<u>Note: All the answers to questions received from UKRAINE Authority are found within Impact Study Report – complete Romanian and English version</u>

Question no.1 - Information on the qualitative, quantitative and temperature indicators of industrial wastewater generated as a result of the activities of the Cernavoda NPP and discharge into the Danube River, mathematical models of the spread of pollutants (chemical, radiological, toxicological, etc.) and temperature indicators in the waters of the Danube River, in particular towards territories of Ukraine

- With regard to your request in address registred at MMAP with the no. R/3755/27.09.2024, requesting information ***on the qualitative, quantitative and temperature indicators of the industrial wastewater*** resulting from the activities of Cernavodă NPP and discharged into the Danube river, we inform you that this information is included in the Environmental Assessment Report for the Project ”*Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*", in chapter 3. DESCRIPTION OF THE RELEVANT ASPECTS OF THE CURRENT STATE OF THE ENVIRONMENT (BASELINE SCENARIO).

The environmental impact assessment for the project " *Refurbishment of Cernavodă NPP U1 and extension of intermediate dry spent fuel storage with MACSTOR - 400 modules*" **had as starting point the quantification of the significant effects on environmental factors as a result of the operation Cernavoda NPP objectives until now**, *based on the monitoring results for each environmental factor, both radiological and non-radiological*.

In terms of water supply and industrial wastewater discharge generated by the activity of the plant, Cernavodă NPP operates on the basis of water management authorizations issued by the competent authorities which establish monitoring programs in terms of **quantity and quality**, both for influent and technological effluent. In the same time, given the specific nature of Cernavodă NPP activities, the authorizations for the operation of the nuclear objectives existing on the site (U1, U2, DICA, DIDSR), issued by the National Commission for Nuclear Activities Control (CNCAN), **provide monitoring programs for radioactive effluents**.

Thus, the EIA presents a conservative synthesis based on the monitoring requirements imposed by regulatory acts issued for the operation of nuclear facilities (*issued by CNCAN, the Ministry of Environment, Waters and Forests, ANAR/ABADL*) - during operation, correlated with the results of previous environmental assessments and the results of the monitoring campaign conducted during the elaboration of the EIA report, in the summer of 2023.

The results of the monitoring programs carried out by NPP's own laboratories were taken into account, covering both the period of analysis up to 2018, referring to the last environmental assessment within the procedure for obtaining a new environmental authorization for the operation of nuclear units, and the subsequent period 2018-2022. Cernavodă NPP has an internal procedure called "Environmental analysis, determination of environmental aspects and establishment of significant environmental aspects at Cernavodă NPP", by which the main environmental aspects related to the operation of nuclear units in operation are assessed.

The results provided by the The National Network for Monitoring the Radioactivity of the Environment, which provides data generated by the Standard Environmental Radioactivity Monitoring Program on the national territory and by the The environmental radioactivity monitoring program in the area of influence of Cernavodă NPP, were also taken into account.

- ***Monitoring results of the <u>quality</u> of technological water discharged from Cernavodă NPP – non-radioactivity indicators, during 2018 ÷ 2022***

  From the results of the monitoring of the chemical parameters of the water discharged from the Cernavodă NPP**, <u>it can be seen that the average annual loadings have been within the limits imposed by the regulatory acts and do not show significant variations in the effluent compared to the influent, similar to the situation recorded since the commissioning of the nuclear units, U1 in 1997 and U2 in 2008</u>**

As regards **the temperature of the influent and of the technological effluent,** they are monitored on a daily basis, at points established by the water management authorizations. The evolution of the water temperature is, broadly speaking, synchronous with the air temperature regime, except for the cold periods of the year when the Danube waters register monthly averages higher with +1.1 – +3.8 ^{o}C.

The results of the monitoring of water temperatures during 2018÷2022 show compliance with the limits regulated by the water management authorizations and respectively by the environmental authorizations – similar to the situation found in the environmental assessments carried out throughout the period of operation of the nuclear units.

Radiological aspects

The EIA shows, broken down by the Danube and CDMN discharge routes, respectively, the evolution of the annual emissions of liquid effluents from the nuclear units in operation at Cernavoda NPP, determined within the framework of the liquid effluent monitoring program.

It is found that, during the entire period of operation, the annual liquid emissions of tritium were constantly below 1% of the approved Derived Discharged Limits. During the entire period of commercial operation, the discharges of radioactive liquid effluents were lower than the Derived Emission Limits approved by CNCAN.

As in the case of the monitoring data presented by RNSRM, the average annual values of **the gross-beta activity concentration reported by Cernavoda NPP for the period 1996-2022 were below the threshold of 2 Bq/l**.

The results obtained from the gamma spectrometry analysis of surface water samples did not reveal artificial radionuclides emitting gamma radiation.

At the same time, during the 2023 monitoring campaign carried out by ICN Pitești, it was found that tritium is the only anthropogenic radionuclide generated in the plant and that was detected in the water from the monitoring location located on the Danube downstream of the confluence with the spillway (similar to location LII-06 of the monitoring of the plant). For each sample, the values of the minimum detectable concentrations of radionuclides emitting gamma radiation from the list of radionuclides for which derived emission limits are established were calculated and are presented in the EIA Report. **None of these radionuclides were detected in the analyzed samples, which is in agreement with the results of the plant's monitoring program**

Conclusions regarding the current radiological state of the environment

The analyzes to determine the activity concentration of radionuclides emitting gamma radiation did not reveal the presence of specific anthropogenic radionuclides at the Cernavoda NPP in: surface waters. The results obtained within the environmental monitoring program at Cernavoda NPP, as well as previous studies regarding the impact of activities on the Cernavoda NPP platform on the environment, showed that the only radionuclide coming from the operation of the plant, which can be detected outside its location, is tritium, and the area where its concentration in environmental factors can have values above the background level has a maximum radius of 10 km. Thus, it can be stated that, under normal operating conditions of the plant, the emissions of radioactive effluents from Cernavoda NPP do not produce any detectable change in the level of radioactivity of the environmental compartments in locations situated on the border with Bulgaria and, consequently, neither within the territory of this country.

As a result of the aspects presented in the EIA, it can be concluded that even on the territory of Ukraine, 112 km away from Cernavodă NPP, the emissions of radioactive effluents from Cernavoda NPP do not produce any detectable change in the level of radioactivity of the environmental compartments

From a ***quantitative point of view***, based on the reporting data of Cernavodă NPP and previous environmental balances, the EIA Report shows that the volumes of technological water, abstracted from the Danube through CDMN, necessary for the operation of the two nuclear units have remained at relatively constant levels, below the maximum authorized volume.

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

Water will be sourced from the same local water supply systems of the holder, and the water requirement during the implementation of the two subprojects will comply with the authorized water flow rates during the operation of all facilities on the site.

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

During the Operation Stage of the refurbished U1 and DICA-MACSTOR 400, the provision of water supply and wastewater discharge will be carried out, similarly as in the current operating situation of the 2 nuclear units, through the same systems currently regulated at Cernavoda NPP. For exemplification of the above-mentioned aspects we present below some excerpts from the RIM.

Aspects related to qualitative, quantitative and temperature indicators of industrial wastewater generated as a result of the activities of Cernavoda NPP as follows:

- the average multiannual flow (1976 – 2019) of the Danube is of 5380 m^3/s in the Bazias section and of 6493 m^3/s at Isaccea.
- the maximum flow transported on CDMN is 225 m^3/s, and the maximum supply flow to Cernavoda NPP is 53 m^3/s per unit operating at full power.

The EIA report, table 30, show the volumes of water intake from the Danube, via CDMN and derivation, in the period 2018 – 2022, respectively the volumes of water returned in this period.

Tab. 1 The volumes of cooling water used annually at Cernavoda NPP during 2018 ÷ 2022, broken down by the two nuclear power units U1 and U2, according to the Monthly Reports on the results of non-radioactive liquid influent and effluent monitoring

Volumes of water at **U1** (thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Total volume	***1201104.4***	***1272235.3***	***1163632.4***	***1260725.5***	***1125234.8***
Fresh water volume	1081872.5	1171373.8	1070339.8	1167611.0	995447.6
Recirculated volume	119231.9	100861.5	93292.6	93114.5	129787.2
Volumes of water at **U2** (thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Total volume	***1275967.8***	***1208063.2***	***1276104.7***	***1188095.8***	***1278589.9***
Fresh water volume	1158895.3	1113655.0	1183363.3	1071511.4	1138561.1
Recirculated volume	117072.5	94408.2	92741.4	116584.4	140028.8

The 2018 environmental balance showed that water consumption for cooling, with the Danube River as source, was at relatively constant levels, both for the period when only the U1 unit operated (1997-2006), and after Unit 2 was put into commercial operation (2007-2016) - when there was a proportional increase in the consumption of technological cooling water.

From a quantitative point of view, in the period 2018 ÷ 2022 the volumes of water used annually were at the level of those presented in the 2018 environmental balance, below the maximum annual volume of 3405888 thousand cubic meters authorized by ANAR.

Tab. 2 The volumes of water returned by Cernavoda NPP into receivers, during 2018 ÷ 2022, broken down by the two nuclear power units U1 and U2

Volumes of water from **U1** (thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Volume of technological water discharged into Danube	1081872.5	1171373.8	1070339.8	1167611.0	995447.6
Volume of technological water discharged into CDMN - race II	0	0	0	0	0
Volumes of water from **U2**(thousands c.m./year)	**2018**	**2019**	**2020**	**2021**	**2022**
Volume of technological water discharged into Danube	1158895.3	1113655.0	1183363.3	1071511.4	1138561.1
Volume of technological water discharged into CDMN - race II	0	0	0	0	0

Analyzing the period 2018 ÷ 2022, based on the reports, it can be seen that water restitution was exclusively into the Danube, through the Seimeni channel. The returned water volumes represented, on average, 91% of the total volumes of water taken annually for each of the two nuclear units, similar to the situation found in the previous environmental assessment (Environmental Balance - 2018).

Monitoring results of the quality of technological water discharged from Cernavodă NPP – non-radioactivity indicators, during 2018 ÷ 2022

The results obtained through the monitoring program carried out by Cernavoda NPP during 2018÷2022, according to the last regulatory act issued by the Ministry of Environment, Water and Forests regarding the NPP operation, are presented synthetically, as annual averages, in the following tables, extracted from EIA report:

Tab. 3 The evolution of the annual averages determined for the physico-chemical indicators analyzed in the influent and effluents of Cernavoda NPP

No. crt.	**Indicator**	**MU**	**Evacuation limits**	**Sampling point**	**2018**	**2019**	**2020**	**2021**	**2022**
1.	pH	-	**6.5 – 9.0**	Danube	8.06	8.1	8.12	8.1	8.0
				Bridge NPP	8.14	8.1	8.17	8.1	8.1
				Bridge Seimeni	8.15	8.1	8.17	8.1	8.1
				Bridge CPPON	-	-	-	-	-
2.	Suspended matter	mg/l	**25**	Danube	19.50	17.3	15.8	15.5	11.8
				Bridge NPP	16.50	12.9	12.8	13.2	10.1
				Bridge Seimeni	16.75	14.8	16.1	15.2	11.1
				Bridge CPPON	-	-	-	-	-
3.	Total ionic iron	mg/l	**1.5**	Danube	0.38	0.4	0.38	0.43	0.26
				Bridge NPP	0.30	0.4	0.33	0.39	0.27
				Bridge Seimeni	0.36	0.4	0.36	0.44	0.30
				Bridge CPPON	-	-	-	-	-
4.	Chloride	mg/l	**250**	Danube	21.00	22.3	20.3	20.8	23.2
				Bridge NPP	18.50	23.3	20.4	21.7	23.8
				Bridge Seimeni	21.25	23.5	20.3	20.9	23.8
				Bridge CPPON	-	-	-	-	-
5.	Sulfates	mg/l	**200**	Danube	27.50	26.8	26.4	27.9	26.8
				Bridge NPP	27.75	27.3	26.3	28.4	27.4
				Bridge Seimeni	27.75	25.8	26.1	28.3	27.3
				Bridge CPPON	-	-			
6.	Ammonium (only in case of use)	mg/l	**3**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	-	-	-	-	-
				Bridge CPPON	-	-	-	-	-

No. crt.	Indicator	MU	Evacuation limits	Sampling point	2018	2019	2020	2021	2022
7.	CBO5	mg/l	**15**	Danube	6.00	5.3	5.2	3.1	2.7
				Bridge NPP	6.08	5.5	5.2	3.5	3.7
				Bridge Seimeni	6.40	5.4	5.2	3.2	2.8
				Bridge CPPON	-	-	-	-	-
8.	Sodium	mg/l	**100**	Danube	14.00	16.0	15.8	16.0	16.3
				Bridge NPP	14.50	16.5	15.8	15.9	16.8
				Bridge Seimeni	14.25	16.3	15.8	15.9	16.4
				Bridge CPPON	-	-	-	-	-
9.	Calcium	mg/l	**150**	Danube	38.75	33.8	44.2	45.0	41.9
				Bridge NPP	37.50	34.5	43.9	44.9	41.9
				Bridge Seimeni	38.75	34.8	44.3	45.1	42.1
				Bridge CPPON	-	-	-	-	-
10.	Magnesium	mg/l	**50**	Danube	14.8	11.3	12.1	12.6	12.3
				Bridge NPP	14.8	11.3	12.0	12.3	12.3
				Bridge Seimeni	14.8	11.5	11.9	12.3	12.3
				Bridge CPPON	-	-	-	-	-
11.	Hydrazine	mg/l	**0.1**	Danube	-	-	-	-	-
				Bridge NPP	-	-	<0.003	<0.003	<0.003
				Bridge Seimeni	<0.003	<0.003	<0.003	<0.003	<0.003
				Bridge CPPON	-	-	-	-	-
12.	Morpholine	mg/l	**0.4**	Danube	-	-	-	-	-
				Bridge NPP	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
				Bridge Seimeni	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
				Bridge CPPON	-	-	-	-	-
13.	Lithium hydroxide	mg/l	**0.025** (Li calc. < 0.007)	Danube	-	-	-	-	Li: 0.005
				Bridge NPP	-	-	Li: 0.005	Li: 0.005	Li: 0.005
				Bridge Seimeni	Li:0.004	Li: 0.006	Li: 0.005	Li: 0.005	Li: 0.005

No. crt.	Indicator	MU	Evacuation limits	Sampling point	2018	2019	2020	2021	2022
				Bridge CPPON	-	-	-	-	-
14.	RGCC-100	mg/l	**1.0** (NO_2 calc. <0.2)	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	NO_2^- <0.03	NO_2^- <0.03	NO_2^- <0.03	NO_2^- <0.03	NO_2^- <0.03
				Bridge CPPON	-	-	-	-	-
15.	Oils	mg/l	**Absent**	Danube	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)
				Bridge NPP	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)
				Bridge Seimeni	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)	absent (vizual)
				Bridge CPPON	-	-	-	-	-
16.	Ethylene glycol	mg/l	**1.0**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	< 1	< 1	< 1	< 1	< 1
				Bridge CPPON	-	-	-	-	-
17.	Petroleum products	mg/l	5**.0 (fără irizații)**	Danube	-	-	-	-	-
				Bridge NPP	<0.05	< 0.24	< 0.24	< 0.2	< 0.1
				Bridge Seimeni	<0.05	< 0.24	< 0.24	< 0.2	< 0.1
				Bridge CPPON	-	-	-	-	-
18.	Biocide MCB-50	mg substanță activă/l	**5,2**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	-
				Bridge Seimeni	0	0	-	0	SLD
				Bridge CPPON	-	-	-	-	-
19.	PRAESTOL A3040L	mg/l	**3**	Danube	-	-	-	-	-
				Bridge NPP	<0.1	<0.1	<0.1	<0.1	<0.1
				Bridge Seimeni	<0.1	<0.1	<0.1	<0.1	<0.1

No. crt.	Indicator	MU	Evacuation limits	Sampling point	2018	2019	2020	2021	2022
				Bridge CPPON	-	-	-	-	-
20.	NALCO 3DT149*	mg/l	**500**	Danube	-	-	-	-	-
				Bridge NPP	<24	<24	-	-	-
				Bridge Seimeni	<24	<24	-	-	-
				Bridge CPPON	-	-	-	-	-
21.	NALCO 3DT449 ** expressed as Total Phosphorus	mg/l	**P_{Total}<1**	Danube	-	-	-	-	-
				Bridge NPP	-	-	-	-	0.07
				Bridge Seimeni	-	-	-	-	0.07
				Bridge CPPON	-	-	-	-	-
22.	Free residual chlorine ***	mg/l	**0,2**	Danube	-	-	-	-	-
				Bridge NPP	-	-	<0.1	<0.02	<0.2
				Bridge Seimeni	-	-	<0.1	<0.02	<0.2
				Bridge CPPON	-	-	-	-	-

* NALCO 3DT149 – it was no longer used in the technological process in STA from 01.09.2019.

** NALCO 3DT449 – started to be used at STA in April 2022; control concentration determined in March 2022, before the start of use: 0.05 mg P_{total}/l)

*** only in case of discharge of hypochlorite solution resulting from washing the drinking-water tanks.

During 2018 ÷ 2022 Cernavoda NPP did not discharge technological waters into the Danube-Black Sea canal. Moreover, during the entire period of operation of the nuclear units, the evacuation in the CDMN was sporadic and was carried out only with the approval of the competent authorities.

From the results of the monitoring of the chemical parameters of the water discharged from the Cernavodă NPP, it can be seen that the average annual loadings have been within the limits imposed by the regulatory acts and do not show significant variations in the effluent compared to the influent, similar to the situation recorded since the commissioning of the nuclear units, U1 in 1997 and U2 in 2008.

The temperature of the influent and of the technological effluent are monitored on a daily basis, at points established by Water License and Environmental License and monitored as per the Protocol concluded with ABADL (regional Water Regulator/Authority).

Starting from September 2020, an automatic water temperature monitoring system was commissioned at points NPP Bridge – for the influent and respectively at the spillway from the Seimeni Valley concrete channel – measuring section 1 for the effluent discharged into the Danube.

The system complements the existing one, which continues to operate at Cernavoda NPP and which covers the following 4 measuring sections downstream, so that it is possible to verify compliance with the regulated limits for discharge into the Danube River (maximum 10°C above the water temperature of the Danube River – at the debouch, but not more than 35°C after passing through the mixing zone). If the temperature measured automatically at the Seimeni spillway exceeds 35ºC, the temperature is measured downstream, in the additional control sections in the mixing area, according to Protocol concluded between the NPP and ABADL (based on a Study dedicated to settle the length and profile of mixing zone), for compliance verification.

The following table shows the monthly averages related to the monitoring of water temperatures during 2018÷2022.

Tab. 4 Monthly averages of water temperatures in influent and the technological effluent from Cernavoda NPP

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
		Average temperature (ºC)											
018	Influent	11.9[1]	9.2[1]	10.1[1]	11.7[1]	21.0	25.1	24.8	26.7	23.3	16.2	11.0[1]	12.4[1]
	Effluent	18.5	15.2	15.9	17.6	27.0	32.6	32.4	34.9	31.4	24.9	16.1	17.6
019	Influent	10.6[1]	11.8[1]	11.6[1]	12.7	17.5	22.6	26.6	27.0	22.7	17.8	13.2	10.9[1]
	Effluent	16.1	17.4	18.3	20.8	23.3	29.5	34.5	35.0	30.1	26.4	21.7	18.2
020	Influent	10.4[1]	11.2[1]	10.1[1]	12.5	19.2	21.9	25.4	26.2	23.3	17.5	10.8	10.3[1]
	Effluent	18.2	18.8	18.6	20.8	27.6	28.8	31.1	33.7	31.9	26.1	19.2	17.1
021	Influent	11.3[1]	10.7[1]	9.5[1]	11.4	17.9	21.9	27.7	27.1	21.2	14.4	10.9	9.3[1]
	Effluent	17.7	17.7	17.2	19.5	24.4	28.8	< 35[2]	< 35[2]	29.6	22.9	19.2	17.1
022	Influent	10.2[1]	11.1[1]	12.3[1]	12.7	19.4	25	27	27.1	22.3	16.9	13.4	10.6[1]
	Effluent	18.1	19	19.8	21.1	26.5	31.4	33.4	< 35[2]	31.1	25.6	22.1	18.3

1) the influent temperature measured in the distribution bay, water recirculation taking place.

2) the temperature measured in section 2 and confirmed in section 5, according to the protocol. In section 1, before the debouch into Danube, the average temperature was 35.2 – 35.3ºC.

The evolution of the water temperature is, broadly speaking, synchronous with the air temperature regime, except for the cold periods of the year when the Danube waters register monthly averages higher with +1.1 – +3.8 ºC.

The results of the monitoring of water temperatures during 2018÷2022 show compliance with the limits regulated by the water management authorizations and respectively by the environmental authorizations – similar to the situation found in the environmental assessments carried out throughout the period of operation of the nuclear units.

Question no.2. Assessment of the impact on the flora and fauna (especially sturgeon) of the Danube River caused by the discharge of industrial wastewater (including hot technical water)

The monitoring programs previously carried out in the framework of the environmental assessments for CNE Cernavodă, as well as the BIOTA programs that focused on the hydrobiology component, with both nuclear units in operation, did not revealed changes in the structure and functioning of the aquatic communities (including ichthyofauna and sturgeon species).

The impact associated with the refurbishment project and subsequent operation of the refurbished U1 unit is insignificant on the aquatic environment, respectively on the hydro-bio-cenotic components, therefore also on the sturgeon species.

The EIA, at ch. 7, subch. 7.5.3, presents a *Proposal for a Monitoring Plan for the environmental factor BIODIVERSITY*, including ichthyofauna, both for the project implementation period and after the refurbished Unit U1 is put into operation.

Question no. 3. Assessment of the impact of emergency situations on the environment, mathematical modeling of the spread of radiological contamination for various scenarios of meteorological conditions and winds in the event of an event or accident with radiological consequences and a nuclear accident at the NPP (including at the intermediate spent fuel storage).

Radiological impact assessment for Cernavoda NPP emergency situations

Section 8.2 of EIA presents in detail the risk assessment based on nuclear safety analyses.

The Cernavoda NPP project is based on updated nuclear safety analyses, which reflect the latest requirements and analysis methods, in accordance with national norms and international standards. The operation of the Cernavoda NPP is carried out in accordance with the limits and technical operating conditions, based on the current nuclear safety analyses, thus ensuring safe operation, with minimal risks for workers, the population and the environment.

Cernavodă NPP has carried out nuclear safety analyzes for the conditions of expanding the design bases, to confirm the feasibility of implementing emergency operating procedures and/or accident management guidelines, with the aim of maintaining physical barriers to the uncontrolled release of fission products in the environment, respectively with the aim of limiting damage to the reactor core and protecting the physical and functional integrity of the reactor building.

For events classified as a design basis accident, the regulatory requirements are aimed at preserving the integrity of the physical barriers designed between the nuclear fuel and the environment: the fuel sheath, the pressure tubes, the main heat transport system and the containment. Similarly, for anticipated transients in operation, after correcting the causes that produced that event, when all plant systems are in a stable and controlled state, the operation of the unit at rated power can be resumed.

For events that exceed the design bases, in accordance with the results of the COG programs, Cernavoda NPP has implemented measures and strategies to restore nuclear safety functions, with the aim of bringing the plant to a stable and controlled state in the long term. Thus, the maximum value of the individual effective dose, following exposure to the postulated radiological release, for a period of 30 days, for the event "Feeder Stagnation Break" is 5.471 mSv, at the limit of the exclusion zone, for the SSW sector. 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).

As it is stated in EIA report, in chapter 8, there is developed the Licensing Basic Document (confidential) entitled „Strategy for Establishing Technical Bases for the Emergency Plan at the Cernavodă NPP”, in accordance with IAEA and Romanian Regulatory Body - CNCAN requirements.

The document is used for all activities performed on site, including the Refurbishment of Unit 1 and the Extension of Intermediate Dry Spent Fuel Storage with MACSTOR - 400 Modules.

In order to limit the consequences of radiological and/or chemical incidents, with or without environmental impact, Cernavodă NPP has established an emergency response plan, which is approved by CNCAN. Periodic exercises are conducted to verify Cernavodă NPP's preparedness for emergency responses, with their results being evaluated, lessons learned being retained, and transferred in the actions tracked system "Action tracking”.

The types of accidents covered by the document:

- Radiological events;
- Medical events;
- Chemical events;

−Fires;

−Loss of the main control room events;

−Transport and transfer events;

−External events;

−Physical protection events.

As stated in EIA report, nuclear category of accidents is applicable only to the Unit 1 refurbishment sub-project and may occur during the periods of reactor operation: until its shutdown and discharge of nuclear fuel (during the retubing preparation stage) or during the commissioning and test-operation stage. The accident scenarios to be considered are similar to those included in the safety analyzes contained in the plant's final safety report.

Based on the evaluation of the nuclear installation project, operating procedures and potential site-specific external influences, Cernavoda NPP has identified a list of internal and external events, covering all states and operating modes of the nuclear installation and all scenarios that could lead to affecting nuclear safety functions. Internal and external events were analyzed both for the purpose of identifying the transient or accident sequences they can generate, and for the purpose of qualifying and protecting systems with nuclear safety functions. These events were evaluated and grouped according to the estimated frequency of occurrence and the consequences on the state of the plant, and thus the design basis events for the systems with nuclear safety functions were established.

Design basis events include anticipated operating transients and design basis accidents, also called postulated accidents.

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. To ensure sufficient nuclear safety margins, the assumptions used in the analyzes are conservative and assume the operation of the protective systems at the minimum level of admissible performance.

As part of the implementation of the defense-in-depth concept, Cernavodă NPP also analyzed more severe conditions than the design basis accidents, called design basis extension conditions, such as those that can be caused by multiple failures, induced by the complete loss of all functions of a protective safety system or by a highly improbable event, including severe accidents, involving damage to the core of the reactor and melting of nuclear fuel.

Through deterministic nuclear safety analyses, probabilistic nuclear safety assessments, as well as on the basis of engineering judgments, using also international experience, the behavior of the nuclear installation was analyzed for those severe conditions,

caused by internal and external events, which are physically possible and for which there are reasonable measures and means, technically possible and practicable for the protection of the nuclear installation, in order to prevent severe accidents, respectively to limit their consequences.

The conditions for expanding the design bases include two categories of events:

- events and combinations of events that can lead to the systematic failure of nuclear fuel inside the reactor core; for these events, dedicated SSCs are provided at Cernavoda NPP and procedural measures are implemented to prevent serious damage to the reactor core and melting of the nuclear fuel in the reactor core;
- events where the capability of the nuclear facility to prevent systematic failure of nuclear fuel is exceeded or where the measures provided are assumed not to function as expected, thus leading to severe accident conditions; at Cernavodă NPP, feasible procedural measures have been established and the nuclear facility includes specific SSCs, provided for stopping the progression of the severe accident and limiting the consequences of these accidents.

Cernavodă NPP has carried out nuclear safety analyzes for the conditions of expanding the design bases, to confirm the feasibility of implementing emergency operating procedures and/or accident management guidelines, with the aim of maintaining physical barriers to the uncontrolled release of fission products in the environment, respectively with the aim of limiting damage to the reactor core and protecting the physical and functional integrity of the reactor building.

The nuclear safety analyzes carried out for Unit 1 at Cernavodă NPP are carried out for Unit 1, in order to demonstrate the fulfillment of the nuclear safety quantitative objectives from the CNCAN norms requirements.

The deterministic nuclear safety analyzes demonstrate that for the initiation events relevant to this nuclear facility, the nuclear safety functions are ensured and the objectives and the nuclear safety criteria are met, without exceeding the dose limits and criteria established by the legislation in force, according to the classification in the table belows.

Tab. 5 Dose criteria for design basis event analysis for nuclear facilities [NSN-24]

Class of event	**Event category**		**Annual frequency estimated by appearance of an event or a sequence of events**	**Maximum effective dose value for the most exposed person outside the exclusion zone, calculated for 30 days from the beginning of the release, for all ways of expected exposure**
Class 1	Anticipated events in	Design basis events	f > 1E-2	0.5 mSv

	exploitation			
Class 2	Design basis accidents		1E-2 > f > 1E-5	20 mSv
Class 3	Conditions for extension of type A design bases	Extension conditions of design bases; they represent a subset of events outside the design basis.	f < 1E-5	-
Class 4	Conditions for extension of type B design bases			-

For events classified as a design basis accident, the regulatory requirements are aimed at preserving the integrity of the physical barriers designed between the nuclear fuel and the environment: the fuel sheath, the pressure tubes, the main heat transport system and the containment. Similarly, for anticipated transients in operation, after correcting the causes that produced that event, when all plant systems are in a stable and controlled state, the operation of the unit at rated power can be resumed.

For events that exceed the design bases, in accordance with the results of the COG programs, Cernavoda NPP has implemented measures and strategies to restore nuclear safety functions, with the aim of bringing the plant to a stable and controlled state in the long term.

According to the Final Safety Report of Unit 1, 2022 edition, the Design Base Event (DBE) that has the most serious consequences in terms of the radiological impact on the population is the "*Feeder Stagnation Break* " event, followed by the shutdown of the reactor, the operation of the emergency core cooling system and the operation of the emergency containment systems.

Thus, the maximum value of the individual effective dose, following exposure to the postulated radiological release, for a period of 30 days, for the event "Feeder Stagnation Break" is 5.471 mSv, at the limit of the exclusion zone, for the SSW sector (South South-West), corresponding to the "99% Cut-off" percentile.

For this type of event, the calculated values of the effective dose for persons in the population, distributed according to their location, are shown in the EIA table below:

Tab. 6 Calculated values of the effective dose for a postulated type event Feeder stagnation break

Distance	Collective individual dose distribution by Distance and Affected Sector (mSv)															
(Km)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0.982	2.020	1.067	0.843	1.628	1.679	1.709	2.841	1.865	5.471	4.915	3.913	3.983	4.205	5.310	5.371
2	0.435	0.663	0.334	0.254	0.518	0.530	0.519	0.865	0.950	1.950	1.757	1.216	1.276	1.347	1.870	1.900
3	0.309	0.339	0.171	0.123	0.260	0.263	0.261	0.424	0.563	0.993	0.889	0.604	0.656	0.703	0.941	0.956
4	0.243	0.208	0.105	0.078	0.157	0.161	0.158	0.257	0.374	0.596	0.518	0.366	0.420	0.446	0.560	0.571
5	0.180	0.138	0.070	0.057	0.107	0.109	0.106	0.173	0.285	0.400	0.349	0.245	0.284	0.321	0.368	0.376
6	0.149	0.101	0.053	0.044	0.078	0.080	0.077	0.126	0.222	0.283	0.240	0.175	0.209	0.232	0.259	0.265
7	0.130	0.078	0.042	0.034	0.060	0.061	0.060	0.095	0.183	0.211	0.180	0.135	0.159	0.174	0.192	0.196
8	0.110	0.062	0.034	0.028	0.048	0.048	0.047	0.075	0.152	0.162	0.140	0.107	0.127	0.131	0.146	0.148
9	0.093	0.051	0.028	0.024	0.040	0.040	0.039	0.061	0.129	0.126	0.108	0.087	0.099	0.101	0.115	0.117
10	0.080	0.041	0.024	0.020	0.033	0.033	0.032	0.051	0.113	0.103	0.089	0.073	0.082	0.083	0.093	0.094
15	0.042	0.022	0.013	0.011	0.017	0.017	0.017	0.025	0.059	0.005	0.036	0.032	0.034	0.036	0.038	0.038
20	0.027	0.014	0.009	0.008	0.011	0.011	0.011	0.014	0.037	0.024	0.020	0.017	0.018	0.020	0.020	0.020
25	0.017	0.009	0.006	0.006	0.008	0.008	0.007	0.009	0.025	0.017	0.013	0.011	0.011	0.013	0.012	0.012
30	0.012	0.006	0.005	0.004	0.006	0.006	0.005	0.007	0.016	0.013	0.009	0.008	0.008	0.009	0.009	0.008
40	0.006	0.004	0.003	0.003	0.004	0.004	0.003	0.004	0.011	0.009	0.006	0.005	0.004	0.006	0.005	0.005
50	0.004	0.003	0.002	0.002	0.003	0.003	0.002	0.003	0.006	0.007	0.004	0.003	0.004	0.004	0.003	0.003
60	0.003	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.005	0.006	0.003	0.003	0.003	0.004	0.003	0.003
70	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002	0.004	0.005	0.003	0.002	0.002	0.004	0.003	0.002
80	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.004	0.004	0.002	0.002	0.002	0.003	0.002	0.002
90	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.002	0.002	0.002	0.003	0.002	0.002
100	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.002	0.002	0.002	0.003	0.002	0.001

As can be seen from the table above, the maximum value of the effective dose at a distance of 30 km from the plant is 16 microSv, which means that for any person located on the territory of neighboring countries (Bulgaria or Ukraine), the effective dose as a result of the Design Base Event (DBA) with the most serious consequences in terms of radiological impact on the population, will be lower than this level. It should be noted that the value of 16 microSv corresponds to exposure to the natural background radiation (including exposure to radon) over a period of 58 hours (considering an average value of the total effective dose due to radiation of natural origin of 2.4 mSv/year).

In conclusion, the Cernavoda NPP project is based on updated nuclear safety analyses, which reflect the latest requirements and analysis methods, in accordance with national norms and international standards. The operation of the Cernavoda NPP is carried out in accordance with the limits and technical operating conditions, based on the current nuclear safety analyses, thus ensuring safe operation, with minimal risks for workers, the population and the environment.