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

CHAPTER 9. NON-TECHNICAL SUMMARY

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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"

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.

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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.[1]

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*

[1] Refurbishment of Unit 1 of the Cernavoda Nuclear Power Plant, Stage 2 – Feasibility study, version v1, 2022

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accordance with nuclear safety analyzes and engineering evaluations; the refurbishment is a planned 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)."*

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❖ **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.

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- ***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.

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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 [2]:

- *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.*

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

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- *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.

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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.

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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.

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- **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[3].

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.

[3] 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

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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.[4]

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.

[4] Raport final de securitate nucleară Unitatea 1 - Rezumat, Februarie 2023

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❖ 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.

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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.

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- ***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.

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- ***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[5] 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***.

[5] **Ecotope -** A particular type of habitat in a region, https://hortiweb.ro/dictionar-general-de-botanica-e

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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.*

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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 Peștera - 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.

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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).

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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***.

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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.

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- 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.

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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.

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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[6] 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

[6] *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[7] 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:

[7] 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.

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 biodiversității	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 policloruraţi	*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 și 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