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# Environment Impact Assessment NPP Cernavoda 1 and Interim Waste Storage (Romania)


Refurbishment of npp Cernavoda 1 and Extension of Intermediate Dry Spent Fuel Storage with MACSTOR-400 Modules

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# ENVIRONMENT IMPACT ASSESSMENT NPP CERNAVODA 1 AND INTERIM WASTE STORAGE (ROMANIA)

## *Refurbishment of npp Cernavoda 1 and Extension of Intermediate Dry Spent Fuel Storage with MACSTOR-400 Modules*

Environment Impact Assessment

Bojan Tomic
Ioana Popa
Oana Velicu

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***Projektleitung*** Franz Meister

***AutorInnen*** Bojan Tomic (Enconet Consulting Ges.m.b.H.)
Ioana Popa (Enconet Consulting Ges.m.b.H.)
Oana Velicu (Enconet Consulting Ges.m.b.H.)

***Layout*** Felix Eisenmenger

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# INHALTSVERZEICHNIS

# EXECUTIVE SUMMARY

The Romanian NPP, located in Cernavoda, ~ 930 km away from the border with Austria, has two units in operation, both CANDU-PHWR-600 type reactors (CANadian Deuterium Uranium), using natural uranium as fuel and heavy water as moderator and cooling agent. They contribute with ~20% to the electricity generated in Romania. Unit 1 (U1) was put in operation in 1996, while Unit 2 (U2) was put in operation in 2007. CANDU reactors have an initial lifetime of 30 years; following a refurbishment process, this lifetime can be extended with another 30 years. The Energy Strategy of Romania considers nuclear energy as an important element for the security of energy supply, and as such a lifetime extension of U1 of Cernavoda NPP is envisaged; for this, a refurbishment and modernization project is proposed. A secondary objective of this project is to extend the on-site Spent Fuel Storage Facility with bigger modules, aiming to have a double storage capacity.

The refurbishment and life extension of U1 of Cernavoda NPP is already licensed by the nuclear safety regulatory authority of Romania, based on the

- Latest revision of the Final Safety Assessment Report (from 2022),
- Global Assessment Report of the Periodic Safety Review Report for U1 (from 2021) and the associated Action plan,
- Safety Case Report for Cernavoda NPP U1 extended operation and
- Operator Strategy and the plan for refurbishing of U1.

Cernavoda NPP has in place a program for surveillance and monitoring, testing and verification of all Systems, Structures and Components (SCC) important for safety, programs for preventive maintenance of these, a program for the management of the lifetime of the plant, including the ageing management, the refurbishment activities, and the nuclear safety analyses, which are all approved and periodically reviewed by the regulatory authority. According to the Romanian legislation, the nuclear safety license for a nuclear facility is preceding the Environmental Authorisation, without which the facility cannot be operated.

Based on the Romanian Environment Impact Assessment Law (EIA Law) transposing the EIA Directive (2011/92/EU as amended), the refurbishment of U1 and extension of the on-site Spent Fuel Storage Facility is subject to an EIA. As required by the Romanian Law ratifying the Espoo Convention, the project developer submitted the necessary documentation to the Romanian Ministry for Environment, Waters and Forests for starting the consultation process within the EIA procedure. A notification was also sent to Austria, which participates in this cross border procedure.

Being a potentially affected party in a case of a radiological release from Cernavoda site, Austria has an interest to participate in the EIA procedure. In this respect, the Austrian Federal Environment Agency (UBA) engaged an expert team of ENCO to assess the EIA and develop this expert statement. The team prepared an expert statement in relation with the scope and the results of the EIA, the procedure and alternatives, as well as the outcomes in terms of transboundary impact, with emphasis on the areas that might be of relevance for aspects of nuclear safety and the radiological impact on Austria, in case of abnormal operation of the plants.

The main conclusions of this Expert statement are:

- The EIA report follows the content required by the EIA Directive. However, the radiological impact – that is the most important one for nuclear projects – is not presented with a sufficient level of detail. Since the nuclear safety analyses for the events or accidents that may occur during the implementation of the refurbishment project (when U1 will not be in operation) were not available at the time of preparation of the report, the radiological impact of accidents was estimated by using the safety analyses or the data reported by other CANDU NPPs during their refurbishment. The results of the postulated nuclear accidents (that may affect U1 in operation) are included in the last versions of the Final Safety Assessment Reports of Cernavoda U1 and the Spent Fuel Storage Facility (in operation). Severe accidents, although identified, are not presented. The cumulative effect of all the nuclear installations at Cernavoda was only qualitatively estimated, without any results to justify reported “insignificant impact”.
- The refurbishment of U1 will generate large amounts of radioactive waste (RW), for which a new storage facility should be built on-site. In fact, this facility will be installed inside the Unit 5 reactor building, which is not finished, being currently in conservation. A feasibility study for changing the purpose of this building was conducted, showing that it has a sufficient storage capacity and structural integrity. The management of the RW that will be generated by the refurbishing process is appropriately described in the EIA report. According to the National Medium and Long Term Strategy for the Safe Management of Radioactive Waste and Spent Nuclear Fuel, the Low and Intermediate Level Waste containing short-lived radionuclides (LILW-SL) will be disposed of in the LILW-SL Repository intended to be built in the exclusion zone of Cernavoda NPP (scheduled to be completed in 2028). The LILW containing long-lived radionuclides (LILW-LL) will be disposed of, together with the spent fuel, in a geological disposal facility, when that will be available; till then, it will be stored on Cernavoda NPP site (in the existing Interim RW Storage Facility and the new facility to be installed inside U5 building).
- Spent Nuclear Fuel (SNF) is considered in Romania as radioactive waste and legally treated as such. According to the National Medium and Long Term Strategy for the Safe Management of Radioactive Waste and Spent Nuclear Fuel, SNF will be disposed of in a facility expected to be operational by 2055. Until then, all SNF generated by Cernavoda NPP will be stored on site. The SNF management strategy of Cernavoda NPP provides for the wet storage of SNF in the SNF pool for minimum 6 years, followed by long-term storage on-site in the Dry Interim Spent Fuel Storage Facility (DICA). DICA is a modular facility, with the modules built one by one. Currently, DICA consists in 17 modules MACSTOR-200 (where 204.000 spent fuel bundles are stored). 20 other modules with double storage capacity

(MACSTOR-400) are planned to be built for the storage of future 480.000 spent fuel bundles (to be generated by U1 and U2, within original design life as well as extended design life – total of 60 years).

- Accidents with involvement of third parties are only marginally mentioned in the EIA Report. The Population Health Impact Assessment Study conducted for the purposes of the EIA concludes that "the potential population health effects arising from a malfunction, radiological/nuclear accident or malicious act are often of interest to members of the public living near a nuclear facility", but it is not clear if malicious acts have been included in the scenarios analysed. The impact of a heavy, commercial aircraft on DICA has been identified as a severe accident, but then screened out based on a very low frequency. The authors of the EIA Report consider that only those scenarios with a frequency higher than $1 \times 10^{-6}$ should be considered in an EIA for a NPP, which is incorrect.
- The only results of an accident analysis presented in a transboundary context are those of a postulated (design-basis) accident, considered in the last revision of the FSAR of Cernavoda U1 as having the most serious consequences. The maximum value of the individual effective dose following the exposure to the postulated release for a period of 30 days is 5.5 mSv, at 1 km distance from the reactor. At 30 km distance, this value drops to 16 μSv; at 100 km distance, the values are 1 – 3 μSv. While this is not surprising – the maximum 1-y effective dose for an adult in Austria estimated by FlexRISK is 10 μSv – severe accidents and accidents affecting more than one nuclear installation at the site could result in higher doses.

It is recommended to submit to the Romanian counterpart the following requests for clarification:

1. *Could you please specify what is the current stage of the DIDR-U5 establishment?*
2. *Could you please specify what is the current stage of the LILW-SL Repository development?*
3. *Could you please explain if the U1 refurbishment activities will involve the Spent Fuel Storage Pool, and if yes, what will happen with the SNF stored there?*
4. *Do the conditions from the EIA procedure have a binding effect on the subsequent procedures, in particular the nuclear law procedure? What would happen if, during the EIA consultations, a negative opinion from the public will be received?*
5. *Please provide the results of the nuclear safety analyses for the refurbishment of Cernavoda NPP U1 and extension of DICA with MACSTOR-400 modules (in case they have been finalised in the meanwhile).*
6. *Please describe in more details how the cumulative radiological impact has been estimated for the refurbishment period and after that.*
7. *Could you confirm that security events have been analysed, and if yes, that they have no significant impact (in terms of radiological consequences)?*
8. *Could you present the radiological consequences of the scenario involving the impact of an aircraft on DICA?*

9. *Have you considered the impact of a military aircraft (flying to/from the 57th Air Base "Captain Aviator Constantin Cantacuzino") too? If yes, could you present the results?*
10. *Please present in a transboundary context the results of the severe accidents that may affect the nuclear installations in operation at any one time on Cernavoda NPP site (i.e. during the refurbishment project and after that).*
11. *Please present in a transboundary context the cumulative radiological impact of the nuclear installations in operation at any one time on Cernavoda NPP site (i.e. during the refurbishment project and after that).*

In case the required information is not immediately available, it is recommended to address the open questions during bilateral consultations to be organised in a further stage of the procedure. If not all requested clarification will be made available by the end of the EIA procedure, the EIA decision should contain conditions that should be taken into account in the subsequent licensing procedures.

# ZUSAMMENFASSUNG

Das rumänische Kernkraftwerk in Cernavoda, ~930 km von der österreichischen Grenze entfernt, verfügt über zwei in Betrieb befindliche Reaktoren vom Typ CANDU-PHWR-600 (CANadian Deuterium Uranium), die mit Natururan als Brennstoff und schwerem Wasser als Moderator und Kühlmittel betrieben werden. Sie tragen mit etwa 20 % zur Stromerzeugung in Rumänien bei. Block 1 (U1) wurde 1996 in Betrieb genommen, Block 2 (U2) 2007. CANDU-Reaktoren haben eine anfängliche Lebensdauer von 30 Jahren; nach einer Modernisierung kann diese Lebensdauer um weitere 30 Jahre verlängert werden. Die rumänische Energiestrategie sieht die Kernenergie als wichtiges Element für die Sicherheit der Energieversorgung an, und daher ist eine Verlängerung der Laufzeit von Block U1 des Kernkraftwerks Cernavoda vorgesehen; hierfür wird ein Sanierungs- und Modernisierungsprojekt vorgeschlagen. Ein weiteres Ziel dieses Projekts ist die Erweiterung des Brennelementlagers vor Ort mit größeren Modulen, um die Lagerkapazität zu verdoppeln.

Die Sanierung und Verlängerung der Betriebsdauer von Block U1 des Kernkraftwerks Cernavoda wurde bereits von der rumänischen Aufsichtsbehörde für nukleare Sicherheit genehmigt. Grundlage hierfür sind:

- die neueste Fassung des abschließenden Sicherheitsbewertungsberichts (ab 2022),
- der globale Bewertungsbericht des Berichts zur regelmäßigen Sicherheitsüberprüfung für U1 (ab 2021) und der zugehörige Aktionsplan,
- der Sicherheitsnachweis für den verlängerten Betrieb des Kernkraftwerks Cernavoda U1 und
- Betreiberstrategie und Plan für die Sanierung von U1.

Das KKW Cernavoda verfügt über ein Programm zur Überwachung und Kontrolle, Prüfung und Verifizierung aller für die Sicherheit wichtigen Systeme, Strukturen und Komponenten (SCC), Programme für deren vorbeugende Wartung, ein Programm für das Management der Lebensdauer der Anlage, einschließlich des Alterungsmanagements, der Sanierungsmaßnahmen und der nuklearen Sicherheitsanalysen, die alle von der Aufsichtsbehörde genehmigt und regelmäßig überprüft werden. Gemäß der rumänischen Gesetzgebung geht die Genehmigung der nuklearen Sicherheit für eine kerntechnische Anlage der Umweltgenehmigung voraus, ohne welche die Anlage nicht betrieben werden kann.

Gemäß dem rumänischen Gesetz über die Umweltverträglichkeitsprüfung (UVP-Gesetz), das die UVP-Richtlinie (2011/92/EU in der geänderten Fassung) umsetzt, unterliegt die Sanierung von U1 und die Erweiterung des Brennelementlagers vor Ort einer UVP. Wie im rumänischen Gesetz zur Ratifizierung des Espoo-Übereinkommens vorgeschrieben, hat der Projektentwickler dem rumänischen Ministerium für Umwelt, Gewässer und Forst die erforderlichen Unterlagen vorgelegt, um das Konsultationsverfahren im Rahmen des UVP-Verfahrens einzuleiten. Auch Österreich, das an diesem grenzüberschreitenden Verfahren beteiligt ist, wurde benachrichtigt.

Als potenziell betroffene Partei im Falle einer radiologischen Freisetzung am Standort Cernavoda hat Österreich ein Interesse daran, sich am UVP-Verfahren zu beteiligen. In diesem Zusammenhang beauftragte das österreichische Umweltbundesamt (UBA) ein Expertenteam von ENCO mit der Bewertung der UVP und der Ausarbeitung der vorliegenden Fachstellungnahme. Das Team erstellte eine Fachstellungnahme zum Umfang und zu den Ergebnissen der UVP, zum Verfahren und zu den Alternativen sowie zu den Ergebnissen hinsichtlich der grenzüberschreitenden Auswirkungen. des Programms und seines Umfangs, wobei der Schwerpunkt auf den Bereichen lag, die für Aspekte der nuklearen Sicherheit und der radiologischen Auswirkungen auf Österreich im Falle eines anormalen Betriebs der Anlagen von Bedeutung sein könnten.

Die wichtigsten Schlussfolgerungen dieser Fachstellungnahme sind:

- Der UVP-Bericht entspricht inhaltlich den Anforderungen der UVP-Richtlinie. Die radiologischen Auswirkungen – die bei Nuklearprojekten bedeutendsten – werden jedoch nicht detailliert genug dargestellt. Da die nuklearen Sicherheitsanalysen für die Ereignisse oder Unfälle, welche während der Durchführung des Sanierungsprojekts und während des geplanten Betriebs auftreten können, zum Zeitpunkt der Erstellung des Berichts nicht verfügbar waren, wurden die radiologischen Auswirkungen von Unfällen anhand der Sicherheitsanalysen oder der von anderen CANDU-KKW gemeldeten Daten geschätzt. Die Ergebnisse der postulierten nuklearen Unfälle sind in den letzten Versionen der abschließenden Sicherheitsbewertungsberichte von Cernavoda U1 und der (in Betrieb befindlichen) Anlage zur Lagerung abgebrannter Brennelemente enthalten. Schwerwiegende Unfälle wurden zwar identifiziert, aber nicht dargestellt. Die kumulative Wirkung aller Kernkraftanlagen in Cernavoda wurde nur qualitativ eingeschätzt, ohne dass die Ergebnisse die gemeldete „unbedeutende Auswirkung“ rechtfertigen würden.
- Die Sanierung von U1 wird große Mengen an radioaktivem Abfall (RW) erzeugen, für den vor Ort ein neues Lager errichtet werden sollte. Tatsächlich wird diese Anlage im Reaktorgebäude von Block 5 installiert, das noch nicht fertiggestellt ist und derzeit konserviert wird. Es wurde eine Machbarkeitsstudie zur Änderung des Verwendungszwecks dieses Gebäudes durchgeführt, die zeigt, dass es über eine ausreichende Lagerkapazität und strukturelle Integrität verfügt. Die Entsorgung der radioaktiven Abfälle, die bei der Sanierung anfallen, wird im UVP-Bericht angemessen beschrieben. Gemäß der nationalen mittel- und langfristigen Strategie für die sichere Entsorgung radioaktiver Abfälle und abgebrannter Brennelemente werden schwach- und mittelaktive Abfälle, die kurzlebige Radionuklide enthalten (LILW-SL), im LILW-SL-Endlager entsorgt, das in der Sperrzone des Kernkraftwerks Cernavoda errichtet werden soll (geplante Fertigstellung 2028). LILW, das langlebige Radionuklide (LILW-LL) enthält, wird zusammen mit dem abgebrannten Brennstoff in einer geologischen Endlagerstätte entsorgt, sobald diese verfügbar ist. Bis dahin wird es auf dem Gelände des Kernkraftwerks Cernavoda gelagert (im bestehenden Zwischenlager für radioaktive Abfälle und in der neuen Anlage, die im U5-Gebäude installiert werden soll).

- Abgebrannte Brennelemente (SNF) gelten in Rumänien als radioaktiver Abfall und werden rechtlich auch als solcher behandelt. Gemäß der nationalen mittel- und langfristigen Strategie für die sichere Entsorgung von radioaktiven Abfällen und abgebrannten Brennelementen werden SNF in einer Anlage entsorgt, die voraussichtlich bis 2055 in Betrieb sein wird. Bis dahin werden alle im Kernkraftwerk Cernavoda erzeugten SNF vor Ort gelagert. Die Strategie des KKW Cernavoda zur Entsorgung von abgebrannten Brennelementen sieht eine Nasslagerung der abgebrannten Brennelemente im Abklingbecken für mindestens 6 Jahre vor, gefolgt von einer langfristigen Lagerung vor Ort im trockenen Zwischenlager für abgebrannte Brennelemente (DICA). DICA ist eine modulare Anlage, deren Module nach und nach gebaut werden. Derzeit besteht DICA aus 17 Modulen MACSTOR-200 (in denen 204.000 abgebrannte Brennelementbündel gelagert werden). 20 weitere Module mit doppelter Lagerkapazität (MACSTOR-400) sollen für die Lagerung von weiteren 480.000 abgebrannten Brennelementen gebaut werden (die von U1 und U2 innerhalb der ursprünglichen und der verlängerten Lebensdauer – insgesamt 60 Jahre – erzeugt werden).
- Unfälle mit Beteiligung Dritter werden im UVP-Bericht nur am Rande erwähnt. Die im Rahmen der UVP durchgeführte Studie zur Bewertung der Auswirkungen auf die Gesundheit der Bevölkerung kommt zu dem Schluss, dass „die potenziellen Auswirkungen auf die Gesundheit der Bevölkerung, die sich aus einer Fehlfunktion, einem radiologischen/nuklearen Unfall oder einer böswilligen Handlung ergeben, für die Mitglieder der Öffentlichkeit, die in der Nähe einer kerntechnischen Anlage leben, oft von Interesse sind“, aber es ist nicht klar, ob böswillige Handlungen in den analysierten Szenarien berücksichtigt wurden. Der Aufprall eines schweren Verkehrsflugzeugs auf das trockene Zwischenlager (DICA) wurde als schwerer Unfall identifiziert, dann aber aufgrund einer sehr geringen Häufigkeit ausgeschlossen. Die Verfasser des UVP-Berichts sind der Ansicht, dass nur Szenarien mit einer Häufigkeit von mehr als 1 x 10-6 in einer UVP für ein KKW berücksichtigt werden sollten, was nicht korrekt ist.
- Die einzigen Ergebnisse einer Unfallanalyse, die in einem grenzüberschreitenden Kontext präsentiert werden, sind die eines postulierten (Auslegungs-)Unfalls, der in der letzten Revision des FSAR von Cernavoda U1 als der Unfall mit den schwerwiegendsten Folgen angesehen wird. Der Maximalwert der individuellen effektiven Dosis nach der Exposition gegenüber der postulierten Freisetzung über einen Zeitraum von 30 Tagen beträgt 5,5 mSv in 1 km Entfernung vom Reaktor. Bei einer Entfernung von 30 km sinkt dieser Wert auf 16 µSv; bei einer Entfernung von 100 km liegen die Werte bei 1–3 µSv. Dies ist zwar nicht überraschend – die maximale effektive Dosis für einen Erwachsenen in Österreich wird von FlexRISK auf 10 µSv geschätzt –, doch könnten schwere Unfälle und Unfälle, die mehr als eine Kernanlage am Standort betreffen, zu höheren Dosen führen.

Es wird empfohlen dem rumänischen Amtskollegen folgende Bitten um Klärung vorzulegen:

1. *Könnten Sie bitte angeben, in welchem Stadium sich die Einrichtung von DIDR-U5 befindet?*
2. *Könnten Sie bitte angeben, in welchem Stadium sich die Entwicklung des Endlagers LILW-SL befindet?*
3. *Könnten Sie bitte erklären, ob die Sanierungsarbeiten von U1 das Lagerbecken für abgebrannte Brennelemente betreffen werden, und wenn ja, was mit den dort gelagerten abgebrannten Brennelementen geschehen wird?*
4. *Haben die Bedingungen des UVP-Verfahrens eine bindende Wirkung auf die nachfolgenden Verfahren, insbesondere das atomrechtliche Verfahren? Was würde passieren, wenn während der UVP-Konsultationen eine negative Stellungnahme der Öffentlichkeit eingeht?*
5. *Bitte legen Sie die Ergebnisse der nuklearen Sicherheitsanalysen für die Sanierung des Kernkraftwerks Cernavoda U1 und die Erweiterung von DICA mit MACSTOR-400-Modulen vor (falls diese inzwischen abgeschlossen wurden).*
6. *Bitte beschreiben Sie genauer, wie die kumulativen radiologischen Auswirkungen für den Sanierungszeitraum und danach geschätzt wurden.*
7. *Können Sie bestätigen, dass die Sicherungsereignisse analysiert wurden und wenn ja, dass sie keine signifikanten Auswirkungen (hinsichtlich radiologischer Folgen) haben?*
8. *Können Sie die radiologischen Folgen des Szenarios mit dem Aufprall eines Flugzeugs auf DICA darlegen?*
9. *Haben Sie auch die Auswirkungen von Militärflugzeugen (im An-/Abflug vom 57. Luftwaffenstützpunkt „Captain Aviator Constantin Cantacuzino“) berücksichtigt? Wenn ja, könnten Sie die Ergebnisse vorlegen?*
10. *Bitte legen Sie in einem grenzüberschreitenden Kontext die Folgen schwerer Unfälle dar, die die zu einem bestimmten Zeitpunkt auf dem Gelände des Kernkraftwerks Cernavoda in Betrieb befindlichen Kernanlagen betreffen können (d. h. während des Sanierungsprojekts und danach).*
11. *Bitte legen Sie in einem grenzüberschreitenden Kontext die kumulativen radiologischen Auswirkungen der zu einem bestimmten Zeitpunkt auf dem Gelände des Kernkraftwerks Cernavoda in Betrieb befindlichen Kernanlagen dar (d. h. während des Sanierungsprojekts und danach).*

Falls die erforderlichen Informationen nicht sofort verfügbar sind, wird empfohlen, die offenen Fragen während bilateraler Konsultationen zu klären, die in einer späteren Phase des Verfahrens organisiert werden. Wenn nicht alle angeforderten Klarstellungen bis zum Ende des UVP-Verfahrens vorliegen, sollte die UVP-Entscheidung Bedingungen enthalten, die in den nachfolgenden Genehmigungsverfahren berücksichtigt werden sollten.

# 1 INTRODUCTION AND OVERVIEW

Cernavoda NPP has two units in operation, U1 since 1996 and U2 since 2007. Both units are CANDU-PHWR-600 type reactors (CANadian Deuterium Uranium), using natural uranium as fuel and heavy water as moderator and cooling agent. U1 generates 706.5 MWe, while U2 generates 704.8 Mwe, contributing in total with ~ 20% to the electricity needs of Romania. CANDU reactors have an initial lifetime of 30 years; following a refurbishment process, this lifetime can be extended with another 30 years.

Nuclear energy is considered in the National Integrated Plan in the field of Energy and Climate Change 2021-2030 an important element for the energy security of Romania. The lifetime extension of U1 (and U2) is considered an efficient solution for provision of electricity with low carbon emissions, with minimum impact on the environment, and at affordable costs, that could contribute in a sustainable way to the decarbonisation of the energy sector of Romania.

Through the refurbishment of U1, the project developer (Societatea Nationala NUCLEARELECTRICA, S.A, - SNN) is aiming to extend the lifetime of U1 in order to ensure the long-term safe operation of the plant with a second operating cycle (i.e. additional 30 years). This is the main objective of the project; the second includes the equipment upgrade and improvement of Cernavoda NPP, to increase its operational safety. To support these objectives, an extension of the Spent Fuel Interim Storage Facility (DICA, in operation at Cernavoda NPP) is also envisaged. This extension implies the transition to MACSTOR-400 modules, which have a double storage capacity compared to the MACSTOR-200 modules already built, which would be needed for storing the spent fuel that will be generated by the two units of the NPP with the extended lifetime for each.

The U1 is planned to be shutdown at the end of 2026. The fuel will be unloaded from the reactor and transferred to the Spent Fuel Storage Pool. The refurbishment will start with preparing the reactor building and reactor assembly, isolation, draining and drying activities. The “retubing” of the reactor is scheduled to start in 2027. The preparation for bringing the reactor back into operation will start in May 2029, with expected  return to service expected at the beginning of 2030. The construction of the first MACSTOR-400 module of DICA is planned to start in the second half of 2025. From then onwards, the modules will be added one by one.

The operation of Cernavoda NPP is subject to licensing in Romania. As such, SNN holds an Environmental Authorisation for operating U1 and U2, issued by the Government Decision No 84/2019. Nuclear safety licenses are also required by the Romanian legislation. The SNN holds a license for operating U1, a license for operating U2, a license for operating modules 1-16 of DICA, and a license to operate the Interim Solid RW Storage Facility.

Reflecting the requirements of the Law No 292/2018 regarding the assessment of the impact of certain public and private projects on the environment, which transposes the EIA Directive (2011/92/EU as amended) in Romania, the refurbishment of U1 and extension of DICA is subject to an EIA. As required by the Law No 22/2001 ratifying the Espoo Convention, SNN submitted in February 2022 to the Romanian Ministry for Environment, Waters and Forests (MEWF) the necessary documentation to start the consultation process within the EIA procedure. MEWF sent the project notification to the competent authorities in Bulgaria, Hungary, Serbia, Ukraine and the Republic of Moldova.

Austria subsequently indicated its intention to participate in the EIA procedure. ENCO, as the Consultant for the Umweltbundesamt (UBA), reviewed the EIA report and proposed questions that are listed in the following sections of the review report.

# 2 THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

The Environmental Impact Assessment Report for the refurbishment of U1 and extension of DICA has been developed in accordance with the provisions of the Law No 292/2018 and the specific guidance issued by the MEWF, applicable to each stage of the EIA procedure. Annex 4 of the Law No 292/2018, which corresponds to Annex IV of the EIA Directive, has been largely followed. The EIA report includes:

- Description of the project,
- Considered alternatives,
- Current state of the environment, including the factors likely to be affected the project,
- Description of the likely significant effects of the project on the environment resulting from the construction and operation of the proposed facilities,
- Use of natural resources,
- Emissions of pollutants, including radioactive discharges,
- Risks to human health, biodiversity, etc.

The methods used for analysis are described, the measures to avoid, prevent or reduce the negative effects are presented.

The radiological impact, which in case of nuclear projects is the most important one, has not been presented with a sufficient level of detail. The EIA report states (in section 8.2) that the "nuclear safety analyses for the events or accidents that may occur during the implementation of the U1 refurbishment and extension of DICA were not available at the time of preparation of the report". As such, the radiological impact of accidents affecting the nuclear installations has been estimated by using the safety analyses or the data reported by other CANDU NPPs, and the results of the accident analyses included in the last versions of the Final Safety Assessment Reports (FSAR) of Cernavoda U1 and DICA.

Although identified, severe accidents which are the most relevant issues regarding transboundary effects, are not presented in the EIA.

The cumulative effect of all the installations existing on Cernavoda NPP site has been considered, however the analysis method is not described, nor supported by any safety analyses of the radiological consequences.

All those issues are discussed in more details in Sections 6, 7, and 8 of this report.

# 3 PROCEDURE AND ALTERNATIVES

## 3.1 Summary of the expert statement

The refurbishment of U1 and extension of DICA is placed in the context of the Romanian Energy Strategy 2025-2035 and the National Integrated Plan in the field of Energy and Climate Change 2021-2030. Romania is one of the 14 EU MS who opted for maintaining nuclear energy as part of its energy mix. At present, nuclear energy covers  about 20 % of the electricity produced in the country (by the two units of Cernavoda NPP), and this share is planned to be increased to 33-35% by 2035.

In the context of the actual geopolitical tensions, Romania considers that it needs to be prepared for the eventual shortages in the electricity provision, thus one of the primary objectives of its Energy Strategy is to secure the electricity needed in the country by its own internal resources. The renewable energy sources, while essential for the decarbonisation, are intermittent. In a case of an energy crisis, there might be periods when the renewable energy production is not sufficient for the internal consumption. From this point of view, Romania is envisaging the use of natural gas and nuclear energy for ensuring the flexibility and adequacy of its energy sector. The provisions are that the nuclear energy production capacities will remain constant by 2029, the introduction of new capacities starting after 2029.

The MEWF decided that the Energy Strategy 2025-2035 was not to be subjected to a Strategic Environmental Assessment. This was so decided because the Energy Strategy does not include concrete projects. Those are defined in subsequent plans, such as the National Integrated Plan in the field of Energy and Climate Change 2021-2030. This Plan is under consultations, its last version (2) being released in September 2024.

Nevertheless, the previous version of the Energy Strategy (for 2020-2030) has been subject to a Strategic Impact Assessment (SEA)[1], which analysed a “Zero alternative”, too. The analysis of the Alternative Zero (i.e. not implementing the strategy) has been conducted within specialised studies based on the existing evaluation methods considering the environment status and its evolution. The conclusions of the SEA show that, by not implementing the proposed strategy (which implies the increase of the nuclear energy production capacities, by refurbishing U1 of Cernavoda NPP, and finalise the U3 and U4 of Cernavoda NPP), the energy mix of Romania will remain unchanged, with the actual share of the non-renewable sources maintained; which will have a negative impact the environment. Extending the lifetime of U1 by 30 years will generate an additional 630 GWth, with a corresponding (hypothetical) value of substituted emission over the extended lifetime of U1, according to EIA, of 509 kt CO2 equivalent. The

[1] https://www.mmediu.ro/app/webroot/uploads/files/Raport%20de%20mediu_aug%202020.pdf

SEA of the Energy Strategy was subject to external consultations, under the SEA Directive, in 2019.

Three alternatives to the refurbishment of U1 and extension of DICA are also analysed in the EIA report, as proposed by the SNN from the perspective of the project developer. The "zero alternative" would mean to not refurbish U1, and so not extend its operation life. This would result in shutting down the Unit in 2026, and start its decommissioning. This would lead to the reduction of the national electricity production by 10%. The decommissioning of U1 would also require a big capital investment.

Not extending the DICA storage capacity with MACSTOR-400 will not have a significant effect in such situation, since the DICA is already licensed to operate with 27 modules MACSTOR-200, which will ensure enough storage capacity for the spent fuel generated by the Units 1 and 2, operating 30 years each.

For the U1 refurbishment project, the reasonable technological alternatives have been analysed under a dedicated Feasibility Study (conducted in 2022), which assessed the condition of the installation and its Systems, Structures and Components (SSC). The study reviewed the technical design of the plant in order to identify the needs for mandatory modifications and safety improvements.

The environmental impact assessment of alternatives proposed in the Feasibility Study was done from the perspective of the magnitude of the effect and the sensitivity of the receiver. The conclusion reached is that the selected alternative will have a major positive environmental impact.

# 4 SPENT FUEL AND RADIOACTIVE WASTE

## 4.1 Summary of the expert statement

The Spent nuclear Fuel (SNF) management strategy of Cernavoda NPP provides for the wet storage of SNF in the Unit's SNF pool for minimum 6 years, followed by long-term storage on-site in the dry Interim Spent Fuel Storage Facility (DICA). The extension of DICA is to provide for the long-term storage of the SNF resulting from the operation of U1 and U2, both the original lifetime and the extended lifetime (30+30 operating years). T

The U1 refurbishment project will start with the shutdown of U1 (expected at the end of 2026), followed by the unloading of the SNF from the reactor into the spent fuel storage pool. No information is provided about the SNF that is currently in the SNF pool of U1, i.e. whether it will be kept in the pool during the refurbishment operations, or it will be moved to DICA. Currently, DICA consists in 17 modules MACSTOR-200 where 204.000 spent fuel bundles are stored. Additional 20 modules with a double storage capacity (MACSTOR-400) are planned to be built for the storage of future 480.000 spent fuel bundles which will be discharged from U1 and U2.

The last MACSTOR-200 module was planned to be built by the end of June 2024, the construction of the first MACSTOR-400 module being scheduled to begin in the second semester of 2025. MACSTOR-400 represents the more compact version of the module MACSTOR-200 developed by AECL. It is a proven and safe technology and it is being used by many other CANDU NPPs. DICA Cernavoda is included in the radiation monitoring program of Cernavoda NPP, and so far, no elevated radiation levels have been detected.

According to the National Medium and Long Term Strategy for the Safe Management of Radioactive Waste and Spent Nuclear Fuel (approved by the Governmental Decision No. 102/2022), the SNF is considered as waste in Romania. It will be disposed of in a deep geological repository, planned to be operational by 2055. Until then, all SNF generated by Cernavoda NPP will be stored on site.

The refurbishment of U1 will generate large amounts of RW, consisting in the reactor components that will be replaced, personal protective equipment, contaminated tools and equipment used in the retubing operations, as well as liquid radioactive waste generated during the operation. Radioactive effluents will be managed by the existing systems, which will be kept in operation throughout the refurbishment period.

The types and quantities of the solid RW that will be generated have been estimated in the "Feasibility Study on the Management of RW generated during the refurbishment of U1 and the operation periods of U1 and U2 from Cernavoda NPP after refurbishment". The Feasibility study conducted in 2021 classifies this radioactive waste in two categories:

a. activated material (including pressure tubes, calandria tubes, spacers and side structural components), and

b. contaminated material (including components and equipment located outside the active area, and equipment, tools and consumables contaminated as a result of the refurbishment operations).

A total of 4816.2 m$^3$ of solid waste is expected to be generated during the refurbishment of U1. Around 3000 l of liquid waste will also be generated. The management of this RW will be integrated into the existing RW Management Program of Cernavoda NPP.

Pre-treatment operations that will be conducted on-site are presented in detail in the EIA. For this purpose, a new facility is to be established on site, the "new Interim RW Storage Facility" (DIDR-U5) to be installed inside the U5 reactor building. The construction of U5 of Cernavoda NPP is 60% completed, currently in a state of preservation. Unit 5 containment building is made of massive reinforced concrete, with 1 m wall thickness. The intention is to use this building for storage of the RW generated by U1 refurbishment as well as the (extended) operation of U1 and U2. To enable the use of the Unit 5 for that purpose, it will be equipped with ventilation, conditioning and monitoring systems. The possibility to use the U5 containment building for storage of RW has been assessed (storage capacity and structural integrity) in the Feasibility Study. The facility is subject to authorisation by the nuclear regulatory authority CNCAN.

According to the National Medium and Long Term Strategy for the Safe Management of Radioactive Waste and Spent Nuclear Fuel, the Low and Intermediate Level Waste containing short-lived radionuclides (LILW-SL) will be disposed of in the LILW-SL Repository, intended to be built in the exclusion zone of Cernavoda NPP. The repository, which will be operated by the National Agency for RW, is scheduled to be completed in 2028. The LILW containing long-lived radionuclides (LILW-LL) will be disposed of together with the SNF, in a geological disposal facility, when the construction of such is completed, after 2055. In the meantime the LILW-LL will be stored on Cernavoda NPP site in the existing Interim RW Storage Facility and DIDR -U5. The SNF will be stored in the new DICA.

## 4.2 Questions

12. *Could you please specify what is the current stage of the DIDR-U5 establishment?*
13. *Could you please specify what is the current stage of the LILW-SL Repository development?*
14. *Could you please explain if the U1 refurbishment activities will involve the Spent Fuel Storage Pool, and if yes, what will happen with the SNF stored there.*

# 5 LONG-TERM OPERATION

## 5.1 Summary of the expert statement

CANDU reactors have an initial design lifetime of 30 years. Following the refurbishment the lifetime can be extended with another 30 years, this being known as "Long-Term Operation" (LTO). According to the Romanian Nuclear Safety Guide for preparation of refurbishing of nuclear installations (CNCAN, GSN 07/2019), the refurbishment of a nuclear installation means capital repairs, modernization and improvement by replacing or modifying some equipment or systems of the installation, in order to extend its operating life, in accordance with nuclear safety analyses and engineering evaluations. The refurbishment does not involve changing the technology of the nuclear installation, nor the operating characteristics or the amount of energy produced (power level). Through the refurbishment of U1, the nominal power of the reactor will not change.

The EIA has been developed to assess the impact onto the environment for the refurbishment of U1 and extension of DICA, in the view of extending the operational lifetime of U1 for a period of 30 years. While the EIA, as required by the national legislation and EU Directives, covers a variety of non-radiological impacts and briefly touches the radiological impact of the refurbishment operations, it does not actually consider (in a proper way) the lifetime extension. It is not to be expected that the modernized U1 will have a higher radiological impact than the Unit 1 as it is now. The EIA contains a very detailed presentation of the actual state of the environmental radioactivity around Cernavoda NPP, showing its minimal impact on the environment. However, the EIA fails to present, in a comprehensive manner, the total radiological impact of the Cernavoda NPP after the refurbishment process, when both units and the extended DICA will be in operation. Moreover, section 5.2.12.2 of the EIA report, dedicated to evaluation of the cumulative impact with the existing and/or approved projects on Cernavoda NPP site, define the stage III (2032-2039) when all nuclear units will be in operation (i.e., including U3 and U4). However, only a qualitative assessment of the radiological impact of all these units (plus DICA) has been done.

One aspect that has to be noted – and that was omitted from being mentioned in the EIA – is that SNN already obtained the nuclear safety license for the refurbishment of U1 and extension of its operating lifetime. The Operating License of U1 of Cernavoda NPP, no. SNN Cernavoda NPP U1 – 01/2023, rev.0, is effective from May 1, 2023 and it is to expire on April 30, 2061. This License gives the right to SNN to refurbish and modernize the U1, to commission it after the refurbishment, to conduct the trial operation and to operate it afterwards until end of the (expended) lifetime[2] One of the conditions of this license is that all

[2] https://www.nuclearelectrica.ro/cne/wp-content/uploads/sites/2/2023/ 10/Autorizatie-exploatare-U1.pdf

other legal and regulatory provisions applicable to nuclear installations in Romania shall be respected. This includes the condition that the nuclear safety license shall precede the Environmental Authorisation. This means that in order to obtain the Environmental Authorisation, which gives the right to the project developer to start the activity, a nuclear safety license shall be obtained. The nuclear license is then to demonstrate that all safety requirements have been fulfilled.

The Operating License for U1 was based on the Final Safety Assessment Report of U1 (from 2022), the Global Assessment Report of the Periodic Safety Review Report for U1 (from 2021) and the associated Action plan, the Safety Case Report for Cernavoda NPP U1 extended operation, the Strategy and the plan for refurbishing of U1, etc. All these documents have been reviewed by the nuclear regulatory authority (CNCAN) and approved during the licensing process. Besides these, Cernavoda NPP has in place a program for surveillance and monitoring, testing and verification of all SSC important for nuclear safety, programs for preventive maintenance of the SSC important for nuclear safety, a program for the management of the lifetime of the plant, including the ageing management, refurbishment activities and the nuclear safety analyses based on hypotheses related with the lifetime of the SSC and their aging, etc. The results of all these programs are required, as per conditions in the Operating License, to be reported to CNCAN every year. While all these prove that the safety requirements for the lifetime extension of U1 have been fulfilled, the EIA report does not mention any of them.

## 5.2 Questions

15. *Do the conditions from the EIA procedure have a binding effect on the subsequent procedures, in particular the nuclear law procedure? What would happen if, during the EIA consultations, a negative opinion from the public will be received?*

# 6 ACCIDENT ANALYSIS

## 6.1 Summary of the expert statement

Accident analysis is very briefly presented in the EIA. This is probably due to the fact that at the moment of preparation the EIA report, radiological safety analyses for the events that may occur during the U1 refurbishment and DICA extension projects and that involve radioactive materials or contaminated components (except the reactor and its supports) are not yet available. The identification and evaluation of such events is, according to the EIA report, currently underway.

The estimated impact of nuclear accidents is therefore based on the analyses done under the framework of the refurbishment project of Darlington NPP, which showed that the resulting doses to the workers and members of the public would be within the limits established by the nuclear regulations. It is not clear if this statement refers to the Canadian regulations or Romanian regulations. Besides this, Darlington NPP operates CANDU reactors that are of (more) advanced design (and higher rated power that Cernavoda), so the relevance of the analysis results for Cernavoda NPP might be questioned.

For the DICA extension, the EIA presents the results of the safety analyses included in the FSAR of the DICA MACSTOR-200 and the analyses performed in preparation of the extension project. The DBA postulated for DICA would result in doses to a member of the public located 800 m away from the centre of the facility lower than 1% of the approved dose constraints for DICA (the actual value in the dose limit is not provided). Three events with a frequency lower than $10^{-6}$ (i.e. beyond-design accidents) are analysed, the conclusion being that they will have no radiological consequences. From these three events, the impact of an aircraft crash on DICA has been classified as a severe accident, and due to its very low frequency, it has not been analysed.

For the U1 refurbishment, the EIA is stating that nuclear accidents are possible during the reactor operation only and is therefore describing the safety analyses included in the FSAR of U1. It is further listing the operational occurrences and the DBA considered in the FSAR, as well as the DEC analysed by Cernavoda NPP in order to confirm the feasibility of implementing emergency operating procedures and/or accident management guidelines. The only results of an accident analysis presented in the EIA are those of the DBA estimated in the last revision of the U1 FSAR (from 2022) as having the most serious consequences. This would be the "Feeder Stagnation Break" event, followed by the reactor shutdown, the operation of the emergency core cooling system, and the operation of the emergency containment systems. The maximum value of the individual effective dose following the exposure to the postulated release for a period of 30 days is 5.5 mSv, at 1 km distance from the reactor, dropping to 16 µSv at 30 km distance.

Severe accidents, or Design Extension Conditions, have not been analysed, since "international experience shows that for the category of operational events or nuclear accidents that should be the subject of an environmental impacts assessment for a nuclear power plant, only those scenarios should be considered that which have a frequency of occurrence greater than 1 x $10^{-6}$, corresponding to operational events or design basis accidents". This statement is not correct. While the EIA Directive requires a description of the expected effects deriving from the vulnerability of the project to risks of "major accidents", the IAEA Technical Report No NG-T-3.11 clearly specifies that the EIA report should provide a description of "impacts on people and the environment due to design base accidents, beyond design base accidents and severe accidents at the nuclear power plant". It has to be noted that all of the recently developed EIAs that supported the lifetime extension performed the severe accident analyses and modelled the impact of those in particular in relation with off site impacts.

The cumulative effects and impacts off site of all of the facilities at the Cernavoda site (on going existing and/or approved activities) should also be presented in more details. Only a qualitative assessment has been done, showing a minor, local, reversible, short-term cumulated radiological impact during the refurbishment of U1 and construction of MACSTOR-400, while U2 is in operation.

For the period 2032-2037 when all four units are expected to be in operation (U1 refurbished, U2, and U3 and U4 expected to be finalised by then), the cumulated radiological impact is considered insignificant, local/regional, reversible, with long-term effect. This has been justified by the expected commissioning of the Tritium Removal Facility, which should result in decreasing the H-3 discharges. No other argument is provided, the analysis method is not described, and from the presentation of the radiological impact in the EIA it is evident that these cumulative impacts are not sustained by any safety analysis. It is to be noted that the EU Post Fukushima Stress test specifically require the assessment of effects of multi-units accidents.

## 6.2 Questions

16. *Please provide the results of the nuclear safety analyses for the refurbishment of Cernavoda NPP U1 and extension of DICA with MACSTOR-400 modules (in case they have been finalised in the meanwhile).*
17. *Please describe in more details how the cumulative radiological impact has been estimated for the refurbishment period and after that.*

# 7 ACCIDENTS WITH INVOLVEMENT OF THIRD PARTIES

## 7.1 Summary of the expert statement

The EIA report indicates that the potential effects of nuclear and radiological accidents have been analysed under the Population Health Impact Assessment Study. The Study concludes that "*The potential population health effects arising from a malfunction, radiological/nuclear accident <u>or malicious act</u> are often of interest to members of the public living near a nuclear facility. The first aspect of health concerns with malfunctions, accidents and malevolent acts is related to physical well-being or potential health effects but also the availability of adequate capacity to respond to a radiological or nuclear emergency*". A number of scenarios concerning possible malfunctions, incident/accidents, and transport of LILW were analysed, the conclusion being that no residual effects on the off-site population health are expected. However, it is not clear if scenarios involving malicious act were included in the Study.

The impact of a heavy, commercial aircraft on DICA is said to have been analysed. The conclusion was that the frequency of potential impact, considering the traffic in the air croutes crossing the site and towards Mihail Kogalniceanu airport, are very low so that such an event could be classified as a severe accident, and excluded from the analyses. No radiological consequences are presented. The Airport Mihail Kogalniceanu (located ~ 40 km away from Cernavoda NPP site) also host a miliary base of the Romanian Air Forces (57th Air Base "Captain Aviator Constantin Cantacuzino"), which is planned to be modernised and extended to become the biggest NATO base in the SE Europe. It would be interesting to know whether military flights to/from this base have been considered for this scenario too.

## 7.2 Questions

18. *Could you confirm that security events have been analysed, and if yes, that they have no significant impact (in terms of radiological consequences)?*
19. *Could you present the radiological consequences of the scenario involving the impact of an aircraft on DICA?*
20. *Have you considered the impact of a military aircraft (flying to/from the 57th Air Base "Captain Aviator Constantin Cantacuzino") too? If yes, could you present the results?*

# 8 TRANSBOUNDARY IMPACTS

## 8.1 Summary of the expert statement

As required by the Espoo Convention, the transboundary impact of a radiological release on Cernavoda site has to be estimated under the EIA. The closest border from Cernavoda NPP is with Bulgaria, located ~ 38 km away, while the border with Austria is ~ 930 km away.

As already mentioned in section 6, no specific safety analyses have been done for the refurbishment of U1 and extension of DICA.

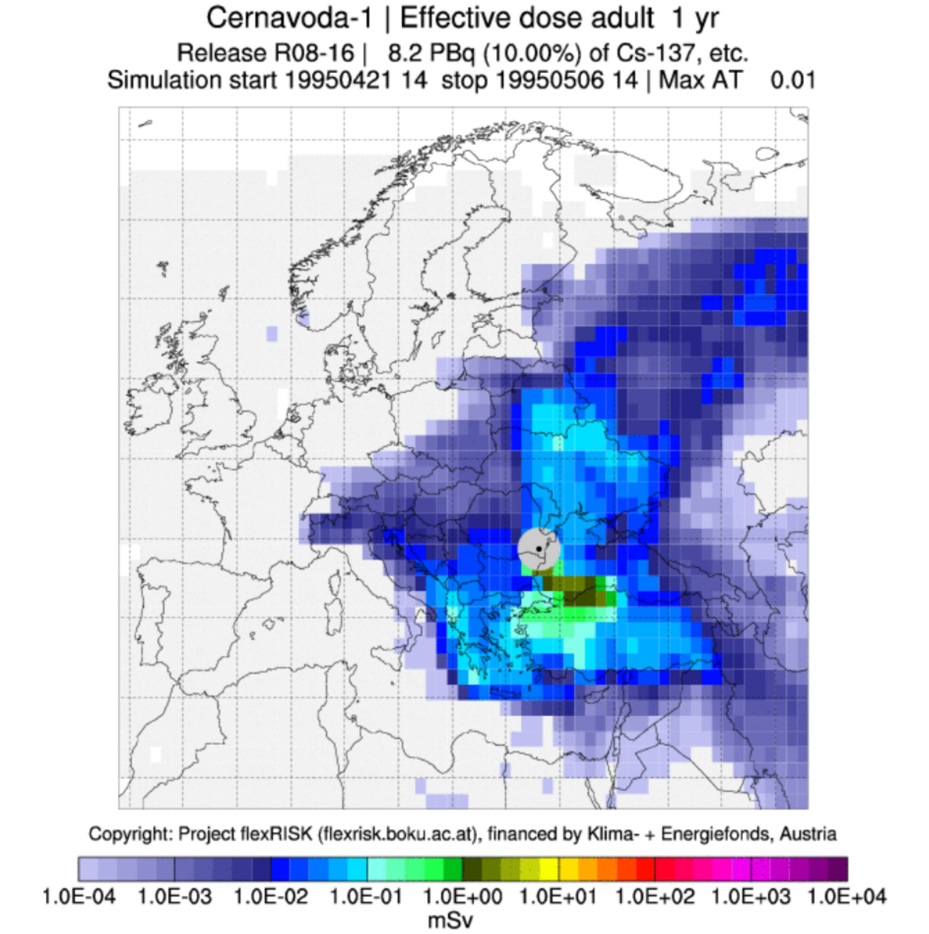
The transboundary impact for normal operation during the refurbishment of U1 and extension of DICA with MACSTOR-400 modules has been estimated under a study of the impact on the population health done by the National Institute of Public Health. Annual doses to the representative members of the population were calculated using the same methodology used for deriving the discharge limits for Cernavoda NPP, under the assumption that the only discharges expected to be modified are those of H-3. This assumption is based on the data reported by similar CANDU reactors (Point Lepreau NPP) showing an increase of H-3 discharges with one order of magnitude during the refurbishment. Considering that the actual H-3 discharges recorded by Cernavoda NPP are one order of magnitude lower than the authorised discharge limit, it is expected that the H-3 discharges during the refurbishment of U1 will be at the level of the authorised discharge limits.

The construction of MACSTOR-400 modules will not involve any radioactive material. Thus this activity will not generate any radioactive discharges. With these, the annual doses to the critical groups in the close proximity of the plant (i.e. 10 km away) will increase with 0.20 – 0.30 µSv only, the conclusion being that the project will have no significant impact on the population health in the proximity area (30 km). Since the doses decrease with increasing distances, in a transboundary context it is concluded that the project will have no radiological impact on the population health.

The only results of an accident analysis presented in a transboundary context are those of the "Feeder Stagnation Break" DBA, which is considered in the last revision of the FSAR of Cernavoda U1 as having the most serious consequences. The maximum value of the individual effective dose following the exposure to the postulated release for a period of 30 days is 5.5 mSv, at 1 km distance from the reactor. At 30 km distance, this value drops to 16 µSv; at 100 km distance, the values are 1 – 3 µSv.

While this is not surprising – the maximum 1-y effective dose for an adult in Austria estimated by FlexRISK is 10 µSv – severe accidents and accidents affecting more than one nuclear installation at the site could result in higher doses.

*Figure 1: FlexRISK: example of the effective adult dose 1 year*




*Quelle: flexrisk.boku.ac.at* umweltbundesamt

## 8.2 Questions

21. *Please present in a transboundary context the results of the severe accidents that may affect the nuclear installations in operation at any one time on Cernavoda NPP site (i.e. during the refurbishment project and after that).*
22. *Please present in a transboundary context the cumulative radiological impact of the nuclear installations in operation at any one time on Cernavoda NPP site (i.e. during the refurbishment project and after that).*

# 9 GLOSSAR

CANDU ............................ CANadian Deuterium Uranium

CNCAN ............................ Romanian Nuclear regulatory authority

DBA ................................ Design Basis Accident

DICA ............................... Dry Interim Spent Fuel Storage Facility

DIDR ............................... new Interim RW Storage Facility

EIA.................................. Environmental impact assessment

EU .................................. European Union

FSAR ............................... Final safety analysis report

GW.................................. Gigawatt

H3 .................................. Tritium ( hydrogen isotope)

IAEA ................................ International Atomic Energy Agency

LILW................................ Low and Intermediate Level Waste

LL ................................... Long lived (radionuclides)

LTO ................................. Long Term Operation

MEWF .............................. Romanian Ministry for Environment, Waters and Forests

MACSTOR ....................... Dry storage module for SNF

MS................................... Member state (of the EU)

NATO............................... North Atlantic Treaty Organisation

NPP.................................. Nuclear power plant

RAW/RW.......................... Radioactive Waste

SE.................................... South east (Europe)

SEA ................................. Strategic Impact Assessment

SL .................................... Short lived (radionuclides)

SNF ................................. Spent Nuclear Fuel

SNN ................................. Societatea Nationala NUCLEARELECTRICA, S.A

SSC.................................. System Structures & Components

SEA ................................. Strategic Impact Assessment

UBA .................................. Umweltbundesamt

UVP .................................. Umweltverträglichkeitsprüfung

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umweltbundesamt

**Umweltbundesamt GmbH**
Spittelauer Lände 5
1090 Wien/Österreich

Tel.: +43-(0)1-313 04

office@umweltbundesamt.at
www.umweltbundesamt.at

EMAS
VERIFIED
ENVIRONMENTAL
MANAGEMENT
AT-000484

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