

**ENVIRONMENT IMPACT ASSESSMENT
REPORT ON**

INVESTMENT PROPOSAL

**CONSTRUCTION OF NATIONAL DISPOSAL
FACILITY FOR LOW AND INTERMEDIATE
LEVEL RADIOACTIVE WASTE – NDF**

PART VI

CUMULATIVE EFFECT

Sofia, January 2015

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6 CUMULATIVE EFFECT

The approach applied to the assessment of cumulative effects is based on a common methodological framework, namely the assessment of potential cumulative effects of existing, approved or in the process of approving and / or development projects on components / environmental factors having analyzed:

1. The cumulative effects - the total impact of various effects on each component / environmental factor;
2. Effects of superposition:
 - ✓ accumulation of the same effects, leading to a new significant impact,
 - ✓ accumulation of different effects, which results in a new significant impact;
3. Effects in time - an assessment of possible impacts that arise in various stages of implementation of the projects (construction, operation and decommissioning) and leading to new significant impact.

The assessment of cumulative effects and significance is carried out taking into account the degree of impact on components / environmental factors.

6.1 THE CUMULATIVE IMPACT FOR THE COMPONENT - AIR

For emissions of air pollutants, the cumulative impact is expected by gas emissions from transport activities related to the project on the national and municipal road network - delivery of finished building blocks (modules), machinery and equipment, removal of unnecessary bulk materials and earth masses movement of staff and other related services to the construction process. Assessment of the levels of emissions from transport is made in the methodology of the *European Guide for emission inventory EMEP/EEA air pollutant emission inventory guidebook-2013* for key pollutants from heavy duty vehicles (1.A.3.b.iii). Transport emissions during construction of the project are given in **Table 4.1-4**, and estimated daily average emission intensity for 2020 in a 6 main categories cars: Cars, Vans, Medium and heavy duty vehicles, Buses (rural) and trucks with trailer in census points of Agency "Road Infrastructure" for road II-11 from the national road network¹ in an additional counting point ДПП-205 in the area of Kozloduy-Lom and ДПП-496 in the section Mizia-Kozloduy around the area of the NDF are given in section **3.1.2.3 - Emissions from road traffic in second class road II-11 - Table 3.1-12**.

The cumulative impact of transport activities related to the project and mid-hour intensity of traffic is presented in **Table 6.1-1**.

TABLE 6.1-1: THE CUMULATIVE IMPACT OF HEAVY DUTY TRAFFIC IN THE PROJECT IN CENSUS POINTS OF AGENCY "ROAD INFRASTRUCTURE" FOR 24 HOURS

Транспортен трафик	CO	NM VOC	NO _x	N ₂ O	NH ₃	Pb	PM ₁₀	Ideno Pyrene	B(k)F	B(b)F	B(a)P	CO ₂	SO ₂	C ₆ H ₆
пункт ДПП-496	0.4%	0.8%	3.3%	0.2%	0.1%	1.4%	2.1%	1.0%	3.6%	2.7%	0.8%	1.0%	0.4%	0.8%
пункт ДПП-205	2.7%	5.3%	19.7%	1.3%	0.6%	9.2%	10.9%	6.7%	24.1%	17.6%	5.2%	6.7%	2.7%	5.3%

In **Table 6.1-1** is a comparison between the emission load (kg / km) by **regular traffic** on the roads of the national road network, which will be used by the project and **transport activities**, delivery of finished building blocks (modules), machinery and equipment, including bulk materials and land masses on portions, movement of staff and others. related services to the construction process.

¹ „Road infrastructure, letter 53-00-9813 from 20.08.2014

The maximum cumulative load in these areas is 44.1% with respect to B (k) F, but these emission levels are very low following appropriate catalytic devices on vehicles in the respective environmental standard EURO.

The expected cumulative load on secondary road II-11 from the national road network is negligible.

Measures to further mitigate the cumulative impacts on air from gas emissions from the transport activities associated with the project requires rigorous analysis and planning the movement of construction vehicles, to include in the project for the organization and execution of construction (Project for organization and execution of construction) and the final plan for the organization of the transport scheme. These documents must include to comply with the following:

- powdered materials to be transported covered;
- coordination of transport scheme with local municipalities and town councils, as well as "NPP Kozloduy";
- limiting passage through populated areas. If this is unavoidable, it must be ensured:
 - rapid and unimpeded passage through the settlement at a steady speed (without stopping and reducing the permitted speed), which ensures a stable operating temperature of the engine, in which the levels of pollutant emissions are much lower,
 - Engines not to drive on free gear trough the populated areas.
- provided vehicles must meet the standards of EURO IV for heavy trucks and Euro 5 for passenger cars,
- movement of oversized trucks for delivery of prefabricated construction elements (modules), machinery and equipment to be delivered in the hours of the day, when the national road network has lower conventional traffic, which ensures smooth movement (without causing congestion).

6.2 THE CUMULATIVE IMPACT FOR THE COMPONENT - WATER

6.2.1 SURFACE WATER

In component surface and wastewater radioactive aspect is not expected cumulative effect due to insignificant volumes of waste fecal waters in the range of up to 8m³/day.

6.2.2 GROUND WATER

Implementation of the investment proposal will have no further impact on the existing quantitative and chemical status of groundwater. Therefore cumulative impact is not expected.

Cumulative effect is not expected by migration of radionuclides in ground water, as provided engineering barriers prevent transfer of radionuclides in the environment. Radioactivity of groundwater in the aquifer will remain with typical background levels under control levels according Ordinance № 1 of 10.10.2007 to study, use and protection of groundwater: total beta activity 1,0 Bq / l, total alpha -activity 0,5 Bq / l, total indicative dose of 0,1 mSv / y.

6.3 THE CUMULATIVE IMPACT FOR THE COMPONENT - SUBSURFACE

Expected impacts on earth is limited within the investment proposal. The most significant of these is the mechanical disruption of earth by the trench excavation, stability of slopes which project is provided as a basic combination of loads and basic combination of loads taking into account seismic impact. This fact excludes the manifestation of gravitational processes that could affect the nearby facilities and communications of the municipality of Kozloduy and NPP "Kozloduy". Furthermore predicted subsidence of the ground is within the permissible deformations, which are

not expected to lead to interactions with existing buildings and the design and equipment at the NPP site "Kozloduy". Therefore, and in view of projected geodetic **monitoring is not expected a cumulative effect** on the subsoil for the realization of the NDF.

6.4 THE CUMULATIVE IMPACT FOR THE COMPONENT - LANDS AND SOIL

The area for the realization of the NDF and before construction was not used appropriately for agricultural purposes. The slope is planted for erosion control purposes to protect the road near the NPP "Kozloduy".

Analyzed to date data on the state of lands and soil around the site "Radiana" provided for the construction of the NDF, and possible interference with the operation of the NDF, give grounds to conclude that the operation of the IP, will have further detrimental impact on land and soil as well as the adjoining and neighboring areas.

Upon *closure of the repository* after the reclamation of the land and its landscape unit, soil condition will improve and green areas will have a high environmental impact on the entire territory.

6.5 THE CUMULATIVE IMPACT FOR THE COMPONENT - NOISE

Anticipated noise characteristic of traffic flow on the main road II-11 for 2015 is 70 dBA (on 7.5 m. From the axis of movement). During construction of the NDF freight transport will increase the level of noise emitted by traffic flows on the road network in the area. Expected increase (cumulative effect) for road II-11 is up to 1 dBA.

6.6 CUMULATIVE IMPACTS ON COMPONENTS - LANDSCAPE

Disturbances in structure and functioning of landscapes are not expected. Changes will be in the construction period, but only in the local structure, no impact on the main type landscape.

Cumulative impact is not expected.

6.7 CUMULATIVE IMPACTS ON BIODIVERSITY

In non-radiation aspect from construction, operation and closure of the repository and the period of institutional control of the NDF is not expected to occur cumulative negative effect on flora and fauna because of the absence of any further large-scale construction and industrial sites in the area of site "Radiana" related to the implementation of large construction space in areas with wooded nature.

In radiation aspect, as a result of the operation and the institutional control of the NDF is not expected an occurrence of a cumulative effect on flora and fauna in the area of NPP "Kozloduy" and the repository, as performed in accordance with statutory radiological monitoring by the plant, radiation background of the environment here corresponds to the natural characteristic of this part of the country, i.e. is not result in an additional charge of plant operations but disposal of already isolated and disposed of in RCC low and intermediate level radioactive waste in the cells of the facility by closing and cover them with a multilayer barrier will completely neutralize the possibility of radioactive contamination of water, soil, air, geological environment and elements of biodiversity in the region, by which it follows that there can be no cumulative radiation impact on the environment of the realization of the object, including even in the implementation of other projects envisaged in the region which could be potential sources of radioactive contamination.

6.8 CUMULATIVE IMPACTS IN TERMS OF WASTE GENERATED

6.8.1 NON-RADIOACTIVE WASTE

Under strict control and effective management of non-radioactive waste generated by the NDF is not expected cumulative impact during construction, operation (small quantities of waste), closure and institutional control.

6.8.2 RADIOACTIVE WASTE

Regarding RAW - is not expected cumulative effect due to the fact that the NDF does not generate such but is a facility for disposal.

6.9 CUMULATIVE IMPACTS IN TERMS OF CHEMICAL SUBSTANCES AND MIXTURES

In periods of construction, operation and closure of the NDF using chemical substances and mixtures in relatively small quantities and under strict control and effective management it is not expected a cumulative effect.

6.10 THE CUMULATIVE IMPACT FOR THE COMPONENT HEALTH-HYGIENE OF ENVIRONMENT AND RISKS FOR HUMAN HEALTH

The assessment of cumulative effects of population health risk in the surveillance zone around the site of the NDF during construction, operation and closure of the NDF is based on the information gathered to identify hazards and the determination of chemical, physical and physiological factors of the environment.

The recommendations of the international organizations and the methodology for health risk assessment are taken (WHO, 1994, WHO / UNEP / ILO, 2001). Taken into consideration are the European indicators to assess the impact of the environment on human health.

Any possible negative impact on the environment and public health, including taking into account the synergistic effects of the radiation background is within permissible under the regulations.

6.11 CUMULATIVE IMPACT ON RADIATION RISK TO THE POPULATION FROM RADIOACTIVE RELEASES

The main task of the assessment of cumulative effects in radiation aspect as part of the EIA is to provide an analysis and assessment of the potential cumulative effect of the investment proposal implementation and operation of the other (present and future) facilities at the NPP site "Kozloduy" and outside, that could result from the aggregation of the effect of the implementation of the NDF and operation of Units 5 and 6 of Kozloduy with increased thermal power (104%), DSSNF (Dry storage of spent nuclear fuel), RSNF (Repository for spent nuclear fuel), decommissioning of units 1 ÷ 4 (Workshop for size reduction and decontamination) plasma incineration facility (PIF) and New nuclear power (NNP) with installed capacity of about 1200 MWe.

Risk assessment for the population of radioactive releases includes:

- Assessment of individual and collective doses to the population;
- Evaluation of radio-biological effects and radiation risk.

Assessment of external and internal exposure of the population in the region take into account the impact of these types:

- External exposure from radioactive cloud;
- External irradiation resulting from the deposition in the ground;
- internal exposure by inhalation;
- internal exposure from the consumption of radioactively contaminated foodstuffs.

Assessments of the radiation risk are in the following range:

1. Risk of radiation-induced cancer for the general population and persons of working age;
2. Risk of hereditary diseases of the whole population and for persons of working age;
3. Risks and damage to some tissues for the general population;
4. Risks of hereditary diseases for first generation and for two generations;
5. Risks of hereditary diseases of the reproductive part of the population evaluated for two generations under irradiation of the first generation before the second;
6. The risks of hereditary diseases for the reproductive part of the population assessed for the first generation after irradiation.

6.11.1 DOSES OF GAS-AEROSOL RELEASES

6.11.1.1 INPUT DATA

As input data is used for radioactive releases into the atmosphere, weather data, statistical demographic data, data on consumption and habits.

⇒ input demographic data and data on consumption and habits are taken:

- on Bulgarian territory from Annual Report, Results of radiation monitoring of the environment of NPP "Kozloduy" in 2012, № 11.RM.DOK.085;
- on Romanian territory from EIA of IP building new nuclear power of the latest generation at the NPP site "Kozloduy".²

According to statistical data from the National Statistical Institute by census of 01.02.2011 the number of population within 30 km zone around KNPP territory of the Republic of Bulgaria is 65 994 people. To compare statistical data from 2007 the number was 10% more - 72 416 people. By sex structure: men - 48.6%, women - 51.4%. In the research area there is 37.7% level of urbanization, which is much lower than the national average - 70.7%.

The distribution by age group in the region is as follows: 0-14 - 14.2%, 15-60 years - 54.3% and over 60 years - 31.5%. For the purposes of assessing the doses a more detailed age distribution is used.

For the calculation of collective doses is taken population density uniformly in all directions 43 people 1 km². The population of the critical group along the river Danube is determined to town Oryahovo with Leskovets with Island and Gorni Vadin) is estimated at 7469 people (NSI last census in 2011).

Used are statistics on production and consumption of basic food products in the region. The data are mainly plant foods, leaf vegetables, meat and milk.

⇒ Meteorological data:

- Annual Report, Results of radiation monitoring of the environment of NPP "Kozloduy" in 2012, №11.RM.DOK.085.

⇒ Emissions to air:

1. **NPP** – Annual report, Results of radiation monitoring of the environment of NPP "Kozloduy" in 2012, № 11.RM.DOK.085.

The EIS of the IP building New nuclear power reported releases of the following items on the site: BT-1, BT-2, 5BT-1, 5BT-2, 6BT-1, 6BT-2, 0BT и BT-XOГ. Considering the shut down of blocks 1÷4, and the fact that the source of emissions of radioactive

² EIA of the IP building new nuclear power of the latest generation at the NPP site "Kozloduy". CONSORTIUM "DICON - Axion ENG. 2013

noble gases (RNG) and Iodine-131 units are in service, the report used a more conservative approach compared to annual administrative borders of the discard components for the entire site at 2000 MWe operating power.

TABLE 6.11-1 GASEOUS RELEASES DURING OPERATION OF NPP "KOZLODUY", 2009-2013

Gaseous releases	2009	2010	2011	2012	2013
Radioactive noble gases (RNG), TBq	0.66	6.43	9.61	0.942	0.585
Radioactive aerosols (LLA), GBq	0.063	0.0282	0.0164	0.0192	0.0141
¹³¹ I, GBq	0.0056	0.0657	0.1220	0.0019	0.0049
³ H, TBq	-	0.376	0.545	0.586	0.441
¹⁴ C, TBq	-	0.519	1.010	0.710	0.557

2. **Decommissioning of units 1÷4** – Average annual levels over the entire period - EIA for decommissioning of units 1÷4, P16 D08 Line 01.6_ EIA - Chapter 11.

Average annual values throughout the decommissioning of Units 1÷4 are given for long-lived aerosols (LLA): 20 MBq. This value includes emissions from planned projects: Workshop for size reduction and decontamination of materials. The distribution of the radionuclide composition and activity in aerosol releases is according to annual limits and reference levels for the total activity of the liquid and gaseous discharges from blocks 1÷4 in the process of decommissioning.

TABLE 6.11-2 DISTRIBUTION OF THE RADIONUCLIDE COMPOSITION AND THE ACTIVITIES IN AEROSOL RELEASES PER YEAR THROUGHOUT THE DECOMMISSIONING OF BLOCKS 1÷4

Radionuclide	BT-1	BT-1	BT-2	BT-2
	%	A, MBq	%	A, MBq
Co-60	46	4.6	50	5.0
Sr-90	0.5	0.05	0.3	0.03
Cs-134	0	0	0.5	0.05
Cs-137	53	5.3	49	4.9
Pu-239, 240	0.2	0.02	0.1	0.01
Am-241	0.3	0.03	0.1	0.01
Total: 20 MBq		10		10

3. **PIF** (Plasma incineration facility) - Report for input data of the EIA on Plasma incineration facility, IBERDROLA, Id.№ I-650-RP-0009.

Annual averages during normal operation of the facility for plasma burning (Plasma Incineration Facility) for long-lived aerosols (LLA): 6 MBq.

The distribution of the radionuclide composition and activity in aerosol releases is given in **Table 6.11-3**.

TABLE 6.11-3: DISTRIBUTION OF THE RADIONUCLIDE COMPOSITION AND THE ACTIVITIES IN AEROSOL RELEASES PER YEAR IN SERVICE OF PLASMA INCINERATION FACILITY

Radionuclide	BT-2
	A, MBq
Mn-54	0.362
Co-58	0.181
Fe-59	0.0603
Co-60	3.44
Nb-95	0.0603
Ag-110m	0.362
Cs-134	0.362
Cs-137	1.21
Total:	6.04 MBq

4. **New Nuclear Power** should meet the emission requirements as described in EUR - European Utility Requirements for LWR Nuclear Power Plants (Requirements of the European organizations operating NPPs with light water reactors).

Limits of radioactive emissions into the atmosphere under EUR for normal operation are:

- For noble gases – 50 TBq;
- For long-lived aerosols and halogens – 1 GBq.

Reference values are set for reactor based on 1500 MWe electric power. These limits shall be adopted for determining a conservative estimate of environmental impacts of new nuclear power and actual releases from various models reactors are expected to be lower.

- ⇒ To assess the normalized collective annual doses are taken the following values for capacity of New Nuclear Power as follows: AP 1000 - 1200 MWe, AES VVER-1000 / V466 - 1000 MWe, under EUR - 1500 MWe and availability 90%.

To assess the exposure of the population within the 30 km zone of gaseous discharges is used a modeling program LEDA-CM, "SHIELD Normal operation", adapted to the geographical and meteorological characteristics of the area of NPP "Kozloduy". The methodology takes into account both external and domestic impact of radioactive discharges and estimated annual individual effective dose equivalent annual individual dose and dose to the critical group, but also the collective dose to the population by age group. The program is based on the adoption by the European Union (EU) methodology CREAM (Consequences of Releases to the Environment Assessment Methodology) Radiation Protection 72 -Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment.

Model programs used for assessment of individual and collective effective dose to the population from radioactive releases into the environment are verified and validated.

6.11.1.2 RESULTS

Estimates of individual and collective doses in the 30 km zone of the gaseous emissions of NPP "Kozloduy" for 2012 are presented in **Table 6.11-4**.

TABLE 6.11-4: EXPOSURE DOSE WITHIN 30 KM AREA OF GASEOUS RELEASES FOR 2012 BY NPP "KOZLODUY"

	Collective dose [manSv]	Individual effective dose [Sv]
Total (RNG+LLA+ ¹³¹I+ ³H+ ¹⁴C)	2.65.10 ⁻²	1.10.10 ⁻⁸ – 1.33.10 ⁻⁶
RNG	4.07.10 ⁻⁵	4.75.10 ⁻¹¹ – 1.84.10 ⁻⁹
Deferred ground - LLA inhalation receipt ¹³¹I	6.05.10 ⁻⁵	3.61.10 ⁻¹¹ – 1.40.10 ⁻⁹
³H	8.45.10 ⁻⁷	4.01.10 ⁻¹³ – 2.81.10 ⁻¹¹
¹⁴C	1.60.10 ⁻⁴	1.70.10 ⁻¹⁰ – 1.08.10 ⁻⁸
	2.62.10 ⁻²	1.07.10 ⁻⁸ – 1.31.10 ⁻⁶

Assessments of individual doses in the 30 km zone of gaseous emissions from the process of decommissioning of the block 1÷4 are presented in **Table 6.11-5**. Annual collective dose is estimated at 8.86.10⁻⁵ manSv/a.

TABLE 6.11-5: RADIATION EXPOSURE WITHIN 30 KM AREA OF AEROSOL GAS EMISSION DECOMMISSIONING OF BLOCK 1÷4

Maximum dose LLA (external), Sv/a	Maximum dose ³ H, Sv/a	Maximum dose ¹⁴ C, Sv/a	Total maximum dose, Sv/a
5.58x10 ⁻¹¹ – 1.37x10 ⁻⁹	-	-	1.47x10 ⁻¹⁰ – 2.46.10 ⁻⁹
1.37x10 ⁻⁹	-	-	2.46x10 ⁻⁹

Assessments of individual doses in the 30 km zone of gaseous emissions from the operation of the facility for plasma burning (Plasma incineration facility) are presented in **Error! Reference source not found.**

Annual collective dose is estimated at 1.98.10⁻⁵ manSv/a.

TABLE 6.11-6: RADIATION EXPOSURE WITHIN 30 KM AREA OF GAS EMISSIONS FROM OPERATION OF THE PLASMA INCINERATION FACILITY (PIF)

Maximum dose LLA (external), Sv	Maximum dose ³ H, Sv/a	Maximum dose ¹⁴ C, Sv/a	Maximum dose total, Sv/a
1.46x10 ⁻¹¹ – 3.60x10 ⁻¹⁰	-	-	3.36x10 ⁻¹¹ – 5.47x10 ⁻¹⁰
3.60x10 ⁻¹⁰	-	-	5.47x10 ⁻¹⁰

Estimates of individual and collective doses in the 30 km zone of gaseous emissions from New nuclear power are presented in **Table 6.11-7**.

TABLE 6.11-7 RADIATION EXPOSURE WITHIN 30 KM ZONE OF GASEOUS RELEASES OF NEW NUCLEAR POWER

New nuclear power	Collective effective dose [manSv]	Individual effective dose [Sv]
AP 1000	1.93.10 ⁻²	3.10.10 ⁻⁸ – 5.99.10 ⁻⁷
AES BBEP-1000/ B466	1.59.10 ⁻⁴	1.93.10 ⁻¹⁰ – 1.79.10 ⁻⁸
EUR borders of releases	2.49.10 ⁻²	2.46.10 ⁻⁸ – 6.13.10 ⁻⁷

The cumulative effect for different sources of gaseous releases is presented in **Table 6.11-8**.

TABLE 6.11-8 CUMULATIVE EFFECT WITHIN 30 KM AREA OF GASEOUS EMISSIONS

Source Description	Collective effective dose [manSv]	Individual effective dose [Sv]
NPP Kozloduy 2012 + Decom1-4 + PIF	$2.65 \cdot 10^{-2}$	$1.10 \cdot 10^{-8} - 1.33 \cdot 10^{-6}$
NPP Kozloduy 2012 + Decom1-4 + PIF + EUR limits on discharges	$5.14 \cdot 10^{-2}$	$3.56 \cdot 10^{-8} - 1.94 \cdot 10^{-6}$

6.11.2 DOSES OF LIQUID DISCHARGES

6.11.2.1 INPUT DATA

⇒ Demographics and consumption data and habits:

1. Bulgarian territory: Annual Report, Results of radiation monitoring of the environment of NPP "Kozloduy" in 2012, № 11.RM.DOK.085
2. Romanian territory: A letter from the Romanian Ministry of Environment and Forests, № 3672 / RP / 18.10.2012.

⇒ Hydrological data:

⇒ Annual Report, Results of radiation monitoring of the environment of NPP "Kozloduy" in 2012, № 11.RM.DOK.085

⇒ Emissions to water:

1. Annual Report, Results of radiation monitoring of the environment of NPP "Kozloduy" in 2012, № 11.RM.DOK.085

The report recorded discharges from these facilities on site: CK-1, CK-2 и CK-3.

TABLE 6.11-9 RADIOACTIVITY OF LIQUID DISCHARGES (DISCHARGE WATER) OF NPP "KOZLODUY", 2009-2013.

Year	2009	2010	2011	2012	2013
Radionuclide	Activity, [MBq]				
⁵¹ Cr	-	-	71.0	82.3	-
⁵⁴ Mn	1.20	30.1	10.8	15.2	8.03
⁵⁸ Co	-	-	8.02	-	-
⁶⁰ Co	25.6	34.4	18.9	22.8	22.1
⁹⁰ Sr (⁸⁹ Sr)	0.35 (0.13)	1.27 (0.31)	0.73 (0.47)	0.56 (0.62)	1.65 (0.29)
⁹⁵ Zr	-	1.14	16.4	-	-
⁹⁵ Nb	0.22	1.76	10.4	12.9	7.69
¹⁰³ Ru	-	-	8.42	-	-
¹⁰⁶ Ru	-	0.071	-	-	-
^{110m} Ag	0.71	-	-	-	-
¹²² Sb	0.64	-	-	37.9	-
¹²⁴ Sb	5.83	2.75	16.8	11.3	9.59
¹²⁵ Sb	-	0.42	21.5	29.2	28.7

¹³¹ I	5.31	67.2	34.3	13.2	12.2
¹³⁴ Cs	11.1	7.87	57.5	37.2	8.24
¹³⁷ Cs	178.0	122.0	131.0	110.0	82.0
Alpha-emitter	0.0059	0.0075	0.0050	0.0086	0.011
⁵⁵ Fe	4.98	8.36	4.36	21.3	12.9
⁶³ Ni	12.6	7.22	5.00	12.6	11.7
Others: ⁷⁶As, ⁷⁵Se	0.59	0.96	4.63	4.04	9.12
Total (without tritium)	<i>247</i>	<i>286</i>	<i>420</i>	<i>411</i>	<i>214</i>
Tritium	Activity, [GBq]				
³ H	23 739	22 700	22 900	24 100	20 700

2. Average annual values throughout the decommissioning EIA for decommissioning of units 1-4, P16 D08 Line 01.6_ EIA - Chapter 11:

- Nuclides (без H-3): 120 MBq.
- Tritium (H-3): 50 GBq.

In these values are included emissions from the above projects: Workshop for size reduction and decontamination of materials and of all activities of the decommissioning of 1÷4 block.

⇒ Distribution of radionuclide composition and activities in liquid discharges (no H-3) is according to annual limits and reference levels for the total activity of liquid and gaseous releases of units 1 ÷ 4 in the process of decommissioning.

TABLE 6.11-10: DISTRIBUTION OF THE RADIONUCLIDE COMPOSITION AND THE ACTIVITIES IN LIQUID DISCHARGES

Radionuclide	CK-1	CK-1	CK-2	CK-2
	%	A, GBq	%	A, GBq
Co-60	2	1.2	2	1.2
Cs-134	1	0.6	1	0.6
Cs-137	93	55.8	93	55.8
Sr-90	0.5	0.3	0.5	0.3
Pu-239, 240	0	0	0	0
Am-241	0	0	0	0
Ni-63	3	1.8	3	1.8
Fe-55	0.5	0.3	0.5	0.3
Total: 120 MBq		60		60

3. **New nuclear power** should meet the emission requirements as described in EUR - European Utility Requirements for LWR Nuclear Power Plants (Requirements of European organizations operating NPPs with light water reactors)

The boundaries of liquid radioactive emissions under EUR for normal operation are:

→ liquid, with the exception of tritium 10 GBq.

These reference values are determined on the basis of 1500 MWe. Can be considered conservative in assessing the environmental impact of the new nuclear capacity and actual releases from various models reactors are expected to be lower.

⇒ To assess the normalized collective annual doses are taken following values for the power of **New nuclear power** as follows: AP 1000 – 1200 MWe, AEC BBEP-1000/B466 –

1000 MWe, when disposing of the limits of radioactive emissions into the hydrosphere under EUR - 1500 MWe and availability 90%.

To assess the exposure of the population to liquid discharges used modeling program DARR-CM, which is adapted to the hydrology of the region of NPP "Kozloduy" and performs a conservative estimation of the exposure dose of the critical group of the population. The program is based on the adoption by the European Union (EU) methodology CREAM (Consequences of Releases to the Environment Assessment Methodology) Radiation Protection 72 -Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment. Model programs used for assessment of individual and collective effective dose to the population from radioactive releases into the environment are verified and validated.

6.11.2.2 RESULTS

In assessing the doses of liquid discharges using a model of complete mixing in the river. River and no distinction is made for left and right bank. On this basis, it is claimed that the assessments of the doses for the mile and the two banks of the Danube are identical.

Critical population group included settlements down the Danube River - the town of Oryahovo, with Leskovets with Island and Gorni Vadin.

The normalized collective dose per unit of electricity is totaled to $2.61 \cdot 10^{-3}$ man.Sv/GW.a. The data is fully comparable with the data for a large number of PWR reactors in the world (UNSCEAR-2000, 2008).

Assessments of individual doses in the 30 km zone of liquid emissions by NPP "Kozloduy" for 2012 are presented in **Table 6.11-11**.

TABLE 6.11-11 EXPOSURE DOSE OF LIQUID EMISSIONS FROM NPP "KOZLODUY" FOR 2012

Population	Individual effective dose without ^3H , Sv/a	Individual effective dose ^3H , Sv/a	Total individual effective dose, Sv/a
30 km area	$6.81 \cdot 10^{-12} - 8.73 \cdot 10^{-10}$	$3.41 \cdot 10^{-7} - 6.37 \cdot 10^{-7}$	$3.42 \cdot 10^{-7} - 6.37 \cdot 10^{-7}$
Critical group	$4.22 \cdot 10^{-9}$	$4.48 \cdot 10^{-6}$	$4.49 \cdot 10^{-6}$

Ratings collective doses along the Danube are presented in **Table 6.11-12**.

TABLE 6.11-12 COLLECTIVE DOSES OF LIQUID EMISSIONS OT NPP "KOZLODUY" FOR 2012

Collective dose without ^3H , manSv/a	Collective dose ^3H , manSv/a	Total collective dose, manSv/a
$7.88 \cdot 10^{-6}$	$4.69 \cdot 10^{-3}$	$4.47 \cdot 10^{-3}$

Assessments of individual doses in the 30 km zone from the liquid emissions from decommissioning of units 1÷4 are presented in **Table 6.11-13**.

TABLE 6.11-13 EXPOSURE DOSE OF LIQUID EMISSIONS FROM DECOMMISSIONING 1÷4 BLOCK

Population	Maximum individual effective dose without ^3H , Sv/a	Maximum individual effective dose ^3H , Sv/a	Total maximum individual effective dose, Sv/a
30 km area	$3.56 \cdot 10^{-12} - 5.50 \cdot 10^{-10}$	$7.07 \cdot 10^{-10} - 1.32 \cdot 10^{-9}$	$8.30 \cdot 10^{-10} - 1.48 \cdot 10^{-9}$
Critical group	$2.31 \cdot 10^{-9}$	$9.30 \cdot 10^{-9}$	$1.16 \cdot 10^{-8}$

Collective doses along the Danube are presented in **Table 6.11-14**.

TABLE 6.11-14 COLLECTIVE DOSES FROM LIQUID EMISSIONS FROM DECOMMISSIONING OF 1-4 BLOCK

Collective dose without ³ H, manSv/a	Collective dose ³ H, manSv/a	Total collective dose, manSv/a
5.01.10 ⁻⁶	9.73.10 ⁻⁶	1.47.10 ⁻⁵

Assessments of individual doses in the 30 km zone by liquid emissions from New nuclear power are presented in **Table 6.11-15**.

TABLE 6.11-15 EXPOSURE DOSE OF LIQUID EMISSIONS FROM NEW NUCLEAR POWER

New nuclear power	Individual effective dose, [Sv]					
	For the population in 30 km area			For critical group		
	³ H	без ³ H	Общо	³ H	без ³ H	Общо
EUR limits on discharges	1.64.10 ⁻⁷ - 3.07.10 ⁻⁷	1.67.10 ⁻¹⁰ - 2.13.10 ⁻⁸	1.71.10 ⁻⁷ - 3.07.10 ⁻⁷	2.16.10 ⁻⁶	1.03.10 ⁻⁷	2.26.10 ⁻⁶

Collective doses along the river Danube by liquid emissions from New nuclear power are presented in **Table 6.11-16**.

TABLE 6.11-16: COLLECTIVE DOSES OF LIQUID EMISSIONS FROM NEW NUCLEAR POWER

New nuclear power	Collective dose without ³ H, manSv/a	Collective dose ³ H, manSv/a	Total collective dose, manSv/a
EUR limits on discharges	1.92.10 ⁻⁴	2.26.10 ⁻³	2.45.10 ⁻³

TABLE 6.11-17: CUMULATIVE EFFECT 30 KM AREA OF LIQUID EMISSIONS

Source Description	Collective effective dose [manSv]	Individual effective dose [Sv]
NPP Kozloduy 2012 + Decom1-4	4.47.10 ⁻³	3.42.10 ⁻⁷ – 6.37.10 ⁻⁷
NPP Kozloduy 2012 + Decom1-4 + EUR limits on discharges	6.92.10 ⁻³	5.13.10 ⁻⁷ – 9.44.10 ⁻⁷

6.11.3 DOSES OF ALL RADIOACTIVE RADIATION

The maximum annual effective dose in the 30 km area of NPP "Kozloduy" resulting from only aerosol emissions during normal operation of existing and new nuclear capacity is estimated at 1.94 $\mu\text{Sv/a}$. This is only 0.08% of exposure to natural background radiation in the country (2.33 mSv / a) and 0.2% of the normal for the population (1 mSv / a) BSRP-2012.

The maximum annual effective dose to the population of 30 km zone of NPP "Kozloduy" resulting from only liquid emissions during normal operation of existing and new nuclear capacity is estimated at 0.94 $\mu\text{Sv/a}$.

Radiological impact on the population during normal operation of the NDF is analyzed in ISAR³ exceptionally because of the presence of external light, since not anticipated gas and liquid feeds by NDF in normal operation. This impact is localized at the site of the NDF and practically there is no cumulative effect for the population in the surveillance zone. The total annual dose is determined to be 18 μSv (≈ 0.02 mSv) from direct radiation and is well below the secondary limit (100 $\mu\text{Sv/a}$) for NDF.

The estimates of the radiation impact of discharges from NPP "Kozloduy" are fully comparable with world practice according to official UN data (UNSCEAR-2000, 2008).

For conservative assessment of the cumulative effect of exposure to radiation in the 30 km area of NPP "Kozloduy" from all radioactive releases into the environment under all operating conditions of the NPP are taken into account:

- NDF – Radiana site,
- from 5 and 6 block, Repository for spent nuclear fuel, Dry storage of spent nuclear fuel,
- from all activities on decommissioning of 1-4 block (Workshop for size reduction and decontamination /ЦНРД/),
- emissions from operation of the facility for plasma incineration (СПИ),
- from New nuclear power - maximum value of EUR limits of discards.

The maximum annual effective dose in the 30 km area of NPP "Kozloduy", including the site of the NDF, even in this extremely conservative (practically impossible) scenario for reference individual continuously resident at the border of the site of the NDF, result of all radioactive emissions into the environment in cumulation with all nuclear facilities on the site: NPP Units 5 and 6, Decommissioning 1-4 block, Plasma incineration facility, New nuclear power and NDF, is estimated of 20.88 $\mu\text{Sv/a}$, which is much lower than the quota 100 $\mu\text{Sv/a}$ for NDF, 250 $\mu\text{Sv/a}$ from exposure to radioactive discharges from nuclear power plants (Regulation on ensuring the safety of nuclear power plants (Prom. SG. issue 66 from 30 July 2004., last. amend. SG. issue 5 of 19 January 2010.) and the rate of population 1000 $\mu\text{Sv} / \text{a}$ (BSRP-2012). The resulting additional radiation exposure is about 100 times lower than the natural background (2330 μSv).

6.11.4 ASSESSMENT OF THE RADIO-BIOLOGICAL EFFECTS AND RADIATION RISK FOR INDIVIDUAL REFERENCE

According to statistical data from the National Statistical Institute from census of 01.02.2011 the number of population within 30 km area around the NPP "Kozloduy" on the territory of Bulgaria is 65,994 people, while in the Romanian territory is 75 150 people. For so considered population can draw the following conclusions about the radio-biological effects and radiation risk due to cumulative effects:

³ Interim safety analysis report (ISAR), R5-NDF-ISA_Rev1, Consortium Westinghouse – DBE Technology – ENRESA. March 11, 2013

6.11.4.1.1 DETERMINISTIC EFFECTS

There is no risk of deterministic effects in the 30-km zone of the NPP "Kozloduy" including the site of the NDF "Radiana".

For normal healthy adult the assessment of LD_{50/60} (i.e. lethal dose for half of the individuals in 60 days) is equal to average about 4 Gy, indicating a range of estimates from 3 to 5 Gy. Assessment of LD₁₀ is in range of 1÷2 Gy. Assessment of LD₉₀ is in range of 5÷7 Gy.

Dose dependence of radiation-induced tissue reactions in adults and children have the property of true dose threshold. Severe reactions do not occur in most tissues of the body in the annual irradiation doses less than 0,1 Gy over many years. Red bone marrow, reproductive cells and crystalline lens have greater sensitivity to radiation.

Individual doses of all radioactive discharges into the cumulation of the NDF with all existing nuclear facilities of the site of NPP "Kozloduy": decommissioning of units 1÷4 (Workshop for size reduction and decontamination / ЦНПД /) and all future IP: facility for plasma incineration (PIF) and New nuclear power (NNP) with a maximum value 20.88 µSv.

These doses **are much lower** than the threshold set under Art. 10 BSRP-2012 of the limit annual effective dose, which is 1000 µSv for the population.

On this basis it is **strongly claimed that there is no risk of deterministic effects** in the 30 km area of the NPP.

6.11.4.1.2 STOCHASTIC EFFECTS

The risk of stochastic effects is negligibly low.

The risk of radiation-induced cancer in the whole population is 1.2×10^{-6} in cumulation with all nuclear facilities of the site of NPP "Kozloduy" - operation of units 5 and 6, decommissioning of 1-4, Plasma incineration facility New nuclear power and NDF and the likelihood of hereditary diseases is 4.3×10^{-8} .

The following tables provide detailed estimates of the cumulative effects of radio-biological and radiation risk from existing and new nuclear power plants:

- **Table 6.11-18** - Risks taking into account the damage from radiation-induced cancer and hereditary diseases for the whole population and for persons of working age;
- **Table 6.11-19** - The risks and damage to some tissues for the population as a whole;
- **Table 6.11-20 ÷ Table 6.11-22** - Risks of hereditary diseases for the reproductive part of the population evaluated for two generations, irradiation of one generation after the other and evaluated for the first generation after the irradiation.

TABLE 6.11-18: RISKS ON THE READING OF DAMAGE FROM RADIATION INDUCED CANCER AND HEREDITARY DISEASES FOR THE WHOLE POPULATION AND PERSONS OF WORKING AGE WITH CUMULATION (KNPP 2012 + DECOM1-4 + PIF + EUR LIMITS OF DISCHARGES + NDF)

Cumulative effect	Cancer		Heritable effects		Total	
	total population	individuals of working age	total population	individuals of working age	total population	individuals of working age
NPP Kozloduy 2012 + Decom1-4 + PIF + EUR limits on discharges+ NDF	1.18E-6	8.87E-7	4.32E-8	2.16E-8	1.23E-6	9.01E-7

TABLE 6.11-19: RISK ASSESSMENT AND DEFEATS FOR SOME TISSUES FOR THE POPULATION IN TOTAL WITH COMULATION (KNPP 2012 + DECOM1-4 + PIF + EUR LIMITS OF DISCHARGES + NDF)

Tissue/Organ	Normal risk	Nominal risk with reporting of	Damage
	(cases of 10 000 people)	deaths	
esophagus	3.24E-04	3.27E-04	2.84E-04
stomach	1.71E-03	1.67E-03	1.47E-03
large intestine	1.41E-03	1.07E-03	1.04E-03
liver	6.49E-04	6.53E-04	5.75E-04
lungs	2.47E-03	2.44E-03	1.95E-03
bones	1.51E-04	1.10E-04	1.10E-04
skin	2.16E-02	8.65E-05	8.65E-05
mammal gland	2.42E-03	1.34E-03	1.73E-03
ovaries	2.38E-04	1.90E-04	2.13E-04
bladder	9.30E-04	5.08E-04	3.61E-04
thyroid gland	7.14E-04	2.12E-04	2.73E-04
marrow	9.08E-04	8.15E-04	1.33E-03
Other solid	3.11E-03	2.38E-03	2.46E-03
gonads	4.33E-04	4.17E-04	5.51E-04
Total	3.71E-02	1.22E-02	1.24E-02

TABLE 6.11-20: ASSESS THE RISKS OF HEREDITARY PROBLEMS OF COMULATION (KNPP 2012 + DECOM1-4 + PIF + EUR LIMITS OF DISCHARGES + NDF)

Condition class	Two generations	First generation
	for the whole population in average	for the whole population in average
	%	%
Mendelian diseases	1.73E-06	1.08E-06
Chronic diseases	6.49E-07	6.49E-07
Congenital anomalies	2.38E-06	1.73E-06
Total	4.76E-06	3.46E-06

TABLE 6.11-21: RISK ASSESSMENT FOR HEREDITARY DISEASES FOR THE REPRODUCTIVE PART OF THE POPULATION EVALUATED FOR TWO GENERATIONS (EXPOSURE FOR ONE GENERATION AFTER ANOTHER) - COMULATION KNPP 2012 + DECOM1-4 + PIF + EUR LIMITS OF DISCHARGES + NDF

Condition class	Reproductive population	
	in range of %	average in %
Mendelian diseases	2.81E-06 – 5.41E-06	4.11E-06
Chronic diseases	6.5E-07 – 2.68E-06	1.73E-06
Congenital anomalies	5.2E-06 – 6,52E-06	5.84E-06
Total		1.17E-05

TABLE 6.11-22 RISK ASSESSMENT FOR HEREDITARY DISEASES FOR THE REPRODUCTIVE PART OF THE POPULATION ASSESSED FOR THE FIRST GENERATION OF POST-IRRADIATION - KNPP 2012 + DECOM1-4 + PIF + EUR LIMITS OF DISCHARGES + NDF

Condition class	Reproductive population	
	in range of %	average in %
Mendelian diseases	1.62E-06 – 3.24E-06	2.38E-06
Chronic diseases	5.41E-07 – 2.6E-06	1.51E-06
Congenital anomalies	–	4.33E-06
Total		8.22E-06

The estimates of the cumulative dose effects are fully comparable with world practice according to official UN data (UNSCEAR-2000, 2008).