construction of U3 and U4 stated that "Exhaust and dust emissions from the machinery and transportation means used for construction will have local, temporary and small-scale effects". As a consequence, the cumulation with the construction of a MACSTOR 400 module ***cannot result in an impact higher than the one analyzed in the construction scenario dealt with in this report, i.e. minor impact.***	
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction+ CTRF in operation	Includes activities of testing the strat-up power plant or a Diesel group at U1/U2/U3/U4.	Given that the recommendations were that these equipments should be tested one by one avoiding simultaneous operation and taking into account that the powers of the diesel generators at U3 and U4 are similar to those at U1 and U2, it can be considered that the ***cumulative impact cannot exceed the maximum impact associated with the individual operation of one equipment as quantified in the current study.***	The air quality monitoring programs at receptors will be REVISED and COMPLETED, following the operation of the 4 nuclear units on the site, in accordance with the authorizations issued by the Ministry of Environment.

Tab. 112 Qualitative impact assessment for the environmental factor SOIL, by cumulating with other projects and operational activities on the CERNAVODA NPP site

Cumulative impact scenario with other projects and activities on site	Description of the scenario	Evaluation/quantification of cumulative impact for non-radioactive pollutants	Remarks
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	Increasing occupancy. Increased volumes of non-radioactive waste generated during infrastructure/building development, construction.	The impact is estimated to be minor, due to the realization of the projects on the authorized site of Cernavodă NPP and, respectively, the measures adopted during the execution and to the internal procedures of Cernavodă NPP.	The internal transportation of non-radioactive waste will be done by appropriate means and waste management will be carried out according to Cernavoda NPP internal procedures. Disposal/recovery of waste from the site will be carried out by authorized operators..
Stage II_2027 – 2029 **SHUTDOWN RETUBING, TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	U1 refurbishment involves generation of non-radiactive wastes. Increasing the volumes of non-radioactive waste generated during U3 and U4 construction operations.	The impact is estimated to be minor, as a result of the measures taken during execution and due to the internal procedures of Cernavoda NPP.	The internal transportation of non-radioactive waste will be carried out by appropriate means and waste management will be done according to Cernavoda NPP internal procedures. Disposal/ recovery of waste from the site will be carried out by authorized operators.
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction+ CTRF in operation	Under the conditions of the successful implementation of the U1 refurbishment project, the same types and quantities of waste are expected to result from the recommissioning of the unit as in the first operating cycle. The commissioning of units 3 and 4 will increase the amount of non-radioactive waste on the Cernavodă site.	The impact is estimated to be minor, as a result of the measures taken during execution and due to the internal procedures of Cernavoda NPP.	NPP's procedures for on-site waste management will be extended as required by applicable legal requirements. On-site waste disposal/recovery will be carried out by authorized operators. Internal procedures for monitoring environmental factors will be updated. When operating the objectives, CNCAN/Ministry of the Environment/ANAR will set up monitoring activities specific for each objective.

Tab. 113 Qualitative assessment of the impact on BIODIVERSITY through cumulation with other projects and operational activities at the CERNAVODĂ NPP site

Cumulative impact scenario with other projects and activities on site	Scenario description from the point of view of the EA evaluator	Evaluation/quantification of cumulative impact	Remarks
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	The potential impact is comparable to large-scale construction works, which in terms of biodiversity involve the generation of the main categories of impact: direct impact (ID), manifest through the occupation of some habitat surfaces - the effects, however, remain extremely limited given the characteristics of the target habitats, with low ecosystem value, heavily anthropized. Manifest ID through the generation of noise during the entire construction period - the effects disappear within a radius of approximately 800-1000m, which actually coincides with the restriction zone belonging to the Cernavoda NPP, from the level of which the elements of biodiversity remain modestly expressed; the avifauna (nesting species) that use the (few) ecological niches within the restricted area of Cernavoda NPP is particularly affected Manifest ID through the generation of particles (dust) during the entire construction period - the effects are extinguished within a radius of approximately 800-1000m, which actually coincides with the restriction zone belonging to the Cernavoda NPP, from the level of which the elements of biodiversity remain	The potential impact is comparable to large-scale construction works, which in terms of biodiversity involve the generation of the main categories of impact: direct impact (ID), manifest through the occupation of some habitat surfaces - the effects, however, remain extremely limited given the characteristics of the target habitats, with low ecosystem value, heavily anthropized. Manifest ID through the generation of noise during the entire construction period - the effects disappear within a radius of approximately 800-1000m, which actually coincides with the restriction zone belonging to the Cernavoda NPP, from the level of which the elements of biodiversity remain modestly expressed; the avifauna (nesting species) that use the (few) ecological niches within the restricted area of Cernavoda NPP is particularly affected Manifest ID through the generation of powders (dust) during the entire construction period - the effects are extinguished within a radius of approximately 800-1000m, which actually coincides with the restriction zone belonging to the Cernavodă NPP, from the level of which the elements of biodiversity remain modestly expressed; the carpet of vegetation is particularly affected by affecting the photosynthetic capacity (screening) Indirect impact (II) is associated with transport sequences. Given the fact that most of the constructive elements for the projects	Measures are taken to reduce the impact and reduce the risks, the generated effects thus remaining only at the level of a theoretical approach, which, however, substantiates the decisions in the direction of increasing security in the operation of the construction site.

Cumulative impact scenario with other projects and activities on site	Scenario description from the point of view of the EA evaluator	Evaluation/quantification of cumulative impact	Remarks
	modestly expressed; the carpet of vegetation is particularly affected by affecting the photosynthetic capacity (screening) Indirect impact (II) is associated with transport sequences. Given the fact that most of the constructive elements for the projects are delivered on well-defined land routes and with precisely outlined routes (road access roads – A2E81; railway), **the generated impact remains limited**; the increase in traffic levels remains modest given the extended supply sequences over long periods of time.	are delivered on well-defined land routes and with precisely outlined routes (road access roads – A2E81; railway), **the generated impact remains limited**; the increase in traffic levels remains modest given the extended supply sequences over long periods of time.	
Stage II_2027 – 2029 **SHUTDOWN RETUBING, TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	At this stage, overlapping work scenarios associated with major construction projects, but also with the operation of some nuclear objectives, appear. Consequently, the particularity is given by summing the effects of dust generation with the potential of radionuclide loading; thus general dust can lead to assimilation (bioaccumulation) at the level of immediately proximal areas (radius of 800-1000m), and extremely fine particles (PM2.5 and PM<2.5), which can cross greater distances, can lead to phenomena of bioaccumulation, when the scenario involving prolonged construction stages overlaps with operation stages.	The impact remains at an insignificant level, as a result of the measures adopted during the execution and the internal procedures of Cernavoda NPP.	Measures are taken to reduce the impact and reduce the risks, the generated effects thus remaining only at the level of a theoretical approach, which, however, substantiates the decisions in the direction of increasing the security in the operation of the works site in parallel with the functional objectives of Cernavoda NPP.

Cumulative impact scenario with other projects and activities on site	Scenario description from the point of view of the EA evaluator	Evaluation/quantification of cumulative impact	Remarks
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction+ CTRF in operation	As it follows from the modeling carried out, the summation of the emissions of these objectives in nominal operating conditions is not able to lead to an increase in the background levels.	The impact remains at an insignificant level, as a result of the measures adopted during the execution and the internal procedures of Cernavoda NPP.	Measures are taken to lessen the impact and reduce the risks, the generated effects thus remaining only at the level of a theoretical approach, which, however, substantiates the decisions in the direction of increasing the security in operation of the functional objectives of Cernavoda NPP.

Tab. 114 Qualitative assessment of the impact on NOISE and VIBRATIONS, by cumulating with other projects and operational activities on the CERNAVODĂ NPP site

Cumulative impact scenario with other projects and activities on site	Description of the scenario	Evaluation/quantification of the cumulative impact	Remarks
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	To the current situation (Board 1 in Annex 6 NOISE), in which U1 and U2 are in operation, are added the specific site activities (Board 6 in Annex 6 NOISE), corresponding to the phase with the highest volume of works, in which the complementary buildings are being constructed in the S-V area of the plant territory, the CTRF, DIDR-U5, U5-DEI 2016 (CFSU), MACSTOR 200/400 modules at DICA. In the current situation (initial situation), the main noise sources located outside the buildings are those associated with U1 and U2, (transformer stations, ventilators whose noise is transmitted through the exhausts), as well as the pump network (pump house) intended to provide the cooling water necessary for the operation of U1 and U2. The development/construction works require the use of site-specific equipment at different stages of the site activities, such as: bulldozer, crawler excavator, tower crane, welding generator, circular saw bench, loader, concrete and mortar pressure equipment, concrete and mortar mixer, auto crane, compressor.	Since the activity of each machine in action is associated with a noise source, the start of construction work means that there are an additional number of noise sources on the power station site. A favorable aspect is that the work areas corresponding to the construction sites are dispersed in areas other than those in which the existing sources are acting in the initial phase, thus avoiding a local increase in noise levels, with the risk of exceeding 65 dB(A) in an area at the territorial boundary. ***The noise mapping (Board 6 in Annex 6 NOISE) shows that the noise levels at the boundary of the power plant remain below the value of 65 dB(A) allowed by the legislation.*** ***In this way the noise levels outside the power plant territory, for relatively small distances from it, decrease to values at which biodiversity is not affected.*** The cumulative impact on environmental factors is insignificant.	The descriptor parameter in the assessment is the A-weighted equivalent continuous sound pressure level for a reference duration T ($L_{eq,T}$). The assessment of the distribution of noise levels was carried out in a conservative approach, by considering the worst-case scenario in which all the areas intended for construction works would be active simultaneously. Thus, if in this hypothesis the noise levels obtained by the assessment fall within the legal limits, it follows that in non-simultaneous operation (the most likely), the limit value at the contour of the territory will also be respected. The aspects presented above, i.e. the distribution of the sources on the NPP territory, as well as the results obtained by modelling, are visible on Board 6 in Annex 6 NOISE, which summarizes the situation of this stage. It can be observed, especially on the 3D map of the assessment, the decrease of noise levels to values below 50-55 dB(A) at relatively small distances from the limit of the territory.

Cumulative impact scenario with other projects and activities on site	Description of the scenario	Evaluation/quantification of the cumulative impact	Remarks
Stage II_2027 – 2029 **SHUTDOWN RETUBING, TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	At this stage U2 is in normal operation. The operation of U1 ends and its associated sources for the operational phase stop their noise emissions. U1 is being refurbished (retubing and other adjacent works) with predominantly indoor activities. Outside the U1, in its immediate vicinity, there will be some construction activities, of some annexes for its endowment. CTRF will operate in test regime, with the associated noise sources of moderate acoustic power. Work is being carried out to complete U3 and U4. In this case, as the buildings of U3 and U4 exist, the construction works will not involve the use of heavy and noisy machinery of the type used on the Stage 2 construction sites. Thus the noise sources associated with the activities carried out here will be correspondingly of lower acoustic powers. The actual operation of the DICA involves only minor noise emissions (transportation of materials and storage maneuvers using an appropriate crane). Activities are rare and of relatively short duration). Significant in the DICA area are noise emissions associated with the construction works of some MACSTOR 400 modules, which are	In terms of noise emissions, the contribution associated with U1 operation stops. The sources associated with the construction of the outbuildings to complete U1 appear. The main retubing activities and other works adjacent to the U1 retubing are carried out indoor. The emission associated with the sources from the CTRF construction will be replaced by the emission associated with the sources related to the CTRF testing phase, of lower acoustic power. The activities for the completion of U3 and U4 will be associated with noise sources characterized by moderate acoustic power levels, compared to the construction sites of the previous phase. The DICA contribution to noise is only relevant through the construction of the new MACSTOR 400 modules. *Board 7* in Annex 6 NOISE shows the areas where the activities described above are taking place, as well as the modeled noise levels at each point within the NPP territory as well as outside it. ***Compared to each of the stages evaluated in this study, this one is characterized by lower noise emissions***, the distribution representations in *Board 7* emphasizing this conclusion.	No monitoring measures are needed.

Cumulative impact scenario with other projects and activities on site	Description of the scenario	Evaluation/quantification of the cumulative impact	Remarks
	carried out at the rate required by the needs of the plant. Funcționarii DIDR-U5 nu i se asociaza surse de zgomot semnificative.	The cumulative impact on environmental factors is insignificant.	
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction+ CTRF in operation	This stage corresponds to the situation where all planned projects have been completed and the noise emissions correspond to the normal operation of NPP with 4 nuclear units.	If the stages described above characterize transition phases in the evolution of the NPP, this stage is the one in which the plant operates at the nominal designed capacity after the implementation of the planned projects. Compared to the U1 refurbishment, the additional sources belonging to other projects contribute correspondingly to the increase of the exposed surface. This increase is evident in the neighborhoods of U3 and U4. (*Board 8 in Annex 6 NOISE*) Compared to the situation of U1 refurbishment, the noise mapping shows the difference resulting from the contribution of U3 and U4. ***The noise levels at the boundary of the premises remain within the limits specified by legislation***. Therefore, as can be seen on Board 8, ***starting from relatively short distances, the levels attenuate to values below 50 - 55 dB(A) favoring the protection of biodiversity.*** ***The cumulative impact is insignificant.***	No monitoring measures are needed.

Tab. 115 Qualitative assessment of the impact on CLIMATE AND CLIMATE CHANGE, by cumulation with other projects and operational activities on the CERNAVOD NPP site

Cumulative impact scenario with other projects and activities on site	**Description of the scenario in terms of climate and climate change**	**Evaluation/quantification of cumulative impact**	**Remarks**
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	GHG emissions from machinery and engines involved in execution activities and from testing activities of Diesel groups. U1 and U2 in operation ensures 20% of the annual electricity production at the national level.	The estimated impact of construction activities is ***insignificant***. The production of "green" electricity generates a ***positive impact***..	High-performance machines and vehicles and fuels that meet the quality requirements will be used. The Diesel group testing schedule will be followed.
Stage II_2027 – 2029 **SHUTDOWN RETUBING, TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	GHG emissions from machinery and engines involved in execution activities and from testing activities of Diesel groups. U2 in operation provides 10% of the annual electricity production at the national level.	The estimated impact is ***insignificant***. The production of "green" electricity generates a ***positive impact through its operation U2.***	High-performance machines and vehicles and fuels that meet the quality requirements will be used. The Diesel group testing schedule will be followed.
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction + CTRF in operation	***Energy production without GHG emissions from 4 nuclear units.***	The estimated impact is ***positive***.	***The energy produced at Cernavoda NPP under the operating conditions of all 4 nuclear units with two operating cycles will be up to approx. 1169 TWhe, avoiding an emission of up to approx. 947844 kt of CO_2*** (Tab. 117)

Tab. 116 Qualitative assessment of the RADIOLOGICAL impact on environmental factors, by cumulating with other projects and operational activities on the CERNAVODA NPP site

Cumulative impact scenario with other projects and activities on site	Description of the scenario from a radiological point of view	Evaluation/quantification of the cumulative impact	Remarks
Stage I_2024 - 2026 **MAINLY EXECUTION** DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation	At this stage, given that the objectives DIDR-U5, U5-DEI 2016 (CFSU) and CTRF will be in construction, the only activities with radiological impact on the environment will be those specific to the operation of the two nuclear power units and the operation of DICA, and the radioactive effluent emissions from the Cernavodă NPP site will be similar to those before the start of the implementation of the construction projects.	The cumulative radiological impact on environmental factors is minor, local, reversible, with short-term effects.	During U1 and U2 operation, so far, the only radionuclide detected in environmental samples taken in the immediate vicinity of the Cernavodă NPP site, outside the site, was tritium - within the limits regulated by CNCAN.
Stage II_2027 – 2029 **SHUTDOWN RETUBING,** **TESTS and CONSTRUCTION** U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction	According to international experience, after the reactor is shut down for refurbishment, during the active systems emptying, drying and decontamination operations, tritium emissions from U1 are expected to increase by up to an order of magnitude in the first year, and then to return to the pre-refurbishment level once the reactor is restarted. Radioactive emissions from U2 will be maintained at the level corresponding to the operational period. The commissioning of the CTRF could contribute to a gradual decrease in tritium emissions from the two units as a result of tritium removal from the tritiated heavy water from the moderator circuits.	The cumulative radiological impact on environmental factors is minor, local, reversible, with short-term effects.	The radioactive emissions corresponding to the period of preparation and implementation of the retubing activities at U1 are estimated on the basis of the experience from the Darlington refurbishment project.
Stage III_2032- 2037 **ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE** Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation +	Under the conditions of successful implementation of the U1 refurbishment project, the radioactive emissions of the unit will be at most at the level before the refurbishment when the unit resumes operation. As a result of the commissioning of CTRF, through the application of tritium removal treatment to the tritiated heavy water from the moderator circuits of the two	The cumulative radiological impact on environmental factors is insignificant, local/regional, reversible, with long-term effects.	Tritium removal is essential to maintain low tritium emissions from the site when operating four nuclear power units simultaneously.

Cumulative impact scenario with other projects and activities on site	**Description of the scenario from a radiological point of view**	**Evaluation/quantification of the cumulative impact**	**Remarks**
DICA MACSTOR 400 modules construction+ CTRF in operation	units (U1 and U2), their tritium emissions will gradually decrease. With the commissioning of units 3 and 4, the level of radioactive effluent emissions at the Cernavoda NPP site will increase corresponding to the period of the operating cycle of these units, but, as the level of tritium concentration in the reactors' active systems will justify it, the application of tritium removal will lead to a limitation of the upward trend of emissions. Thus, the simultaneous operation of the four units, with CTRF in place and properly operated, is expected to reduce tritium emissions from the site to a lower level than at present.		

5.2.12.3 Cumulative impact with projects approved/developed in the neighborhood of the Cernavoda NPP platform

In order to analyze the cumulative impact of the project "REFURBISHMENT OF CERNAVODĂ NPP U1 AND EXTENSION OF INTERMEDIATE DRY SPENT FUEL STORAGE WITH MACSTOR - 400 MODULES" with other existing or planned projects in the vicinity, which could have similar environmental effects, the licensee SNN SA – Cernavoda NPP requested the EPA Constanța the list of projects/plans under environmental assessment procedure/finalized located in the area of Cernavodă.

EPA Constanța communicated to the licensee, by address No. 3581/03.04.2024, the list of projects for which the decisions regarding the development approval have been issued and those currently under the environmental assessment procedure, projects located in the area of Cernavodă locality.

The analysis of this information shows that all of the 19 projects mentioned in the environmental authority's address ***are outside the exclusion zone*** (an area within a radius of 1 km around the reactors in operation).

Of the 19 projects, 12 were approved without undergoing the environmental assessments.

In the same sense, in order to take into account in the cumulative impact analysis also the developments in the neighboring localities of Cernavodă, the licensee submitted requests to the Mayoralties of Râșnova and Seimeni. Answers were received stating that there are no investment projects in progress in the area of these communes. (Annex 4).

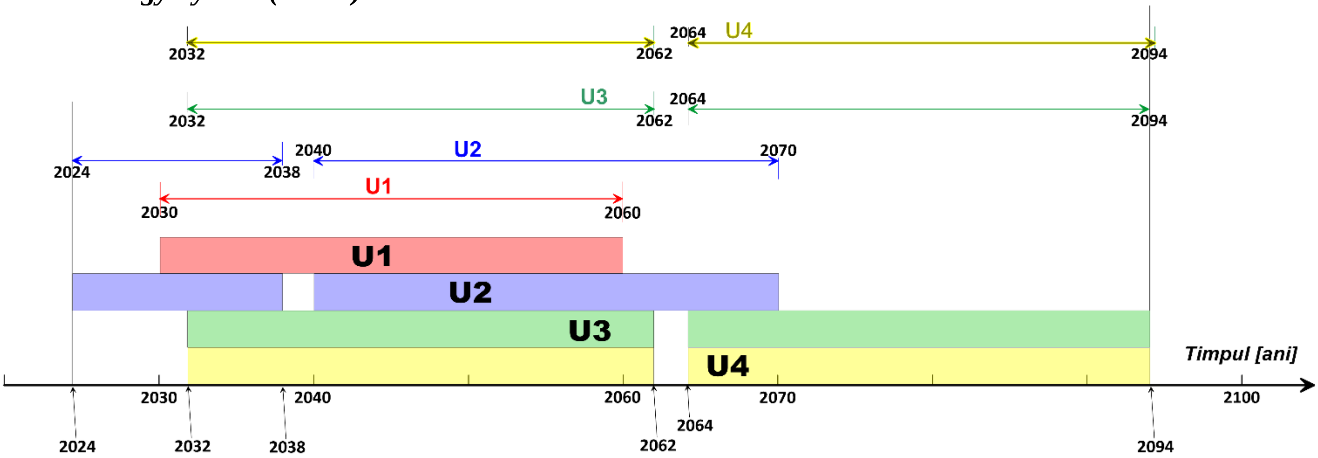
As a result of the above, we assess that the RT-U1 and DICA-MACSTOR 400 Extension project will not have cumulative effects with existing or planned projects in Cernavoda locality.

5.2.13 Project specific issues addressed in the context of sustainable development and circular economy principles

U1 refurbishment refers to the capital repair, upgrading and improvement by replacement of plant equipment or systems to significantly extend the operating life of the plant. Refurbishment creates the opportunity to improve reactor safety. The implementation of the project will be a model for extending the application of technical solutions to the other units U2, U3 and U4.

- ***The refurbishment of the unit U1 makes it run for one more operating cycle beyond the expected lifetime of the unit at commissioning***, thus producing approx. 181 million kWh during the second operating cycle. If the other 3 nuclear units (U2, U3 and U4) will also have two operating cycles in the period 2024 - 2094, the total amount of energy to be produced will be ≅1169 TWhe.

Fig. 114 Operation of units U1...U4 with two operating cycles and the increase of energy supplied to the National Energy System (TWhe)



Interval	2024-2030	2030-2032		2032-2038				2038-2040				2040-2060				2060-2062				2062-2064			2064-2070			2070-2094	
Nuclear Unit	U2	U1	U2	U1	U2	U3	U4	U1	U2	U3	U4	U1	U2	U3	U4	U1	U2	U3	U4	U2	U3	U4	U2	U3	U4	U3	U4
Years of operation	6	2	2	6	6	6	6	2	0	2	2	20	20	20	20	0	2	2	2	2	0	0	6	6	6	24	24
TWhe/ year. period	36.1	12.1	12.0	36.2	36.1	36.2	36.2	12.1	0	12.1	12.1	120.6	120.3	120.6	120.6	0	12	12.1	12.1	12	0	0	36.1	36.2	36.2	144.7	144.7
Total TWhe/ period	36.1	24.1		144.6				36.2				482.2				36.2				12			108.5			289.5	
Total TWhe/ cumulative	36.1	60.2		204.8				241				723.2				759.3				771.4			879.8			**1169.3**	

- ***Energy will be produced without GHG emissions*** – which would amount to 947844 kt of CO2 when operating all 4 nuclear units with two operating cycles (Tab. 117 and Tab. 118).

During the period of the U1 refurbishment, the Cernavodă nuclear power plant will operate with a single unit, U2, which will supply 12 TWh of electricity. In total, the energy supplied by all the units during the entire period of operation of the NPP will be approx. 1169 TWh.

Tab. 117 shows the advantages of applying the second principle of the National Circular Economy Strategy (SNEC): "keeping products and materials at their highest use value for as long as possible". During the extended operation of the unit U1, about 181 TWhe (U1) will be generated for the national energy system, avoiding the emission of 146757 kt CO_2 - equivalent of burning coal in a thermal power plant to obtain the same amount of energy.

The assessment of electricity generated during operation was based on the following elements (assumptions):

a. the amount of energy delivered to SEN is the same for all the units and for a single unit in one operating cycle it is: 181 TWhe

b. a capacity factor of 98% was considered which corresponds to the delivery of energy in the reported quantity (a)
c. it was considered the refurbishment period for the other units would be the same as in the project (2 years/unit shutdown for refurbishment).
   At present, the electricity generated by U1 and U2 units represents about 20% of the energy consumed at national level.

The following table shows the quantities of electricity supplied by the operation of the 4 two-cycle units and the GHG emissions that would result from burning fossil fuel - coal - to supply the same quantities of energy.

Tab. 117 Indirect effect of RT-U1 and DICA-MACSTOR 400 project to reducing CO_2 emissions by substituting fossil fuel consumption (Fig. 114)

Nuclear Unit	Years of operation (end of year)	Operation interval of refurbished Unit U1, and units U2 ,U3,U4 (years)	Energy produced TWh_e	Avoided CO_2 emission Kt $CO_{2\ equivalent}$
U1	2030 -2060	30	181	146757
U2	2024-2038 2040-2070	14 30	264	214059
U3	2032-2062 2064-2094	30 30	362	293514
U4	2032-2062 2064-2094	30 30	362	293514
Total			1169	947844

The assessment of avoided CO2 equivalent emissions was done by applying the average values of the default factors - presented in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change - Working Group III Volume, Annex III Costs and Technology-Specific Performance Parameters - Table A.III.2 - for producing the same amount of energy by burning coal, i.e.:

- for nuclear process: $FE_{total\ emission}$ =12 $gCO_{2equiv.}$/kWh
- for burning coal: $FE_{total\ emission}$ =820 $gCO_{2equiv.}$/kWh.

- ***The reuse of heavy water*** is an obvious application of the circular economy strategy. Used as a moderator, heavy water makes an essential contribution, along with fuel, to the cost of energy. For a reactor with an average power of 500 MWe, according to a Canadian estimate quoted by Peculea M. in 1984[130], the share of heavy water in the unit price of electricity production is:
  - capital invested: 71.5% of which 16.4% for D_2O
  - operation and maintenance: 7.9%
  - processing of D_2O: 2.7%
  - fuel:14.9%.

[130] Marius Peculea, ***Heavy Water***, 1984

Therefore, the share of this energy-intensive product is important in nuclear energy production.

- ***Heat recovery from the residual heat incorporated in the cooling water*** of condenser U1 is an illustrative solution for implementing the circular economy strategy (R9 of the strategic framework of the circular economy). This solution mitigates the thermal pollution of the Danube River and ensures the supply of heat to about 75% of the population of Cernavodă.

  Extending the lifetime of U1 by 30 years will generate an additional 630 GWht, with a corresponding hypothetical value of substituted emissions over the extended lifetime of U1 of 509 kt CO_2 equivalent.

- ***Recycling of recoverable waste from the Cernavodă NPP operation*** is included in the project and is an action that falls within the SNEC requirements. Out of 799 tonnes per year generated annually in operation (maximum amount of recoverable waste), 630 tonnes/year are iron and copper waste, max. 25 tonnes/year paper and cardboard, max. 25 tonnes/year wood waste. All the recoverable waste generated is stored in specially set up spaces on the premises of the NPP and handed over to authorised economic operators for recovery. The transfer to authorised economic operators is made on the basis of a service contract, the transport being carried out by the provider with authorised means of transport.

- ***Reuse*** by recirculating the cooling water of nuclear reactor condensers through the aspiration basin - homogenisation/uniformisation has the main effect of reducing the flow of technological water taken from the Danube via the derivation channel.

The approach to the energy sector in the circular economy is " transversal ", according to the SNEC (National Strategy for the Circular Economy). The energy sector is not included in the nine economic sectors in which the environmental impact on the one hand and the potential application in the circular economy on the other are taken into account.

The refurbishment of the U1 nuclear plant corresponds - as an action - to the second principle on which the circular economy is based: ***keeping products and materials at their highest use value for as long as possible***.

Although the energy sector is not included in the economic sectors directly targeted by the SNEC, the implementation of the U1 refurbishment and DICA extension project has elements that fit into the general principles of the circular economy: Rethink (R1), Reduce (R2), Reuse (R3), Repair (R4), Refurbish (R5), Recycle (R8), Recover (R9).

The following table shows the links between some of the project's provisions, in the Cernavodă energy complex as a whole, and the circular economy.

Tab. 118 Effects of the implementation of the National Action Strategy/Plan (SNEC/PAEC) on the Circular Economy (EC) in the RT-U1 and DICA- MACSTOR 400 project

The “9R Strategies” in the SNEC	Project provisions	Effect
Repair (R4) Refurbish (R5)	-Refurbishment: the old product is brought up to date and used (R5 in Circular Economy) -Repairs of some components of U1 and continued use with the original functions, of generating electricity without greenhouse gas emissions	Generation of 181 TWh electricity for another 30 years (Fig. 114. and Tab. 117), without GHG emissions
Reuse (R3) Recycle (R8)	Reuse of heavy water Heavy water is treated for tritium removal and reuse (510 t/year, with a loss of 3.75 t/year - reported value)	Reduced energy consumption (energy embodied in heavy water)
Recover (R9)	Use of residual heat (from nuclear reactor condenser cooling water) for residential heating in Cernavodă.	-Improving the living conditions of the population - Win-win effect: cost-effective energy supply and reduced thermal pollution of the Danube River Thermal energy delivered to the population of Cernavodă through the heating system is of 42 GWht annually.
Recycle (R8) Recover (R9)	Recycling of non-radioactive waste, except for household waste which is disposed of by authorised operators, for final disposal in a controlled landfill for urban waste.	Recovery of 799 t/year waste, of which 630 t/year Fe and Cu waste, wood waste - max 25 t/year
Reduce (R2) Refurbish (R5) and Rethink (R1)	Efficient use of the intermediate storage space in DICA by the implementation of the new MACSTOR400 module design solution.	Efficient land use.
Reuse (R3)	Cooling water recirculation	Reducing water intake.

5.3 Transfrontier nature - the impact on potentially affected states

The impact on biodiversity in a transboundary context remains **insignificant**:

- ***In the implementation stage***, the activities are of the construction-assembly type, without leading to the affectation of populations of migratory species.
- ***In the operational stage***, the potential for radionuclide pollution is greatly reduced, as a result of the solutions applied, implementing the latest technologies in the field; in the conditions where no effects of radiological pollution have been detected in the current operating regime, along with the decrease in the potential of pollution with such compounds, the risks of impact generation are also diminished.

6. DESCRIPTION OF THE PREDICTION METHODS USED TO IDENTIFY AND ASSESS SIGNIFICANT ENVIRONMENTAL EFFECTS, INCLUDING DETAILS OF DIFFICULTIES ENCOUNTERED

The prediction methods used to identify and assess possible significant environmental effects of project implementation and operation fall into two categories:

- ***quantitative methods***: using e.g. calculation of noise levels, emission levels for the environmental factor air, calculation of quantities of generated waste, etc.;
- ***global qualitative methods:*** analogy method, mapping method, matrix method.

The analogy method was used to assess the environmental effects of the project, comparing and analysing (in terms of similarity) the project with other similar projects that have already been carried out. The knowledge and experience gathered, the results and effects obtained from similar works carried out were used.

6.1 Radioactive emission estimation methodologies for dispersion modelling of pollutants. Uncertainties and difficulties in radiological impact assessment

6.1.1 Estimation of radioactive emissions

RT-U1 sub-project - For the estimation of radioactive emissions in the preparation and implementation phase of the U1 refurbishment, as well as in the commissioning and trial operation phase of the refurbished U1, monitoring data recorded in similar projects carried out at the Bruce A and Bruce B nuclear generating stations in Canada and at the Point Lepreau nuclear generating station (PLGS) were used. These data were made available to Cernavodă NPP by CANDU Energy, in addition to the report on *Technical Solutions for the Replacement of Fuel Channels, Calandria Tubes and Feeders at Cernavodă NPP's U1 reactor*. The worst case scenario, that of the PLGS plant, whose refurbishment lasted 4 years, was used for the estimates.

DICA-MACSTOR 400 sub-project - The report stated that no liquid or gaseous effluent emissions are anticipated for the DICA extension sub-project. However, meteoric waters collected in the drainage system on the DICA platform are considered potentially radioactively contaminated and are monitored radiologically, with arrangements in place to transfer them, depending on the outcome, to the U1 liquid radioactive waste collection system.

6.1.2 Dispersion of radioactive pollutants

Modelling of the atmospheric dispersion of tritium emitted as gaseous effluents was carried out using a simple Gaussian statistical model conservatively using the values of the maximum dispersion factors determined by this model for the calculation of the exposure of the representative person in the population. The conservatism of these dispersion factors was assessed in a 2012 study using a Gaussian model with special routines for the effect of buildings (ISC-PRIME), and the recommendations of this study were to determine experimental dispersion factors based on monitoring data of gaseous effluent emissions and tritium concentrations in the environment, with which to verify the results of the mathematical models.

The dispersion of radioactive pollutants associated with liquid effluent emissions was assessed by calculating the dilution factor as the ratio of the average effluent concentration at the point of discharge to the average concentration at the point of water use. Thus, for the discharge of effluent into the Danube-Black Sea Canal, which does not have a significant flow for the dilution of liquid discharges, the dilution factor is considered to be unitary, while for the discharge into the Danube, the dilution factor is the inverse of the average discharge flow of liquid effluents.

6.1.3 Uncertainties about the precise details of the project and its environmental impact

The radiological environmental impact assessments following the implementation of the U1 refurbishment and DICA extension project were carried out based on the impact data due to the operation of the plant so far and on the estimates of the change in radioactive emissions during the preparation and actual implementation of the U1 refurbishment.

Anticipated emissions associated with the U1 refurbishment sub-project have been assessed based on the experience of refurbishment projects at similar plants in Canada.

6.1.4 Difficulties in processing data needed in forecasting and assessing effects

With regard to ***the assessment of the radiological impact*** on the environment and the population as a result of the implementation of the U1 refurbishment and DICA extension project, the existence of a plant operating history of more than 26 years constitutes a safety element, since the activities associated with this project will be carried out under the existence of a well-structured and proven framework for ensuring the nuclear safety of activities on the site. At the same time, the radioactive effluents emitted from the project activities are radiologically similar to the effluents resulting from the operation of the plant, and will be managed and discharged into the environment within existing systems, therefore having a known impact on the environment. However, some difficulties in assessing and forecasting the environmental impact of project implementation activities may arise from uncertainties in estimating the level of radioactive effluent emissions. Even so, given the minor or insignificant impact on environmental factors estimated on the basis of the level of radioactive effluent emissions, these uncertainties are not likely to alter the level of this impact.

6.2 Methods for estimating the types and quantities of radioactive waste generated in the implementation and operation of the project

The types and quantities of solid radioactive waste expected to be produced as a result of the Unit 1 reactor refurbishment activities have been assessed, based on international experience and taking into account the technical solutions to be adopted in the pre-disposal stage, in the study *KHNP, Feasability Study on Management of Radwaste Generated during Unit 1 Refurbishment and Operation of Unit 1,2 in Cernavodă NPP – Environmental Issues Report*.

6.3 Methodologies for estimating emissions of non-radioactive pollutants in the atmosphere and for pollutant dispersion modeling. Uncertainties and difficulties in assessing the impact on air quality

6.3.1 Estimation of non-radioactive emissions into atmosphere

The mass flows of pollutants characteristic of the construction phase were determined with:

- US EPA/AP-42 methodology (Air CHIEF - Fifth Edition updated 2007) for dust from all sources. It is noted that the US EPA/AP-42 methodology is the only one of its kind scientifically based to cover the types of sources associated with the project.
- EEA/EMEP/2023 methodology for pollutants from mobile machinery.

The following table describes the emission processes associated with the various operations/activities, the activity data and associated pollutants as well as other information required in the emission calculation.

Tab. 119 Description of emission processes associated with different activities/operations during the construction phase

Name of operation/activity	Name of issuing process	Date of activity	Pollutants emitted	Further information
Excavations	Excavation and piling of earth/waste	Amount of earth excavated (tonnes) Number of hours required to perform the operation	TSP, PM_{10}, $PM_{2,5}$	
	Loading trucks with earth/waste	Amount of earth/waste loaded (tonnes)	TSP, PM_{10}, $PM_{2,5}$	
Construction of embankment	Unloading aggregates from trucks	Quantity of aggregates unloaded (tonnes)	TSP, PM_{10}, $PM_{2,5}$	
	Spreading/levelling material	Kilometres travelled by equipment (grader) in the levelling operation	TSP, PM_{10}, $PM_{2,5}$	
Asphalting	Emulsion primer application	Quantity of primer applied (tonnes)	VOC	A bitumen content of max. 60 % in the bitumen primer, and a VOC content of max. 1 % in the

Name of operation/activity	Name of issuing process	Date of activity	Pollutants emitted	Further information
				bitumen shall be considered.
	Asphalt pouring (binder and wearing course)	Quantity of asphalt used (tonnes)	VOC	A maximum of 1% VOC in the bitumen used in asphalt concrete is considered. Bitumen also represents max. 5% of the mass of asphalt concrete
Equipment operation	Exhaust emissions due to the operation of equipment engines: bulldozers, excavators, loaders, backhoe loaders, compactors	Number of operating hours per equipment type	TSP, PM_{10}, $PM_{2,5}$, CO_2, NO_x, N_2O, CH_4, CO, VOC, SO_2, heavy metals, polycyclic aromatic hydrocarbons (PAH)	Particulate emissions are due exclusively to exhaust from equipment engines Information is needed on the average power of the equipment by type In the absence of activity data, information on equipment productivity by type, engine power and other characteristics may be used
Transport of materials and workers	Exhaust emissions due to the operation of engines of motor vehicles for the transport of materials and workers	Vehicle kilometres travelled	TSP, PM_{10}, $PM_{2,5}$, CO_2, NO_x, N_2O, CH_4, CO, COV, SO_2, heavy metals	Assumes the use of a standard type of truck (20 t) or concrete mixer ($8m^3$) equipped with a Euro V diesel engine. Emissions associated with on-site traffic will be assessed using an average vehicle journey around the site
	Emissions due to tyre and brake wear	Vehicle kilometres travelled	TSP, PM_{10}, $PM_{2,5}$	
	Emissions due to re-suspension of particulates from road surfaces (including from surface wear)	Vehicle kilometres travelled	TSP, PM_{10}, $PM_{2,5}$	

The sources associated with construction work are open, free surface sources with unducted emissions.

The working hypotheses were as follows:

- It will be operated with equipment having a minimum emission performance level STAGE IV
- In estimating the number of hours allocated to each operation, the average productivity for each type of equipment was taken into account
- Material transport vehicles shall be 16 to 25 tonne trucks equipped with engines having a minimum EURO V emission performance level.
- Control and reduction of particulate emissions with an average efficiency of 75 % will be ensured by wetting the surfaces subject to the works, especially during periods without rainfall.

Tables A1 – A3 in Annex 6 AIR QUALITY - A show the emission factors used, the calculation relations by which they are obtained in the case of functional dependencies of several parameters, together with their methodological references.

During the operating period, emissions of non-radioactive pollutants were estimated in accordance with the recommendations of Order No. 3299/2012 approving the methodology for the preparation and reporting of inventories of pollutant emissions into the atmosphere, using emission factors from the EMEP/EEA air pollutant emission inventory guidebook - 2023.

In the case of SO_2, emissions were estimated by mass balance, assuming a sulphur content of the fuels equal to the legal limit values.

The emission factors used are given in Annex 6 AIR QUALITY - A tables A3 – A5.

6.3.2 Methodologies for modelling of non-radioactive pollutants dispersion

The AERMOD model, described below, was used to model the dispersion of pollutants generated by non-radioactive atmospheric emission sources at the Cernavodă NPP site.

AERMOD - short description of the model

AERMOD is a Gaussian stationary plume model, applicable to both rural and urban areas, flat or complex terrain, for surface or height emissions and for multiple sources of all categories: point, surface and volume.

AERMOD (AMS-EPA Regulatory Model) was developed by AERMIC (AMS-EPA Regulatory Model Improvement Committee), a working group of AMS (American Meteorological Society) and U.S. Meteorological Service (AMS) scientists. EPA (U.S. Environmental Protection Agency), established in 1991 to develop a state-of-the-art model for regulatory applications, capable of taking into account, for example, new concepts on the planetary boundary layer, interaction of the pollutant plume with land, surface emissions, building effect, dispersion under urban conditions, and to follow that model:

- provide reasonable estimates of pollutant concentrations under a variety of conditions with a minimum of discontinuities;
- be "user-friendly", with reasonable input data requirements and computing system resources;
- to capture essential physical processes while keeping it simple;
- easily integrate changes due to the evolution of science over time.

Thus, new or improved algorithms have been implemented in AERMOD for:

- dispersion in both the convective and stable boundary layer;

- the plume-rise and the buoyancy of the pollutant plume;
- penetration of the inversion layer from above;
- calculation of vertical wind, turbulence and temperature profiles;
- urban, nocturnal boundary layer;
- treating receptors on any type of terrain, from the surface to above the pollutant plume;
- treatment of building effects;
- an improved approach to characterising fundamental boundary layer parameters.
- o abordare îmbunătăţită a caracterizării parametrilor fundamentali ai stratului limită.

Over time, improvements have been made to the model, such as the implementation of wet and dry deposition processes for gases and particles.

The AERMOD modelling system consists of the AERMOD dispersion model itself and two preprocessors: the AERMET meteorological preprocessor, which provides the dispersion model with the meteorological information it needs to characterise the planetary boundary layer, and the AERMAP terrain preprocessor, which characterises the terrain and generates receptor grids for the dispersion model.

Input data

The input data for the AERMOD dispersion model are represented by:

- hourly meteorological data: boundary layer parameters (friction velocity, Monin-Obukhov length, convective velocity scale, potential temperature scale, mixing height and sensible heat flux) provided by AERMET;
- terrain data: terrain elevation scale grid provided by AERMAP; data related to land use and land cover type by season (for deposition calculation);
- receptor network data: geographical coordinates and height above mean sea level for each receiver, transmitted by AERMAP in rectangular and/or spherical networks and/or for single receivers;
- data related to emission sources: physical parameters of the sources (geographical coordinates, elevation, emission height for point sources and inner diameter at the stack)
- emission data: emission rate for each pollutant, for point sources temperature and gas velocity at exit release, and for volume sources the initial plume size;
- factors of temporal (hourly) variation of emissions;
- background concentrations;
- data related to buildings influencing dispersion: geographical coordinates of building corners and building height.

Dispersion calculations were performed on a grid of receptors with dimensions of 5 km x 5 km and 100 m pitch, which includes the Cernavodă NPP site, the city of Cernavodă and the town of Ştefan cel Mare.

Output data

The output data is represented by the concentration fields in the nodes of the defined receptor network. AERMOD calculates, for each receptor, maximum concentrations, averages, percentiles, values exceeding a certain threshold, etc., over various averaging periods: hourly, daily, monthly, yearly, multi-yearly, etc.

Weather data

The meteorological data used to run the AERMET weather processor consisted of surface and profile data extracted from output data generated by downscaling a mesoscale dynamic weather model - TAPM.

TAPM (The Air Pollution Model) is a combined meteorology-dispersion model developed by CSIRO (Australia).

The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation forecast model solved in coordinates that track topography.

The model solves the momentum equations for the horizontal wind components, the incompressible continuity equation from which the vertical velocity is derived, and the scalar equations for the potential virtual temperature and specific humidity of water vapour, cloud water and precipitation water.

The solution for the wind field, potential virtual temperature and specific humidity is sequentially assimilated through the synoptic values of these quantities provided in the model database.

The meteorological data used by TAPM as input to the model are provided by a Limited Area Prediction System (LAPS) synoptic scale analysis model and consist of data modelled at six-hour intervals on a geographic grid - longitude/latitude with 0.75 degree resolution (approximately 75 km) covering the Northern Hemisphere.

Field data are provided by the US Geological Survey, Earth Resources Observation Systems (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC), with a latitude resolution of 30 seconds (approximately 1 km).

The US Geological Survey also provides land use data at the same resolution.

The data required to run the AERMET meteorological processor were extracted in the central point of the calculation grid associated with the AERMOD model. For this purpose, an external application was developed to interface the TAPM model with the AERMET weather processor.

6.3.3 Difficulties in processing data needed in forecasting and assessing effects

The estimates for the construction phase took into account the areas subject to the works and the volumes of materials handled. Where volumes of works were not available, they were calculated using information on areas subject to works, number of building levels and average specific consumption of concrete/iron/brick/other materials used in civil and industrial construction.

For the future operating period, given that there is no information on projected fuel/fuel consumption for the start-up power power plant/diesel generator equipment, it was assumed that this consumption will be similar to that reported for 2022.

Also, given that information on the timing of the construction works for the retrofitting infrastructure and MACSTOR 400 was not available at the time of processing the activity data, a conservative worst-case scenario approach was used (the works with the highest emission intensity for all objectives were considered to be in simultaneous deployment).

6.4 Methods used to collect information on species and/or habitats of community interest

6.4.1 Steps taken in gathering information

As for the documentation and information gathering stage, this involved:

a. *technical-administrative documentation*
The entire technical documentation related to the implementation of the project that was the basis of the environmental assessment was made available by the beneficiary: SNN Nuclearelectrica SA through the Cernavodă NPP Branch. In addition, there were a whole series of consultations and documentation stages that were able to provide the full set of technical data needed.

b. *environmental documentation*
During the assessment, a stage of on-site documentation and initial assessment was undertaken, on the basis of which a Baseline Survey was carried out. In the present case, the identification of the potential impact of the project on the criteria elements that were the basis for the designation of Natura 2000 sites (as well as the sites as a whole) in the area of influence of the project was undertaken, field studies completed by a documentation stage, which involved consulting the Site Designation Forms[131], but also studies and published data that retain relevance in this regard. Historical data were consulted starting from own studies carried out previously at the level of the target site, starting from 2012[132].
Descriptive and relational aspects of the project with the natural environment, including the criterion elements that were the basis for the designation of Natura 2000 sites, were taken from: The integrated management plan for the protected natural areas included in the Custody Agreement no. 0038/2010 of the Constanța Forestry Directorate.
Management plan for protected natural areas ROSCI0071 Dumbrăveni - Valea Urluia - Lake Vederoasa, ROSPA0036 Dumbrăveni, ROSPA0001 Aliman - Adamclisi, ROSPA0007 Balta Vederoasa, 2361 Dumbrăveni Forest, 2350 Limestone walls from Petroșani - Deleni Commune, 2351 Fossil site Aliman and IV.30 Lake Vederoasa, approved by Order of the Minister of Environment, Water and Forests no. 1557/2016.

c. *administrative documentation*
In the creation of this documentation, the format (shape) of some studies completed previously and which enjoyed formal validation within environmental institutions was replicated, ensuring in this way the superposability and comparison of some aspects.

[131] Standard site designation forms revised at:
https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=ROSPA0071
https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=ROSCI0162
[132] Contract 75/2017 project *Natural gas transport pipeline Black Sea Coast – Podisor*
Contract 18/2016-2022 Biodiversity *Monitoring project*
Consultancy contract 32/2012 project *Improving the state of conservation of biodiversity in protected natural areas in the custody of the Constanța Forestry Directorate CF Bucharest - Constanța*

6.4.2 Methods used to collect information on species and habitats of community interest

The documentation on the species and habitats of community interest was done starting from the elements included in the standard forms for the designation of Natura 2000 sites. Using bibliographic reference sources, but also calling on original information, obtained from field studies, by applying some methods established, attributes associated with species and habitats were established, and using GIS technology, arealographic models, distribution maps and overlays with design schemes were made, which were refined through the comparative analysis of queries from the base-of- own data that appealed to the platform made available by the Central Environmental Authority - BIMS (Biodiversity Information Management System).

The arealographic and biome structure models were considered as a first analytical phase, representing the initial (pre-project) phase that illustrated the landscape-level structure of land categories, habitat types or the potential for the spread of some species.

In the evaluation carried out, at the level of the investigated perimeter, a documentation (including cartographic) was carried out in the field, but also by overlapping with the distribution maps of some species of conservation interest.

It can be observed that the maps regarding the distribution of the criteria species, which were the basis for the foundation of the Management Plan, remain at a large granularity, rather showing the potential arealographic presence of the species in question; the signaling points (where they are marked) maintain an average degree of accuracy (lacking geographic coordinates or descriptive aspects to facilitate identification in the field).

6.4.2.1 Use of aerial photogrammetry and GIS technology

The documentation on the species and habitats of community interest in the area of influence was done in the field starting from the elements contained in the standard forms for the designation of Natura 2000 sites. Using bibliographic reference sources, but also calling on original information, obtained from the studies of land, by applying established methods, attributes associated with species and habitats were established, and using GIS technology, arealographic models, distribution maps and overlays with design schemes were made.

The study was documented both by taking high-resolution digital photos (min. 10MPx) taken from the operator level (perspectives) or by using aerial photographs taken with the help of drones (prototype 4qrs, DJI Phantom II and DJI Phantom III Advanced) – see Fig. 115.

Fig. 115 DJI Phantom III-Advanced drone ready for flight (left); DJI Matrice 600 PRO drone with LiDAR unit

Starting from the aerial images, cartographic models of the perimeters in the area of influence of the project were made. The method of creating the cartograms took into account the detail pursued (granulation-target) which was established taking into account the ecological-target characteristics associated with each criterion element that was the basis of the designation of the site, in part. The approach is presented synthetically in Fig. 116.

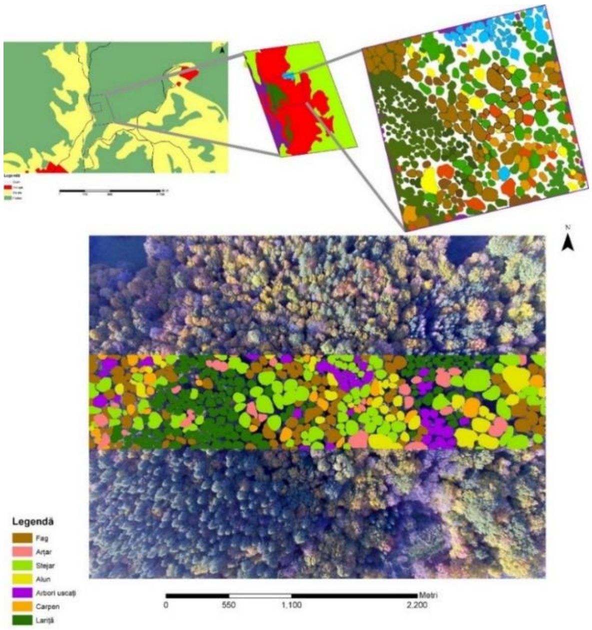


Fig. 116 The method of creating cartograms starting from aerial images, through the technique of digitization with the help of GIS technology

At the top: approaching a habitat in depth by increasing the digitization details (increasing the grain); at the bottom: the evaluation of some forest habitats using the strip analysis technique

Starting from the cartographic analysis and GIS models, knowing the ecological requirements of the criteria species that were the basis for the designation of the sites, respectively analyzing the distribution maps of the species, potential distribution maps[133] were made at the level of the area of influence of the studied perimeter.

Going through the data set on the basis of which the entire environmental assessment was built, it was established that the level of impact associated with the project in the construction and operation phase remains **insignificant**, including as a result of the assumption and application of some sets of proposals to reduce the impact, from the perspective application of the precautionary principle. As a result environmental effects and risks have been minimized (and/or removed).

6.4.2.2 Methodologies applied in field evaluation

The evaluation in the field involves the application of established, standardized methodologies, which allow a statistical interpretation of the data and ensure their superposability, giving the possibility of performing some spatio-temporal comparative approaches. Under these

[133] Gontier, M., Balfors, B., Mörtberg, U. (2006): "Biodiversity în environmental assessment-current practice and tools for prediction", Elsevier, Environ.Imp. Assess. Rev. 26: 268-286

conditions, in the evaluation of the elements of conservative interest, the working protocols proposed by the Specific Guidelines[134], were used, as follows:

- Monitoring guide for plant species of Community interest in Romania,
- Synthetic monitoring guide for habitats of community interest (salt flats, continental dunes, meadows, fresh water) in Romania
- Synthetic monitoring guide for habitats of community interest: thickets, peatlands and marshes, rocky outcrops, forests,
- Synthetic monitoring guide for amphibian and reptile species of community interest in Romania,
- Synthetic guide for monitoring caves and bat species of community interest in Romania,
- Synthetic monitoring guide for mammal species of community interest in Romania,
- Synthetic guide for monitoring community fish species in Romania,
- Synthetic guide for monitoring invertebrate species of community interest in Romania,

and taking into account the Annex to the Order of the Minister of Environment, Waters and Forests no. 3351/2023 for the approval of the Guidelines on protocols and standard methodologies for monitoring the conservation status of species of Community interest, within the project "Completing the level of biodiversity knowledge through the implementation of the system for monitoring the conservation status of species and habitats of Community interest in Romania and reporting under Article 17 of the Habitats Directive 92/43/EEC", funded by the Large Infrastructure Operational Programme 2014-2020.

Taking into account the approach assumed within the environmental assessment course, the applied methodologies primarily focused on qualitative aspects (presence/absence) related to the criteria elements pursued; quantitative aspects (population levels) could only be assessed from a perspective given by the documentation used as a source of comparative reporting (in particular the Site Activity Monitoring Reports).

6.5 Methodology for Technological Risk Assessment and Evaluation of Consequences of Possible Accidents

Methodology for Technological Risk Assessment

For the installations located at the Cernavodă Nuclear Power Plant (CNPP) site, where hazardous chemicals falling under the scope of Law 59/2016 on the control of major accident hazards involving dangerous substances, are present, the risks of chemical technological accidents have been identified and analyzed in the Safety Report, 2018 edition, revision 2, 2023.

Law 59/2016 on the control of major-accident hazards involving dangerous substances does not apply to the hazards created by ionizing radiation from radioactive materials, so the technological risk assessment methodology is developed according to the provisions of Law 59/2016, only for the risks induced by the presence of dangerous chemical substances and not for the risk of a nuclear accident.

The process of technological risk assessment was carried out in two major stages:

- Preliminary risk analysis. Qualitative analysis;
- Detailed risk analysis. Quantitative analysis.

[134] https://www.ibiol.ro/posmediu/rezultate.htm

For the preliminary risk analysis, the "Preliminary Hazard Analysis - PHA" method was used.

Preliminary Hazard Analysis (PHA) is a stage in the qualitative risk analysis process, where hazards in the technological process are identified and evaluated, and the risk of each identified hazard is estimated in a qualitative manner.

The main points considered in the study are:

- substances used in the process, hazardous properties, hazards,
- main and secondary equipment in the installation,
- interfaces between system components,
- surrounding environment,
- operations carried out in the facility (including maintenance and testing),
- equipment and safety devices.

The assessment is conducted by identifying the following factors:

- the hazard;
- the causes leading to the occurrence of the hazard;
  - the immediate and final consequences that are expected in case the hazard transforms into an accident;
  - the severity level, probability, and risk, by assigning scores of acceptability (defined in the risk assessment matrix);
- existing prevention measures;
  - recommended actions for reducing the risk or mitigating negative effects.

The PHA process utilizes data about the process and hazards to deduce the incidents with the highest probability of occurrence and their triggering factors.

For each installation within the site, a PHA analysis was developed by completing the PHA table.

Factors that must be considered in conducting the PHA analysis include:

- Hazardous components: energy sources, fuels, combustibles, pressurized systems.
- Subsystem interferences: signals, voltages, synchronizations, human interactions.
- System compatibility constraints: material compatibility, electromagnetic interferences, transient currents.
- Environmental constraints: leaks, shocks, extreme temperatures, noise, health hazards, fire, electrostatic discharges, lightning, X-rays, laser radiation.
- Undesirable system states: accidental activations, fire or explosion initiations and their progression, damage to safety systems.
- Incorrect system, subsystem, or computer system operations.
- Software errors: programming errors, programming omissions, logistical errors.
- Operation, testing, maintenance, and emergency procedures.
- Human errors.
- Product life cycles: transportation, handling, storage, disposal.
- Installations, support equipment, and training.
- Safety equipment and warranties: safety mechanisms, system protection, fire

suppression systems, personal protective equipment, warning labels.
- Defense equipment and devices.
- Training and certification programs related to system safety and maintenance.
- System phases: testing, manufacturing, operation, maintenance, transportation, storage, disposal.

Each identified hazard is listed and analyzed in the PHA table.

The risk is estimated according to the equation: R = P x S, where P represents the probability of the event and S represents the severity of the consequences.

After completing the PHA table, the risk matrix was constructed, and the identified scenarios were entered into the matrix.

The measure of the probability of occurrence was accomplished by categorizing into five levels, which have the following meanings:

1. *Improbable:* It can only occur under exceptional conditions.
2. *Isolated:* It might happen sometime during the project's lifetime.
3. *Occasional:* It may occur at some points during the project's lifetime.
4. *Probable:* It is likely to occur in many situations during the project's lifetime.
5. *Frequent:* It occurs in most situations during the project's lifetime.

The qualitative measure of consequences is also achieved by categorizing into five severity levels, which have the following meanings:

1. *Insignificant* No significant emissions. Minor injuries to humans. Some minor adverse effects on few species or parts of the ecosystem, short-term and reversible. Social effects are insignificant, no cause for concern.

2. *Minor* - Emissions within the facility immediately contained. First aid required for injured individuals. Damages are minor, quick, and reversible for few species or parts of the ecosystem. Social effects present few reasons for concern for the community.

3. *Moderate* - Emissions within the facility contained with external assistance. Medical treatment required for affected individuals. Temporary and reversible damages to habitats and wildlife migration, with some plants and animals unable to survive, potential damage to aquatic life, limited soil contamination. Reduced production capacity observed. Social effects present moderate reasons for concern for the community.

4. *Major* - Emissions outside the site with harmful effects. Severe injuries to humans, death of animals, damages to local species and extensive habitat destruction. Soil remediation only possible in the long term. Production activities interrupted. Social effects pose serious concerns for the community.

5. *Catastrophic* - Toxic emissions outside the site with harmful effects. Human fatalities, mass animal deaths, destruction of flora species, permanent and extensive soil contamination, and cessation of production activities. Social effects pose extremely high concerns.

It should be noted that the 5 levels are qualitative and do not have a direct connection with probability calculations.

Among the accident scenarios identified in the preliminary PHA analysis and analyzed in the risk matrix (qualitative analysis), scenarios that could lead to major accidents, were selected. These scenarios were further analyzed to assess the magnitude and severity of the consequences (quantitative risk analysis).

The selection criteria for the scenarios analyzed in the quantitative risk analysis were as follows:

- Scenarios with high or extreme risk (risk levels ranging from 13 to 25 in the risk matrix)

or,

- Scenarios with major or catastrophic consequences (levels 4 and 5 in the risk matrix)

or,

- Scenarios that do not meet the above criteria but are considered relevant for the safety of the installations (expert team's opinion).

The methodology for quantitative analysis relied on evaluating the consequences of possible accidents by calculating the distance at which the physical size describing a consequence (thermal radiation, concentration, radiant energy, overpressure) reaches a corresponding limit value (threshold) associated with the onset of adverse effects. The thresholds used were as follows:

- *Order No. 3710/1212/99/2017* dated July 19, 2017, approving the Methodology for establishing adequate distances from potential risk sources within the sites falling under the provisions of Law No. 59/2016 regarding the control of major accident hazards involving dangerous substances in land planning and urbanism activities, and
- *Methodological Norms* dated December 11, *2017*, regarding the development and testing of emergency plans for major accidents involving dangerous substances, approved by Order No. 156 dated December 11, 2017.

The effects generated by the occurrence of an accident depend on the type of scenario defining the analyzed accident and the specific indicator value determined.

The threshold values used were as follows:

- For thermal radiation from stationary fires (pool fire type; and jet fire type):
  - 12.5 kW/m^2 for the high mortality area and the Domino effects threshold;
  - 7 kW/m^2 for the mortality threshold area,
  - 5 kW/m^2 for the area with irreversible injury;
  - 3 kW/m^2 for the reversible injury zone.
- For flash fires:
  - Lower flammable or explosive limit (LFL or LEL) for high mortality area;
  - ½ LFL LFL for the area with threshold mortality;
  - 10% LFL for irreversible injury zone;
  - 5% LFL for reversible injury zone.
- For VCE and UVCE explosions:
  - 300-600 mbar (0.3-0.6 bar) for the domino effects threshold;
  - 300 mbar (0.3bar) for the area of high mortality;
  - 140 mbar (0.14 bar) for the mortality threshold area;
  - 70 mbar (0.07bar) for the irreversible injury zone;
  - 30 mbar for the reversible injury zone.

- For toxic dispersions:
  - LC50 for area with high mortality;
  - AEGL 3 for area with threshold mortality;
  - AEGL 2 for the area of irreversible injury;
  - AEGL 1 for area with reversible injury.

LC50 – (Lethal concentration with 50% death of victims) is a value of the concentration of a toxic substance in the atmosphere expressed in ppm (parts per million) or mg/m^3, calculated or experimentally determined for a specific exposure duration, above which effects are considered lethal. This limit is used to determine Zone I planning area - high mortality.

AEGL 3 represents the airborne concentration value of a substance expressed in ppm or mg/m^3, above which it is predictable that the majority of individuals, including susceptible individuals, will experience life-threatening effects or death. This limit is used to determine Zone II planning area - mortality threshold.

AEGL 2 represents the airborne concentration value of a substance expressed in ppm or mg/m^3, above which it is predictable that the majority of individuals, including susceptible individuals, will experience irreversible or serious long-term effects affecting health or the ability to self-evacuate. This limit is used to determine Zone III planning area - irreversible injury limit.

AEGL 1 represents the airborne concentration value of a substance expressed in ppm or mg/m^3, above which it is predictable that the majority of individuals, including susceptible individuals, will experience significant discomfort, irritation, or specific asymptomatic effects that do not impair the senses. However, the effects do not cause incapacitation, are transient, and are reversible when exposure ceases. This limit is used to determine Zone IV planning area - reversible injury.

It should be noted that depending on the specific of the accident and the exposure time, the LC50 and AEGL1-2-3 threshold values for toxic chlorine dispersions and hydrazine vapor were selected for exposure durations of 10, 30, and 60 minutes (where these data were available).

Exposure to toxic concentrations may have shorter durations if the toxic cloud moves at high speed or when the cloud size is small and the spillage duration is short.

In cases where the exposure duration calculated by the modeling program is shorter than the standard duration defined for an AEGL concentration level, the toxic dose corresponding to the exposure was calculated. The calculation is based on Haber's rule:

Toxic dose = $C^n \times t$ = const., where C - concentration of the toxic gas (ppm), t - exposure time (min), n - exponential factor depending on the substance.

Modeling and simulating the selected accident scenarios

For modeling scenarios involving fires, explosions, and toxic dispersions, the EFFECTS program Environmental and Industrial Safety, was used. This program is developed for analyzing the effects of industrial accidents and their consequences. Initially, the program was developed by TNO (Netherlands Organisation for Applied Scientific Research) - Built Environment and Geosciences in the Netherlands. After TNO merged with the multinational company Gexcon, the program continued to be developed based on the latest scientific research in the field. The program's models are based on the "Yellow Book" (*Van den Bosch, 2005*), internationally recognized as a standard in risk analysis development.

Regarding the selection and input data of the scenarios, the following points are noted:

1. According to the requirements of Order 156/2017, for scenarios dependent on meteorological conditions, such as toxic dispersions and "flash fire" incidents, modeling is conducted for two specific meteorological conditions in the analyzed area: the most common weather conditions and the most unfavorable but possible weather conditions.

2. For scenario modeling, facilities such as tanks, vessels, barrels, cylinders, pipelines, etc., where dangerous substances falling under the provisions of Law No. 59/2016 are stored or handled on-site, and posing risks due to their location or processing, have been selected.

3. Since tanks, barrels, or cylinders of the same capacity have relatively equal dimensions, the modeling performed can be applied to any tank, barrel, or cylinder with the same capacity and content (e.g., the two hydrogen storage tanks).

4. In modeling flammable dispersion scenarios, it is possible that the calculated concentrations may not reach threshold values (e.g., concentrations equal to the LEL). In reality, these values may be reached at short distances that the program cannot calculate. Therefore, when determining emergency intervention measures, it is recommended to consider a minimum distance of 10 meters from the liquid surface as a potentially affected area.

5. For scenarios involving hydrogen leakage in the generator room, a 3-minute leak resulting in a flammable dispersion with a VCE explosion through deflagration was considered. The quantity of gas involved in the explosion was calculated through modeling, assuming that the flammable gas sensor and alarm are not functioning. The explosion curve used in the program was selected according to the "Yellow Book" (Van den Bosch, 2005). The VCE model in calculating overpressure does not account for the presence of building walls, thus the effects obtained in modeling are maximum. In reality, overpressure propagates over shorter distances due to the explosion occurring inside the building.

6. For the proposed situation in the RT-U1 and DICA-MASTOR 400 project, no accident scenarios requiring additional quantitative analyses for the implementation period were identified other than those presented and analyzed in the existing situation.

7. The rays (distances) resulting from modeling that define the affected zones are measured from the center (containment basin/bund, liquid pool, emission point, etc.).

8. The risk analysis focuses only on parts of the installation where hazardous chemicals are stored, conveyed, or processed. Possible domino effects caused by nuclear accidents are not analyzed in the Security Report as they are not covered by Law 59/2016.

6.6 Assessment Methodology for Noise and Vibration

Noise propagation modelling was made in accordance with the provisions of Law no. 121/2019 on the assessment and management of environmental noise, which transposes the provisions of Commission Directive 2015/996 of 19 May 2015 on the establishment of common methods for noise assessment in accordance with Directive 2002/49/EC of the European Parliament and of the Council.

Input data - *Descriptive parameters and targeted area*

The following steps have been taken in order to assess the noise levels:

- *Measurements of the noise levels* in order to characterize the existing situation and to highlight the existing noise sources on the site.
  Methods of analysis:
    - SR ISO 1996-1: 2016: Acoustics. Description measurement and assessment of environmental noise. Part 1: Fundamental measurements and assessment methods
    - SR ISO 1996-2: 2018: Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise levels
    - SR 6161-1:2022 Building acoustics. Acoustics - Part 1: Determination of noise levels in civil constructions and urban settlements. Determination methods.
- *The development of a 3D* digital acoustic model of the area, with buildings and noise sources associated with the activities of the plant and its surroundings, which was created using dedicated software for noise mapping of different source categories, SoundPlan - version 9.0
- Integration in the digital acoustic model of the noise sources associated with the activities envisaged in the U1 retrofitting and DICA extension stage as well as in the operational status of the U1 Unit and its annexes, with their characteristics of *acoustic power, spectral composition, directivity, duration of operation of each one in a period of time (e.g. 24 h);* consideration has been given to both the noise sources associated with equipment on the premises and those associated with exterior equipment and activities, including the levels at which the sources act.
- Establishing and including in the acoustic model of the acoustic indices of building surfaces, their transmissivity coefficients and the acoustic characteristics of the terrain.
- Identification, by the above-mentioned method, of the sensitive receivers (*inhabited houses*), as well as of the buildings that constitute obstacles in the way of noise propagation, with their shapes and details relevant in terms of wave phenomena - *reflections and diffractions*, existing in the chosen area..

Acoustic mapping

- Modeling of noise propagation in order to produce noise maps based on the parameters listed above, for the baseline situation, in order to identify/estimate the noise levels on the site.
- Updating the digital acoustic model realized for the forecast situation, with the actual data for the different phases of the U 1 Unit refurbishment and DICA facility extension, including the industrial road traffic noise generated by the internal transportation of materials.
- Modeling of noise propagation in order to realize noise maps based on the parameters listed above for the operational phase.

The similarity of the post-refurbishment situation with the current operating stage of Cernavoda NPP leads to the conclusion that the noise and vibration impact during the operating stage of the project will remain insignificant. Thus, in the present study, the noise and vibration impact assessment focused on the project realization stage, with two distinct phases in terms of noise sources: the phase of execution of the infrastructure and constructions supporting the project (construction site) and the phase of U1 shutdown, retubing, testing (the actual refurbishment).

Acoustic modeling was carried out for clusters of construction activities and internal traffic within suitable construction areas, based on the neighborhood criterion. Each site construction area was modeled by a surface-type noise source, to which an emission resulting from the acoustic powers of the working machinery required to be present during the construction phase was assigned, with the necessary corrections for the working time of each within the set reference duration, as well as for the type of activities in the different phases of the construction site. For the information needed to assign their acoustic characteristics, GD no 1756/2006 and the British Standard BS 5228 – 1:2009 + A1:2014 Part 1 were consulted.

The uncertainties related to the timing of the activities have been covered by a conservative approach, considering the simultaneous operation of the mini- construction sites. With this approach it is obvious that if the mini-sites are active simultaneously and the noise levels are within the legal limits, then the conclusion is valid even if their activity is non-simultaneous. Road traffic noise within the plant territory on the established access roads was calculated by assigning to each road section 6 vehicle crossings/hour with travel speeds of 20 km/h.

Vibration analysis

In Germany, DIN 4150 norms set limit values in such a way that the integrity of the construction is not impaired - the descriptor parameter being ppv (*peak particle velocity*).

In the Romanian legislation, reference to the limits concerning the ppv parameter in the case of ground transmitted vibrations can be found in the Technical Prescriptions on the Measurement of the Seismic Wave Travel Velocity - annex to the NSPM for the Storage, Transportation and Use of Explosive Materials, ed.1997, in which the correlation between the seismic intensity (MSK scale - Medvedev, Sponheuer, Karnik - 1964) according to STAS 3684/71, the velocity of ground particle oscillations and the effects on structures in the case of earth movements produced by shooting works is also presented (Tab. 96).

In the United Kingdom the standard BS 7385: Part 2 1993, provides limit values for transient vibration in relation to cosmetic damage to buildings (peak velocity ppv in [mm/s]).

Vibration sources taken into account are ***the construction site machinery during their work (bulldozers, etc***.), and ***the internal heavy traffic transporting the necessary construction materials, including truck concrete mixers***. The movement of these heavy vehicles on a road with its inherent unevenness is the cause of the vibrations generated by transportation.

The method considered suitable for use in this case is the one presented in ”Transportation and Construction Vibration. Guidance Manual”[135].

[135] Jim Andrews, David Buehler, Harjodh Gill, Aesley L. Bender Transportation and Construction Vibration . Guidance Manual. Caltrans, 2013

6.7 Basis for assessing significance and importance of impact

For the assessment of the possible impact, the criteria of Order no. 269/20.02.2020 on the significance of the impact (with the ranges significant, moderate, minor, negligible, with no value or positive) were taken into account.

The criteria are presented in the sub-chapter 5.2.

The quantitative evaluations were based on modeling with the use of specific, appropriate software, including the use of GIS support.

In situations where a precise quantification is not possible (information is missing, there is no quantification method, the degree of uncertainty is high, etc.), the qualitative assessment classes of each parameter as defined in Order 269/2020 are used.

Tab. 120 Significance of impact by magnitude and sensitivity of the receptor

	Magnitude small	**Magnitude medium**	**Magnitude large**
Sensitivity low	Minor	Minor	Moderate
Sensitivity medium	Minor	Moderate	Major
Sensitivity high	Moderate	Moderat	Major
Significance of impact			
No impact or insignificant	The impact does not result in quantifiable (visible or measurable) effects on the natural state of the environment.		
Significance minor	The impact is small in magnitude, within standards and/or associated with receptors of low or medium value/sensitivity. mpact of medium magnitude affecting receptors of low value.		
Significance moderate	Impact falling within limits, with small magnitude affecting high value receptors, or medium magnitude affecting medium value receptors, or large magnitude affecting medium value receptors.		
Significance major	Impact that exceeds the limits and standards and is of large magnitude affecting medium value receptors or of medium magnitude affecting high value receptors.		

7. A DESCRIPTION OF THE MEASURES PLANNED TO AVOID, PREVENT, REDUCE OR, IF POSSIBLE, COMPENSATE FOR ANY SIGNIFICANT ADVERSE ENVIRONMENTAL EFFECTS IDENTIFIED AND A DESCRIPTION OF ANY PROPOSED MONITORING MEASURES

In accordance with the requirements of the General Guide applicable to the stages of the environmental impact assessment procedure, of 20.02.2020, in this chapter should be developed the measures for AVOIDING, PREVENTING, REDUCING OR, IF POSSIBLE, COMPENSATING ANY SIGNIFICANT ADVERSE EFFECTS ON THE ENVIRONMENT, identified.

In the development of the previous chapters no. 2, 3, 4 and 5 there were not identified any significant negative effects on the environment.

It should also be noted that the Ministry of Environment, Waters and Forests - DEI no. 1/23.02.02.2022 - established that the realization of this project does not have a significant potential negative impact on the integrity of protected natural areas of community interest in the vicinity of the Cernavodă NPP and does not lead to changes in the quality of surface and underground water bodies, and thus the project does not lead to the deterioration of the state of water bodies in the area of works.

However, as required by the Guidance, we present below the considered measures and/or proposed monitoring for the identified environmental effects.

7.1 Measures taken into account when choosing alternatives

***The selected feasible alternatives, sustainable from a technical-economic point of view, have* positive effects** by:

- Improvements at Unit 1 aimed at increasing nuclear, radiological security/safety, physical protection and cybersecurity, health and safety of the population and employees, the environment, so that the refurbished Unit 1 reaches the configuration of Unit 2,
- Increased measures to ensure the nuclear and radiological safety of personnel, the population and the environment,
- Increased safety measures, increased reliability and improved operating configuration,
- Choosing the best location for the expansion of DICA with MACSTOR 400 modules, which is part of the "good foundation rock" area”.

Conclusion - following the impact assessment for the studied alternatives for RT-U1 and DICA-MACSTOR 400 - it resulted that this project causes **a positive impact in the chosen reasonable alternative, *irreversible, with a local, regional and transboundary extent of high intensity and long term***.

7.2 Measures envisaged to avoid, prevent, reduce or if possible, compensate for any adverse environmental effects identified for the RT-U1 and DICA-MACSTOR 400 project

In Chapter 5, Tab. 91, the positive and negative effects for the project stages are presented.

We present next the measures envisaged by the project in order to avoid, prevent, reduce negative effects on the environment.

Tab. 121 Measures to reduce negative effects on environmental factors in the stages of realization and operation of the RT-U1 and DICA-MACSTOR 400 project, the effect of the measures, responsibility and implementation deadlines

Environmental factor	Measures	Effect of measures	Responsible	Time limits
Air	***During implementation***: - internal transport planning - Covering materials during transport - use of high-performance vehicles/machinery	- revention of particulate emissions from construction works - reduced emissions of pollutants through the automotive exhaust	Constructor	Permanent
	- the new DIDR-U5 will be equipped with a ventilation system, filtration with HEPA filters and an exhaust air monitoring system. - the systems for the collection, treatment and monitoring of radioactive effluents from Unit U1 will be kept in operation.	- prevention of radioactive effluent discharges	Holder	Permanent
	During operation: - Following the U1 refurbishment, the frequency of using CTP will decrease, as a result of the chosen construction alternative. - The testing of the Diesel groups will be carried out successively, so that the limit values of the concentrations of specific pollutants in the environment are not exceeded.	prevention of emission of combustion gases	Holder	Permanent
	- the systems for the collection, treatment and monitoring of radioactive effluents from DIDR-U5 and from the refurbished Unit U1 will be kept in operation.	- limiting the discharge of radioactive effluents	Holder	Permanent
Water	***During implementation:*** - The existing local systems on the site allow the direction and collection of any rainwater runoffs, and their discharge follows the current flow of control and discharge from the site. - An ecotoxicological study was carried out for the use of OdaconF.	- preventing uncontrolled discharges of uncontaminated/radioactively contaminated water from the site - providing water for a potential fire extinguishing	Holder	Permanent

Environmental factor	Measures	Effect of measures	Responsible	Time limits
	- Supplementing the intangible fire reserve by executing 2 new water storage tanks.			
	During operation: - Additional measures and conditions for monitoring the groundwater aquifer are implemented, which will be provided for in the Water Management Permit issued for the project: - additional observation drilling in the DICA-MACSTOR400 area - new observation boreholes in the area of the new DIDR-U5 - Quantitative and qualitative monitoring of the volumes of water abstracted and discharged, respectively, according to the internal procedures of Cernavoda NPP and according to the Environmental Authorization and Water Management Authorizations.	- monitoring the quality of the aquifer - monitoring consumption - preventing uncontrolled discharges of uncontaminated/radioactively contaminated water from the site	Holder	Permanent
Soil, land	***During implementation:*** - After the completion of the works, the land will be rehabilitated by scarification and grassing.	- return to the original state	Constructor	At the end of the works
	During operation: -The additional measures and conditions for monitoring the groundwater aquifer will be provided for in the Water Management Permit issued for the project and will also cover the soil quality control in the extended DICA and the new DIDR-U5 areas. - Soil quality monitoring	- preventing soil pollution	Holder	Permanent
Waste generation				
- radioactive, low and intermediate active	***During implementation:*** - completion and endowment of the new DIDR-U5 in order to intermediate the low- and intermediate radioactive waste resulting from the refurbishment	controlled intermediate storage of low- and intermediate radioactive waste resulting from refurbishment	Constructor Contractor/ Holder	During the refurbishment period

Environmental factor	Measures	Effect of measures	Responsible	Time limits
	- internal transfer of radioactive waste according to the updated procedures of Cernavoda NPP			
	During operation: - intermediate storage in DIDR-U5 until transfer to the national repositories (DFDSMA, DGR) for final storage.	controlled intermediate storage of low- and medium-active waste	Holder	Permanent
Spent nuclear fuel	***During implementation/ During operation***: Intermediate storage on site under controlled conditions, similar to the current situation, according to the Cernavoda NPP procedures approved by CNCAN, until the transfer for final storage in the national repository (DGR).	controlled intermediate storage	Holder	Permanent
Non-radioactive	***During implementation/ During operation***: Separate collection and storage of waste, for the purpose of recovery/disposal through authorized operators	Recovery/disposal	Holder through authorized operators	Permanent
Hazardous non-radioactive	***During implementation/ During operation***: Storage under controlled conditions and in the spaces specially provided on the site, for the purpose of recovery/disposal by authorized operators.	Recovery/disposal	Holder through authorized operators	Permanent
Household waste	***During implementation/ During operation***: Collection and storage in dedicated containers and disposal by authorized operators.	Disposal	Holder through authorized operators	Permanent
Management of hazardous substances (other than radioactive)	***During implementation:*** - Compliance with procedures for the management of hazardous substances - updating the Security Report	accident prevention	-Contractor/ Holder -Holder by RS certified expert	Permanent
	During implementation: - reviewing and updating the Safety Report in the event of changes to a facility, site, storage area or process, or changes in the nature, classification or quantity of hazardous substances used.	accident prevention	Holder by RS certified expert	Permanent

Environmental factor	Measures	Effect of measures	Responsible	Time limits
Climate	***During implementation/ During operation***: No additional measures to reduce the effects are necessary compared to those provided for in the implementation projects.			
The human factor Population and population health	***During implementation/ During operation***: - radiological monitoring of the environment, the working environment and workers as well as the population according to the provisions of the regulatory acts (Environmental Agreement/Environmental Authorization) - Compliance of the emissions of radionuclides (gaseous and liquid effluents) with the authorized limits by implementing a Survey and Monitoring Program by carrying out measurements: gamma spectrometric, 3H and 14C with liquid scintillators and alpha and beta global radioactivity systems *Monitoring of liquid radioactive effluents* monitoring through the Liquid Effluent Monitor (MEL) of the gamma activity carried out for radioactive liquid waste – from the selectively collected tanks, at the time of discharge (Danube, Danube Canal – Black Sea) under the conditions in which the authorization limits are not exceeded; - additionally, weekly monitoring of a continuously collected sample from the Condenser Cooling Water Channel by gamma spectrometry, T and 14C analyses (liquid scintillator) and a composite sample by the global alpha-beta measurement system; *Monitoring of gaseous radioactive effluents*: - continuous control of radioactivity discharges; - radioactivity measurement for instantaneous discharges to track compliance with regulated limits;	limiting negative effects on the environment and the population	Holder	Permanent

Environmental factor	Measures	Effect of measures	Responsible	Time limits
	- daily monitoring: H3 and C14 vapour collectors in water, particulate and iodine filters (gamma spectrometry and global alpha-beta analyses) - weekly/monthly monitoring: H3 and C14 (gamma spectrometry and global alpha-beta analyses) from storage cylinders from the Intermediate Spent Fuel Storage Facility (DICA) *Limits and conditions for the operation and maintenance of DICA:* - are established and will be complied with according to the conditions of the CNCAN authorization; - when the dose rate limit of 25μSv/h is exceeded on the external surface accessible to the storage modules, the exposure time shall be immediately reduced and additional protective screens of adequate thickness shall be installed throughout the duration of the workers' presence.			
	Against the feeling of discomfort of the population through the production of possible noises, vibrations, smells, dust, smoke of the proposed investment, which affects the public tranquility or the comfort of the tenants adjacent to the objective, the appropriate means of limiting the harmfulness will be ensured, so that they fall within the norms of the standards in force.	- prevention of effects on the human factor	Contractors/ Holder	For the entire duration of the project
Biodiversity (fauna, flora, aquatic environment)	***During implementation***: Usual impact mitigation measures are taken, consisting of: 1. verification of the site and its release (translocation) of any species of flora and fauna with reduced locomotor capacity, towards suitable proximal areas (green spaces), before the start of land sealing works; ecological surveillance of the site will be ensured to ensure the translocation of possible species of	- preventing impacts on biodiversity	Contractors/ Holder	Throughout the project implementation period

Environmental factor	Measures	Effect of measures	Responsible	Time limits
	fauna that enter areas with potential technological risk (construction site, work fronts, etc.) 2. Installation of textile mesh (site shading net - green) with the role of reducing the spread of dust at the site boundary 3. Wetting (sprinkling) work fronts and unstructured access ways 4. The use of light sources without the UV component in order to attract species with nocturnal activity. 5. Keeping ramps in the ground at 45° inclinations at the level of excavations, trenches and foundation pits, to allow micro/mesofauna species that may accidentally fall into them, to climb them. 6. Driving at low speed on unstructured access roads inside the site perimeter. 7. Realization of a convex profile at the level of the access roads, to allow the drainage of rainwater towards their limit and thus to avoid the appearance of puddles. 8. Realization of networks of grassed rain gutters along the access roads and along the perimeter, at the limit of the site perimeter, to ensure an efficient drainage of rainwater; they will function as breeding areas for species of amphibians, invertebrates, etc., effectively limiting their penetration to areas that may raise technological risk issues; in addition, they will function as mechanical steps to retain dust particles washed from the site.unt asumate măsuri de diminuare a impactului uzuale, constând din: 1. verificarea amplasamentului și eliberarea acestuia (translocare) a eventualelor specii de floră și faună cu capacitate locomotorie redusă, spre zone proximale (spații verzi) adecvate, înainte de demararea lucrărilor de pegătire a terenului; se va asigura supravegherea ecologică a amplasamentului pentru a se asigura translocarea eventualelor specii de faună ce pătrund în zonele cu potențial de risc tehnologic (şantier, fronturi de lucru etc.)			

Environmental factor	Measures	Effect of measures	Responsible	Time limits
	2. Instalarea de meshuri textile (plasă de umbrire de șantier – verde) cu rol de diminuare a propagării prafului la limita șantierului 3. Umectarea (stropirea) fronturilor de lucru și a căilor de acces nestructurate 4. Utilizarea de surse luminoase lipsite de componenta UV în măsură a atrage specii cu activitate nocturnă. 5. Păstrarea unor rampe din pământ la înclinații de 45^o la nivelul săpăturilor, a șanțurilor și a gropilor de fundare, pentru a permite speciilor de micro/mezofaună ce pot cădea accidental în acestea, să le escaladeze. 6. Rularea cu viteză scăzută pe căile de acces nestructurate din interiorul perimetrului de șantier. 7. Realizarea unui profil convex la nivelul căilor de acces, pentru a permite scurgerea apelor pluviale spre limita acestora și astfel să fie evitată apariția băltirilor. 8. Realizarea unor rețele de rigole pluviale înierbate în lungul căilor de acces și perimetral, la limita perimetrului de șantier, pentru asigurarea unui drenaj eficient al apelor pluviale; acestea vor funcționa ca zone de aregare pentru specii de amfibieni, nevertebrate etc., limitându-se eficient pătrunderea acestora spre zonele ce pot ridica probleme de risc tehnologic; în plus acestea vor funcționa ca trepte mecanice de reținere a particulelor de praf spălate de la nivelul amplasamentului.			
	During operation: At the level of free spaces, measures will be applied to ensure a revitalization of biocenoses by installing microhabitats and artificial structures. Colonization with species of flora and fauna will be encouraged by promoting the natural succession of vegetation[136] and implementing active measures to create	- limiting and preventing impacts on biodiversity	Holder	Permanent

[136] *environmental friendly nuclear plant*: https://www.bbc.com/news/business-59212992 , https://www.power-technology.com/features/featurenuclear-power-good-for-biodiversity-4583904/?cf-view , https://sciencemediahub.eu/2023/02/08/bent-lauritzen-interview-nuclear-energy-innovation-and-sustainability/

Environmental factor	Measures	Effect of measures	Responsible	Time limits
	ecological niches. In this way, conditions will be created for the observation and surveillance of flora and fauna under conditions of maximum exposure, thus generating an extremely effective biodiversity monitoring potential, having the potential to function as an early warning system[137], in a way to detect possible effects associated with the functioning of the built structural components, their bioindicator capacity being known.			

[137] C. Patrick Doncaster & Colab. (2016): Early warning of critical transitions in biodiversity from compositional disorder, Ecology, 97(11), 2016, pp. 3079–3090
Huang H, Wu W and Li K (2023) Editorial: Nuclear power cooling-water system disaster-causing organisms: outbreak and aggregation mechanisms, early-warning monitoring, prevention and control. Front. Mar. Sci. 10:1218776. doi: 10.3389/fmars.2023.1218776

7.3 Measures envisaged to avoid, prevent, reduce or, if possible, compensate for any significant adverse environmental effects identified in the event of the cumulative impact

The potential negative effects on the environment are mentioned in Chapter 5 – on the environmental factors, as well as in the SEVESO accident analysis presented in Chapter 8.

Summarizing the information in these chapters, we present below the potential significant effects as well as the measures to avoid, prevent, reduce or, if possible, compensate them in the scenario variants analyzed in chapter 5 for ***the cumulative impact***, considering that these scenarios are the most disadvantageous for the operation of Cernavoda NPP.

This chapter presents the measures envisaged with regard to the negative effects that could be generated ***in the case of cumulative impact scenarios*** as presented in sub-chapter 5.2.12 – for each environmental factor.

Tab. 122 Recommended measures for STAGE I_2024 - 2026 MAINLY EXECUTION (DIDR-U5 construction + DICA MACSTOR 200/400 construction + U5-DEI 2016 construction (CFSU) + CTRF construction + U1 and U2 in operation + DICA MACSTOR 200 in operation)

Environmental factor	Effect(s) identified in the case of cumulative impact	Measures
Air	***Non-radioactive pollutants*** The analysis of the results by cumulation lead to the following conclusions: **- the possibility of exceedances of the limit in case of maximum hourly concentrations of NO_2, on a restricted area** in Cernavoda locality, - maximum hourly or daily values below the limit in the case of SO_2 - maximum daily values below the limit for PM_{10} - given that the emissions associated with these activities are short-term, it can be estimated that the average annual values of the area background are insignificantly affected	- Recommendation to test a single start/emergency/breakdown power support equipment (CT and Diesel Generators) for each installation separately, at a given time. - -
	Radioactive effluents he emissions of radioactive effluents will be similar to those recorded in previous periods, being associated exclusively with U1 and U2 operation. Tritium is the only radionuclide present in radioactive emissions from on-site facilities, which can be detected in the air up to distances of several kilometers, in the vicinity of the plant, but at insignificant concentrations of activity.	Ensuring compliance with the authorized emission limits, by fulfilling the provisions of the radioactive effluent monitoring program
Water	***Non-radioactive pollutants*** The non-radioactively contaminated wastewater is discharged according to the conditions of the regulatory acts issued by ANAR/ABADL, through the existing systems on site. Consequently, the cumulation of projects cannot result in a higher impact than the one analyzed in the realization scenario in the present report.	no additional measures to reduce the effects are necessary compared to those existing in the operating procedures
	Radioactive effluents Radioactive effluent emissions will be similar to those recorded in previous periods, being exclusively associated with the operation of U1 and U2.	Ensuring compliance with the authorized emission limits, by fulfilling the provisions of the radioactive effluent monitoring program

Soil, land	***Non-radiological impact*** The environmental factor is not affected as: - the storage of raw materials and materials is carried out in a controlled manner, in specially arranged spaces. - the movement of vehicles is done on the routes predetermined by the project and approved - the generated non-radioactive waste is stored in spaces arranged on the site	- monitoring programs established for projects are to be respected - separately collected waste is handed over to authorised operators for recovery/disposal
	Radiological impact Outside the plant site, the soil environmental factor is not affected by the plant's radioactive effluent emissions.	Ensuring compliance with the provisions of the environmental radioactivity monitoring program in order to promptly identify the occurrence of conditions that could lead to radioactive contamination of the soil.
Climate	No significant effects on the climate are generated. Since the feasibility phase, materials resistant to temperature fluctuations have been provided for the various nuclear objectives (U1, DIDR-U5, DICA-MACSTOR 200/400, CTRF, etc.), as well as for the internal road infrastructure within the site.	No additional measures are required to reduce the effects compared to those provided by the execution projects.
Population and human health	No significant effects on the health of the population are generated.	Continuation of existing on-site monitoring programs approved by CNCAN and the Ministry of Environment, Water and Forests.
Biodiversity	The impact remains insignificant, with local expression, due to the emissions of noxes from the engines of the machines involved in the construction activities, dust and noise. The affected perimeter does not exceed a radius of 1 km, which actually overlaps with the exclusion zone of the Cernavodă NPP area. At the level of the target site, there are missing valuable habitats or important species whose damage would lead to disturbance waves for proximal biocens.	Usual impact mitigation measures are taken, consisting of: 1. verification of the site and its release (translocation) of any species of flora and fauna with reduced locomotor capacity, towards suitable proximal areas (green spaces), before the start of land sealing works; ecological surveillance of the site will be ensured to ensure the translocation of possible species of fauna that enter areas with potential technological risk (construction site, work fronts, etc.) 2. Installation of textile mesh (site shading net - green) with the role of reducing the spread of dust at the boundary of the site 3. Wetting (sprinkling) work fronts and unstructured access ways 4. The use of light sources without the UV component in order to attract species with nocturnal activity.

		5. Keeping earthen ramps at 45^{o} inclinations at the level of excavations, trenches and foundation pits, to allow micro/mesofauna species that may accidentally fall into them, to climb them. 6. Driving at low speed on unstructured access roads inside the site perimeter. 7. Realization of a convex profile at the level of the access roads, to allow the drainage of rainwater towards their limit and thus to avoid the appearance of puddles. 8. Realization of a network of grassed rain gutters along the access roads and perimeter, at the edge of the site perimeter, to ensure an efficient drainage of rainwater; they will function as breeding areas for species of amphibians, invertebrates, etc., effectively limiting their penetration to areas that may raise technological risk issues; in addition, they will function as mechanical steps to retain dust particles washed from the site.
Material assests, Cultural heritage, Landscape	The projects are being developed on the industrial site of Cernavoda NPP.	N/A
The interaction between the environmental factors mentioned above	According to Law 292/2018, the effect of a project on environmental factors is estimated to the extent that the project generates a significant impact on a receptor. *As a result of the fact that the RT-U1 and DICA-MACSTOR 400 project cumulated with the normal functioning of U2 – do not generate significant effects on the respective receptors (population and protected natural areas mentioned in chapter 5) and* ***considering the exclusion zone established in relation to the Cernavoda NPP site, it is considered that the effect on the population through the interaction between environmental factors, in this area, is insignificant.*** Going through the effects generated by a possible scenario of interaction of ionizing radiation with flora and fauna populations, including some criterion elements that were the basis for the designation of some perimeters of conservation interest, taking into account the conservation objectives established for them, indicates impact levels insignificant. The generated effects remain limited expressed as a result of the short duration of manifestation, but also of the low potential of radioactive radiation	

	emissions; the summation of the generated effects retains a low mutagenic potential. The construction phase does not affect vital surfaces that support behavioral sequences of important populations of flora and fauna species. Their strongly anthropized character makes the residual impact nullified. The conclusions of the Impact Study on Population Health show that "*under the conditions of compliance with the project and the recommendations of the specialized opinions/studies, the activities carried out will not negatively affect the health of the population in the area, by applying the measures provided*”.	

Tab. 123 Recommended measures for the Stage II_2027 – 2029 – SHUTDOWN RETUBING, TESTS and CONSTRUCTION
(U1 shutdown, retubing, tests + DIDR-U5 in operation + Tests with H3 / CTRF operation + U2 in operation + DICA MACSTOR in operation + DICA MACSTOR 400 construction + U3/U4 construction)

Environmental factor	Effect(s) identified in the case of cumulative impact	Measures
Air	***Non-radioactive pollutants*** EIA conclusions regarding the construction of U3 and U4 stated that "Exhaust gas and dust emissions from machinery and vehicles of transport used for construction will have local, temporary and small-scale effects". Consequently, by cumulating it with the construction of a MACSTOR 400 module, it cannot result in a greater impact than that analyzed in the construction scenario dealt with in this report.	no additional measures to reduce the effects are necessary compared to those existing in the operating procedures
	Radioactive effluents The emissions of tritium to air may increase in the first year of the interval after the shutdown of U1 for refurbishment, but will subsequently decrease below the levels specific to the last period of simultaneous operation of the two units (U1 and U2), even after the recommissioning of U1 (refurbished), as a result of the tritium removal from the heavy water in the active circuits of the reactors.	- bringing CTRF into operation, as planned
Water	***Non-radioactive pollutants*** The uncontaminated radioactive wastewater is discharged according to the conditions of the regulatory acts issued by ANAR/ABADL, through the existing systems on site. Consequently, the cumulation of projects cannot result in a greater impact than the one analyzed in the implementation scenario in this report.	no additional measures to reduce the effects are necessary compared to those existing in the operating procedures
	Radioactive effluents The releases of tritium into the water, in the form of liquid effluents, may increase in the first year of the interval after the shutdown of U1 for refurbishment, but will subsequently decrease below the levels specific to the last period of simultaneous operation of the two units (U1 and U2), even after the recommissioning of U1 (refurbished), as a result of tritium removal from the heavy water from the active circuits of the reactors.	- bringing CTRF into operation, as planned

Soil, land	**Non radiological impact** The environmental factor is not affected because: - the storage of raw materials and materials is carried out in a controlled manner, in specially designed spaces. - the movement of vehicles is made on the routes predetermined by the project and approved - the non-radioactive waste generated is stored in spaces arranged on site	- the monitoring programs established for the projects are respected - the selectively collected waste is handed over to authorized operators for recovery/disposal
	Radiological impact Outside the plant site, the soil environmental factor is not affected by the plant's emissions of radioactive effluents.	Ensuring compliance with the provisions of the environmental radioactivity monitoring program in order to promptly identify the occurrence of conditions that could lead to radioactive contamination of the soil.
Climate	There are no significant effects on the climate. Already in the feasibility phase, materials resistant to temperature fluctuations were provided for the various nuclear objectives (U1, DIDR-U5, DICA-MACSTOR 200/400, CTRF, etc.), as well as for the internal road infrastructure at the site.	No additional measures to reduce the effects are necessary compared to those provided for in the implementation projects.
Population and human health	No significant effects on the health of the population are estimated in terms of complying with the project requirements and authorizations specific to this stage.	Continuation of the existing on-site monitoring programs approved by CNCAN and the Ministry of Environment, Water and Forests, through the regulatory acts issued for each projec.
Biodiversity	The hypothetical impact due to the emissions of Radioactive effluents is **local and insignificant**, as a result of the presence of tritium and C-14 at very low levels in the environmental factors in the immediate vicinity of the plant (see subsection 3.9.3 and the radiological impact estimates from chapter 5).	At the level of free spaces, measures will be applied to ensure a revitalization of biocenoses by installing microhabitats and artificial structures. Colonization with species of flora and fauna will be encouraged by promoting the natural succession of vegetation and implementing active measures to create niches ecological. In this way, conditions will be created for the observation and surveillance of flora and fauna under conditions of maximum exposure, thus generating an extremely effective biodiversity monitoring potential, having the potential to function as an early warning system, in a way to detect possible effects associated with the functioning of the built structural components, their bioindicator capacity being known.

Material assests, Cultural heritage, Landscape	The projects are being developed on the industrial site of Cernavoda NPP.	N/A
The interaction between the environmental factors mentioned above	The stages of shuitdown, retubing, testing of the U1 unit, respectively the testing at CTRF commissioning take place under the supervision of CNCAN and the conditions for radioactive effluents releases into the environment will be observed, respectively the dose constraints imposed for each objective. Under these conditions, no significant effects on the environment and the health of the population are anticipated.	The requirements imposed by CNCAN during the testing period are respected.

Tab. 124 Recommended measures for Stage III_2032- 2037 ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE

(Simultaneous operation U1 cycle 2 + U2 + U3+ U4 + DICA in operation + CTRF in operation + DICA MACSTOR 400 modules construction + CTRF in operation)

Environmental factor	**Effect(s) identified in the case of cumulative impact**	**Measures**
Air	***Non-radioactive pollutants*** Includes testing of a start-up boiler or a Diesel unit from U1/U2/U3/U4 Given that the recommendations were that this equipment should be tested one by one, avoiding simultaneous operation and taking into account that the powers of the Diesel generators at U3 and U4 are similar to those at U1 and U2, it can be considered that the cumulative impact cannot exceed the maximum impact associated with the individual operation of an equipment, as quantified in the present study.	no additional measures to reduce the effects are necessary compared to those existing in the operating procedures
	Radioactive effluents The emissions of radioactive gaseous effluents will be those corresponding to the simultaneous operation of four units with CANDU 6 nuclear reactors, under the conditions of optimizing the tritium inventory in the plant's systems through the operation of CTRF.	No additional measures are required compared to the previous stages
Water	***Non-radioactive pollutants*** By operating all the nuclear objectives on the site, it is estimated that no significant effects on water will be generated, the water supply necessary for the operation of the 4 units as well as the discharge of the generated water will be done under the same regulatory conditions provided by ANAR/ABADL. From the point of view of water resources, it is expected that the catchment intake (Danube River - race 1 of the CDMN) will ensure the operation of the 4 units considering the positive effect on ensuring the minimum flow of water for cooling the reactors as a result of the implementation of the project *Restoration and renaturation of the bifurcation area of the Bala Arm to ensure navigation and environmental protection conditions on the Danube within the project "Improvement of the conditions of navigation on*	The monitoring conditions provided by the regulatory acts issued by the Ministry of Environment, Water and Forests/CNCAN/ANAR will be observed.

	the Danube between Calarasi and Braila, km 375 – KM 175" - approved by Environmental Agreement.	
	Radioactive effluents The emissions of radioactive liquid effluents will be those corresponding to the simultaneous operation of four units with nuclear reactors type CANDU 6, under the conditions of optimizing the tritium inventory in the plant's systems through the operation of CTRF.	No additional measures are needed compared to the previous stages.
Soil, land	***Non radiological impact*** The environmental factor is not affected because: - the non-radioactive waste generated will be stored in the spaces specially provided on the site and will be disposed of/recovered – as the case may be, by authorized operators.	The waste management procedures of the Cernavoda NPP are to be complied with, correlated with the requirements imposed by the operating regulatory acts for all 4 units.
	Radiological impact Outside the plant site, the soil environmental factor is not affected by the plant's emissions of radioactive effluents.	No additional measures are required compared to the previous stages.
Climate	There are no significant effects on the climate. Already in the feasibility phase, materials resistant to temperature fluctuations were provided for the various nuclear objectives (U1, DIDR-U5, DICA-MACSTOR 200/400, CTRF, etc.), as well as for the internal road infrastructure at the site.	No additional measures to reduce the effects are necessary compared to those provided for in the implementation projects.
Population and human health	No significant effects on the health of the population are estimated under the conditions of compliance with the requirements provided by the operating authorizations.	Carrying out monitoring according to the programs approved by CNCAN and the Ministry of Environment, Water and Forests, through the regulatory acts on the operation.
Biodiversity	The hypothetical impact due to Radioactive effluents emissions is local and insignificant, as a result of the presence of tritium and C-14 at very low levels in the environmental factors in the immediate vicinity of the plant (see subchapter 3.9.3 and chapter 5).	At the level of free spaces, measures will be applied to ensure a revitalization of biocenoses by installing microhabitats and artificial structures. Colonization with species of flora and fauna will be encouraged by promoting the natural succession of vegetation and implementing active measures to create ecological niches. In this way, conditions will be created for the observation and surveillance of flora and fauna under conditions of maximum exposure, thus

		generating an extremely effective biodiversity monitoring potential, having the potential to function as an early warning system of possible effects associated with the functioning of the built structural components, their bioindicator capacity being known.
Material assests, Cultural heritage, Landscape	The projects are being developed on the industrial site of Cernavoda NPP.	N/A
The interaction between the environmental factors mentioned above	By complying with the derived emission limits approved by CNCAN for the operation of each nuclear objective, compliance with the regulated dose constraints will be ensured. We estimate that, in this situation, the radiological impact on the environment will be insignificant.	

7.4 Residual impact remaining after all mitigation measures have been taken

Following the analyzes carried out, we appreciate that the implementation and operation of the RT-U1 and DICA-MACSTOR 400 project does not result in residual impact.

From the point of view of biodiversity, the occupation of the land by built objectives definitely defines a category of residual impact (at least from the perspective of the support function). But taking into account:

1. The nature of the targeted sites, deeply modified by previous works and current human activity (industrial function of the technological platforms belonging to Cernavoda NPP)
2. The reduced bio-eco-cenotic value of these sites that only maintain ruderal formations that provide installation conditions (trophic niches/support niches) only for a limited number of synanthropic, omnivorous species, etc.
3. The measures undertaken for the ecological restoration and revitalization of some green and free proximal spaces in order to support some highly diversified components of flora and fauna as part of a dynamic component aimed at supporting a monitoring program based on bioindicators,

it causes the residual impact to be considered to be nil.

7.5 Monitoring measures for environmental factors

7.5.1 Non-radiological aspects

7.5.1.1 Environmental factor WATER

From a non-radiological point of view, both ***during the implementation and operation of the project***, the current programs for monitoring the quality of generated waters discharged from the site will be continued, in accordance with the regulatory acts in force - Environmental Authorization and Water Management Authorizations issued for the objectives on the site.

The water management authorization in force stipulates the conditions for the discharge of water from the Cernavoda NPP platform, the quality indicators and the maximum values allowed for discharge:

Tab. 125 The quality indicators and the maximum values allowed for discharge for the water discharged from **Cernavoda NPP, according to the Water Management Authorization in force**

Category of discharged water	**Quality indicators**	Maximum allowed values mg/l
Domestic wastewater (not radioactively contaminated)	According to the provisions of GD no. 188/2002 – NTPA 002/2002 and the service contract concluded with S.C. RAJA. S.A. Constanţa	
Technological waters	Temperature	*
	pH	6.5 – 9.0
	Suspended matter	25
	Total ionic iron	1.5
	Chlorides	250

Category of discharged water	**Quality indicators**	Maximum allowed values mg/l
	Sulphates	200
	Amonium	3
	Phosphorus	1
	BOD_5	15
	Sodium	100
	Calcium	150
	Magnezium	50
	Petroleum product	5 (without iridescence)
	Free residual chlorine	0.2
	Hydrazine	0.1
	Morpholine	0.4
	Cyclohexylamine	0.1
	Lithium hydroxide	0.025
	Mixture of hydrazine + lithium hydroxide	0.1 + 0.025
	Mixture of hydrazine + morpholine	0.1 + 0.4
	Mixture of hydrazine + morpholine + cyclohexylamine	0.1 + 0.4 + 0.1
	Rhodamine - with evacuation in CDMN - with discharge into the Danube	2.0 10.0
	Fluorescein - with discontinuous discharge	0.25
	RGCC-100	1.0 commercial product
	Biomate 5716	1.0
	Biocide ARQUAD MCB-50	5.2 active substance 0.01 (ml/l) commercial product
	Ethylene glycol (DOWCAL 10)	< 1.0
	Scintillation liquid Ultima Gold LLT	0.001 active substance 0.00195 commercial product
	PRAESTOL A3040L	3
	NALCO 3DT149	500
Rainwater, including that from the underground drainage and that stored in the external drainage sump	In compliance with the reference objectives for surface water quality classification.	

* Regarding the temperature of the discharged technological waters:

- into CDMN - race II (in the stilling basin of the CHE Recuperare) - it is of maximum 10°C above the water temperature of race I of the CDMN, so that the water temperature in race II, downstream the discharge point of the canal, does not exceed 25°C;
- into Danube - it is of maximum 10°C above the water temperature of the Danube River, but not higher than 35°C, after passing through the mixing zone. During hot water injection periods in the distribution basin, the Δt setting will be analyzed by NPP according to the temperature of the water in the distribution basin and the Seimeni section

For biocides, flocculants and other indicator substances with discontinuous use, the limits stipulated by the Water Management Authorization are respected, the verification of the concentrations in discharged water being correlated with the intervals of use.

With the refurbishment of U1, the ODACON®F solution is put into use, for the preservation of the plant's systems, for which an eco-toxicological impact study was carried out to determine the discharge limit for which there are no adverse effects on aquatic flora and fauna. The use of the solution will be applied based on the discharge limit approved by the Water Management Permit/Authorization issued by the competent authority in the field of water. The monitoring of this substance in discharged technological water will be included in the monitoring program of Cernavoda NPP.

The control sections and frequencies provided by the current monitoring program of Cernavoda NPP will be maintained.

7.5.1.2 Environmental factor AIR

Construction phase

Emissions monitoring

During the construction of the infrastructure required for the refurbishment of Unit 1 and the extension of the DICA, given that the emission sources associated with the various construction works are uncontrolled sources, ***emission monitoring cannot be proposed***.

Air quality monitoring

Given that the air quality assessment for the construction period has determined that "*By aggregating the impacts due to the construction phase with local background concentration levels, there will be no exceedances of limit values, target values or critical levels within inhabited areas*", air quality monitoring in inhabited areas is not required.

The mathematical modelling in the proposed scenario showed hourly maximum and respectively daily maximum values of NO_2 and PM_{10} concentrations increased at the site boundary.

Considering that in the estimation of emissions in the construction scenario in many cases specific average information was used (equipment productivity, work volumes, average specific material consumption, etc.) and no technical design data were available, it can be considered that there is a significant level of uncertainty regarding pollutant emissions in the proposed modelling scenario. In order to ensure the validity of the results, it is proposed to carry out ***air quality monitoring campaigns during the construction period of the objectives, especially during the periods when the works included in the proposed scenario take place. Monitoring should be carried out for the pollutants NO_2 și PM_{10}/$PM_{2.5}$.***

The locations of the monitoring points should be in inhabited areas closest to the boundaries of the Cernavodă NPP site.

Future operation phase

Emissions and air quality monitoring

During the post-retrofit operation of Unit 1, the sources of non-radioactive pollutants that could be subject to emission/air quality monitoring are combustion plants (Start-up Power Plant and Diesel Units with different functionalities) that have rated thermal outputs greater than 20 MW and 1 MW respectively.

According to Annex 3: Emission Monitoring and Compliance Assessment, Part 1 of *Act 188/2018 on Limitation of Air Emissions of Certain Pollutants from Medium Combustion Plants* operators of medium combustion plants are obliged to ensure that periodic emission measurements are carried out under the following conditions:

a) every 3 years for medium combustion plants with a rated thermal input equal to or greater than 1 MW and less than or equal to 20 MW;
b) annually for medium combustion plants with a rated thermal input of more than 20 MW.

At the same time, Article 2 of this Annex states that, in the case of medium combustion plants operating for less than 500 hours per year, the territorial public authorities for environmental protection may require operators to carry out periodic measurements at least every time after the following number of operating hours has elapsed:

- 3 times the maximum average annual operating hours for installations with a rated output of less than 20 kw
- Number of maximum average annual operating hours for those with a rated output greater than 20 MW.

The frequency of periodic measurements shall in no case be less than once every 5 years.

Measurements are only required for:

a) pollutants for which an emission limit value is laid down in this Act for the installation concerned;
b) carbon monoxide (CO) for all installations.

The emission limit values required by law for medium combustion plants using liquid fuel are shown in Tab. 126, but the law does not require compliance with the limit values for plants operating less than 500 hours per year.

Tab. 126 Emission limit values (mg/Nm)^3 for average combustion plants with a power output greater than 5 MW

SO_2	NO_x	Particles
350	650	30

All emission limit values provided are defined at a temperature of 273.15 K, a pressure of 101.3 kPa and after correction for the water vapour content of the effluent gases and a standardised O_2 content of 3%.

In the case of engines associated with DIESEL units with a power output greater than 1 MW, the law requires emissions monitoring every 3 years, with the limit values for NO_x being as follows:

- 1850 mg/Nm^3 for diesel engines whose construction started before 18 May 2006
- 250 mg/Nm^3 for engines with a rated thermal input of more than 1 MW and less than or equal to 5 MW
- 190 mg/Nm^3 for the rest of the equipment.

In the case of SO_2 and particulates for engines with power greater than 1 MW and less than 20 MW, the limit values are 120 mg/Nm^3 and 20 mg/Nm^3 respectively.

Diesel engines are also exempted from the emission limit values for equipment operating less than 500 hours per year.

With regard to the special operating situation on site, it should be noted that the combustion installations, i.e. the Start-up Power Plant and the Diesel Units (emergency/standby), do not operate as long as the operating conditions of the nuclear power units are normal, but 2 to 4 hours of testing per month are foreseen for each equipment. However, the reduced number of test hours is not sufficient to ensure the representativeness of the results of any stack monitoring over such a short period. These aspects are substantiated by the documentation of the Basis of Approval for the Greenhouse Gas Permit held by Cernavoda NPP.

The measures provided for by the aforementioned normative acts, in the particular case of the Cernavodă NPP are applied, according to the protocol concluded with APM Constanța (Protocol no. 2258/27.02.2020 in conjunction with the Environmental Authorization issued by GD no. 84/2019, art. 3.2.2 Non-radioactive gaseous effluents. Thus, on the basis of the above-mentioned documents, for the Start-up Power Plant the monitoring program consists of notifying the corresponding laboratory APM Constanța in case at least one boiler operates for more than one week (duration established so that the measured emission values are representative) and performing measurements in air quality.

Air quality monitoring during the possible operation of the start-up power plant should be done especially for the pollutants NO_2 and SO_2, and the location of the monitoring points is recommended to be in the inhabited areas closest to the boundaries of the Cernavodă NPP site.

Air quality monitoring, both during the construction period of the objectives and during the operation period (under the conditions described above), is also necessary in view of the fact that other construction projects will be implemented on the site or operational activities will be carried out which, when combined with the activities associated with the project under analysis, may lead to increased values or even exceedances of air quality limit values in inhabited areas in the immediate vicinity of the Cernavodă NPP site.

7.5.1.3 Environmental factorul SOIL

Not the case.

In the case of accidental pollution, pollutant concentration determinations will be carried out according to the nature of the pollution. Accidental pollution will be notified immediately after its occurrence to the environmental authority, according to GEO no. 195/2005 with subsequent additions and amendments, art. 94 lit. l).

7.5.1.4 Noise and vibrations

Not the case.

7.5.2 Radiological aspects

The monitoring of the state of the environment will consider the use of the available information provided by the programs regarding the control of emissions, monitoring of environmental factors and waste management established by the regulatory acts issued by the Ministry of the Environment/CNCAN and currently carried out by the holder. Considering the specifics of the activities carried out on the Cernavoda NPP platform, the monitoring programs are established in such a way as to highlight the radiological, chemical and thermal impact on the environment.

During the implementation of the project, the existing monitoring programs will be supplemented as follows:

- ***For unit U1***: the current monitoring programs, provided by the authorizations issued by the Ministry of Environment, Water and Forests/ CNCAN/ ANAR, will be continued.
- ***pentru noul DIDR-U5***:
  - the management of the waste generated from refurbishment and stored intermediately in this facility will be carried out;
  - continuous monitoring of beta and gamma radiation levels in gaseous effluents will be carried out;
  - a radioactive effluent monitoring program will be implemented;
  - the internal monitoring network (TLD) will be extended around the new DIDR-U5 for monitoring gamma radiation in the ambient environment.
- ***For DICA***: the existing monitoring will be continued through the programs imposed by the competent environmental authorities and CNCAN.

During the operation period of the project - the existing monitoring programs will be expanded by introducing qualitative and quantitative monitoring of the phreatic aquifer, for the observation boreholes provided in the new DIDR-U5 and the area of DICA extension.

Considering the nuclear specificity of the activities carried out at the Cernavoda NPP site, ***the programs for monitoring radioactive emissions and environmental radioactivity, respectively,*** currently carried out at the Cernavoda NPP will continue both during the implementation period and after the commissioning of the refurbished U1.

Monitoring of radioactive gaseous effluents from U1 – will continue both during the implementation of the project and after commissioning of the refurbished U1. Representative samples are taken from the ventilation stack. The analyzes performed on sample types are:

Tab. 127 - Samples of gaseous effluents from the ventilation stack of U1

Sample type	Analysis	Frequency	MU
Particle filter	Spectrometry y, α - ß gross	daily	Bq/m^3
Active carbon filter	Spectrometry y	daily	Bq/m^3
Water vapor collectors	Tritium - liquid scintillator	daily	Bq/m^3
CO_2 collector	C-14 - liquid scintillator	daily	Bq/m^3
Radioactive noble gases	online measurements with the Gaseous Effluent Monitor		

Additionally, the project provides for ***the continuous monitoring of beta and gamma radiation levels in the gaseous effluents from the new DIDR-U5***. The monitoring system will have to be functional throughout the operation period of the new DIDR-U5, including the shutdown stage of the unit U1 for refurbishment.

Monitoring of radioactive liquid effluents – The liquid radioactive waste produced on the NPP site, including from the new objectives on the site, are directed to the Aqueous Liquid Radioactive Waste Management System within the U1/U2 units.

Samples of liquid effluents from the tanks of the liquid radioactive waste management system are taken by the Liquid Effluents Monitor during the evacuation of the tanks. The following analyzes are performed on the liquid samples collected for each individual tank:

***Tab. 128* - Samples of liquid effluents from tanks of the aqueous liquid radioactive waste management system**

Sample type	Analysis	Frequency	MU
Daily	Spectrometry y, Tritiu, C-14	Daily	Bq/l
Weekly composite	α-ß gross	Weekly	Bq/l

To control liquid effluent discharges, a sample is taken from the Condenser Cooling Water Channel, in accordance with the Environmental Radioactivity Monitoring Program.

The environmental radioactivity monitoring program currently carried out at Cernavoda NPP will be continued both during the implementation period and after the commissioning of the refurbished U1 and will include the following types of samples, types of analysis, sampling and analysis frequencies. **The environmental radioactivity monitoring program will be extended by introducing new sampling points (infiltration water, external gamma dose, soil) according to specific requirements under the authority of CNCAN).**

Tab. 129 Types of samples, methods of analysis and sampling frequencies within the environmental radioactivity monitoring program at Cernavoda NPP

Sample type	Sampling frequency	Analysis type	Analysis frequency	Development proposals
Environmental radioactivity monitoring program at Cernavoda NPP				
Particles in the air	continuously	gross β analyses γ spectrometry	monthly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
Iodine in the air	continuously	γ spectrometry	quarterly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
Tritium in air	continuously	LSC - tritium	monthly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
C-14 in the air	continuously	LSC - C-14	monthly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
TLD (ambient gamma radiation)	continuously	integrated exposure	quarterly - evacuations < MDA	Extended internal network around new DIDR-U5 and DICA expansion,
			monthly - evacuations > 6 % DEL	
Surface water	weekly	gross β analyses	monthly	
		γ spectrometry		
		LSC - tritium		
Condenser cooling water (CCW channel)	Continuous / weekly	gross β analyses	weekly	Gross α – β composite sample
		γ spectrometry		
		Tritium		
Meteoric rain water	depending on weather conditions	gross β analyses	Depending on the period in which the sampling is made	
		γ spectrometry		
		Tritium		
Infiltration water	monthly	gross β analyses	monthly	Qualitative and quantitative monitoring of observation boreholes provided for in the new DIDR-U5
		γ spectrometry		
		Tritium		

Sample type	Sampling frequency	Analysis type	Analysis frequency	Development proposals
Environmental radioactivity monitoring program at Cernavoda NPP				and the extended DICA
Deep groundwater	monthly	gross β analyses γ spectrometry Tritium	monthly	
Drinking water	monthly	gross β analyses γ spectrometry Tritium	monthly	
Soil	biannual	gross β analyses γ spectrometry Tritium	biannual	
Sediment	biannual	gross β analyses γ spectrometry Tritium	biannual	
Milk	weekly	gross β analyses γ spectrometry Tritium C-14	weekly (gamma spectrometry and H-3) monthly (gross beta and C-14)	
Atmospheric deposits	continuously/ monthly	gross β analyses γ spectrometry Tritium	monthly	
Fish	biannual	gross β analyses γ spectrometry Tritium C-14	biannual	
Meat	biannual	gross β analyses γ spectrometry Tritium C-14	biannual	
Vegetables	annually	gross β analyses γ spectrometry Tritium C-14	annually	
Fruits	annually	gross β analyses γ spectrometry Tritium C-14	annually	
Spontaneous vegetation	monthly, may – October	gross β analyses γ spectrometry Tritium C-14	monthly	
Eggs	annually	gross β analyses γ spectrometry Tritium C-14	annually	
Cereals	annually - wheat biennial - corn	gross β analyses γ spectrometry Tritium C-14	annual - wheat biennial - corn	

MDA = minimum detectable activity; DEL = Derived Emission Limit; TLD = thermoluminescent dosimeters; CCW channel = condenser cooling water channel.

In the light of the above, it is proposed that the monitoring program should include the following:

- AIR - ***Expansion of the inner ring of TLDs*** - currently surrounding the controlled areas of U1+U2+DIDSR and DICA respectively - to include the DICA extension area and the new DIDR-U5 area. The instrumentation will have to be functional once U1 is shutdown and the new DIDR-U5 is operational.
- WATER - monitoring of ***infiltration water from the new observation boreholes*** to be drilled in the DICA extension area and in the area of the new DIDR-U5. It is recommended that the new observation boreholes in the area of the new DIDR-U5 should be drilled ***until the new DIDR-U5 is operational***. Boreholes in the DICA-extended area will be drilled as the modules are constructed.

7.5.3 The environmental factor BIODIVERSITY

In establishing the key elements for the proposal of a Monitoring Program aimed at biodiversity components with relevance in the field of effects generated by radiological pollution, it started from reference documentation in the field, recalling here:

- Bioindicators for Monitoring Radioactive Pollution of the Marine Environment, Risø National Laboratory, DK-4000 Roskilde, Denmark May 1981
- The Uses of Bioindicators in Radionuclide Contamination Assessment, McGee, E.I. and McGarry, A. Radiological Protection Institute of Ireland
- Bonisoli-Alquati, A., Møller, A.P., Rudolfsen, G., Mousseau, T.A. (2022). Birds as Bioindicators of Radioactive Contamination and Its Effects. In: Wood, M.D., Mothersill, C.E., Tsakanova, G., Cresswell, T., Woloschak, G.E. (eds) Biomarkers of Radiation in the Environment. NATO Science for Peace and Security Series A: Chemistry and Biology. Springer, Dordrecht. *https://doi.org/10.1007/978-94-024-2101-9_11*
- Some Bioindicators of Radioactive Contamination, Cosma, C., Cozmuța, I., Micu, C. UBBCluj
- Fontana, C, and Aebischer, M. Mosses as bioindicators of environmental radioactivity: The experience of monitoring in Italy. Bulgaria: N. p., 1994. Web.

It also took into account the reference elements generated by the monitoring reports from the period of operation, which constitute a comparative basis for the dynamics of some taxonomic groups and their response to the possible effects induced by the radionuclides released into the environment as a result of the Cernavodă NPP activity.

In the evaluation of the elements of conservative interest, the work methodologies proposed by the Specific Guidelines[138], will be used, as follows:

- Monitoring guide for plant species of Community interest in Romania
- Synthetic monitoring guide for marine species and coastal and marine habitats of community interest in Romania

[138] https://www.ibiol.ro/posmediu/rezultate.htm

- Synthetic monitoring guide for habitats of community interest (salt flats, continental dunes, meadows, fresh water) in Romania
- Synthetic monitoring guide for habitats of community interest: thickets, peatlands and marshes, rocky outcrops, forests
- Synthetic monitoring guide for amphibian and reptile species of community interest in Romania
- Synthetic guide for monitoring caves and bat species of community interest in Romania
- Synthetic monitoring guide for mammal species of community interest in Romania
- Synthetic guide for monitoring community fish species in Romania
- Synthetic guide for monitoring invertebrate species of community interest in Romania.

In the application of the work protocols, appeal will be made to aspects derived from the Annex to the Order of the Minister of Environment, Water and Forests no. 3351/2023 *for the approval of the Guide regarding the protocols and unitary methodologies for monitoring the state of conservation of species of community interest*, within the project "Completing the level of knowledge of biodiversity by implementing the system for monitoring the state of conservation of species and habitats of community interest from Romania and reporting based on Article 17 of the Habitats Directive 92/43/EEC", financed by the Large Infrastructure Operational Program 2014—2020, which transposes elements of the above-mentioned Guidelines.

Integrating the defining elements of the project (constructive milestones, phases and stages of implementation, etc.), a proposal for a Monitoring Plan was built in order to allow the observation of any changes generated at the level of the biodiversity environmental factor and thus allow the application of some early warning measures, but also the most accurate quantification of the measures that need to be taken.

The number of sampling points and the proposed period/frequency allow simultaneous monitoring by an experienced team; moreover, in the (very likely) working scenario of attacking the construction stage of subprojects RT-U1 and DICA-MACSTOR 400 simultaneously, these measures are corroborated, making it practically necessary to go through only one such set of actions.

Tab. 130 Proposal for a Monitoring Plan for the environmental factor BIODIVERSITY

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
Construction stage						
RT-U1	Phytobenthos	1km	3	During the construction period	Monthly 1 Monthly sample	OMNIDIA
	Macrozoobenthos	1km	3	During the construction period	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
	Ichthyofauna	1km	3	During the construction period	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
	Invertebrates (Lepidoptere)	1km	3	During the construction period	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Invertebrates (Coleoptere edafice)	1km	3	During the construction period	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Herpetofauna	1km	3	During the construction period	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative
	Avifauna	1km	1	During the construction period	Monthly 1 monthly session fixed point observations	Qualitative/quantitative

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		1km	2	During the construction period	Monthly 1 monthly session – transect method (default)	Qualitative/quantitative
	Micromammals	1km	3	During the construction period	Monthly (March-October) 1 monthly session – transect method (default) using live-trap (12 Shermann traps)	Qualitative/quantitative
	Chiroptera	1km	1	During the construction period	Monthly 1 monthly session fixed-point ultrasonometric recordings	Qualitative/quantitative
		1km	2	During the construction period	Monthly 1 monthly session ultrasonometric recordings – transect method (default)	Qualitative/quantitative
	Grassy carpet (ground vegetation)	1km	3	During the construction period	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative
	Woodland flora	1km	3	During the construction period	Monthly (March-October) 1 monthly session at the predetermined point level	Leaf screening (with dust)
DICA-MACSTOR 400	Phytobenthos	1km	3	During the construction period	Monthly 1 Monthly sample	OMNIDIA
	Macrozoobenthos	1km	3	During the construction period	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10%

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
						–OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
	Ichthyofauna	1km	3	During the construction period	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
	Invertebrates (Lepidoptere)	1km	3	During the construction period	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Invertebrates (Coleoptere edafice)	1km	3	During the construction period	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Herpetofauna	1km	3	During the construction period	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative
	Avifauna	1km	1	During the construction period	Monthly 1 monthly session fixed point observations	Qualitative/quantitative
		1km	2	During the construction period	Monthly 1 monthly session – transect method (default)	Qualitative/quantitative
	Micromammals	1km	3	During the construction period	Monthly (March-October) 1 monthly session – transect method (default) using live-trap (12 Shermann traps)	Qualitative/quantitative

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
	Chiroptera	1km	1	During the construction period	Monthly 1 monthly session fixed-point ultrasonometric recordings	Qualitative/quantitative
		1km	2	During the construction period	Monthly 1 monthly session ultrasonometric recordings – transect method (default)	Qualitative/quantitative
Functioning stage						
RT-U1+ DICA-MACSTOR 400	Phytobenthos	1km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA
		3km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA
		5km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA
		10km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA
		20km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA
		30km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA
		40km	3	During the functioning period*	Monthly 1 Monthly sample	OMNIDIA

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
	Macrozoobenthos	1km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
		3km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
		5km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
		10km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20%

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
						–Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
		20km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
		30km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10% –Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
		40km	3	During the functioning period*	Monthly 1 Monthly sample	–Saprob index (IS) 30% –EPT_I index (indivizi) (IEPT) 10% –Shannon-Wiener index (ID) 20% –Number of families index (FAM) 10% –OCH index (Oligochaeta-Chironomidae) (IOCH/IO) 10%

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
						–Functional groups index (IGF) 10% – Water flow preference index (reofil or limnofil) (REO/LIM) 10%
	Ichthyofauna	1km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
		3km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
		5km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
		10km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
		20km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
		30km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
		40km	3	During the functioning period*	Quarterly 1 Monthly sample	Qualitative/quantitative Population attributes (age groups) Gonad evaluation
	Invertebrates (Lepidoptere)	1km	3	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		3km	3	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		5km	2	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		10km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		20km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		30km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		40km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Invertebrates (Coleoptere edafice)	1km	3	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		3km	3	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		5km	2	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		10km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		20km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		30km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		40km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Herpetofauna	1km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative
		3km	3	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		5km	2	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		10km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		20km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		30km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
		40km	1	During the functioning period*	Monthly (March-October) 1 Monthly sample	Qualitative/quantitative
	Avifauna	1km	1	During the functioning period*	Monthly 1 monthly session fixed point observations	Qualitative/quantitative

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		1km	2	During the functioning period*	Monthly 1 monthly session – transect method (default)	Qualitative/quantitative
	Micromammals	1km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default) using live-trap (12 Shermann traps)	Qualitative/quantitative
	Chiroptera	1km	1	During the functioning period*	Monthly 1 monthly session fixed-point ultrasonometric recordings	Qualitative/quantitative
		1km	2	During the functioning period*	Monthly 1 monthly session ultrasonometric recordings – transect method (default)	Qualitative/quantitative
	Mammmals (*Lepus europaeus*)	1km	1	During the functioning period*	Quarterly sacrifice	Biological samples
		3km	1	During the functioning period*	Quarterly sacrifice	Biological samples
		5km	1	During the functioning period*	Quarterly sacrifice	Biological samples
		10km	1	During the functioning period*	Quarterly sacrifice	Biological samples

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		20km	1	During the functioning period*	Quarterly sacrifice	Biological samples
		30km	1	During the functioning period*	Quarterly sacrifice	Biological samples
		40km	1	During the functioning period*	Quarterly Sacrifice	Biological samples
	Mammmals (*Capreolus capreolus*)	1km	1	During the functioning period*	Annual Sacrifice	Biological samples
		3km	1	During the functioning period*	Annual Sacrifice	Biological samples
		5km	1	During the functioning period*	Annual Sacrifice	Biological samples
		10km	1	During the functioning period*	Annual Sacrifice	Biological samples
		20km	1	During the functioning period*	Annual Sacrifice	Biological samples
		30km	1	During the functioning period*	Annual Sacrifice	Biological samples

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		40km	1	During the functioning period*	Annual Sacrifice	Biological samples
	Grassy carpet (ground vegetation)	1km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
		3km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
		5km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
		10km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
		20km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
		30km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
		40km	3	During the functioning period*	Monthly (March-October) 1 monthly session – transect method (default)	Qualitative/quantitative Biological samples
	Woodland flora	1km	4 (puncte cardinale)	During the functioning period*	Monthly (March-October) 1 monthly session at the predetermined point level	isotopes
		3km	4 (puncte cardinale)	During the functioning period*	Annual leaf sample (June) Annual wood sample (January)	isotopes

Object	Taxonomic group	Radius	No. of points	Monitoring duration	Monitoring period and frequency	Monitored indices
		5km	4 (puncte cardinale)	During the functioning period*	Annual leaf sample (June)	isotopes
		10km	4 (puncte cardinale)	During the functioning period*	Annual wood sample (January)	isotopes
		20km	4 (puncte cardinale)	During the functioning period*	Annual leaf sample (June)	isotopes
		30km	4 (puncte cardinale)	During the functioning period*	Annual wood sample (January)	isotopes
		40km	4 (puncte cardinale)	During the functioning period*	Annual leaf sample (June)	isotopes

* NOTE: "In service life" means the period of 36 months after the entry into operation of the refurbished U1 unit.

The realization of the monitoring measures will be done by self-monitoring or by delegating responsibility, the analysis reports to be issued based on measurements made with calibrated/certified equipment.

The monitoring program will cover the construction period, followed by a monitoring program lasting 36 months from the commissioning of the refurbished Unit 1. The results will be reported to the environmental authority, according to the reporting requirements set out in the Environmental Agreement.

Based on the annual reports, the effects of the project on biodiversity will be evaluated, and the indicators of interest that should be included in an ecological surveillance program, in correspondence with the monitoring program for other environmental factors, will be established. The monitoring programs have the role of providing information on the effects of Cernavoda NPP activity on biodiversity.

A proposed monitoring calendar can be found summarized in the following table:

Tab. 131 Proposal for a calendar for the implementation of monitoring measures

Stage	**Month**		
	M-1	**M 1:36 Functioning ****	**> M 36 Operation**
RT-U1 sub-project implementation monitoring programme			
Monitoring programme in the implementation phase of the sub-project DICA-MACSTOR 400*			
Monitoring programme of the functioning stage			
Ecological monitoring program***			

where M = Month of start of works

** The biodiversity monitoring program for the DICA-MACSTOR 400 sub-project will correlate with the execution planning of the MACSTOR 400 modules.*

***M 1:36 Functioning – represents the period of 36 months after the refurbished Unit U1 went into functioning.*

**** The ecological monitoring program – will be established according to the monitoring results of the first 36 months of operation of the refurbished U1 Unit.*

7.6 Decommissioning phase

The project owner has the obligation to comply with the procedures, the way of working and the measures described in the environmental impact assessment documentation that will be the basis for issuing the environmental agreement for decommissioning.

The project holder will take all the measures provided for in the national legislation, including that in the nuclear field, as well as in the international one, in order to implement and ensure the highest requirements of physical protection and nuclear safety for the period of decommissioning and restoration of the site, in order to ensure a high level of protection of personnel, the population and the environment.

The main measures to protect the population and the environment are the following: source control, effluent control, environmental monitoring, re-evaluation of the monitoring program in accordance with the changes that occur during the decommissioning process.

8. DESCRIPTION OF THE EXPECTED SIGNIFICANT NEGATIVE EFFECTS OF THE PROJECT ON THE ENVIRONMENT, DETERMINED BY THE VULNERABILITY OF THE PROJECT TO THE RISKS OF MAJOR ACCIDENTS AND/OR DISASTERS RELEVANT TO THE PROJECT IN QUESTION

Assessment and risk management is a control tool for undertaking any major project.

The concepts of hazard and risk are closely related and represent essentially the contents of this chapter.

8.1 Risk assessment associated with activities that present major accident hazards involving dangerous substances

Cernavodă NPP site falls within the provisions of Law 59/2016 *on the control of major accident hazards involving dangerous substances,* as an upper tier establishment.

The provisions of Law 59/2016 do not apply to the hazards created by ionising radiation originating from substances (according to article 2, point b).

In accordance with the provisions of Article 10, Law 59/2016, the operator of an upper tier site has the obligation to draw up a Safety Report and in accordance with Article 11, has the obligation to review and update this report in the event of the modification of an installation, establishment, storage facility, or process or changes in the nature, classification or quantity of the dangerous substances used.

The 2018 edition, revision 2, of the Safety Report developed in 2023 includes the changes expected through the implementation of the project „*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*”.

Technological hazards and risks

Law 59/2016 defines:

- *hazard* – means the intrinsic property of a dangerous substance or physical situation, with a potential for creating damage to human health or the environment;
- *risk* – means the likelihood of a specific effect occurring within a specified period or in specified circumstances;

Risk is the probability that the existing hazard will turn into an incident/accident.

A very important point is that the risk cannot be reduced to zero because there is no absolutely safe system in which there is no risk of accident.

With regard to the potential danger generated by the presence of hazardous substances and the quantities of hazardous substances that may be present, during the implementation of the project "*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*", the same hazardous substances that fall under the scope of Law 59/2016 will be used, and the quantities will not exceed the maximum quantities already in place.

No hazardous chemicals will be used in the implementation of the sub-project ”*Extension of the Intermediate Storage of Spent Fuel with MACSTOR 400 type modules (DICA-MACSTOR 400*”. On the current DICA site there is a Diesel generator that has the role of supplying electricity for the equipment of this objective, in case of emergency. There is an IVECO 8061/ ECO 40-1S/4 diesel engine installed with a power of 69 kW. The capacity of the diesel tank is 500 liters, a quantity well below 2% of the relevant quantity for the classification of diesel, under Law 59/2016.

So, from the perspective of the Control of Major Accident Hazards involving Dangerous Substances, sub-project RT-U1 is relevant.

Shutting down and restarting a plant can be dangerous because the processes are not in their normal operating mode. Good practice in the field of control of major accident hazards involving dangerous substances recommends the establishment, safety measures in place during these operations (specific protective measures and correct application of procedures).

Carrying out the refurbishment process will involve draining most systems to facilitate inspections, maintenance and other necessary activities. Maintenance activities involve the opening of systems and equipment that allow exposure to air and implicitly favor the initiation of corrosion processes. The phenomenon of corrosion on the internal and/or external surfaces of the equipment inevitably leads, if no measures are taken, to a reduction in the safety and duration of the life cycle of the installation.

Maintaining the integrity and performance of systems and components, from shutdown to restart, will be possible by establishing, implementing and strictly following certain conditions specific to a conservation program.

Many support systems will remain operational except for maintenance periods.

Cernavodă NPP has implemented a solid Management System, with clear procedures and instructions and verified in the experience of operating the plant. Additional enforcement procedures will be developed where necessary.

For the activity of conditioning/conservation of the systems during the shutdown period, procedures will be developed within the contract: "Elaboration of the program for the conservation of U1 systems/components during the refurbishment period and technical assistance in its implementation at Cernavodă NPP". The necessary maintenance or revision procedures can be applied as already mentioned in the specific operation and design manuals.

It should also be mentioned the risks generated by construction activities, demolitions, the presence of a larger number of people (own employees and contractors) on the site as well as, transport on the site roads that can be initiating causes of a major accident.

Considering that during the entire duration of the project, all activities will be carried out in safe conditions, in accordance with the specific procedures of Cernavodă NPP, it is unlikely that the risk will increase. Also, all activities will be carefully monitored and checked, and special attention will be paid to the training and preparation of both own and contracted staff.

General description of typical hazards and risks, specific to the Cernavodă NPP location

1. Spills and emissions of hazardous substances

In the areas where hazardous material are present, leakage of hazardous substances can occur as well as vapor emissions from leakages, caused by:

- leaks in pumps, flanges, valves, connections or other fittings;
- cracks due to some mechanical stress: damage to pumps, damage to mixers, vibrations, contractions caused by temperature, corrosion and/or abrasion, material defect or maintenance, or earthquake, strong wind,
- uncontrolled movement of the tanker being unloaded due to human errors;
- human errors in coupling the tankers being unloaded;
- human errors by opening loose taps
- human errors in performing maintenance activities, by not following the work procedures; including in the case of the RT U1 and DICA MASTOR 400 Project;
- release of contaminated water into the environment.

The occurrence of leaks is favored by:

- the specifics of the unloading facilities from the tankers into the storage tanks, which requires the coupling of some mobile equipment (hoses);
- the relatively large number of tools and other equipment: existing tanks, pumps and pipelines, with a large number of joints.

The quantities of hazardous substances that may leak are relatively small due to:

- small quantities transported (tanks and vessels of small or medium capacity);
- the reduced pressure on the routes through which liquids are transported, limited by the pump pressure required for unloading/pumping in/from the production facilities;
- small pipe routes (diameters generally below 100 mm);
- the materials used in the construction of the equipment: tanks, vessels and routes are made of stainless steel or other corrosion-resistant materials;
- working time limited to the period required for unloading from tankers, pumping in process facilities.

Spills are dangerous because of:

- the risk of fire and explosion, some of the liquid raw materials are flammable: light liquid fuel (LLF), diesel, morpholine, various substances stored in the Seiru warehouse. Also, hydrogen gas in the turbine hall, hydrogen gas stored in tanks and cylinders, hydrogen (deuterium and tritium) within the Cernavodă Tritium Removal Facility - CTRF (project approved and under implementation), acetylene stored in cylinders, as well as a number of substances stored in the Seiru warehouse are flammable. Vapors of these hazardous substances can form flammable/explosive atmospheres with air;
- the danger of intoxication and/or personal injury. Chlorine, hydrazine hydrate, morpholine as well as a number of substances stored in the Seiru warehouse are classified as toxic to humans by inhalation of vapors. Highly toxic substances (chlorine) can cause serious poisoning of personnel in case of spillage. Other hazardous substances, although of somewhat lower toxicity (classified as harmful, irritant or corrosive): a number of substances stored in the Seiru

warehouse can cause injury to personnel by splashing. Accidental spills of volatile liquid substances and emissions of highly toxic vapors can cause toxic dispersions. Due to the existing protection measures the risk of personnel injury is a low one. The use of protective equipment and the training of personnel with the awareness of the danger of serious injury to which they are exposed make the risk of such accidents reduced.

2. The fires

Fires can occur on site by burning inside equipment such as tanks and other storage vessels, tanker trucks containing flammable hazardous substances, as well as by igniting liquid leaks or vapors resulting from highly flammable and highly volatile liquid leaks . Fires can also follow explosions by igniting flammable substances released by the explosion. Relevant for such events are "Pool fire" type fires - when "pools of liquid" are ignited (including fires in storage tanks, on the free surface of the tank are of the "Pool fire" type) and "Flash fire" type fires " - clearance fires.

In the event of an accidental spill of highly volatile and flammable liquids, a dispersion phenomenon of vapors resulting from the evaporation of the spill into the atmosphere will occur. Clouds of flammable vapors can form in this way, forming explosive atmospheres, if the concentration of vapors in the cloud is higher than the lower flammability limit (explosion): LFL or LEL ("Lower Explosive or Flammable Limit"). Due to non-uniformities in the vapor cloud, fire conditions may also occur at concentrations lower than the LFL, with a concentration of ½ LFL being considered in this respect. In case of ignition of a cloud of flammable vapors/gases in atmospheric dispersion, "Flash fire" type fires occur. "Flash fire" type fires are fires with a very short duration of 2-3 seconds, corresponding to the time required for the flames to pass through the gas cloud, characteristic of the ignition of vapors or gases in atmospheric dispersion. "Flash fire" type fires occur in the open air or in spaces with little constraint and usually accompany explosions, producing the thermal - fiery effect of the explosion (see also the description of explosions). "Flash fire" type fires are characteristic of the ignition of extremely flammable gases (e.g. hydrogen), in atmospheric dispersion, but they can also occur, on a smaller scale, in the case of evaporation and ignition of the vapors of flammable liquids.

Ignition of a flammable substance can occur if the temperature is higher than the flash point* of that substance or, at temperatures below the flash point, if the energy of the ignition source is strong enough to produce local heating of the substance and fire initiation.

Note* The flash point is the temperature at which combustion initiated in a flammable mixture persists and propagates. The flash point is higher than the ignition point by several degrees Celsius.

From this point of view (of the possibility of ignition) dangerous substances with a low flash point are more vulnerable to fire, while diesel and LLF (flammable substances) are more difficult to ignite, only with high energy ignition sources or at high temperatures.

Potential sources of ignition can be:

- short circuits produced in the electrical installations, as a result of breakdowns or malfunctions;
- mechanical, electrical or electrostatic sparks. Although sparks have very low energy, they can cause the ignition of highly flammable substances and those of lower flammability at high temperatures;
- atmospheric electric discharges (lightning) can cause the ignition of flammable vapor emissions, with the transmission of fire inside the equipment or/and can cause the heating of

the metal parts of the equipment struck by lightning, with the ignition of the flammable substances with which they come into contact;

- unauthorized open fire or without sufficient removal of the flammable environment from the work area or/and insufficient protection means, during maintenance and maintenance works that involve the use of open fire
- actions of intentional arson - "arson" type;
- the transmission of fire from some combustible elements present in the installation area, such as combustible waste or fires of some equipment containing combustible parts (e.g. cable bridges);
- transmission of fire to the unloading facility and tanks from fires to the tankers used for transport;
- the transmission of fire from electric power motors that actuate the pumps and agitators in the event of an accident with their ignition;
- transmission of fire from sources outside the site.

Fires can generally occur outside equipment by igniting leaks of flammable substances. Fires can occur inside some equipment only where the air required for combustion is present, such as tanks and other storage vessels as well as tankers for flammable liquid raw materials. Fires inside the equipment are most often explosive and in the case of tanks lead to "throwing the lid", the explosion being followed by a violent fire on the remaining free surface of the tank. Widespread fires over the entire surface of large tanks are difficult to extinguish, due to the large burning surface and the difficulties related to the possibility of foam suppression over the entire surface at the same time. Over time, if the fire inside the tank is not controlled, exposure to fire can lead to damage to the tank jacket, with the hollow part of the jacket (the top of the tank without liquid) tending to "fall in" due to excessive heating. Covered areas can thus remain where the foam used for extinguishing cannot reach and which can later become a source of re-ignition of the fire. Also, exposure to fire can cause the tank shell to crack with the release of ignited flammable substance into the tank bund. On site, due to the relatively small capacity of the tanks, their technical sealing (with breathing valves and flame arresters), the risk of internal ignition of the tanks is very low. Also, the extent of a possible fire in one of the tanks containing flammable substances cannot be very large due to the small size of the tanks.

Fires are most often initiated by igniting small amounts of flammable substances (fire starters) that can be quickly extinguished with the existing equipment at each workplace. Fires of high severity can occur by amplifying some fire starts if limitation and protection measures are not taken in a short time to control and extinguish the fire. Also, large-scale fires can occur as a result of explosions, when large quantities of flammable substances, released as a result of the explosion, can be involved in the fire. In assessing the seriousness of a fire, the amount and nature of the flammable substance involved, the burned surface, the speed with which it evolves and the danger it represents to neighboring equipment and installations are relevant. The amount and nature of the substance on fire indicates the fire potential of the fire, the area on fire is relevant to the extinguishing action (the larger the area of a fire is, the more difficult it is to extinguish), the rate of evolution is important for the speed with which protection and intervention measures must be taken, and the potential danger to neighboring equipment and installations is important due to the possibility of extension and amplification of the accident.

Fires are dangerous because of the thermal radiation they cause, atmospheric pollution with combustion gases and smoke, as well as pollution with the debris resulting from the fire.

Thermal radiation can cause serious injury to operating and intervention personnel as well as damage to machinery and equipment, caused by exposure to fire and high temperatures, with the amplification of the accident by expanding the burned area and causing explosions.

Smoke and combustion gases can cause poisoning of operating or intervention personnel caught in the fire area without adequate protective equipment, this phenomenon being more serious in the case of closed rooms where the possibilities of exhausting smoke and combustion gases are lower.

The remains resulting from the fire, mainly being the contaminated water in large quantities resulting from the extinguishing of the fire, can pollute the soil and groundwater, if they reach unprotected areas. Also, since we are talking about large quantities of contaminated water that can result from the extinguishing action, collection and then decontamination can create difficulties. On the site, thanks to the protection of exposed areas by concreting, the collection and treatment system of technological waters and potentially contaminated rainwater, the risk of pollution with contaminated water resulting from a possible fire is very low.

3. Explosions

Due to the nature of the substances present in the facilities on-site, explosions can occur through the formation and ignition of explosive mixtures of flammable gases/vapors - air. Hydrogen present in the facilities can be highly susceptible to the formation of explosive atmospheres, as it is an extremely flammable and highly reactive gas, especially when in contact with oxygen. The formation of explosive mixtures is possible through the vaporization of accidental leaks of highly volatile liquids inside tanks and other storage vessels, as well as tank trucks, where flammable vapors and air are present above the liquid surface.

Explosive atmospheres form when the concentration of flammable vapors in the air is within the explosion limits (lower explosion limit - LEL and upper explosion limit - UEL). In reality, explosions can occur even if the vapor concentration is outside the explosion limits, due to turbulence and non-uniformities within the explosive cloud. The ability of flammable liquids to form explosive atmospheres depends on their nature and volatility. The more volatile a liquid is, the greater the amount of vapors formed. Upon contact with a source of fire or spark, vapor cloud explosions (VCE) can occur). These explosions are chemical explosions caused by the rapid combustion of components and the conversion of part of the resulting energy into a pressure wave. Depending on the rate of combustion, can occur:

- detonations - high-intensity explosions (when the rate of combustion is high) or
- deflagrations - low-intensity explosions (when the rate of combustion is low).

In the event of an explosion, can occur severe injury to operating or intervention personnel caught in the blast and by the associated thermal radiation. Also can occur significant damage to machinery and facilities. The explosion may be followed by a violent fire of the flammable substances released as a result of the damage to the installations.

The main characteristic of an explosion is the overpressure in the shock wave front - the blast. The power of the explosion depends on:

- the nature and quantity of the substance present in the explosive cloud. The nature of the substance in the explosive cloud influences the combustion rate through its physico-chemical characteristics, while the quantity determines the size of the explosive cloud;
- the configuration of the space within the cloud. The more congested the space, with smaller distances between machinery and equipment and the presence of walls limiting dispersion: enclosed spaces or with lateral walls and/or roofs, the greater the power of the explosion. A certain degree of space confinement is therefore necessary to create conditions for the occurrence of a relatively powerful explosion. In the on-site installations, conditions for the occurrence of a relatively powerful explosion may exist, by point of view of spacial configuration, inside tanks and other storage vessels, in tank trucks, as well as in technological installations located in enclosed spaces. In open spaces, where there are no elements favoring vapor accumulation, explosive atmospheres can only form locally, in which case low-intensity deflagrations accompanied by "flash fire" type fires occur, due to the lack of space confinement. In the case of low-power explosions (low-intensity deflagrations), the effect produced by the thermal radiation of the fire which is accompanying the explosion (flash fire) is more significant than the blast (it manifests over a distance and has greater effects).
- the ignition source. Strong ignition sources that increase the power of the explosion are explosions initiated by explosive means (explosive charges) and pre-existing explosions caused by an ignition with a low-energy source, such as an explosion inside a room initiated by a pre-existing explosion outside the building (e.g., the explosion of accidental accumulations of vapors or flammable gases in buildings, initiated by a low-intensity deflagration outside the room). The reverse phenomenon of ignition initiation outside the building from an explosion inside it is also possible.

  Low-energy ignition sources are considered open flames, sparks, short circuits, and hot surfaces.

Good sealing of installations (without leaks of liquids or flammable vapors), absence of potential ignition sources, including through zoning of Ex areas of installations and prohibition of ignition sources or sparks in these areas, only use of tools and equipment suitable for Ex zones, as well as nitrogen blanketing of the tanks for flammable products, reduces the risk of fire/explosion.

Due to the specific nature of the installations on-site, only relatively small leaks of flammable liquids or vapors can occur. For this reason, it can be appreciated that the risk of forming explosive atmospheres is only local in the area of the leak and in the area where a possible leak would reach.

During the implementation period of subproject RT-U1, the same hazardous substances falling under Law 59/2016 will be present as during the operation of Unit 1 (existing situation before shutdown and anticipated situation after commissioning of refurbished Unit 1).

From the perspective of quantities present, it should be noted that there will be no significant changes. Except for Unit 1, the other installations will remain in normal operating condition during the implementation of subproject RT-U1. It is also expected that many support systems of Unit 1 will remain operational, except during maintenance periods.

The main preservation strategy is the retention and maintenance of specific working fluids in all systems. Achieving this objective will ensure that all expected availability requirements are met and that all necessary maintenance or revision procedures can be carried out, as already mentioned in the specific operation and design manuals. Implementing this preservation strategy is the most cost-effective and time-saving strategy.

Risk Assessment

The technological risk assessment process was carried out in two major stages, namely:

- Preliminary risk analysis - Qualitative analysis;
- Detailed risk analysis - Quantitative analysis.

The relevant installations from safety point of view, analyzed were:

A. Hydrogen Storage and Distribution System;

B. Backup Diesel Groups (Diesel tanks within SDG 1,2);

C. Emergency Power Supply System (Diesel tanks within EPS 1,2);

D. Light Liquid Fuel Depot;

E. Hydrogen Addition System in the primary heat transport circuit;

F. Technical Gas Distribution System for the chemical laboratory;

G. Water Chemical Treatment Facility (chemical addition room);

H. Machinery Room;

I. Technical Gas Depot;

J. Seiru Chemical Substances Depot;

K. Drinking Water Chlorination Station;

L. Starting Thermal Power Plant;

M. Fire Water Pump Station;

P. Technical Space Racks at Units 1 and 2;

N. Heavy Water Tritium Removal Facility (CTRF);

O. Emergency Facilities Building (CFSU).

The CTRF and CFSU installations are proposed situations, both projects having been approved and are currently in progress.

In the case of U1 refurbishment, hazardous substances will be used as follows:

- *Hydrazine and morpholine* will continue to be used for the chemical conditioning of the water/steam circuit. During shutdown, tank 1-4540-TK3 from the chemical addition system is dosed with hydrazine and morpholine. From 1-4540-TK3, demineralized water tank 1-4322-TK99 is dosed, subsequently used for boiler filling, degassing filling, and system flushing at start-up. The secondary circuit will be dosed with film-forming amine (FFA), so hydrazine and morpholine will be used for additions in other classic part systems (e.g., RCW/ CW).

From a risk perspective, the level remains similar to the risks of normal operation because the quantities of substances do not change.

- *Diesel fuel* will be stored in the same quantities in SDG and EPS tanks, which are operationally active.

From a risk perspective, the level decreases during the RT-U1 subproject, as internal diesel transport with tank trucks and transshipment into tanks will no longer be necessary once the tanks are filled and preserved.

− *Technical gases for the Chemical Laboratory (acetylene and hydrogen)*: there will be no changes in the quantities of these gases, as the laboratory is functional during the RT-U1 subproject.

From a risk perspective, the level remains similar to the risks of normal operation because the quantities of substances do not change.

- *Hydrogen* will be removed from the hydrogen addition system and the electric generator system. Its removal from the two systems will occur according to the operating manual and specific maintenance procedures, by degassing the systems and filling them with , CO_2, then with air. Upon restart, the system must be cleaned and initially purged with CO_2 before being filled with hydrogen.

From a risk perspective, the level decreases compared to the risks of normal operation because hydrogen will be eliminated from the system.

Qualitative Analysis

PHA analyses were developed for the facilities/parts of facilities, on-site, where hazardous substances are present in small quantities (below the 2% threshold of the relevant quantity from Law no. 59/2016, Annex 1, col.2), but where the "substance hazard criterion" was considered (a hazardous substance or more, classified according to Law no. 59/2016, which may be present or may be produced as a result of uncontrolled processes).

Separate PHA analyses were developed for each present facility, completing PHA tables. Analyzing these tables revealed that a series of hazards could lead to major accidents.

For the qualitative risk assessment, the matrix method described in chapter 6.5 was used. Numeric values were assigned for each severity level of consequences and probability of scenario occurrence identified, the associated risk of each scenario being represented by the product of the two assigned values. When establishing values for the probability and severity levels, the potential impact and the envisaged prevention measures are taken into account.

From the qualitative risk analysis, it resulted that the ***risk of major accidents on-site*** is between 2-12, which means a ***moderate risk*** for the site. This is due to the relatively small quantities of hazardous substances present and existing protective measures: retention tank bunds, protected tanks (concrete or buried constructions, insulation, etc.), protected surfaces, spill collection vessels, automated flow control, detection sensors, adherence to work procedures, and safety standards.

Scenarios that could have catastrophic consequences are scenarios with isolated (level 2) or improbable (level 1) probabilities, while scenarios that could have major consequences are scenarios with isolated (level 2) or occasional (level 3) probabilities.

In the event of an incident leading to an emergency situation, specific standard procedures are followed, with involvement from workplace management.

Scenarios that could have major or catastrophic consequences were further subjected to quantitative risk analysis and evaluated through consequence and frequency analysis.

The description of the identified and selected major accident scenarios in the PHA analysis, along with a summary of triggering events, is presented in Annex 6 RS_SEVESO 2024 – Table 8.1 and 8.2.

Following the preliminary risk analysis for the RT-U1 and DICA–MACSTOR 400 projects, no accident scenarios requiring additional quantitative analyses were identified for the implementation period of the RT-U1 and DICA–MACSTOR 400 project, other than those analyzed for the existing situation prior to the shutdown of Unit 1.

Quantitative Analysis - Evaluation of Effects and Consequences through Modeling and Simulation

Among the accident scenarios identified in the preliminary PHA analysis and analyzed in the risk matrix (qualitative analysis), were selected the scenarios that could lead to major accidents, scenarios which were further analyzed to assess the magnitude and severity of the consequences (quantitative risk analysis).

Tables 8.3 and 8.4 in Annex 6 RS_SEVESO 2024 present the sizes of the calculated zones for the accident scenarios analyzed quantitatively.

Since some of the hazardous substances on-site will continue to be used in the same quantities (technical gases, diesel fuel, hydrazine, morpholine), and others will be reduced for a limited period of time within U1 (hydrogen) due to the emptying of the system during the project implementation, it can be concluded that the RT-U1 and DICA–MASTOR 400 projects do not increase the chemical risk on-site.

Measures Considered for Preventing or Mitigating Significant Negative Environmental Effects and Details Regarding Preparedness and Proposed Response in Emergency Situations

a. Measures Considered for Preventing Significant Negative Environmental Effects

For systems that will remain in normal operation during the project implementation, the technical parameters and equipment used for facility safety will not undergo modifications.

During the refurbishment period, including before shutdown and restart, the risk of deterioration and loss of efficiency will be minimized while ensuring the reliability of system components.

Best practices, principles, and specific methodologies will be established and documented to maintain the integrity and performance of the systems and components of Unit 1 at the Cernavodă Nuclear Power Plant. The Conservation program will need to establish conditions to maintain the integrity of the system materials and instalation components throughout the refurbishment period and address all possible causes of degradation.

Most of the systems under conservation will require supervision and monitoring by plant personnel or contractors. It will be necessary that the operations personnel to monitor system parameters (flow, pressure, temperature), as well as to check equipment integrity (leaks, vibrations, etc.), and operate temporary equipment (pumps, drying equipment, etc.). Chemistry personnel will need to sample and analyze specimens to verify that chemical conditions meet the design specifications to protect system integrity and the environment.

As refurbishment shutdowns are more complex than regular maintenance shutdowns, the preservation program will need to be detailed and flexible, ensuring adequate control of preservation program elements.

Actions will be required upon restart to ensure the safe operation of the system. Existing processes for field checks, inspections, supervision, work completion, flow checks, commissioning, recommissioning testing, temporary operating instructions, will be used to ensure that the system is available for operation once the preservation period is over.

In all implementation phases of the project, the technical parameters established by procedures and instructions will be respected, including the procedures developed under the contract: "Elaboration of the conservation program of U1 systems/components during the refurbishment period and technical assistance in its implementation at Cernavodă NPP".

Technical parameters and equipment used for facility safety are described in Annex 6 RS_SEVESO 2024.

b. ***Measures considered for mitigating significant negative environmental effects and details regarding the level of preparedness and proposed response in such emergency situations***

The operation of the Cernavodă nuclear power plant entails assumed risks that may occur with a certain probability.

In accordance with CNCAN requirements, the Strategy for Establishing Technical Bases for the Emergency Plan at the Cernavodă NPP site has been developed.

The document is used for:

- Grounding the Emergency Plan (EP) at Cernavodă NPP
- Training personnel for participation in EP activities (Operation, Technical support group for emergencies).

In order to limit the consequences of radiological and/or chemical incidents, with or without environmental impact, Cernavodă NPP has established an emergency response plan, subject to CNCAN approval. To ensure the plan's implementation, the necessary material and human resources are allocated, as well as specific emergency preparedness programs. Periodic exercises are conducted to verify Cernavodă NPP's preparedness for emergency responses, with their results being evaluated, lessons learned being retained, and transferred in the actions tracked system "Action tracking".

To prevent and reduce the impact of a major accident involving hazardous chemical substances and preparations at the Cernavodă NPP site, several measures are taken, including:

- The Organizational Structure for Emergency Situations at the Nuclear Power Plant ensures comprehensive on-site response actions and also covers Cernavodă NPP's responsibilities off-site;
- The organization of plant personnel required for emergency response is established according to Cernavodă NPP's specific internal procedures;
- Cernavodă NPP's responsibilities for emergency response actions, measures necessary for intervention preparedness, measures for emergency situation control, and for reducing on-site and off-site consequences are defined to protect the health of on-site personnel and population, safeguard the environment, and protect the plant's assets;
- Instructions and procedures necessary for plant personnel in the event of an emergency at Cernavodă NPP are developed;
- Provision of necessary emergency means and equipment for adequate support of response actions to all types of emergencies is ensured, covering requirements related to plant condition assessment, radiological conditions, personnel protection, deficiency control, fire suppression, first aid, chemical substance cleanup, communication, and data transfer;
- Suitable spaces and arrangements designated for emergency response are equipped with appropriate communication means and operational equipment for immediate use in emergencies, providing support for emergency activities.

The Operations Manual - Emergency Procedures- 0/1/2-03420-OM-001 provides instructions and guidance to plant personnel on actions to be taken in case of an emergency.

Specific requirements for emergency plan preparation and implementation are found in documents associated with the planning and preparation process for emergency response situations described in document RD-01364-RP008. The coordination of the process is ensured by the Radiation Protection Technical Service within the Department of radiation protection, safety work and fire prevention and extinguishing (DRSM-PSI). The organization of personnel involved in emergency response is also described.

OM 03420 Operations Manual consists of procedures that identify:

- The person responsible for implementing the procedure;
- Specific circumstances under which the procedure should be applied;
- Instructions and guidance for actions to be taken.

The types of accidents covered by the manual include:

- Radiological events;
- Medical events;
- Chemical events;
- Fires;
- Loss of the main control room events;
- Transport and transfer events;
- External events;
- Physical protection events.

In the Operation Manual - Emergency Procedures - OM 03420 - Actions in case of various emergency situations, the emergency procedure, code PU-D8 deals with the actions in case of major Seveso-type events (control of major accident hazards involving dangerous substances).

The planning and preparation process for emergency situations - On-site Emergency Plan - RD-01364-RP008 presents specific criteria for identifying and classifying each type of accident.

Procedure RD-01364-RP008 establishes Cernavodă NPP's responsibilities for emergency response actions, measures necessary for intervention preparedness, measures necessary for emergency situation control, and for reducing radiological consequences on-site and off-site, to protect the health of on-site personnel and the population, safeguard the environment, and protect the plant's assets.

Emergency response equipment, facilities, and structures are presented and inspected according to PSP-RP008-001-Verification and Assurance of Equipment, Structures, and Facilities Essential for Emergency Response.

To protect the plant against fire hazards, a fire prevention and suppression program is established and implemented. The program contains requirements regarding methods and systems used for prevention, detection, control, and prompt extinguishing of fires in accordance with CNCAN requirements in the ”Norms regarding the protection of nuclear power plants against internal fires and explosions" (NSN-09) approved by CNCAN President's Order no.141/2006.

The program establishes interface with military firefighters, interface communication, and joint exercises.

Each area where fire hazards exist, such as: combustible material storage areas, working offices, transformer areas, or areas with high density of electrical equipment like panels, cables, etc., are equipped with firefighting equipment and systems. The description of the equipment installed on-site for limiting the consequences of major accidents is presented in Annex 6 RS_SEVESO 2024.

Firefighting equipment and materials are periodically checked and tested to be available for use at any time.

To maintain a high fire response capacity, an exercise and training program has been established. Requirements for fire prevention and suppression are found in procedures associated with the " Cernavodă NPP Fire Protection Program" described in procedure RD-01364-RP15. The process is coordinated by the Labor Safety and PSI Service within DRSM.

The existing procedural system will be applied to the activities related to the implementation of the project "Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules".

Cernavodă Nuclear Power Plant will supplement the set of emergency procedures with provisions specific to the activities carried out during the project implementation.

The adoption and implementation of procedures aimed at identifying foreseeable emergencies through systematic analysis are ensured by the fact that emergency planning is based on representative accident scenarios and there is a strategy for intervention and necessary resources for each representative scenario. For this purpose, the internal emergency plan was prepared in accordance with Order no. 156 - Methodological Norms of December 11, 2017, regarding the elaboration and testing of emergency plans for major accidents involving hazardous substances, issued by the Ministry of Internal Affairs.

The internal emergency plan is based on the risk analysis results from the Safety Report, identified accident scenarios, and outcomes.

In the process of developing the internal emergency plan, specialized departments and personnel working at the site, including subcontracted personnel for various long-term services relevant to site security, are consulted.

All employed or contracted personnel conducting activities at the site are periodically trained on the relevant parts of the internal emergency plan.

Relevant aspects and elements from the internal emergency plan are included in the annual training agenda and schedule in the field of emergency situations, which are appropriately updated. Visitors are instructed on alarm signals and behavior in the event of a major accident or activation of the internal emergency plan before being allowed access on the site.

The internal emergency plan is exercised, tested, and evaluated through exercises organized by the operator. The conduct of exercises is based on an annual planning approved by the management.

Exercise planning is transmitted to the Emergency Situations Inspectorate (ISU) in the current year for the following year, and the evaluation of the internal emergency plan is carried out based on an evaluation report.

The evaluation report is prepared after each exercise execution, based on observations and reports presented by the specially designated personnel for this purpose and is approved by the management of Cernavodă Nuclear Power Plant. A copy of the evaluation report is sent to ISU.

The technical document underpinning the Emergency Plan at the Cernavodă Nuclear Power Plant site, the "Strategy for Establishing Technical Bases for the Emergency Plan at the Cernavodă

Nuclear Power Plant Site," is under revision to include the project "Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules". From preliminary results, no modifications are anticipated in the Emergency Plan at the site due to the implementation of the Unit 1 Refurbishing Project. Consequently, no modification to the Organizational Structure for Emergency Situations of the Plant is necessary.

Regarding emergency intervention means, no modifications are anticipated, and their operational status is periodically verified based on checking routines.

Personnel performing works within the project (both own and contractors) will participate in theoretical and practical training sessions in accordance with the Emergency Plan at the site and the Internal Emergency Plan.

8.2 Risk assessment based on nuclear safety analyses

Events or accidents with radiological implications

This category refers to the events or accidents that may occur during the implementation of the project for Unit 1 refurbishment and DICA extension and which involve radioactive materials or contaminated components of the installations, except for the reactor and its annexes. At the time of the preparation of this report, no radiological safety analyzes are available at Cernavodă NPP for postulated events in this category, but an identification and evaluation process regarding this is underway.

Considering the above, in order to formulate a point of view on the radiological consequences on the environment as a result of some events in the above category, the relevant international experience will be used in this report. Thus, we can cite the analysis carried out in the framework of the refurbishment project carried out at the Darlington Nuclear Generating Station, Canada (DNGS), where, following the evaluation of possible accident scenarios, four scenarios of reference as follows:

- The fall of the transfer container for retubing components, with the loss of its containment capacity
- Traffic accident on site involving dry storage container (DSC) transporter
- Leakage of tritiated heavy water from the moderator circuit as a result of a broken pipe
- Damage to spent nuclear fuel in the storage pool.

The results of assessments of the radiological consequences of such events have shown that the additional doses to workers and the public will be within the exposure limits established by national regulations (Environmental Impact Statement New Nuclear – Darlington Environmental Assessment NK054-REP-07730-00029 – EIS Darlington).

Regarding the DICA extension sub-project, from the point of view of this type of events relevant are: the safety analyzes presented in the Final Nuclear Safety Report for DICA MACSTOR 200 and the safety analyzes carried out in preparation for the implementation of the project for extension with MACSTOR 400 modules. Thus, a series of events postulated for the period of operation of the storage facility were analyzed, as well as events related to operations in the area of transfer and loading of spent fuel. In the following, the events analyzed are briefly presented, together with the conclusions of the analyses.

The results of the radiological risk assessment for project-based accident cases (with the frequency of occurrence greater than 10^{-6} / year), postulated at DICA Cernavoda, indicate that the radiation dose values for the stable population, located at least 800 m from the center of the storage facility, are less than 1% of the annual dose constraint established by CNCAN for DICA Cernavoda. The doses for DICA being so small, they will not affect the maximum limits allowed in the event of an accident at the NPP.

Events with a frequency of occurrence lower than 10^{-6}/year, whose consequences may be more serious, are called severe accidents or accidents beyond design limits. This category includes the following analyzed events:

- DICA (random) impact with a small plane or a (commercial) airliner;
- strong storms (tornadoes);
- the fall of the gantry crane.

The evaluation of the frequency of impact between the storage module and a heavy, commercial aircraft was made taking into account the characteristics of the traffic on the air corridors and towards Mihail Kogălniceanu airport. These frequencies have such low values that this event was classified as a severe accident.

The event of blocking the air inlets and outlets on the same side of the storage module can occur in case of heavy snow accumulations, which are very unlikely for Cernavoda. For the reference project, however, this event is part of the set of Design Base Events.

The event was analyzed and it was found that the temperature of the stored fuel will increase by a maximum of 10ºC, and the temperature of the stored fuel will increase slowly up to 156.5ºC. As the design limit of 160ºC is not reached, this event of blocking air inlets and outlets on the same side of the storage module will not have consequences for personnel or the population.

The event of complete blocking of the air vents (on both sides of the module), highly improbable for DICA Cernavodă (could occur in case of catastrophic flooding or massive snowfall), was analyzed for the reference project. If this event were to occur by flooding, the water would have to reach an incredible height; even in this situation, water would constitute a credible source of cooling. If this event were to occur due to solid deposition (abundant dust brought by cyclones, storms or snow in the form of extremely high snowdrifts), the consequence would be a slow rise in fuel temperature up to 202ºC (summer at 40ºC) respectively 162ºC (winter at 0ºC). During winter, the air circulation can be easily restored under the conditions in which the cold source is ensured.

At the Cernavodă NPP site, F5 storms (on the Fujita scale) are unlikely, but DICA's reference project considered the consequences of strong winds and projectiles generated by F5 tornadoes. The storage modules were designed to withstand the loads generated by strong storms, combining the rotation and translation generated by wind speeds of 420 km/h. Storage module stress analyzes also include projectile qualification from these storms. The effect of this event is to produce a hollow in the concrete at the point of impact with the projectile. Repair is common in construction work. Consequently, even if this event were to occur, there would be no radiological consequences for personnel and the population.

The gantry crane is equipped with anti-derailment clips, which prevent accidental derailment and possible overturning during seismic events.

The gantry crane on row 1 of modules is qualified for an earthquake with pga=0.3g which is higher than the value of pga=0.2g taken into account for DBE Cernavoda NPP. The earthquake qualification of the crane falls into seismic category A and its structural integrity is ensured in the event of an earthquake.

The gantry crane on string 2 was procured to withstand an earthquake corresponding to a horizontal acceleration at ground level of 0.3 g (similar to the seismic data for the crane on string 1), ensuring a seismic margin of HCLPF>0.4g (HCLPF - High Confidence Low Probability of Failure, representing the peak ground acceleration in an earthquake (PGA) for which it can be said with a high level of confidence that the plant will have a low probability of severe damage to the active area).

Thus, in the event of an earthquake, the gantry crane will maintain its position (it will not derail or overturn) as well as its structural integrity. The fall of the gantry crane is only possible in the case of an event beyond the design bases and, consequently, classified in the category of severe accidents. If this event were to occur, the impact of the gantry crane fall on the module is less than that produced by projectiles generated by tornadoes and would have no radiological consequences.

The structure of the MACSTOR storage module is compact and robust, with significant strength reserves with a large margin of safety against the design loads. These characteristics lead to the limitation of possible damages induced by the postulated severe accidents. Due to the dry storage of the fuel after its cooling for 6 years and due to the protective barriers, the release of volatile radionuclides is only possible by heating the stored fuel to a temperature above 600°C.

The on-site emergency plan of Cernavodă NPP covers all postulated events from DICA.

The emergency plan and procedures also contain the emergency measures and actions that are applicable to the DICA facility.

Transport accidents

All activities associated with the Unit 1 refurbishment project and DICA extension, which involve the transfer of radioactive waste, radioactively contaminated materials and components or spent nuclear fuel between Cernavodă NPP facilities will be carried out only by using internal transport routes (within the Cernavodă NPP premises), so the possibility of a transport accident is excluded. Two of the accident scenarios in the previous category can be associated with the activities of transferring radioactive waste from the retubing to the intermediate storage facility (the new DIDR) and spent nuclear fuel to the DICA.

Nuclear accidents

This category of accidents is applicable only to the Unit 1 refurbishment sub-project and may occur during the periods of reactor operation: until its shutdown and discharge of nuclear fuel (during the retubing preparation stage) or during the commissioning and test-operation stage. The accident scenarios to be considered are similar to those included in the safety analyzes contained in the plant's final safety report.

Based on the evaluation of the nuclear installation project, operating procedures and potential site-specific external influences, Cernavoda NPP has identified a list of internal and external events, covering all states and operating modes of the nuclear installation and all scenarios that could lead to affecting nuclear safety functions. Internal and external events were analyzed both for the purpose of identifying the transient or accident sequences they can generate, and for the purpose of qualifying and protecting systems with nuclear safety functions. These events were evaluated and grouped according to the estimated frequency of occurrence and the consequences on the state of the plant, and thus the design basis events for the systems with nuclear safety functions were established.

Design basis events include anticipated operating transients and design basis accidents, also called postulated accidents.

Anticipated operational transients represent events that may occur once or more during the plant's operational life. For a CANDU-type nuclear power plant, anticipated operational transients include:

- Failure of reactor control systems;
- Malfunction of the instrument air system;
- Loss of normal electricity supply;
- Triggering in operation of a main pump in the primary heat transport system;
- Untimely opening of the pressure control or discharge fittings of the primary heat transport system or systems connected to it;
- Unavailability or malfunctioning of moderator system.

Design basis accidents for a NPP represent events with significant consequences, with a low probability, which are not expected to occur in reality but which must be considered in nuclear safety analyzes in order to ensure the protection of the population in the situation where such events would occur. For a CANDU type NPP, they include:

- Rupture of any pipe or manifold in the primary reactor cooling system;
- Rupture of a pressure tube and its associated calandria tube;
- Rupture of steam generator tubes;
- Failure of a terminal fitting of the fuel channel;
- Blockage of flow in the fuel channel;
- Failures of the fueling machine;
- Damage to the steam generator feed water system or live steam system, including pipe breaks.

Also, to ensure sufficient nuclear safety margins, the assumptions used in the analyzes are conservative and assume the operation of the protective systems at the minimum level of admissible performance.

As part of the implementation of the defense-in-depth concept, Cernavodă NPP also analyzed more severe conditions than the design basis accidents, called design basis extension conditions, such as those that can be caused by multiple failures, induced by the complete loss of all functions of a protective safety system or by a highly improbable event, including severe accidents, involving damage to the core of the reactor and melting of nuclear fuel.

Through deterministic nuclear safety analyses, probabilistic nuclear safety assessments, as well as on the basis of engineering judgments, using also international experience, the behavior of the nuclear installation was analyzed for those severe conditions, caused by internal and external events, which are physically possible and for which there are reasonable measures and means, technically possible and practicable for the protection of the nuclear installation, in order to prevent severe accidents, respectively to limit their consequences.

The conditions for expanding the design bases include two categories of events:

- events and combinations of events that can lead to the systematic failure of nuclear fuel inside the reactor core; for these events, dedicated SSCs are provided at Cernavoda NPP and procedural measures are implemented to prevent serious damage to the reactor core and melting of the nuclear fuel in the reactor core;

- events where the capability of the nuclear facility to prevent systematic failure of nuclear fuel is exceeded or where the measures provided are assumed not to function as expected, thus leading to severe accident conditions; at Cernavodă NPP, feasible procedural measures have been established and the nuclear facility includes specific SSCs, provided for stopping the progression of the severe accident and limiting the consequences of these accidents.

The following scenarios are examples of conditions for expanding the analyzed design bases:

- damage of the primary cooling system of the reactor without the intervention of the emergency core cooling system;
- total interruption of electricity supply from alternating current sources (Station Black-Out);
- loss of heat transfer function to the final cooling source;
- severe accident scenarios derived from the events mentioned above, in the event of additional failures.

Cernavodă NPP has carried out nuclear safety analyzes for the conditions of expanding the design bases, to confirm the feasibility of implementing emergency operating procedures and/or accident management guidelines, with the aim of maintaining physical barriers to the uncontrolled release of fission products in the environment, respectively with the aim of limiting damage to the reactor core and protecting the physical and functional integrity of the reactor building.

The nuclear safety analyzes carried out for Unit 1 at Cernavodă NPP are presented in the Final Nuclear Safety Report, which constitutes a basic authorization document. As presented in Chapter 15 "Design basis nuclear safety analyses", through the deterministic nuclear safety analyzes carried out for Unit 1, the fulfillment of the nuclear safety quantitative objectives from the CNCAN norms is demonstrated.[139]

The deterministic nuclear safety analyzes presented in Chapter 15 "*Design Basis Nuclear Safety Analyzes*" of the Unit 1 Nuclear Safety Final Report demonstrate that for the initiation events relevant to this nuclear facility, the nuclear safety functions are ensured and the objectives and the nuclear safety criteria are met, without exceeding the dose limits and criteria established by the legislation in force, according to the classification in the table belows.

Tab. 132 Dose criteria for design basis event analysis for nuclear facilities [NSN-24]

Class of event	**Event category**		**Annual frequency estimated by appearance of an event or a sequence of events**	**Maximum effective dose value for the most exposed person outside the exclusion zone, calculated for 30 days from the beginning of the release, for all ways of expected exposure**
Class 1	Anticipated events in exploitation	Design basis events	f > 1E-2	0.5 mSv
Class 2	Design basis accidents		1E-2 > f > 1E-5	20 mSv
Class 3	Conditions for extension of type A design bases	Extension conditions of design bases; they represent a subset of events outside the design basis.	f < 1E-5	-
Class 4	Conditions for extension of type B design bases			-

[139] Final Safety Report of Unit 1 - Summary, February 2023

For events classified as a design basis accident, the regulatory requirements are aimed at preserving the integrity of the physical barriers designed between the nuclear fuel and the environment: the fuel sheath, the pressure tubes, the main heat transport system and the containment. Similarly, for anticipated transients in operation, after correcting the causes that produced that event, when all plant systems are in a stable and controlled state, the operation of the unit at rated power can be resumed.

For events that exceed the design bases, in accordance with the results of the COG programs, Cernavoda NPP has implemented measures and strategies to restore nuclear safety functions, with the aim of bringing the plant to a stable and controlled state in the long term.

According to the Final Safety Report of Unit 1, 2022 edition, the Design Base Event (DBE) that has the most serious consequences in terms of the radiological impact on the population is the "*Feeder Stagnation Break* " event, followed by the shutdown of the reactor, the operation of the emergency core cooling system and the operation of the emergency containment systems.

Thus, the maximum value of the individual effective dose, following exposure to the postulated radiological release, for a period of 30 days, for the event "Feeder Stagnation Break" is 5.471 mSv, at the limit of the exclusion zone, for the SSW sector (South South-West), corresponding to the "99% Cut-off" percentile. (according to the address CNE_FRZI-24-02587).

For this type of event, the calculated values of the effective dose for persons in the population, distributed according to their location, are shown in the table below:

Tab. 133 Calculated values of the effective dose for a postulated type event Feeder stagnation break

Distance	Collective individual dose distribution by Distance and Affected Sector (mSv)															
(Km)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0.982	2.020	1.067	0.843	1.628	1.679	1.709	2.841	1.865	5.471	4.915	3.913	3.983	4.205	5.310	5.371
2	0.435	0.663	0.334	0.254	0.518	0.530	0.519	0.865	0.950	1.950	1.757	1.216	1.276	1.347	1.870	1.900
3	0.309	0.339	0.171	0.123	0.260	0.263	0.261	0.424	0.563	0.993	0.889	0.604	0.656	0.703	0.941	0.956
4	0.243	0.208	0.105	0.078	0.157	0.161	0.158	0.257	0.374	0.596	0.518	0.366	0.420	0.446	0.560	0.571
5	0.180	0.138	0.070	0.057	0.107	0.109	0.106	0.173	0.285	0.400	0.349	0.245	0.284	0.321	0.368	0.376
6	0.149	0.101	0.053	0.044	0.078	0.080	0.077	0.126	0.222	0.283	0.240	0.175	0.209	0.232	0.259	0.265
7	0.130	0.078	0.042	0.034	0.060	0.061	0.060	0.095	0.183	0.211	0.180	0.135	0.159	0.174	0.192	0.196
8	0.110	0.062	0.034	0.028	0.048	0.048	0.047	0.075	0.152	0.162	0.140	0.107	0.127	0.131	0.146	0.148
9	0.093	0.051	0.028	0.024	0.040	0.040	0.039	0.061	0.129	0.126	0.108	0.087	0.099	0.101	0.115	0.117
10	0.080	0.041	0.024	0.020	0.033	0.033	0.032	0.051	0.113	0.103	0.089	0.073	0.082	0.083	0.093	0.094
15	0.042	0.022	0.013	0.011	0.017	0.017	0.017	0.025	0.059	0.005	0.036	0.032	0.034	0.036	0.038	0.038
20	0.027	0.014	0.009	0.008	0.011	0.011	0.011	0.014	0.037	0.024	0.020	0.017	0.018	0.020	0.020	0.020
25	0.017	0.009	0.006	0.006	0.008	0.008	0.007	0.009	0.025	0.017	0.013	0.011	0.011	0.013	0.012	0.012
30	0.012	0.006	0.005	0.004	0.006	0.006	0.005	0.007	0.016	0.013	0.009	0.008	0.008	0.009	0.009	0.008
40	0.006	0.004	0.003	0.003	0.004	0.004	0.003	0.004	0.011	0.009	0.006	0.005	0.004	0.006	0.005	0.005
50	0.004	0.003	0.002	0.002	0.003	0.003	0.002	0.003	0.006	0.007	0.004	0.003	0.004	0.004	0.003	0.003
60	0.003	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.005	0.006	0.003	0.003	0.003	0.004	0.003	0.003
70	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002	0.004	0.005	0.003	0.002	0.002	0.004	0.003	0.002
80	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.004	0.004	0.002	0.002	0.002	0.003	0.002	0.002
90	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.002	0.002	0.002	0.003	0.002	0.002
100	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.002	0.002	0.002	0.003	0.002	0.001

As can be seen from the table above, the maximum value of the effective dose at a distance of 30 km from the plant is 16 microSv, which means that for any person located on the territory of neighboring countries (Bulgaria or Ukraine), the effective dose as a result of the Design Base Event (DBA) with the most serious consequences in terms of radiological impact on the population, will be lower than this level. It should be noted that the value of 16 microSv corresponds to exposure to the natural background radiation (including exposure to radon) over a period of 58 hours (considering an average value of the total effective dose due to radiation of natural origin of 2.4 mSv/year).

In conclusion, the Cernavoda NPP project is based on updated nuclear safety analyses, which reflect the latest requirements and analysis methods, in accordance with national norms and international standards. The operation of the Cernavoda NPP is carried out in accordance with the limits and technical operating conditions, based on the current nuclear safety analyses, thus ensuring safe operation, with minimal risks for workers, the population and the environment.

In addition to the above, international experience shows that for the category of operational events or nuclear accidents that should be the subject of an environmental impact assessment for a nuclear power plant, only those scenarios should be considered which have a frequency of occurrence greater than $1x10^{-6}$, corresponding to operational events or design basis accidents.[140] Thus, in the case of the Darlington nuclear power plant, the radiological safety analyzes for the design base accident scenario indicated a possible exceedance of the provincial intervention level for sheltering, only in the range from 1 to 3 km, in the vicinity of the plant, while the provincial evacuation response level could not be reached in any location in its vicinity. It is also estimated that the risk of a nuclear accident at Darlington NPP does not change as a result of refurbishment activities, meaning that it will remain at the same, very low level as in the previous period (EIS Darlington).

Criticality outside the active zone

This category of events implies the achievement of the conditions for the occurrence of criticality when handling the nuclear fuel outside the reactor core. Given that for CANDU power plants, the nuclear fuel contains natural uranium (in which U-235, the fissile isotope, has an abundance of about 0.7%, insufficient to create a critical mass), the occurrence of criticality is practically impossible without the heavy water moderator, which makes any such event outside the reactor systems extremely unlikely.

Measures envisaged to prevent or mitigate significant adverse environmental effects and details of preparedness and proposed response to such emergencies

With regard to the Unit 1 refurbishment sub-project, as indicated above, the events with the most serious radiological consequences for the environment and the population are those which, although extremely unlikely, may occur during the operating period of the plant, the severity of the consequences being closely linked to the state of operation of the nuclear reactor at the time of the accident.

The design of Unit 1 provides for several levels of protection in depth, ensuring the prevention of accidents and adequate protection, should they occur:

- The first level of protection is provided by the multiple measures to prevent deviations from normal operation, as well as system failures, which were considered in the selection of the design: application of quality control in design, construction, testing, maintenance and operation activities, conservative design, use of redundancy, independence and diversity, consideration of applicable hazards and internal and external operating experience.

[140] Environmental Impact Statement New Nuclear – Darlington Environmental Assessment NK054-REP-07730-00029

- The second level of protection refers to features considered in the design of the SSCE that allow control of deviations from normal operating states so that an anticipated transient does not develop into an accident. The results of the nuclear safety analyses have led to the inclusion in the design of Unit 1 of specific SSCEs, which ensure an adequate response to process disturbances.
- The third level of protection is given by the nuclear safety features provided in the draft SSCE for situations where a transient could not be suppressed and thus could evolve into a design-basis accident. For this level, special nuclear safety systems have been foreseen to ensure that the reactor can be brought to a safe shutdown state and at least one of the barriers against radioactive releases is maintained by applying the *Abnormal Plant Operating Manual* procedures (APOP).
- The fourth level of protection is provided by those SSCEs specifically designed to ensure containment of radioactive materials and mitigation of consequences in severe accident events, where „*Severe Accident Management Guidance*” (SAMG) procedures are applied.
- The final, fifth level of protection is provided by the use of on-site and off-site emergency control centre facilities that mitigate the consequences of potential accidents.

Tab. 134 Environmental impact assessment in case of design-based accidents

Project stage	Event	Environmental factor likely to be significantly affected	Impact assessment		
			Probability of occurrence	**Extent of impact**	**Significance of impact - Measure of consequences**
RT-U1 + DICA MACSTOR 400					
Construction stage **Preparation + Implementation of refurbishment** **+** **Execution of MACSTOR 400 modules**	**Design-based accident - DICA**	**Human factor -** Cernavodă NPP employees	*Improbable*	*On site*	*Minor*
	Severe accident - DICA	**Human factor -** Cernavodă NPP employees, general population	*Highly improbable*	*Local*	*Minor*
		Soil	*Highly improbable*	*Local*	*Insignificant*
	Design-based accident – U1 refurbishment activities	**Human factor -** Cernavodă NPP employees, general population	*Improbable*	*Local*	*Minor*
Operation stage **U1 operation 2nd operation cycle** **+** **DICA operation extended with MASTOR 400 modules**	**Design-based accident - DICA**	**Human factor -** Cernavodă NPP employees	*Improbable*	*On site*	*Minor*
	Severe accident - DICA	**Human factor -** Cernavodă NPP employees, general population	*Improbable*	*Local*	*Minor*
	Design-based accident – U1 operation	**Human factor -** Cernavodă NPP employees, general population	*Improbable*	*Local*	*Minor*
		Air	*Improbable*	*Local*	*Insignificant*
	Severe accident – U1 operation	**Human factor -** Cernavodă NPP employees, general population	*Highly improbable*	*Regional*	*Moderat*
		Water	*Highly improbable*	*Regional*	*Moderat*
		Air	*Highly improbable*	*Regional*	*Moderat*
		Soil	*Highly improbable*	*Regional*	*Moderat*

Potential health effects on the population arising from a malfunction, radiological/nuclear accident

The population health impact assessment study analysed the potential population health effects arising from a malfunction, a radiological/nuclear accident. Thus, the conclusions of this study indicate the following:

Potential population health effects arising from a malfunction, radiological/nuclear accident or malicious act are often of interest to members of the public living near a nuclear facility. The first aspect of health concerns with malfunctions, accidents and malevolent acts is related to physical well-being or potential health effects but also the availability of adequate capacity to respond to a radiological or nuclear emergency.

Boundary scenarios with possible radiological impact were analysed in order to determine a potential radiological impact on human health in the population in the vicinity, based on the information in subchapter 8.2. Thus, ***a number of scenarios concerning possible malfunctions and incidents/accidents and those related to the transport of low and intermediate level radioactive waste were examined.*** The analysis showed that ***no residual effects on the human health of the off-site population are expected as a result of these events***.

A series of events with potential radiological consequences and accident scenarios were also evaluated to determine a number of credible scenarios and to determine the resulting doses to members of the public from these accident scenarios. ***From their analysis, it was found that all doses were within the annual regulatory limits and no adverse effects on human health are anticipated***.

Various scenarios of possible nuclear accidents were also evaluated. Nuclear accidents are those malfunctions and accidents that are assumed to involve the operation of the reactor and associated systems and may lead to a release of radioactive material into the environment. Accident scenarios were also analysed by considering potential internal and external initiating events that could lead to an abnormal release of radioactivity into the environment during radioactive waste management activities.

Thus, according to the *Final Safety Report of Unit 1, edition 2022*, the Design-Based Accident (DBA) with the most severe consequences in terms of radiological impact on the population is the Feeder Stagnation Break event, followed by reactor shutdown, fuel failure cooling system operation and envelope systems operation. Under this assumption, ***the maximum individual effective dose value following exposure to the postulated radiological release for a 30-day period for the Feeder Stagnation Break event is 5.471 mSv at the exclusion zone boundary for the SSV (South South West) sector, corresponding to the percentile „99% Cut-off”***.

From the dose distribution analysis, it appears that the maximum effective dose at a distance of 30 km from the plant is 16 µSv, which means that for any person located on the territory of neighbouring countries (Bulgaria or Ukraine), the effective dose following the Design-Based Accident with the most severe consequences in terms of radiological impact on the population will be lower than this level. It should be noted that the value of 16 µSv corresponds to the exposure to the natural background radiation (including radon exposure) over a period of 58 hours, considering an average value of the total effective dose due to radiation of natural origin of 2.4 mSv/year.

The regulated dose limit for members of the public is 1 mSv/year (1000 μSv/year). For emergency exposure situations, the reference level, expressed in terms of residual dose to the public, is in the range 20 - 100 mSv for the first year after the accident. These regulatory limits have been used for comparison with doses resulting from radiological or nuclear failure and accident scenarios. As can be seen from the doses above, the doses to members of the public resulting from each scenario are all lower than the regulatory dose limits.

Consequently, no residual effects on human health are expected as a result of radiological failures and accidents on site as a consequence of the implementation of the Project „ Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”.

Public health concerns in relation to malfunctions, major accidents and/or disasters relevant to the project in question relate to physical, mental and social well-being. In the event of a malfunction or accident, appropriate remedial action will be taken. The operator's intervention can help minimise or prevent environmental consequences. There is also a comprehensive on-site and off-site emergency response plan to deal with malfunctions and accidents.

A number of psychosocial effects are likely to occur on members of the public, should a nuclear accident occur during the course of the project. The severity and duration of these effects would most likely be related to the time period during which the protective actions are implemented, and the amount of radioactive material. Implementation of emergency response procedures and programs to ensure that appropriate response and remediation actions are taken, where appropriate, will help restore a sense of safety and security to members of the public. Notification of an accident scenario and subsequent frequent communication with members of the public and workers on the progress of response activities will help minimize potential accident concerns. Awareness of emergency planning and preparedness both on and off site helps mitigate stress related to potential incidents. In addition, frequent communication about the Cernavodă NPP's regular activities, as well as the emergency response programmes and policies in place, will help provide a sense of safety and security.

In order to limit the consequences of radiological and/or nuclear incidents, with or without impact on the health of workers and the population, ***Cernavodă NPP has established its own emergency response plan.***.

For the same reasons, ***in the unlikely event of the declaration of a radiological or nuclear emergency, the National Radiological or Nuclear Emergency Response Plan is triggered***.

In order to ensure the implementation of the plans, the necessary material and human resources and specific emergency preparedness programmes are established. Regular drills are established and conducted regularly, to verify the readiness of the Cernavodă NPP for emergency response.

Decommissioning stage

Once the project reaches the final period of the operational phase, a closure and decommissioning plan will be drawn up in accordance with the provisions of the regulations in force at that time. The planning of decommissioning activities will use applicable international standards and experience gained in other similar decommissioning projects.

At present, the safety requirements for decommissioning nuclear and radiological facilities are detailed in the Annex to CNCAN Presidential Order No 102 of 26.05.2022.

The requirements for the quality management system of the organisation responsible for decommissioning activities are detailed in the Annex to the Order of the President of CNCAN No. 75 of 30.05.2003 (Rules on specific requirements for quality management systems applied to the decommissioning of nuclear installations - NMC-11).

Annex 6 Decommissioning presents the radiological hazards that may arise during decommissioning.

8.3 Project exposure to natural disasters

Drought

Although at European level the largest amount of water (from surface waters) is used for agriculture, in Romania the largest amount is used for industry, followed by agriculture. According to climate projections for the period 2021-2050 and 2071-2100, an extended aridization trend is expected in most parts of the country, particularly towards the end of the century. The most vulnerable areas are the western and mountainous regions, where the trend is more pronounced compared to the current situation, and the southern, eastern and south-eastern regions, where the current arid conditions are maintained.[141]

Considering that the operation of the Cernavodă NPP is closely linked to the water source and taking into account that the reuse of cooling water of the nuclear reactors condensers by recirculating it through the suction basin has the main effect of reducing the flow of technological water abstracted from the Danube via the derivation channel, it is estimated that in the future, 2071-2100, the phenomenon of aridization will have an insignificant effect on the operation of the objectives on the Cernavodă NPP platform.

Seismic movements

Analyses of the characteristics of seismic movements likely to occur on-site have been carried out extensively since the siting phase of the nuclear facilities at Cernavodă. An assessment of seismic response margins was carried out in the framework of the probabilistic analysis programme to determine how the Cernavodă NPP units can be operated under nuclear safety conditions. The conclusions are that the Cernavodă NPP is sufficiently robust to withstand on-site seismic events with probabilities of 10^{-4}/year under nuclear safety conditions.[142]

[141] Environmental Report, National Strategy on preventing and combating desertification and land degradation 2019-2030, elaborator EPC Environmental Consultancy, 2023, beneficiary MMAP - General Directorate of Forests and Forestry Strategies

[142] Nuclearelectrica" S.A. Cernavoda NPP, Nuclear Safety Report for DIDRS - Chapter 2, Document Code 79-01320-RFS-DIDSR-CAP2/2022

Since the commissioning of the first unit at the Cernavodă NPP, a seismic monitoring system for structures and buildings important for nuclear safety has been in operation. This system uses instrumentation that records seismic activity through sensors located at specific locations on the plant site and transmits real-time alarms to the control rooms of the two units if a significant seismic event is recorded. If the seismicity exceeds a pre-determined threshold, the necessary measures are taken in the nuclear installations, which aim to assess the impact on the operability of the SSCE, or to manually shut down the reactors, as appropriate. A second seismic monitoring system uses the on-site seismic stations at Târgușor and Matei Corvin, which are connected to the seismic monitoring system of the National Institute for Earth Physics Research and Development.[143]

[143] "Nuclearelectrica" S.A. Cernavoda NPP, Nuclear Safety Report for Unit 1 - Summary - 2023

9. NON-TECHNICAL SUMMARY

This summary is drafted to present in a non-technical language the conclusions of the *Report on the Impact on the Environment for the project "Refurbishment of Unit 1 of Cernavoda NPP and Extension of the Intermediate Spent Fuel Storage with MACSTOR 400 modules"*.

The environmental impact assessment was carried out for the ***project implementation stage*** and for ***the operational stage of the refurbished U1 Unit and the extended DICA facility with MACSTOR 400 type modules***.

NOTE: The environmental impact assessment related to the **decommissioning of U1 unit** *will take place in the future, in accordance with Law 292/2018, appendix 1, point 2b) which provides for the environmental impact assessment for "nuclear power plant decommissioning or disassembly projects".* ***The decommissioning project of Unit U1 will be approved*** *by the competent environmental authority by issuing the Environmental Agreement for decommissioning,* **in accordance with the applicable legislation***. Thus, the environmental impact assessment procedure will be distinct from the present environmental procedure.*

Environmental factors, as defined in Art. 7 of Law 292/2018, and the aspects/elements for which the environmental impact assessment was carried out in the *Report on the Impact on the Environment for the project "Refurbishment of Unit 1 of Cernavoda NPP and Extension of the Intermediate Spent Fuel Storage with MACSTOR 400 modules"*, are:

- population and human health,
- biodiversity;
- land, soil, water, air, climate;
- material assets, cultural heritage and landscape;
- interaction between the above factors.

The environmental assessment was carried out considering the following:

- The necessity and importance of the project;
- Project description;
- Project development - Alternatives studied;
- Description of the initial state of the environment – Baseline scenario;
- Relevant environmental factors likely to be affected by the project;
- The predicted impact on the environment through the implementation of the project, including the cumulative impact with other approved/developed projects on the Cernavoda NPP site and in the vicinity
- The measures proposed by the project in order to maintain the current state of the environment in the Cernavoda NPP area
- Proposals for monitoring the state of the environment during the implementation of the project and during the operation of the objectives.
- Assessment of the relevant risks associated with the project in case of accidents/disasters and measures envisaged to prevent/mitigate significant negative effects on the environment.

From the point of view of the applicable legislation, the method of drafting the *Environmental Impact Report* is based on the following main normative acts:

- → Law no. 292/2018 regarding the assessment of the impact of certain public and private projects on the environment
- → Order no. 269/2020 on the approval of the general guide applicable to the stages of the environmental impact assessment procedure, the guide for environmental impact assessment in a transfrontier context and other specific guidelines for different fields and categories of projects
- → The general guide applicable to the stages of the environmental impact assessment procedure, from 20.02.2020 provided in Appendix no. 1
- → Guide regarding environmental impact assessment in a transfrontier context, which represents the adaptation to the requirements of national legislation of the guide for the implementation of art. 7 of the EIA Directive elaborated by JASPERS in 2013, is provided in Appendix no. 2
- → G.E.O. no. 57/2007 regarding the regime of natural protected areas, conservation of natural habitats, flora, and fauna, with subsequent amendments and additions
- → Convention regarding environmental impact assessment in a transfrontier context, adopted in Espoo on February 25, 1991, ratified by Law no. 22/2001
- → Law no. 111/1996 regarding the safe conduct, regulation, authorization, and control of nuclear activities, republished, with subsequent amendments and additions.

❖ General elements of the project

S. N. Nuclearelectrica S.A. - The Cernavoda NPP branch has 2 nuclear power units in operation, **Unit 1 in commercial operation since December 1996** and Unit 2 since November 2007. Each unit has one turbogenerator that provides an electric power of 706.5 MWe, for U1, respectively 704.8 MWe for U2, using the steam produced by one CANDU-PHWR-600 type nuclear reactor. The nuclear energy production technology at the Cernavoda Nuclear Power Plant is based on the CANDU (CANadian Deuterium Uranium) nuclear reactor concept, which operates with natural uranium and uses heavy water (D_2O) as a moderator and cooling agent.[144]

The operation of the two reactors at Cernavoda currently provides approximately 20% of Romania's energy needs. At the same time, the two units provide heating for more than 75% of the population of Cernavodă town.

Currently, the activity of the nuclear facilities U1, U2 and DICA on the Cernavoda NPP platform is regulated by the Environmental Authorization published by *"Decision no. 84/2019 regarding the issuance of the environmental authorization for the National Company "NUCLEARELECTRICA" - S.A. - Branch "Cernavoda NPP - Unit 1 and Unit 2 of Cernavoda Nuclear Power Plant"* and through the operating authorizations issued by CNCAN for carrying out activities in the nuclear field for each nuclear objective.

CANDU reactors have an initial lifetime of 30 years. Following a refurbishment process, this lifetime can be extended - this concept being known as "Long - Time - Operation" - LTO.

According to the *Nuclear Safety Guide regarding the preparation for the refurbishment of nuclear installations, dated 12.12.2018,* art. 4 para. (2): *by refurbishment of a nuclear installation it is understood capital repair, modernization and improvement by replacing and/or modifying some equipment or systems of the installation, in order to significantly extend its operating life, in accordance with nuclear safety analyzes and engineering evaluations;* the refurbishment is a planned

[144] Refurbishment of Unit 1 of the Cernavoda Nuclear Power Plant, Stage 2 – Feasibility study, version v1, 2022

long-term shutdown of the nuclear installation and it creates the opportunity to improve nuclear safety to the level required by modern regulations and standards, including by using the latest technical solutions and knowledge in the field of design and operation of nuclear installations; *the refurbishment does not involve changing the technology of the nuclear installation as a whole, nor the operating characteristics-parameters and the amount of energy produced*.

Through the refurbishment process, the nominal power of the U1 unit does not change.

❖ **The necessity and importance of the project**

Through the refurbishment project of SN Nuclearelectrica S.A. aims at *extending the life of Unit 1 to ensure the long-term safe operation of the plant with a second operating cycle*. This is *the main objective of the project*. The investment is in line with Romania's electricity needs, considering that the demand for electricity is expected to increase in the medium and long term, with significant investments needed to reduce the gap between production and demand. Nuclear energy can prove to be a cost-effective solution in the long term, capable of meeting ever-increasing electricity needs while decarbonizing the energy sector. Nuclear energy is considered a "climate neutral" energy source.

The refurbishment project of Unit U1 at Cernavoda NPP is of national importance and is considered a priority investment project by the Romanian state, being included in:

→ *Romania's energy strategy 2025-2035, with the perspective of 2050*.

→ *The National Integrated Plan in the field of Energy and Climate Change 2021-2030* (PNIESC) April 2020 – approved by GD no. 1076/2021.

→ *The medium- and long-term national strategy regarding the safe management of spent nuclear fuel and radioactive waste* - approved by GD no. 102/2022.

→ *The nuclear safety guide regarding the preparation of the refurbishment of nuclear installations - GSN 07*, approved by the Order of the President of CNCAN no. 341/09.01.2019.

Within the National Energy Strategy, nuclear energy production is one of the priority directions for Romania's energy security and for the reduction of greenhouse gas (GHG) emissions in the energy production sector. Thus, *the refurbishment of existing nuclear units and the construction of new large nuclear units* - are considered priority investments, which lead to the achievement of the fundamental objectives of the strategy.

The Integrated National Plan in the field of Energy and Climate Change 2021-2030 (PNIESC) April 2020 includes the refurbishment project stating: *"Extending the operating life of Units 1 and 2 from Cernavoda NPP is an efficient solution, given that the extension by another life cycle is done at costs around 40% of the value of a new objective of the same capacity, which can ensure the supply of electricity without greenhouse gas emissions, with minimal impact on the environment, at competitive costs , thus contributing sustainably to the decarbonization of the energy sector and reaching Romania's energy and environmental targets for 2030, in line with the objectives assumed at the European and even global level (the Paris Agreement).”*

❖ **Description of the project**

The project: "**Refurbisment of Unit 1 of Cernavoda NPP and extension of the Intermediate Spent Fuel Storage with MACSTOR 400 modules"** includes two sub-projects:

➢ ***Sub-project Refurbishment of Unit 1 of Cernavoda NPP (RT-U1)*** - which will consist in the replacement of the components of the reactor assembly, in the rehabilitation and modernization of the systems in the nuclear part and in the classical part of the unit and the realization of the infrastructure necessary for the implementation of the subproject;

➢ ***Sub-project Extension of the Intermediate Spent Fuel Storage with MACSTOR 400 modules (DICA-MACSTOR 400)*** - which will consist in increasing the current capacity of the storage by building and putting into use modules with double the storage capacity compared to those currently used, to ensure the intermediate storage of the spent and cooled nuclear fuel that will result from the operation of the nuclear-electric units U1 and U2 at Cernavoda NPP, including their second operating cycle. Thus, the DICA-MACSTOR 400 sub-project is constituted as support for the operation of the refurbished Unit 1.

- **Stages for project implementation**

Subproject RT-U1

- *preparing the necessary infrastructure*, setting up the appropriate space in the U5 Reactor Building (the new DIDR-U5) for the intermediate storage of radioactive waste, setting up facilities (light structures) for the temporary storage of recoverable/recyclable waste, setting up spaces for the temporary storage of materials, used equipment in the refurbishment activities, separation of access and provision of physical protection for Unit 2, special arrangements for ensuring the physical protection during the refurbishment project.
- *shutdown of the U1* unit and unloading of nuclear fuel, preparation of the reactor building and the reactor assembly, isolation, decontamination, drainage, drying, *reactor retubing activities*, management and intermediate storage of radioactive waste, *technological tests and commissioning*, *project closure* - reception and the decommissioning or conservation of temporary facilities used for refurbishment.

Subproject DICA-MACSTOR 400

- *extension of DICA site* from an area of approximately 24000 m^2 to approx. 40000 m^2 (the area between the boundaries of the objective's outer fence),
- *land preparation, the construction of MACSTOR 400 modules* having a double storage capacity compared to MACSTOR 200 modules, with phased execution, module by module, staggered in such a way as to ensure the necessary intermediate storage space for the spent fuel from the nuclear-power units U1 refurbished and U2, in operation,
- *carrying out other planned works*, identified in the process of defining the purpose of the project (e.g. relocation of electricity poles from the DICA extension area).

- **Activities for the project implementation**

Subproject RT-U1

All spaces necessary for the preparatory and support activities of the refurbishment will be located within the site, property of SNN-SA Cernavoda NPP Branch.

The specific, refurbishment activities will be carried out inside the existing buildings, related to Unit 1 and in the support spaces that will be specially built and set-up.

- ***Setting up the spaces and supporting infrastructure for refurbishment, outside U1 unit***

The preparation for the refurbishment of Unit 1 involves the following main improvements on the Cernavoda NPP site:

a) construction of new buildings and temporary constructions:

- *Buildings that will not contain radioactive material:* (Command center of the retubing activities, Building for the specific training of the personnel involved in the retubing activity of the U1 reactor, Reactor components building, clean room, Building for the EPS batteries, control panels, automation, signaling and cables, etc.).
- *Buildings that will be in the controlled area:* (Active Components Building - for the reception and preparation of the tools required for retubing, Auxiliary Building U5 - for the unloading of the radioactive waste transport containers and for loading the storage containers, Space for the temporary storage of some equipment removed from the radiological area and which have fixed contamination, Extension of the locker rooms at Unit 1).

b) improvements to existing structures:

- Arrangement of the space inside the Unit 5 Reactor Building (***the new DIDR-U5***) for the intermediate storage of low and medium radioactive waste resulting from the refurbishment of Unit 1 and the long-term operation of the nuclear-power units.
- Relocation of overhead heating water/steam pipes and electrical cables, approximately 120 m long.

DIDR-U5 will be set up inside the envelope of the former reactor structure of Unit 5, located on the Cernavoda NPP site, *completed from a constructive point of view in proportion to 60%* and whose initial destination has changed for this purpose. *The construction made of massive reinforced concrete elements, with a thickness of over 1 m, is intended for the intermediate storage of containers with radioactive waste (correlated with the types of waste to be stored - activated, contaminated).* The building will be equipped with ventilation, conditioning, and monitoring systems, specific for the storage of low and intermediate-level radioactive solid waste (T1, T2 and T3).

DIDR-U5 will be connected with a new building provided for the transfer of radioactive waste from transport containers to intermediate storage containers.

c) arrangement of access ways used temporarily (for access to equipment/devices/materials) and permanently (for transporting radioactive waste), parking lots, other related works:

The existing roads within Cernavoda NPP premises will be used, during the U1 refurbishment works, for the transfer of heavy and bulky equipment on the route between the Unit 1 area and the area of warehouses and workshops located on the platforms next to the U3-U5 units. These roads will be used during the refurbishment works of U1 for the transfer of low and intermediate-level radioactive waste resulting from the refurbishment, on the route from Unit 1 to the future intermediate storage facility that will be located in the reactor building of Unit 5: DIDR-U5.

The internal transfer of spent nuclear fuel - from the spent fuel pool from the U1 Unit shut-down for refurbishment and from the U2 unit in operation respectively - to DICA, respectively the transfer of low and medium radioactive waste resulting from the refurbishment of U1 to the new DIDR-U5, will be on different routes. This way, the transfer of radioactive waste from the refurbishment of U1 will not interfere with the activity of U2 unit.

d) construction of a concrete platform for the organization of the construction site and for the storage of containers.

➢ ***The actual refurbishment of Unit 1 involves the following activities:***

- ***Shutdown of the unit and unloading nuclear fuel***

After the controlled shutdown of the U1 reactor for refurbishment, the nuclear fuel will be discharged from the reactor into the spent fuel pool (BCU).

After unloading the spent nuclear fuel, the following activities will be carried out:

- ***Preparation of the reactor building and the reactor assembly, isolation, drainage, drying.***
  - *Drainage and storage of heavy water.* During the refurbishment, the entire amount of heavy water discharged from the reactor systems – approx. 202.5 m^3 from the primary heat transport system and approx. 264 m^3 of moderator – will be stored in storage tanks specially designed for this purpose, on the Cernavoda NPP site.
  - *After draining the heavy water, the systems in the nuclear part where work is to be carried out will be decontaminated and dried.*
  - *Conditioning/preservation of systems during the shutdown period.* This activity is carried out both in the nuclear part and in the secondary part. The preservation of the systems will be carried out according to the recommendations contained in the program: "Elaboration of the conservation program for the U1 systems/components during the refurbishment period and technical assistance in its implementation at Cernavoda NPP", based on programs applied within CANDU units previously refurbished in "CANDU" nuclear power plants from Canada and Argentina.

    The conservation program aims to maintain the integrity and performance of the nuclear power unit's systems and components throughout the refurbishment period, and will complement the existing SSCE reliability maintenance programs.

The conservation process is complex and aims to reduce general corrosion, localized corrosion because of the potential difference between surfaces, that induced microbiologically and by biofouling, or that due to mechanical stress. System conservation involves checks – inspections and monitoring – of both the systems under conservation and the supporting equipment used to install and maintain the conservation.

- ***RT-U1 retubing the Unit 1 reactor***

This activity involves several steps [145]:

- *Dismantling feeders.* After removing the feeders, the inlet collectors and the outlet collectors are inspected. The resulting feeders and other decommissioned components are collected in containers for radioactive waste and are transferred to the spaces specially arranged for the intermediate storage of low and medium radioactive waste, inside the Unit 5 Reactor Building of Cernavoda NPP.
- *Dismantling fuel channels, calandria tubes and their preparation for storage as radioactive waste.*

[145] Presentation memoir - Project ”Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”, November 2021

- *Installation of fuel channels (pressure tube assembly, calandria tube) and new feeders.*
- *Installation of new feeders, calandria tubes, pressure tubes together with related assemblies*.

- ***Activities regarding radioactive waste management***

It should be noted that all the equipment related to the operation of Unit U1 - the collection, treatment and evacuation systems of liquid and gaseous effluents, in operation - will also serve the activities during the refurbishment time of Unit 1.

Radioactive waste resulting from dismantling activities of pressure tubes and calandria and their related assemblies, after volume reduction and containerization in Small Waste Container/Large Waste Container (SWC/LWC) - as appropriate, subsequently to be placed in authorized containers, which will be transferred for interim storage in the new DIDR-U5.

In the process of Unit 1 refurbishment, the transfer and intermediate storage of the generated radioactive waste is an activity of major importance.

The transfer of the radioactive waste from the active area during the refurbishment at Cernavoda NPP to the intermediate radioactive waste storage (the new DIDR-U5) will be carried out in accordance with the technical solution for retubing proposed by Candu Energy Inc. Thus, Cernavoda NPP will construct and provide the intermediate storage facilities for intermediate level radioactive waste, and consequently, the design and supply of the storage containers shall ensure:

- compatibility with the new facility;
- shielding compliant with radiological security regulations;
- satisfying the acceptance criteria of Cernavoda NPP.

For the transport and transfer in the intermediate storage structures, special containers are needed that ensure shielding and transport under radiological safety conditions in the controlled area of the Cernavoda NPP.

- **Route of Terminal Fittings**

The terminal fittings removed from the fuel channels are transported inside the controlled area (by industrial road) to the Hall for unloading containers with radioactive waste and storing containers with waste (hereinafter referred to as the Hall) related to DIDR-U5.

The transfer activity takes place in a shielded and ventilated enclosure. After filling a K-Box container, it is sealed and then transfered to the intermediate storage area located in the Reactor Building U5 – DIDR-U5.

- **Route of pressure tubes, calendria tubes and calandria tube inserts**

The pressure tubes, calandria tubes and calandria tube inserts are removed using retubing tools. To reduce the volume, the pressure tubes and the calandria tubes are shredded directly after removing them from the active area, using a special shredding system equipped with HEPA filters to retain small radioactive particles. This activity is carried out in the Unit 1 Reactor Building. After this step, calandria tube inserts, i.e. shredded pieces of calandria tubes and pressure tubes, are placed in unshielded containers (SWC) and then loaded into a shielded transfer flask (SWTF). These full screened containers are transported to the Hall by industrial road. The transport of the shielded containers from U1 to the Hall is done behind U1-U5. During this transport, staff access to this route is restricted.

Once the shielded transport container has arrived in the Hall, the transfer of the unshielded containers containing the shredded pressure and calandria tubes and calandria tube inserts from the shielded transport container to the shielded intermediate storage container (K-Box), begins.

The transfer activity is carried out in a shielded and ventilated enclosure (ventilation that is equipped with HEPA filters and that is connected to the active ventilation system in the Building where the radioactive waste will be stored (U5 Reactor Building). After filling a container K- box this is closed tightly, and is then transfered to the intermediate storage area located in DIDR-U5.

- ***Carrying out other planned works, identified in the project definition process***

At the same time with the retubing works of the reactor, during the long-term shutdown period, other planned modernization works of Cernavoda NPP will be carried out.

The main modernization works (apart from retubing the reactor) consist of:

- refurbishment works of process computers;
- refurbishment of the micro computers of the reactor's fast shutdown systems;
- eddy current inspections of tubular bundles of heat exchangers;
- replacement of the manual valves in the moderator system;
- replacing the pumps on the service water system and related valves;
- replacing the valves related to the pumps on the condensate extraction system;
- replacing the heat exchangers of the Intermediate Cooling Water System;
- internal inspections of tanks;
- moderator pump inspection;
- radiographic inspections of the bellows related to the liquid poison injection system to determine the degree of aging and their replacement if necessary;
- overhaul of the turbine and rewinding of the electric generator;
- replacement of emergency diesel generators and backup diesel generators (SDG);
- major overhaul of the motorized valves of the cooling system in case of failure of the core;
- replacement of the main condenser tubes, etc.

The non-radioactive equipment that will be replaced will be stored in the plant's warehouses, after which a technical commission will carry out an evaluation regarding the possibility of reuse or recovery.

- ***Activities necessary for Unit 1 to be put back into operation***

After the completion of all the refurbishment activities, the necessary activities will be initiated to put Unit 1 back into operation. In this sense, the following activities will be done:

- restoring the configuration of the systems, filling them, if necessary, and performing tests;
- fuel loading;
- carrying out all technological tests and putting the unit into operation;
- closing/completion of the refurbishment project (planned shutdown) – reception of works and decommissioning or preservation of temporary facilities used for refurbishment.

Subproject DICA-MACSTOR 400

The increase in the capacity of the spent nuclear fuel intermediate storage will be achieved both by extending the surface of the existing storage - and implicitly the number of modules - and by building MACSTOR-400 modules with double the spent fuel storage capacity compared to those currently used.

The expansion of the storage facility will be done on a land with good foundation conditions ("good bedrock" according to the Geotec2000 Study), land where the current DICA-MACSTOR 200 authorized by CNCAN and the Ministry of the Environment is also located.

- ***Activities involved in the extension of the DICA site***

The area of the DICA site will expand by about 16000 m^2 towards the new DIDR-U5, respectively from 24000 m^2 to approx. 40000 m^2 (the area between the boundaries of the external fence of the objective), to allow the placement of a total number of 37 modules.

The increase of the surface of the facility involves:

- expansion of the site's fence;
- expansion of the storm sewer network system;
- the execution of the new boreholes for monitoring the phreatic aquifer - 2 pcs. - according to the specifications of the hydrogeological expert report issued by INHGA.

- ***Activities involved in building MACSTOR 400 type modules***

Ensuring the intermediate storage capacity of the dry spent nuclear fuel resulting from the operation of the two nuclear units U1 and U2 with two operating cycles, involves the construction - starting with Module no. 18 – of 20 MACSTOR 400 type modules, that have double the capacity of the currently used MACSTOR 200 modules.

The preparation of the land and the construction of the modules will be carried out in stages, correlated with the rate of generating spent nuclear fuel from the operation of the two nuclear units.

The execution of MACSTOR 400 type modules involves the same activities as in the case of MACSTOR 200 modules and consists of the following works:

- excavations for the construction of foundations for modules, platforms, roads, gutters, carriage-ways, and rain water collection;
- works for the construction of modules, platforms, roads, gutters, carriage-ways and rainwater collection manholes;
- installation of the equipment/circuits that serve the DICA - MACSTOR 400 subproject;
- the installation of the gantry crane that serves each row of modules;
- technological tests and commissioning.

- ***Demolition/decommissioning activities necessary for project implementation***

The refurbishment of Unit 1 does not involve the demolition of any constructions, but there will be works to relocate some water/heating pipe overpasses and existing cable routes over a length of approx. 150 m.

- **Ensuring utilities**

Water supply – Ensuring water supply for all specific consumptions during the RT-U1 subproject will be carried out from the existing, authorized sources of Cernavoda NPP.

In order to ensure an additional fire reserve, compared to the existing and regulated reserve on the Cernavoda NPP site, by setting up the infrastructure of the objectives that will serve the specific activities of the RT-U1 subproject, 2 water storage tanks are planned to be built. The additional water supply for the fire will be equipped with a pumping station, which will be arranged in the area of the new objectives specific to the sub-project RT-U1.

Water evacuation – Ensuring the evacuation of waste water generated during the realization of the project RT-U1 and DICA-MACSTOR 400 will be carried out through the same evacuation systems provided in the Cernavoda NPP plant with two nuclear units, authorized by the current regulatory act.

For the newly envisaged objectives to be achieved by the project, the existing water supply and waste water discharge systems on the Cernavoda NPP site will be expanded.

Management of non-radioactive waste - will be carried out according to the provisions of the applicable normative acts in force, regulatory acts and specific procedures approved and implemented by Cernavoda NPP.

Radioactive waste management – The management of radioactive waste resulting from the refurbishment of Unit 1 and the operation of Units 1 and 2 will be carried out in a similar way, in an integrated manner with the existing radioactive waste management plan from Cernavoda NPP[146].

NOTE: Regarding the management of radioactive waste resulting from the project, we present the following general information that constitutes Romania's development directions:

- The medium- and long-term national strategy regarding the safe management of spent nuclear fuel and radioactive waste, approved by GD 102/2022 **applies to**:

- *„activities for the safe management of spent nuclear fuel from the operation of nuclear installations for the production of electricity* and research reactors;
- *safe management activities of radioactive waste* ***from the operation, refurbishment*** *and decommissioning of nuclear power generation installations*, research reactors and from industrial, medical and research activities that use radioactive sources.”

The content of the National Program for the responsible and safe management of spent nuclear fuel and radioactive waste is established in accordance with the provisions of Directive 2011/70/EURATOM, as well as with those of the applicable national legislation.

- The National Agency for Radioactive Waste (ANDR) has the responsibility of building a surface repository for low and medium activity waste - *Final Repository for Low and Intermediate Radioactive Waste (DFDSMA*),
- The operation of the two nuclear units at Cernavoda NPP results in quantities of radioactive waste that are interim stored on the Cernavodă NPP site, to be disposed of definitively and safely after the construction and commissioning of the final repository DFDSMA.

[146] Feasability Study on Management of Radwaste Generated during Unit 1 Refurbishment and Operation of Unit 1,2 in Cernavodă NPP, Doc. RWM-E-T8-001R1, April 2021, Doc. RWM-E-T8-001R1, April 2021

DFDSMA aims to ensure the final and safe storage of low- and intermediate-level radioactive waste with short-lived radionuclides, resulting from the operation, maintenance, refurbishment, and decommissioning of a maximum of 4 nuclear-power units at Cernavoda NPP.

- **The planned measures for the management of low and intermediate level long-lived radioactive waste and spent nuclear fuel** provide for their final disposal in a deep geological repository (DGR). Until the deep geological repository is commissioned, they are intermediately stored in dedicated facilities on the site of the Cernavoda NPP.

- **Location of the project**

The project will be developed on the current site of the Cernavoda NPP authorized by CNCAN exclusively for the development of nuclear objectives, and the extension of the DICA is done in the area with *"good bedrock"* on the site.

Exclusion and low populated zones were defined based on the nuclear security analyzes approved by CNCAN.

As a result, the following areas have been established around Cernavoda NPP:

- *an exclusion zone within a radius of 1 km around the reactors in operation* - area in which measures are taken to exclude the location of permanent residences for the population and the performance of social and economic activities that are not directly related to the operation of the nuclear objectives of the Cernavoda NPP;
- *a low populated area with a radius of 3 km around the reactors in operation* - in which measures are taken to restrict the location of permanent residences for the population and the performance of social and economic activities.[147]

The nearest localities in the area of influence of Cernavoda NPP are:
- Cernavoda town - located approx. 1.6 km NW of the Cernavoda NPP platform,
- Stefan cel Mare village - located approx. 2 km SE of Cernavoda NPP,
- Seimeni locality - at approx. 2.4 km NE,
- Dunarea locality - at approx. 8.5 km NE,
- Capidava locality - at approx. 15 km NE,
- Topalu locality - at approx. 22 km N.

In the framework of the environmental impact assessment procedure in a transfrontier context, the neighboring states were consulted and the states: Bulgaria, Ukraine, the Republic of Moldova, Serbia, Hungary, and Austria expressed their interest in participating in the EIA.

The distances from the Cernavoda NPP site to the borders of neighboring states and those interested in participating in the environmental impact assessment procedure:

- approx. 36 km from Bulgaria,
- approx. 112 km from Ukraine,
- approx. 128 km from Republic of Moldova,
- approx. 421 km from Serbia,
- approx. 575 km from Hungary,
- approx. 926 km from Austria.

[147] Raport final de securitate nucleară Unitatea 1 - Rezumat, Februarie 2023

- **Project development - Alternatives studied**

The technological alternatives for the sub-project of the refurbishment of Unit 1 are based on the analysis carried out within the "*Feasibility Study for the Refurbishment Project Unit 1 Cernavoda NPP*", version v1, 17.01.2022, drawn up by Ernst & Young SRL. *Technologically reasonable alternatives* – which have been selected are described based on the following 3 scenarios:

- Scenario 1 – "mandatory"
- **Scenario 2 – "enhanced safety"**
- Scenario 3 – "good to be done".

For the sub-project RT-U1, alternative 2 was chosen ***based on Scenario 2 from the SF – "enhanced safety" –*** which provides measures to improve nuclear, radiological, physical, and cyber security, health and security of the population and employees, of the environment, under conditions of optimal efficiency and economic-financial effectiveness.

For the extension of DICA with MACSTOR 400 type modules compared to the project regarding the realization of the DICA-MACSTOR 200 investment approved by the Environmental Agreement no. 2058 of 22.04.2002 and currently underway, a series of alternatives have been studied, starting from 2014, regarding the intermediate storage of spent nuclear fuel resulting from the operation of the U1 and U2, with two operation cycles each. For this subproject, out of the two 2 analyzed alternatives, alternative 2 was selected because:

- provides intermediate storage space for two operating cycles for nuclear units;
- allows keeping an identical mode of operation.

The alternatives selected for the two sub-projects ensure technical-economic sustainability.

In the situation in which the process of the U1 unit will not be carried out, the nuclear unit will be shut down and decommissioned, a situation that will lead to the cessation to supply the National Energy System with approx. 10% of the national electricity production. This amount of energy that is currently produced without GHG emissions will have to be supplied from other sources, possibly polluting. At the same time, ***the General Guidelines for the stages of the environmental impact assessment procedure of 20.02.2020,*** shows that ***"the do-nothing scenario cannot be considered as a feasible political option, as some projects are very clearly needed and are required by policies at national, regional or local level...".***

- **Description of the initial state of the environment**

The baseline scenario is the starting point of the environmental impact assessment procedure and represents the description of the current state of the environment in and around the project site.

For the nuclear installation of Unit 1 at Cernavoda NPP, the Regulatory Authority in the field of nuclear activities issued authorizations for all authorization phases, starting in 1978 when the location authorization was issued - until now when the unit holds the *Power Plant Operation Authorization Cernavoda Nuclear Power Plant, Unit 1, no. SNN Cernavoda NPP U1 – 01/ 2023, rev. 0,* in effect.

The location, construction, commissioning, and operation of DICA were carried out based on the regulatory acts issued by CNCAN, starting 2001 when the location authorization was issued until now when the objective operates based on the *Authorization for carrying out activities in the nuclear field No. SNN DICA -11/2024.*

From the point of view of environmental regulations, from the moment of commissioning U1 until now, Cernavoda NPP has operated based on environmental authorizations issued according to the regulations in force on the date of their issuance. Currently, the operation of Cernavoda Nuclear Power Plant is regulated by GD no. 84/2019 regarding the issuance of the environmental authorization for the National Company "NUCLEARELECTRICA" - S.A. - Branch "Cernavoda NPP - Unit 1 and Unit 2 of the Cernavoda Nuclear Power Plant.

The description of the relevant aspects of the current state of the environment ***(the basic scenario)*** **presents a synthesis of the monitoring results imposed by the regulatory acts issued for the operation of nuclear facilities** (issued by the Ministry of the Environment, Water and Forests, the National Commission for the Control of Nuclear Activities, the Romanian National Water Administration / Dobrogea Litoral Water Basin Administration, etc.) – during the period of operation, in conjunction with the results of the previous environmental assessments and the results of the monitoring campaign carried out during the development of the RIM, in the summer of 2023. At the same time, the results of the programs carried out at the national level for the characterization of environmental factors, through the National Network of Environmental Radioactivity Monitoring, the National Administration of Romanian Waters, were also taken into account.

The results of the monitoring carried out during the period of operation of the nuclear objectives, as well as those obtained in the measurement campaign carried out in the summer of 2023, indicated the following:

- **emissions of radioactive gaseous effluents fell within the derived emission limits** established by CNCAN for each nuclear objective
- **radioactive liquid effluent emissions fell within the derived emission limits** established by CNCAN for each nuclear objective
- **the environmental radioactivity indicators fell within the regulated limits**
- **the dose constraints** established by CNCAN for each nuclear objective **were met**
- **the limits imposed by the competent environmental authority for the values of non-radioactive indicators in WATER, AIR, SOL were met.**
  - From a quantitative point of view, the volumes of water abstracted for technological purposes fell within the limits established by the regulatory act (Water Management Authorization).
  - **The volume of industrial wastewater**, represented by technological circulation wastewater and hot technical water resulting from the activity of Cernavoda NPP, is discharged into the Danube through the Seimeni canal, **amounting 91% of the total volume** captured from the race I of the CDMN.
  - From the analysis of the results of the monitoring the ***chemical parameters of the waters discharged*** from the Cernavoda NPP, it is found that the ***average annual loads fell within the limits imposed*** by the regulatory acts and do not show significant variations in the effluent compared to the influent, similar to the situation recorded since the start of operation of the nuclear units, U1 in 1997 and U2 in 2008.

- ***The results of monitoring the temperatures of the influent and the technological effluent*** in the period 2018÷2022 ***indicated compliance with the limits regulated*** by the water management authorizations and respectively by the environmental authorizations - like the situation found in the environmental assessments carried out throughout the operating period of the nuclear units.

The results of the monitoring activities carried out as a result of the requirements of the regulatory acts, in conjunction with the results of the environmental investigations carried out during the previous environmental assessments on site (the environmental balance studies regarding the operation of the Cernavoda NPP, the impact studies developed for the developments on the site, the adequate assessment study and the biota monitoring programs) together with the investigations carried out in the summer of 2023 as part of this evaluation demonstrate that **the impact of the operation of Cernavoda NPP objectives remains at an insignificant level on environmental factors, within the limits regulated by the Ministry of the Environment/CNCAN.**

❖ **Relevant environmental factors likely to be affected by the project**

Taking into account the activities provided for in the stage of implementation (construction and refurbishment of U1), respectively of the operation of the project, it is appreciated that there are periods of time during which there are vulnerabilities of some environmental factors, as follows:

➢ ***in the implementation stage*** (infrastructure construction and shutdown for Unit 1 refurbishment), the susceptibility of environmental factors to being affected by the project, due to the nature of the activities, is related to radioactive emissions and the generation of radioactive waste.

As a result of the refurbishment works, significant volumes of solid radioactive waste will result, which will be managed within the radioactive waste management program, using for their intermediate storage, the existing facilities (DIDSR) and/or those that will be developed for the purpose of the project (the new DIDR U5), facility completed and in operation before the shutdown of U1 for refurbishment.

Regarding the biodiversity environmental factor, the works targeted in the refurbishment stage determine an insignificant impact.

Regarding the socio-human factor, *the Population Health Impact Assessment Study - May 2024* - developed by the National Institute of Public Health mentions:

- *protective measures were provided to reduce the impact on the environment and the health of the population*. Compliance with these measures and the technical conditions regarding the facilities, as well as the safe operation of the installations in the monitored system will lead to the minimization of the impact on the environment and the health of the population. *The quality of life and living standards of the local community will not be adversely affected by the implementation of the project, under normal operating conditions*.
- under the conditions of compliance with the project and the recommendations from the expert opinions/studies, the activities that will be carried out within *this investment objective will not negatively affect the health of the population in the area, through the application of the provided measures.* It is considered that the investment objective can have a *positive impact* in the area *from a socio-economic* and administrative point of view, and the possible negative impact on the health of the population can be avoided by complying with the listed conditions.

- ***in the operational stage***, there are no vulnerabilities for environmental factors estimated as the resulting emissions are similar to those from the current operation of the U1, U2 and DICA units and will fall within the limits provided by the regulatory acts issued by the Ministry of the Environment, Water and Forests and respectively by the operating authorizations issued by CNCAN – for all nuclear objectives on the site.

- **The predicted impact on the environment through the implementation of the project**

Since the design of the nuclear power plant with CANDU-type reactors in Cernavodă, the main focus has been on the possible positive or negative effects on the ecosystems within the defined ecotope[148] area around this facility, as well as on safety measures and the prevention of potential pollution accidents.

The main concerns in the operation of nuclear power plants are related ***to nuclear safety*** and ***the storage of generated radioactive waste***, as well as ***the provision of nuclear fuel*** necessary for energy production, the protection of the environment and health of the population.

Following a detailed analysis using the experience of similar international projects, various evaluation techniques and methods, it resulted that through the implementation of the project there will be a series of benefits on the environment as well as on the socio-human factor.

The project has the following positive aspects:

- **the refurbished U1 will continue to supply approx. 10% of the national electricity production, avoiding approx. 5 million tons of CO_2 annually, this activity being part of the decarbonization measures**,
- the extension of DICA will be done on land with "*good bedrock*”
- **both sub-projects are being developed on the Cernavoda NPP site, designated by CNCAN exclusively for the development/carrying out of nuclear activities**.

- **Criteria for environmental impact assessment**

For the assessment of the possible impact, the criteria of Order no. 269/20.02.2020 on the significance of the impact (with the ranges significant, moderate, minor, negligible, with no value or positive) were taken into account:

- magnitude of impact;
- receptor sensitivity.

Magnitude of impact is *small, medium, large* in relation to:

- Effect intensity: ***low, medium, high***
- Type of effect: ***direct, indirect, secondary, cumulative***
- Extent of effect: ***local, regional, national, transfrontier***
- Nature of effect: ***negative, positive, both***
- Duration of effect: ***temporary, short-term, long-term***
- Reversibility of effect: ***reversible, irreversible***.

[148] **Ecotope -** A particular type of habitat in a region, https://hortiweb.ro/dictionar-general-de-botanica-e

Receptor sensitivity is ***low, medium, high*** in relation to:

- Sensitivity of the receptor environment on which the effect is produced
- The capacity of the receptor environment *(physical factors - water, air, soil - biological factors - species or habitat - and social factors - specific group/community or material goods and socio-economic elements)* to adapt to the changes that the project may produce.

The environmental impact assessment was carried out for ***the implementation stage of the project*** (construction/arrangement of the supporting infrastructure and the actual refurbishment, respectively the preparation of the land and the construction of MACSTOR 400 modules) and for ***the operation stage of the refurbished U1 and the extended DICA facility with MACSTOR 400 type modules***.

The evaluation of the radiological impact considered the international experience, namely monitoring data in the case of the operation, refurbishment, and post-refurbishment operation of similar CANDU-type units (Point Lepreau, Bruce).

As a result of the environmental impact assessment ***for the operation stage of the project***, it was found that **following the implementation of the project**, the situation corresponding to the operation of the refurbished U1 and the DICA-extended with MACSTOR 400 type modules **will be similar to the current situation**, of the operation of the U1 in the first cycle and exploitation of DICA with MACSTOR 200 type modules, the resulting impact being insignificant for both the radiological and non-radiological components.

Thus, for the environmental factors analyzed, the following types of impact were estimated:

Significance of impact due to project implementation and operation

Environmental factors	**Implementation** Stage		**Operation** Stage	
	Impact significance in terms of:		Impact significance in terms of:	
	non-radiological	**radiological**	**non-radiological**	**radiological**
WATER	Insignificant Positive	Minor Negative	Insignificant Positive	Insignificant Negative
AIR	Minor Negative	Minor Negative	Insignificant Positive/Negative	Insignificant Negative
SOIL	Minor Pozitive/ Negative	Minor Negative	Insignificant Negative	Insignificant Negative
CLIMATE	Insignificant Negative		Positive	
BIODIVERSITY	Insignificant Negative	Insignificant Negative	Insignificant Negative	Insignificant Negative
MATERIAL ASSETS	Insignificant Negative		N/A	
CULTURAL HERITAGE	N/A		N/A	
LANDSCAPE	N/A		N/A	

Note: *The insignificant negative impact, from a radiological point of view, is an impact that does not generate visible effects, the negative nature being given by the values detectable by measurement against the background of the area, due to current activities on the Cernavoda NPP platform.*

From a radiological point of view - The Health Impact Assessment Study - prepared by the National Institute of Public Health (INSP) - ***indicates that there will be no significant impact on the population's health in the proximity area of Cernavoda NPP as a result of the implementation of the project***.

The socio-economic impact is positive - by generating jobs.

The main aspects considered when assessing the impact on biodiversity, following the development of the project, are:

- *the project is being developed inside the Cernavoda NPP industrial platform, land allocated by CNCAN exclusively for the development and carrying out of nuclear-specific activities.*
- The Ministry of the Environment, Water and Forests published the Decision of the scoping stage no. 1/23.02.2022 by which it is proposed to start the environmental impact assessment procedure, *without the need for adequate assessment and assessment of the impact on water bodies.*
- *the Cernavoda NPP site is located on the site of a former limestone quarry.*
- *the results of the BIOTA programs (2009-2012, 2013-2016), the conclusions of the adequate assessment study for U3 and U4 and the results of the environmental monitoring program carried out by Cernavoda NPP have highlighted an insignificant impact on biodiversity.*

Location of the project in relation to Natura 2000 sites:

- *located within a radius of 15 km from the project*: ROSPA0039 Dunăre - Ostroave, ROSCI0022 Canaralele Dunării (which includes 2.534 Cernavodă Fossil Site and 2.355 Seimenii Mari Fossil Site), ROSPA0012 Brațul Borcea, RAMSAR RORMS0014 - Brațul Borcea, ROSPA0002 Allah Bair - Capidava (which includes Nature Reserve 2.367 Allah Bair Hill), ROSPA0001 Aliman - Adamclisi, ROSCI0353 Peştera - Deleni, ROSCI 0412 Ivrinezu.
- *located up to 30 km from the project*: ROSCI0053 Allah Bair Hill, ROSCI0071 Dumbrăveni - Valea Urluia - Lacul Vederoasa (also includes 2.351 Aliman Fossiliferous Site and IV.30 Vederoasa Lake), ROSCI0172 Padurea and Valea Canaraua Fetii - Iortmac, ROSCI0278 Bordușani - Borcea, ROSCI0319 Mlastina de la Fetești, ROSPA0007 Balta Vederoasa, ROSPA0012 Brațul Borcea, ROSPA0054 Lacul Dunăreni), to which are added the natural reserves of national interest IV.26 - Bratca Forest (included in ROSCI0022 Canaralele Dunării) and 2.352 Neo-Jurassic Reef from Topalu (included in ROSCI0022 Canaralele Dunării).
- *located at distances greater than 30 km from the project*: 2.350 Limestone walls from Petroșani - Deleni Commune (approximately 34 km in a straight line), 2.361 Dumbrăveni Forest (approximately 33 km in a straight line), 2.369 Canaralele from Port Hârșova (approx. 39 km in a straight line), IV.24 Celea Mare - Valea lui Ene (approx. 36 km in a straight line), IV.19 Ostrovul Șoimul (approx. 47 km in a straight line), IV. 25 Padurea Cetate (approximately 39 km in a straight line).
- *located on the territory of Bulgaria:* SCI BG0000106 Harsovska Reka and SPA BG0002039 Harsovska Reka – 61 km from the project, SCI BG000017 Suha Reka and SPA BG0002048 Suha Reka – 37 km from the project.

The direct impact on biodiversity manifests insignificantly on the area that does not exceed the limits of the exclusion zone (0.8 -1 km), in the construction stage and in the operation stage. During the construction stage, there may be disturbances to the nesting of songbirds. The foliar photosynthetic capacity is estimated to be reduced to the existing vegetation insignificantly during the execution.

The indirect impact caused by transport inside and outside the NPP premises is insignificant, judging by the experience of the previous years of operation. The structures of the access roads to the NPP and the external roads are in satisfactory condition. Incidents with birds or mammals (foxes, jackals, etc.) are very unlikely.

Under current operating conditions, the designed constructions and installations ensure the quality of the environment. Contamination of flora and fauna in the area of influence has not been noticed in the current operation of U1 and U2 since commissioning until now.

The impact on biodiversity (aquatic environment, flora, fauna) during the execution period of the RT-U1 and DICA-MACSTOR 400 project is insignificant.

The impact on biodiversity (aquatic environment, flora, fauna) during the operational period of the RT-U1 and DICA-MACSTOR 400 project is insignificant.

Given that the potential for a negative impact on the criterion elements that were the basis for the designation of Natura 2000 sites in Romania in the considered area of influence remains insignificant, we also estimate an insignificant impact on the sites that complete the Pan-European network on the territory of Bulgaria (SCI: BG0000106 Harsovska Reka, BG000017 Suha Reka SPA: BG0002048 Suha Reka, BG0002039 Harsovska Reka etc.).

- **Evaluation of the impact on the health of the population**

In order to assess the impact on the environment for the project *" Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules "*, the Study of the impact on the health of the population - May 2024 was developed by the National Institute of Health Public (INSP).

Radiological impact on population health - From the analysis of the results of environmental radioactivity monitoring at Cernavoda NPP, it emerged that the only radionuclides for which a potential additional dose to the population, as a result of radioactive emissions from the plant are tritium (H-3) and carbon-14 (C-14). For these radionuclides, the annual doses that may be received by representative members of the population have been estimated, according to the methodology for calculating the derived release limits for Cernavoda NPP (IR-96002-027).

The doses for the critical population groups (adults and children 0-1 years) were calculated starting from the gaseous and liquid emissions (evacuations) of the two nuclear units (for H-3 and C-14) as well as based on the concentrations measured in the samples in the routine environmental radioactivity monitoring program at the Cernavoda NPP (for H-3, as C-14 is not detectable in the environmental samples taken outside the exclusion zone of the Cernavoda NPP – 1 km around each reactor).

To provide a context for the possible significance of these doses, *the dose* and the *(estimated) risk for a member of the critical groups living in the vicinity of Cernavoda NPP were considered* for the analysis.

For conservative reasons, the calculations regarding the effects on the health status of the population were performed using the *maximum doses*. Considering the final LAR result (lifetime attributable risk), *the average value of the dose over the ten years* was used in calculations. At the same time, *the minimum and maximum values* for the two age groups from the three locations were estimated. (Cernavoda, Seimeni, Constanta).

According to the hypothesis of the evolution of the radioactive emissions of Unit 1 of Cernavoda NPP during the refurbishment processes and during the commissioning period after refurbishment, the only radioactive emissions whose significant increase could be anticipated as a result of the activities during the refurbishment interval are those of Tritium, with a low probability of exceeding the approved derived emission limits for Unit 1 during normal operation (the derived emission limits approved for Unit 1 are more than ten times higher than the recorded emission levels during the period of operation).

This hypothesis is supported by the radioactive emission data of the nuclear power plant at Point Lepreau (PLGS) and the nuclear power plants Bruce A and Bruce B during a similar refurbishment process.

Starting from the assumption that the annual emissions of tritium, via liquid radioactive effluents, will increase by an order of magnitude in the first year of the time interval in which the refurbishment works will be carried out at Unit 1, an increase in the effective dose for people from Seimeni, at values of 0.72 µSv for adults and 1.30 µSv for children, compared to the maximum dose values calculated during the period of operation of 0.53 µSv for adults and 0.96 µSv for children.

Consequently, it is not expected that the LAR (lifetime attributable risk) values will change significantly during the project development compared to the normal operating situation.

To further put the risk analyzes into context, the results of the *Health Surveillance Study of the populations living in the vicinity of some major nuclear objectives in Romania*, a study developed by the National Institute of Public Health since 1989, were analysed.

According to the methodology of this ecological study, a series of health indicators are analyzed annually, namely demographic data, the incidence of specific types of cancer and the mortality related to these populations. The population size was obtained for the localities situated 30 km around the Cernavoda NPP site (called the proximity zone) and includes the resident population in this area. The health indicators relevant to this study and which allowed a dynamic analysis of the last 10 years, were: Standardized incidence reports of leukemias/lymphomas and solid tumors and Standardized reports of specific mortality from leukemia/lymphomas and solid tumors (new cases observed/new cases expected). The reference population was considered the population of Romania.

The results of this ecological study reveal the fact that the *standardized reports of the incidence of leukemia/lymphomas and solid tumors* ***are sub-unit*** *for the population in the vicinity of Cernavoda NPP for the entire analyzed period.* In other words, if the specific incidences per age group from the considered reference population (the population of Romania) had been applied, a higher number of specific cancers than the one recorded would have been expected. Similarly, *the standardized reports of specific mortality due to leukemia/lymphomas as well as the standardized reports of specific mortality due to solid tumors for the population in the vicinity of Cernavoda NPP* ***are, in this case also, subunits****, for the entire analyzed period.* These results indicate that, if the specific mortality by age groups of the entire country had been applied to the population in the analyzed area, a higher number of specific deats than the one recorded would have been expected.

Thus, ***the health impact assessment study - developed by the INSP - indicates that there will be no significant radiological impact on the health of the population in the proximity area (30 km) of the Cernavoda NPP because of the implementation of the project***.

Given that the risks for people who live further from the proximity zone (of 30 km) of Cernavoda NPP will be lower, because the dose decreases with increasing distance, in a transfrontier context, the implementation and operation of the project will not have a significant radiological impact on the population health.

Non-radiological impact on the health of the population – Based on the assessment of the non-radiological impact on the abiotic environmental factors, the study of the impact on the health of the population estimated that both during the project implementation period and during the operation period:

- ***there will be no significant impact*** on the health of the population in the area adjacent to the Cernavoda NPP due to the AIR environmental factor;
- ***there will be no significant impact*** on the health of the population in the area adjacent to the Cernavoda NPP due to the WATER environmental factor;
- ***there will be no significant impact*** on the health of the population in the area adjacent to the Cernavoda NPP due to the SOIL environmental factor;
- from the analysis of the NOISE maps, it is observed that exceeding the values of 50/55 dB could occur outside the location of the Power Plant only in certain phases (constructions complementary to the refurbishment) and on a limited area - but which could overlap with some existing constructions, located in the north-west vicinity.

Note: In accordance with *ORDER no. 994 of August 9, 2018 for the modification and completion of the Hygiene and Public Health Norms regarding the living environment of the population, approved by Order of the Minister of Health no. 119/2014*, the limits of noise level values refer to protected areas, i.e. those containing *sensitive receptors (homes, schools, hospitals)* as defined by Law 121/2019 on the assessment and management of ambient noise.
There are no sensitive receivers in the vicinity of the Cernavoda NPP territory, the existing buildings have other uses.

Following the analysis carried out to characterize the current state in the Cernavoda NPP area, it was found that ***the noise levels generated by the operation of the objectives on the site fall within the limits established by SR 10009: 2017***. Acoustics. Admissible noise level limits in the ambient environment.

- the SOCIO-ECONOMIC **impact** is a **positive** one - through the generation of jobs.
- under the conditions of compliance with the project and the recommendations from expertise/studies, the activities that will be carried out within this investment objective will not negatively affect the health of the population in the area, through the application of the provided measures.

- **Residual impact**

Following the analyzes carried out, we appreciate that the implementation and operation of the RT-U1 and DICA-MACSTOR 400 project does not result in residual impact.

From the point of view of biodiversity, the occupation of the land by built objectives definitely defines a category of residual impact (at least from the perspective of the support function). But taking into account:

- The nature of the targeted sites, deeply modified by previous works and current human activity (industrial function of the technological platforms belonging to Cernavoda NPP)
- The reduced bio-eco-cenotic value of these sites that only maintain ruderal formations that provide installation conditions (trophic niches/support niches) only for a limited number of synanthropic, omnivorous species, etc.

- The measures undertaken for the ecological restoration and revitalization of some green and free proximal spaces in order to support some highly diversified components of flora and fauna as part of a dynamic component aimed at supporting a monitoring program based on bioindicators,

it causes the residual impact to be considered to be nil.

Following the analysis carried out within the Population Health Impact Assessment Study, it is estimated that the implementation and operation of the RT-U1 and DICA-MACSTOR 400 project does not generate a residual impact.

- **Transfrontier impact**

Regarding the cross-border impact generated by the RT-U1 and DICA-MACSTOR 400 project, it is estimated that:

- ***during the project implementation stage - there will be no significant negative effects*** on the environmental factors of water, air, soil, human factor and biodiversity, since - based on the international experience for similar projects - the emissions will be within the limits established by the regulatory acts.
- ***during the operation period of the project - there will be no significant negative effects*** on the environmental factors water, air, soil, human factor and biodiversity, since the operation of the refurbished U1 unit and DICA-MACSTOR 400 will be similar to the operation of U1 in the first operating cycle, with DICA-MACSTOR 200.

As a result of the environmental assessment, the transfrontier impact on the environment and population of Bulgaria is assessed to be insignificant at 25 km and at 40 km*,* as the operation of the refurbished U1 + U2 + extended DICA has the same effects as in the current, regulated operation.

- **Cumulative impact**

For the evaluation of the cumulative impact, the following were considered:

- ***the list of projects on the Cernavoda NPP site,*** approved by the environmental authorities/CNCAN and their development schedules
- ***current activities*** - ongoing on site and regulated from the point of view of environmental protection, such as the operation of the U1 unit until shutdown for refurbishment, the operation of the U2 unit, the operation of DICA, other support activities for operation,

being analyzed 3 relevant scenarios corresponding to the development stages.

The estimated schedule for the development of the RT-U1 and DICA–MACSTOR 400 project and the existing and/or approved projects at the Cernavoda NPP site, in conjunction with the current activities carried out 2023-2037

Project / Objective	2023	2024		2025		2026		2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	Legend
	sem II	sem I	sem II	sem I	sem II	sem I	sem II												
U2																			construction
U1 first cycle of operation																			operation
DIDR-U5		April 2024				April 2026	DIDR U5 in operation from July 2026 -												
RT-U1								shutdown, retubing		tests May-Sep 30/09/2029									
U1- post refurbishment											REBURBISHED U1 IN OPERATION								
DICA-MACSTOR 200	OPERATION with modules MACSTOR 200				DICA IN OPERATION with 17 modules type MACSTOR 200														
	construction M16 MACSTOR 200		construction M17 MACSTOR 200																
DICA-MACSTOR 400					from sem II 2025 - construction M18 ... 1.5 years/module MACSTOR 400														
								DICA IN OPERATION with MACSTOR 400 modules											
U5-DEI 2016 Works necessary to change the destination of the existing buildings on the site of Unit 5	execution of works for U5 until Dec. 2024																		
CTRF	construction + tests without tritium							tests with tritium March - Aug 2027	CTRF IN OPERATION starting Sep 2027										
U3, U4							construction and tests						U3 , U4 IN OPERATION						

NOTE: The period analysed for cumulative impact is 2023 – 2037, and the period 2032 - 2037 for Stage III is the peak period of activity on site, as all nuclear units, including U3 and U4, will be in operation from 2032. The year 2037 represents the time when Unit 2 will enter the refurbishment process.

Analyzing the sequence of activities in the timetable of existing and/or approved projects and activities on the Cernavodă NPP site - presented in above table, the EIA developer established 3 stages corresponding to the *relevant scenarios* for **the cumulative impact assessment**:

- Stage I_2024 - 2026 MAINLY EXECUTION
- Stage II_2027 - 2029 SHUTDOWN RETUBING, TESTS and CONSTRUCTION
- Stage III_2032 - 2037 ALL NUCLEAR OBJECTIVES IN FUNCTION ON NPP SITE.

The time periods for these milestones were chosen according to the predominance of the types of activities to be carried out: construction, refurbishment and testing, operation.

The cumulative impact assessment was carried out for the relevant environmental factors, on non-radiological and radiological aspects, for each of the three phases/scenarios.

Considering the nuclear specificity, it was estimated:

- for Stage I and Stage II – ***the cumulative radiological impact on environmental factors is minor, local, reversible, with short-term effects***.
- for Stage III - in which all the nuclear objectives operate at the Cernavoda NPP site" - ***the cumulative radiological impact on environmental factors is insignificant, local/regional, reversible, with long-term effects***.

From a non-radiological point of view, the following were estimated:

- for Stage I and Stage II – ***the cumulative non-radiological impact on the environmental factors water, biodiversity, climate, the human factor through noise emissions and vibrations, is insignificant, and for the environmental factors air and soil it is minor***.
- for Stage III – in which all the nuclear objectives on the Cernavoda NPP site operate - ***the cumulative non-radiological impact on the environmental factors water, air, soil, biodiversity, population health is insignificant, and for the climate it is a positive impact***.

Regarding the projects approved/developed in the localities in the vicinity of the Cernavoda NPP platform, considering their profile and the fact that they are outside the exclusion zone (of 1 km around the reactors in operation), it was estimated that **the project RT-U1 and DICA-MACSTOR 400 Extension will not have cumulative effects with these projects**.

- **Measures proposed by the project in order to maintain the current state of the environment in the Cernavoda NPP area**

No significant negative effects were identified in the environmental impact assessment.

The measures considered by the owner to maintain the current state of the environment in the Cernavoda NPP area are presented below.

Environmental factor	*Measures provided by the project*
Air	***During the execution:*** - measures to limit emissions during transport and execution of excavations - internal transport planning - covering the materials during transport - the use of modern vehicles/equipment - the new DIDR-U5 will be equipped with a ventilation system, a filtration system with HEPA filters and an exhaust air monitoring system. - the collection, treatment, and monitoring systems of radioactive effluents from U1 will be kept in operation. ***During the operation:*** -Following the refurbishment of U1, the frequency of CTP use will decrease, because of the chosen constructive alternative. -The testing of Diesel groups will be carried out successively, so that the limit values of the concentrations of specific pollutants in the environment are not exceeded
Water	***During the execution:*** - The existing local systems on the site allow the routing and collection of possible rainwater runoff, and their evacuation follows the current flow of control and evacuation from the site. - Supplementing the intangible fire reserve through the construction of 2 new storage basins. - An ecotoxicological study was carried out for the use of Odacon F. ***During the operation:*** - Additional measures and conditions for monitoring the phreatic aquifer are implemented and will be provided for in the Water Management Permit issued for the project: - additional observation boreholes in the DICA-MACSTOR400 area -new observation boreholes around the new DIDR-U5 - Quantitative and qualitative monitoring of abstracted water volumes according to Cernavoda NPP internal procedures and according to the Environmental Authorization and Water Management Authorizations.
Soil	***During the execution:*** - After the completion of the works, the land will be rehabilitated by scarification and grassing. ***During the operation:*** - The additional measures and conditions for monitoring the phreatic aquifer will be provided in the Water Management Permit issued for the project and will also cover soil quality control in the extended DICA and the new DIDR-U5 areas.
Waste generation	
- radioactive, low and intermediate-level	***During the execution:*** - the arrangement of the new DIDR-U5 for the intermediate storage of low and medium active waste resulting from refurbishment - the internal transfer of radioactive waste according to the updated procedures of Cernavoda NPP ***During the operation:*** - intermediate storage in DIDR-U5 until final disposal to the national repositories (DFDSMA, DGR).

Environmental factor	*Measures provided by the project*
Spent nuclear fuel	***During the execution/ During the operation:*** Intermediate storage on site under controlled conditions, like the current situation, according to Cernavoda NPP procedures approved by CNCAN, until transfer for final storage in the national repository (DGR).
Non-radioactive	***During the execution/ During the operation:*** Collection and separate storage of waste, for the purpose of recovery/disposal by authorized operators
Dangerous non-radioactive	***During the execution/ During the operation:*** Storage under controlled conditions and in specially provided spaces on site, for the purpose of recovery/disposal by authorized operators.
Household	***During the execution/ During the operation:*** Collection and storage in dedicated containers and disposal by authorized operators.
Management of hazardous substances (other than radioactive)	***During the execution:*** The Security Report 2018 edition, revision 2, drafted in 2023 includes the changes expected through the implementation of this project. ***During the operation:*** reviewing and updating the Safety Report if changes are made to an installation, a location, a storage area or a process, or changes to the nature, classification or quantity of hazardous substances used.
The human factor Population health	***Pe durata realizării/Pe durata funcționării***: - for the project: implementation of a surveillance and monitoring program for liquid and gaseous radioactive effluents - for DICA - installation of additional protective shields of adequate thickness for the duration of the workers' presence if the dose rate limit of 25μSv/h is exceeded at the accessible external surface of modules.
Biodiversity (fauna, flora, environment aquatic)	***During the execution:*** - verification of the site and its release (translocation) of any species of flora and fauna with reduced locomotor capacity, towards suitable proximal areas (green spaces), before the start of land sealing works; ecological surveillance of the site will be ensured to ensure the translocation of possible species of fauna that enter areas with potential technological risk (construction site, work fronts, etc.) - Installation of textile mesh (site shade net - green) with the role of reducing the spread of dust at the boundary of the site - Wetting (sprinkling) work fronts and unstructured access ways - The use of light sources without the UV component to attract species with nocturnal activity. - Keeping earth ramps at 45^o inclinations at the level of excavations, ditches, and foundation pits, to allow micro/mesofauna species that may accidentally fall into them, to climb them. - Driving at low speed on unstructured access roads inside the site perimeter. - Realization of a convex profile at the level of the access roads, to allow the drainage of rainwater towards their limit and thus to avoid the appearance of puddles. ***During the operation:*** At the level of free spaces, measures will be applied to ensure a revitalization of biocenoses by installing microhabitats and artificial structures. Colonization with species of flora and fauna will be encouraged by promoting the natural succession of vegetation[149] and implementing active measures to create ecological niches. In this way, conditions will be created for the observation and surveillance of flora and fauna under conditions of maximum exposure, thus generating an extremely effective biodiversity monitoring potential, having the

[149] *environmental friendly nuclear plant*: https://www.bbc.com/news/business-59212992 , https://www.power-technology.com/features/featurenuclear-power-good-for-biodiversity-4583904/?cf-view , https://sciencemediahub.eu/2023/02/08/bent-lauritzen-interview-nuclear-energy-innovation-and-sustainability/

Environmental factor	*Measures provided by the project*
	potential to function as an early warning[150] system, in a way to detect possible effects associated with the functioning of the built structural components, knowing their bioindicator capacity.

❖ **Monitoring**

The monitoring of the state of the environment will consider the use of the available information provided by the programs regarding the control of emissions, monitoring of environmental factors and waste management established by the regulatory acts issued by the Ministry of the Environment/CNCAN and currently carried out by the holder. Considering the specifics of the activities carried out on the Cernavoda NPP platform, the monitoring programs are established in such a way as to highlight the radiological, chemical and thermal impact on the environment.

During the implementation of the project, the existing monitoring programs will be supplemented as follows:

- ***For unit U1***: the current monitoring programs, provided by the authorizations issued by the Ministry of Environment, Water and Forests/ CNCAN/ ANAR, will be continued.
- ***For the new DIDR-U5***:
  - the management of the waste generated from refurbishment and stored intermediately in this facility will be carried out;
  - continuous monitoring of beta and gamma radiation levels in gaseous effluents will be carried out;
  - a radioactive effluent monitoring program will be implemented;
  - the internal monitoring network will be extended around the new DIDR-U5 for monitoring gamma radiation in the ambient environment.
- ***For DICA***: the existing monitoring will be continued through the programs imposed by the competent environmental authorities and CNCAN.

During the operation period of the project - the existing monitoring programs will be expanded by introducing qualitative and quantitative monitoring of the phreatic aquifer, for the observation boreholes provided in the new DIDR-U5 and the area of DICA extension.

Considering the nuclear specificity of the activities carried out at the Cernavoda NPP site, ***the programs for monitoring radioactive emissions and environmental radioactivity, respectively,*** currently carried out at the Cernavoda NPP will continue both during the implementation period and after the commissioning of the refurbished U1.

Monitoring of radioactive gaseous effluents from U1 – will continue both during the implementation of the project and after commissioning of the refurbished U1. Representative samples are taken from the ventilation stack. The analyzes performed on sample types are:

[150] C. Patrick Doncaster & Colab. (2016): Early warning of critical transitions in biodiversity from compositional disorder, Ecology, 97(11), 2016, pp. 3079–3090
Huang H, Wu W and Li K (2023) Editorial: Nuclear power cooling-water system disaster-causing organisms: outbreak and aggregation mechanisms, early-warning monitoring, prevention and control. Front. Mar. Sci. 10:1218776. doi: 10.3389/fmars.2023.1218776

Samples of gaseous effluents from the ventilation stack of U1

Sample type	**Analysis**	**Frequency**	**MU**
Particle filter	Spectrometry y, α - ß gross	daily	Bq/m^3
Active carbon filter	Spectrometry y	daily	Bq/m^3
Water vapor collectors	Tritium - liquid scintillator	daily	Bq/m^3
CO_2 collector	C-14 - liquid scintillator	daily	Bq/m^3
Radioactive noble gases	online measurements with the Gaseous Effluent Monitor		

Additionally, the project provides for ***the continuous monitoring of beta and gamma radiation levels in the gaseous effluents from the new DIDR-U5***. The monitoring system will have to be functional throughout the operation period of the new DIDR-U5, including the shutdown stage of the unit U1 for refurbishment.

Monitoring of radioactive liquid effluents – The liquid radioactive waste produced on the NPP site, including from the new objectives on the site, are directed to the Aqueous Liquid Radioactive Waste Management System within the U1/U2 units.

Samples of liquid effluents from the tanks of the liquid radioactive waste management system are taken by the Liquid Effluents Monitor during the evacuation of the tanks. The following analyzes are performed on the liquid samples collected for each individual tank:

Samples of liquid effluents from tanks
Aqueous liquid radioactive waste management system

Sample type	**Analysis**	**Frequency**	**MU**
Daily	Spectrometry y, Tritiu, C-14	Daily	Bq/l
Weekly composite	α-ß gross	Weekly	Bq/l

To control liquid effluent discharges, a sample is taken from the Condenser Cooling Water Channel, in accordance with the Environmental Radioactivity Monitoring Program.

The environmental radioactivity monitoring program currently carried out at Cernavoda NPP will be continued both during the implementation period and after the commissioning of the refurbished U1 and will include the following types of samples, types of analysis, sampling and analysis frequencies. **The environmental radioactivity monitoring program will be extended by introducing new sampling points (infiltration water, external gamma dose, soil) according to specific requirements under the authority of CNCAN.**

The environmental radioactivity monitoring program carried out at the Cernavoda NPP and proposals for the project " Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules"

Sample type	Sampling frequency	Analysis type	Analysis frequency	Development proposals
Environmental radioactivity monitoring program at Cernavoda NPP				
Particles in the air	continuously	gross β analyses γ spectrometry	monthly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
Iodine in the air	continuously	γ spectrometry	quarterly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
Tritium in air	continuously	LSC - tritium	monthly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
C-14 in the air	continuously	LSC - C-14	monthly - evacuations < MDA	
			weekly - MDA < discharges < 6 % DEL	
			daily - discharges > 6 % DEL	
TLD (ambient gamma radiation)	continuously	integrated exposure	quarterly - evacuations < MDA	Extended internal network around new DIDR-U5 and DICA expansion,
			monthly - evacuations > 6 % DEL	
Surface water	weekly	gross β analyses	monthly	
		γ spectrometry		
		LSC - tritium		
Condenser cooling water (CCW channel)	Continuous / weekly	gross β analyses	weekly	Gross α – β composite sample
		γ spectrometry		
		Tritium		
Meteoric rain water	depending on weather conditions	gross β analyses	Depending on the period in which the sampling is made	
		γ spectrometry		
		Tritium		
Infiltration water	monthly	gross β analyses	monthly	Qualitative and quantitative monitoring of observation boreholes provided for in the new DIDR-U5 and the extended DICA
		γ spectrometry		
		Tritium		

Sample type	Sampling frequency	Analysis type	Analysis frequency	Development proposals
Environmental radioactivity monitoring program at Cernavoda NPP				
Deep groundwater	monthly	gross β analyses γ spectrometry Tritium	monthly	
Drinking water	monthly	gross β analyses γ spectrometry Tritium	monthly	
Soil	biannual	gross β analyses γ spectrometry Tritium	biannual	
Sediment	biannual	gross β analyses γ spectrometry Tritium	biannual	
Milk	weekly	gross β analyses γ spectrometry Tritium C-14	weekly (gamma spectrometry and H-3) monthly (gross beta and C-14)	
Atmospheric deposits	continuously/ monthly	gross β analyses γ spectrometry Tritium	monthly	
Fish	biannual	gross β analyses γ spectrometry Tritium C-14	biannual	
Meat	biannual	gross β analyses γ spectrometry Tritium C-14	biannual	
Vegetables	annually	gross β analyses γ spectrometry Tritium C-14	annually	
Fruits	annually	gross β analyses γ spectrometry Tritium C-14	annually	
Spontaneous vegetation	monthly, may – October	gross β analyses γ spectrometry Tritium C-14	monthly	
Eggs	annually	gross β analyses γ spectrometry Tritium C-14	annually	
Cereals	annually - wheat biennial - corn	gross β analyses γ spectrometry Tritium C-14	annual - wheat biennial - corn	

MDA = minimum detectable activity; DEL = Derived Emission Limit; TLD = thermoluminescent dosimeters; CCW channel = condenser cooling water channel.

The biodiversity monitoring program will cover the construction period, followed by a monitoring program lasting 36 months from the commissioning of the refurbished Unit 1.

The monitoring programs have the role of providing information on the effects of Cernavoda NPP activity on biodiversity.

Based on the annual reports, the effects of the project on biodiversity will be evaluated, and the indicators of interest that should be included in an ecological surveillance program, in correspondence with the monitoring program for other environmental factors, will be established.

The proposed monitoring program targets various species (fauna, flora, aquatic environment), within a radius of 1 km around the Cernavoda NPP site during the construction phase, respectively at distances of 1, 3, 5, 10, 20, 30, 40 km on 3-4 cardinal points during the operation period.

A proposed monitoring calendar can be found summarized in the following table:

Proposal for a calendar for the implementation of biodiversity monitoring measures

Stage	Month		
	M-1	M 1:36 Functioning **	> M 36 Operation
RT-U1 sub-project implementation monitoring programme			
Monitoring programme in the implementation phase of the sub-project DICA-MACSTOR 400*			
Monitoring programme of the functioning stage			
Ecological monitoring program***			

where M = Month of start of works
** The biodiversity monitoring program for the DICA-MACSTOR 400 sub-project will correlate with the execution planning of the MACSTOR 400 modules.*
***M 1:36 Functioning – represents the period of 36 months after the refurbished Unit U1 went into functioning.*
**** The ecological monitoring program – will be established according to the monitoring results of the first 36 months of operation of the refurbished U1 Unit.*

❖ **Assessment of the relevant risks associated with the project in case of accidents/disasters. Measures considered to prevent/mitigate significant negative effects on the environment**

- ***Risk assessment associated with activities that present major accident hazards involving dangerous substances***

Cernavodă NPP site falls within the provisions of Law 59/2016 *on the control of major accident hazards involving dangerous substances*, as an upper tier establishment, according the competent authorities decision.

The provisions of Law 59/2016 do not apply to the hazards created by ionising radiation originating from substances (according to article 2, point b).

Based on the Decision of the scoping stage, Cernavoda NPP developed the Safety Report, edition 2018, revision 2, in 2023, which includes the changes expected through the implementation of the project ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*”.

The Safety Report highlighted the following aspects:

– Regarding the danger potential generated by the presence of hazardous substances and the quantities of hazardous substances that may be present, during the implementation of the project " *Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*” are not expected changes compared to the existing situation. The same hazardous substances covered by Law 59/2016 will be used, and the quantities will not exceed the maximum quantities already in place.
– No dangerous chemical substances will be used in the implementation of the sub-project *"Extension of the Spent Fuel Intermediate Storage with MACSTOR 400 Modules"*. Thus, from the perspective of the Control of the dangers of major accidents involving dangerous substances, sub-project RT-U1 is relevant.

Accidents involving dangerous substances that can occur at the Cernavoda NPP site can be grouped as follows: Leaks and emissions of dangerous substances, Fires, Explosions.

The technological risk assessment process was carried out in two major stages, namely:
– Preliminary risk analysis - Qualitative analysis;
– Detailed risk analysis - Quantitative analysis.

From the qualitative risk analysis, it resulted that the ***risk of major accidents on-site*** is ***moderate*** due to the relatively small quantities of hazardous substances present and existing protective measures: retention tank bunds, protected tanks (concrete or buried constructions, insulation, etc.), protected surfaces, spill collection vessels, automated flow control, detection sensors, adherence to work procedures, and safety standards. *Scenarios that could have catastrophic consequences are scenarios with isolated or improbable probabilities, while scenarios that could have major consequences are scenarios with isolated or occasional probabilities.*

Scenarios that could have major or catastrophic consequences were further subjected to quantitative risk analysis and evaluated through consequence and frequency analysis.

Following the preliminary risk analysis for the RT-U1 and DICA–MACSTOR 400 projects, ***no accident scenarios requiring additional quantitative analyses were identified for the implementation period of the RT-U1 and DICA–MACSTOR 400 project, other than those analyzed for the existing situation*** prior to the shutdown of Unit 1.

As some of the dangerous substances on the site will continue to be used in the same quantities (technical gases, diesel, hydrazine, morpholine) and others will be reduced for a limited period of time in U1 (hydrogen) following the emptying of the system during the implementation of the project, it can be concluded that the RT-U1 and DICA-MASTOR 400 project ***does not increase the chemical risk on the site***.

The distances calculated following the quantitative risk analysis and the analysis of the consequences, do not exceed the low population zone established around Cernavoda NPP.

Thus, in case of a possible major chemical accident there will be no potential impact in a transfrontier context.

The results of the risk assessment associated with activities that present major accident hazards involving dangerous substances are presented in Annex 6.

Measures Considered for Preventing Significant Negative Environmental Effects

Cernavoda NPP has adopted a policy for the prevention of major accidents involving dangerous substances with the aim of preventing and limiting the consequences on the health of the population and the environment, by ensuring a high level of protection, in an adequate and efficient manner. The major accident prevention policy is integrated into the Cernavoda NPP Policy. Also, Cernavoda NPP has implemented a solid Management System, with clear procedures and instructions and verified in the plant's operating experience.

The Internal Emergency Plan was drawn up (2018 edition, revision 3, 2022), according to Order no. 156 - Methodological Norms of December 11, 2017 regarding the development and testing of emergency plans in case of major accidents involving dangerous substances, issued by the Ministry of Internal Affairs.

The internal emergency plan is based on the risk analysis results from the Safety Report, identified accident scenarios, and outcomes.

- ***Risk assessment based on nuclear security analyses***

Events or accidents with radiological implications

This category refers to the events or accidents that may occur during the implementation of the project for Unit 1 refurbishment and DICA extension and which involve radioactive materials or contaminated components of the installations, except for the reactor and its annexes. At the time of the preparation of this report, no radiological safety analyzes are available at Cernavodă NPP for postulated events in this category, but an identification and evaluation process regarding this is underway, which will form the basis of the analysis and approval by CNCAN in the stages of authorization specific to the activities of the project *"Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*”.

In order to formulate a point of view on the radiological consequences on the environment as a result of some events in the above category, the relevant international experience was used in this report. Thus, it is possible to cite the analysis performed within the refurbishment project carried out at the power plant in Darlington, Canada (DNGS), where, following the evaluation of possible accident scenarios, four scenarios of reference as follows were chosen in order to carry out radiological safety analyses:

- The fall of the transfer container for retubing components, with the loss of its containment capacity
- On-site traffic accident involving the dry storage container (DSC) transporter
- Leakage of tritiated heavy water from the moderator circuit as a result of a broken pipe
- Damage to spent nuclear fuel in the storage.

The results of the assessments, regarding the radiological consequences of such events, showed that the additional doses for workers and the population will fall within the exposure limits established by national regulations (Environmental Impact Statement New Nuclear – Darlington Environmental Assessment NK054-REP-07730-00029).

As far as the DICA extension sub-project is concerned, from the point of view of this type of events, relevant are the safety analyses presented in the Final Nuclear Safety Report for DICA-MACSTOR 200 and the safety analyses carried out in preparation for the implementation of the MACSTOR 400 extension sub-project. For this purpose, a series of events postulated for the period of operation of the storage facility were analyzed, as well as events related to the operations in the area of transfer and loading of spent fuel. Next, the events analyzed are briefly presented, together with the conclusions of the analyses.

The results of the radiological risk assessment for project-based accident cases (with a frequency of occurrence greater than 10^{-6}/year), postulated at DICA Cernavoda, indicate that the radiation dose values for the stable population, located at least 800 m from the center of the storage facility, are less than 1% of the annual limit value imposed by CNCAN for DICA Cernavoda (50 microSv/year). The doses for DICA being so small, they will not affect the maximum limits allowed in the event of an accident at the NPP.

Events with a frequency of occurrence less than 10^{-6}/year, the consequences of which may be more serious, are called severe accidents or accidents beyond design limits. This category includes the following analyzed events:

- the (random) DICA impact with a small plane or an airliner (commercial);
- strong storms (tornadoes);
- the fall of the gantry crane.

  - The event of blocking the air inlets and outlets on the same side of the storage module can occur in case of heavy snow accumulations, which are very unlikely for Cernavoda. For the reference project, however, this event is part of the set of Design Base Events.
  - At the Cernavoda NPP site, F5 level storms (on the Fujita scale) are unlikely, but DICA's reference project considered the consequences of strong winds and projectiles generated by F5 level tornadoes. The storage modules were designed to withstand the loads generated by strong storms, combining the rotation and translation generated by wind speeds of 420 km/h.
  - The gantry crane is equipped with anti-derailment clips, which prevent accidental derailment and possible overturning during seismic events.

    The gantry crane on row 1 and row 2 of the modules are qualified for an earthquake with pga=0.3 g. The cranes' earthquake qualification falls under seismic category A and structural integrity is ensured in the event of an earthquake.

    The fall of the gantry crane is only possible in the case of an event beyond the design bases and, consequently, classified in the category of severe accidents. If this event were to occur, the impact of the fall of the gantry crane on the module is less than that produced by projectiles generated by tornadoes and would have no radiological consequences.
  - The structure of the MACSTOR storage module is compact and robust, having significant strength reserves with a large margin of safety against the design loads. These characteristics lead to the limitation of possible damages induced by the postulated severe accidents. Due to the dry storage of the fuel after its cooling for 6 years and due to the protective barriers, the release of volatile radionuclides is only possible by heating the stored fuel to a temperature above 600°C.

The on-site emergency plan of Cernavoda NPP covers all events postulated by DICA.

The emergency plan and procedures also contain the emergency measures and actions that are applicable to the DICA objective.

Transport accidents

The possibility of transport accidents that may arise from the activities associated with the U1 refurbishment and DICA extension project is excluded.

Nuclear accidents

This category of accidents is applicable only to the U1 refurbishment sub-project and can occur during the periods of reactor operation: until its shutdown and discharge of nuclear fuel (during the preparation stage of retubing) or during the commissioning and test operation stage. The accident scenarios that must be taken into consideration are similar to those included in the safety analyzes included in the final safety report of the plant, approved by CNCAN.

Based on the assessment of the nuclear installation design, operating procedures and potential site-specific external influences, Cernavoda NPP has identified a list of internal and external events, covering all states and operating modes of the nuclear installation and all scenarios that could lead to affecting nuclear safety functions.

Design basis events include anticipated operating transients and design basis accidents, also called postulated accidents.

Anticipated operational transients represent events that may occur once or more during the plant's operational life. For a CANDU-type nuclear power plant, anticipated operational transients include:

– Failure of the reactor control systems;
– Failure of the instrument air system;
– Loss of normal electricity supply;
– Triggering in operation of a main pump in the primary heat transport system;
– Untimely opening of the pressure control or discharge fittings of the primary heat transport system or the systems connected to it;
– Unavailability or malfunctioning of the moderator system.

Design basis accidents for a NPP represent events with significant consequences, with a low probability, which are not expected to occur in reality but which must be considered in nuclear safety analyzes in order to ensure the protection of the population in the situation where such events would occur. For a CANDU type NPP, they include:

– Rupture of any pipe or any collector in the primary cooling system of the reactor;
– Rupture of a pressure tube and its associated calandria tube;
– Rupture of the steam generator tubes;
– Failure of a terminal fitting of the fuel channel;
– Blockage of flow in the fuel channel;
– Failures of the fueling machine;
– Damage to the water supply system of the steam generators or the live steam system, including pipe breaks.

Also, to ensure sufficient nuclear safety margins, the assumptions used in the analyzes are conservative and assume the operation of the protective systems at the minimum level of admissible performance.

As part of the implementation of the protection in depth concept, Cernavoda NPP also analyzed conditions more severe than the design basis accidents, called design basis extension conditions.

The conditions for expanding the design bases include two categories of events:

- events and combinations of events that can lead to the systematic failure of the nuclear fuel in the core of the reactor; for these events, dedicated SSCEs are provided at Cernavoda NPP and procedural measures are implemented to prevent serious damage to the reactor core and the melting of nuclear fuel in the reactor core;
- events in which the capability of the nuclear facility to prevent systematic failure of nuclear fuel is exceeded or in which it is assumed that the provided measures do not work as expected, thus leading to severe accident conditions; at Cernavoda NPP, feasible procedural measures have been established and the nuclear facility includes specific SSCEs, provided for stopping the progression of the severe accident and limiting the consequences of these accidents.

Additional information representing examples of extending the analyzed design bases can be found in the EIA in subchapter 8.2. Also, this sub-chapter provides dose criteria for the analysis of design basis events for nuclear installations as well as the measures and strategies implemented at Cernavoda NPP for events that exceed the design basis.

From subchapter 8.2 of the RIM it is noted that the maximum value of the effective dose at a distance of 30 km from the plant is 16 microSv, which means that for any person located on the territory of neighboring countries (Bulgaria or Ukraine), the effective dose as a result of the Design Base Event (DBA) with the most serious consequences in terms of radiological impact on the population, will be lower than this level. It should be noted that the value of 16 microSv corresponds to exposure to the natural background radiation (including exposure to radon) over a period of 58 hours (considering an average value of the total effective dose due to radiation of natural origin of 2.4 mSv/year).

In conclusion, the Cernavoda NPP project is based on updated nuclear safety analyses, approved by CNCAN, which reflect the latest requirements and analysis methods, in accordance with national norms and international standards. The operation of the Cernavoda NPP is carried out in accordance with the limits and technical operating conditions, based on the current nuclear safety analyses, in this way ensuring safe operation, with minimal risks for workers, the population and the environment.

Criticality outside the core

This category of events implies the realization of the conditions for the occurrence of criticality when handling the nuclear fuel outside the core of the reactor. Given that for CANDU plants, the nuclear fuel contains natural uranium (in which U-235, the fissile isotope, has an abundance of about 0.7%, insufficient to create a critical mass), the occurrence of criticality is practically impossible when handling fresh nuclear fuel outside the reactor core, making any such event outside the reactor systems extremely unlikely.

Measures taken to prevent or mitigate significant negative effects on the environment and details of the degree of preparedness and proposed response in such emergency situations

Regarding the Unit 1 refurbishment sub-project, as shown before, the events with the most serious radiological consequences for the environment and the population are those which, although with an extremely low probability, may occur during the operation period of the plant, the severity of the consequences being closely related to the state of operation of the nuclear reactor at the time of the accident.

The Unit 1 project provides several levels of protection in depth, which ensures the prevention of accidents and adequate protection, should they occur:

- The first level of protection is given by the multiple measures to prevent deviations from normal operation, as well as system failures, which were considered when choosing the design: the application of quality control in design, construction, testing, maintenance and operation activities, conservative design, use of redundancy, independence and diversity, consideration of applicable hazards and internal and external operating experience.
- The second level of protection refers to the characteristics considered in the design of the SSCE that allow the control of deviations from normal operating states, so that an anticipated transient does not evolve into an accident. The results of the nuclear safety analyzes led to the inclusion in the Unit 1 design of specific SSCEs, which ensure an adequate response in the event of process disturbances.
- The third level of protection is given by the nuclear safety features provided in the SSCE project for situations where a transient could not be suppressed and thus could evolve into a design-based accident. Special nuclear safety systems were provided for this level, to ensure that the reactor can be brought to a safe shutdown state and at least one of the barriers against radioactive releases is maintained, by applying the operating procedures in abnormal conditions "*Abnormal Plant Operating Manual*" (APOP).
- The fourth level of protection is given by those SSCEs specially provided to ensure the containment of radioactive materials and the mitigation of consequences in severe accident events, when the "*Severe Accident Management Guidance*" (SAMG) procedures are applied.
- The last level of protection, the fifth, is ensured by the use of on-site and off-site emergency control centre facilities that mitigate the consequences of potential accidents.

The assessment of the impact on the environment in the event of the occurrence of the design basis accident can be found in subchapter 8.2 of the EIA.

- ***The potential effects on the population health arising from a malfunction, a radiological/nuclear accident***

The public health impact assessment study analyzed the potential public health effects arising from a malfunction, a radiological/nuclear accident. Thus, the conclusions of this study indicate the following:

The potential public health effects resulting from a malfunction, radiological/nuclear accident, or malicious act are often of interest to members of the public living near a nuclear facility. The first aspect of health concerns with malfunctions, accidents and malevolent acts is related to physical well-being or potential health effects but also the availability of adequate response capacity to a radiological or nuclear emergency.

Boundary scenarios with possible radiological impact were analyzed to determine a potential radiological impact on human health in the population in the proximity area, based on the information in subchapter 8.2. Thus, *a series of scenarios were examined regarding*:

1) Possible malfunctions and incidents/accidents and those related to the transport of low- and medium-level radioactive waste. The analysis concluded that no residual effect on the human health of the off-site population is expected because of these events.

2) A series of events with potential radiological consequences and accident scenarios to determine a series of credible scenarios and, respectively, to determine the resulting doses to members

of the public from these accident scenarios. From their analysis, it emerged that all doses were within the annual regulatory limits and no adverse effects on human health are anticipated.

3) Various scenarios regarding possible nuclear accidents. Nuclear accidents are those malfunctions and accidents that are believed to involve the operation of the reactor and associated systems and may lead to a release of radioactive material into the environment. The accident scenarios were also analyzed by considering potential internal and external initiating events that could lead to an abnormal release of radioactivity into the environment during radioactive waste management activities.

Additional information representing examples of extending the analyzed design basis can be found in the EIA in subchapter 8.2.

The regulated dose limit for members of the public is 1 mSv/year (1000 µSv/year). For emergency exposure situations, the reference level, expressed in terms of residual dose for the population, is in the range of 20 – 100 mSv, for the first year after the accident.

These regulatory limits were used for comparison with the doses resulting from radiological or nuclear malfunction and accident scenarios. As can be seen from the doses above, the doses to members of the public resulting from each scenario are all lower than the regulatory dose limits.

Consequently, no residual effects on human health are expected following events with radiological consequences and accidents on the site because of the implementation of the Project " Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules”.

In the unlikely event of declaring a radiological or nuclear emergency, the National Radiological or Nuclear Emergency Intervention Plan is triggered, which provides for the integrated implementation of measures, actions of the responsible authorities, to considerably reduce the effects of a possible event with major consequences.

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Note: There are multiple footnote references throughout the environmental study.