CONSORTIUM
DICON-ACCIONA ING.

TERMS OF REFERENCE ON THE SCOPE AND CONTENTS OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

for investment proposal:

CONSTRUCTION OF A NEW NUCLEAR UNIT OF THE LATEST GENERATION AT KOZLODUY NPP SITE

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Authors:	Nelly Gromkova - Team Leader Verginia Dimitrova – Project Manager	Revision 04
Validator:	Tzvetanka Dimitrova - Technical Quality Control Expert	Date: 23.03.2013

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Approved by:		
Compiled by	**Team Leader**	**Project Manager**
Nelly Gromkova – Team Leader **Verginia Dimitrova – Project Manager**		
Validated by:		
Tzvetanka Dimitrova – Technical Quality Control Expert		

Recipients				
Organization	**Name of the recipient**	**# of copies**	**Re.:**	
			Activities	**Information**
Kozloduy NPP New Build EAD	**Lyuben Marinov** - Executive Director	**1**	**x**	**x**
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Consortium Dicon-Acciona Ing.	Key experts	**1 copy each**	**x**	**x**

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NA	Statement by Valentin Avramov, Radioactivity Measurments Section Leader, Radioecological Monitoring Department, and Rusian Tsibranski, Head of REM Department, concerning the Terms of Reference on the Scope and Contents of the Environmental Impact Assessment Report, version 03 dated 18.03.2013 of the Consortium Dicon-Acciona Ing.	03
NA	Statement by K. Batachki, Chief Nuclear Safety Expert, units 5 and 6, concerning the Terms of Reference on the Scope and Contents of the Environmental Impact Assessment Report, version 03 dated 18.03.2013 of the Consortium Dicon-Acciona Ing.	03
NA	Statement by Valentin Iliev, Head of New Build Division, concerning the Terms of Reference on the Scope and Contents of the Environmental Impact Assessment Report, version 03 dated 18.03.2013 of the Consortium Dicon-Acciona Ing.	03
		04

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NAMES AND ABBREVIATIONS

COMPANIES

Kozloduy NPP - New Build EAD, Property of Kozloduy NPP EAD	Herein referred to as the **Employer**
Consortium Dicon-Acciona Ing.	Herein referred to as the **Contractor**

ABBREVIATIONS

AB	Auxiliary Building
AER	Atomenergoremont
AIS AMB	Automatic Information System Archeological Map of Bulgaria
AMS	Automatic Meteorological Stations
BDWMDR	Basin directorate for water management in Danube region
BNRA	Bulgarian Nuclear Regulatory Agency
BNRP	Basic norms of radiation protection
BRPS	Basic Requirements for Provision of Safety
CA	Controlled Area
CA	Compatibility Assessment
CHA	Cultural Heritage Act
ClA	Clean Area
CM	Council of Ministers
CM	Cultural Monuments
CPB	Common Purpose Building
DCS	Depot for Contaminated Soil
DE	Design Earthquakes
DGS	Diesel Generator Station
DNHIW	Depot for Non-Radioactive Household and Industrial Wastes
DSCRAW	Depot for storage of conditioned RAW
DSFSF	Dry Spent Fuel Storage Facility
EAMSDR	Executive Agency for Maintenance and Study of the Danube River
EBRD	European Bank for Reconstruction and Development
EIA	Environmental Impact Assessment
ELB	Engineering Laboratory Building
EMF	Electromagnetic Fields
EP	Electricity production
EUR	European Utility Requirements

EURATOM	The European Atomic Energy Community
FFPS	Fire-fighting pumping station
FP	Fission Products
GIS	Geographic Information System
HLRAW	High-level RAW
HM	Heavy Metal
HMS	Hydro-Meteorological Station
HPD	High-Pressure Deaerators
HS	Household Sewage
HTF	Hydro-Technical Facilities
I(C)C	Intake (Cold) Channel
IAEA	International Atomic Energy Agency
ICH	Immovable Cultural Heritage
ICRP	International Committee for Radiation Protection
IEL	Individual Emission Limits
IP	Investment Proposal
ISAR	Intermediate Safety Analysis Report
LLA	Long-lived aerosols
LWR	Light water reactor
MCR	Main Control Room
MDA	Minimum Detectable Activity
MDE	Maximum Design Earthquake
MEW	Ministry of Environment and Water
MH	Ministry of Health
MLF	Medium- and Low-Frequency
MLRAW	Medium-level RAW
MPC	Maximum Permissible Concentrations
MRDPW	Ministry of Regional Development and Public Works
MSC	Main Sewage Channel
MSK	Scale of Medvedev-Sponheuner-Karnik
MW	Mechanical Workshop
NAIM - BASc	National Archeological Institute with Museum at the Bulgarian Academy of Science
NCRBRP	National Center for Radiobiology and Radiation Protection
NEN	National Ecological Network
NICM	National Institute of Cultural Monuments
NIICH	National Institute of Immovable Cultural Heritage
NIMH	National Institute of Meteorology and Hydrology
NNU	New Nuclear Unit

NPP	Nuclear Power Plant
NPP	Nuclear Power Plant
NSME	National System for Monitoring of the Environment
NSR	Nuclear Safety Rules
O(H)C	Outlet (Hot) Channel
OS	Open Switchgear
PAZ	Precautionary Action Zone
PFZ	Potential Focal Zones
PMU	Project Management Unit
PS	Pumping Ctation
PSA	Preliminary Safety Analysis
PWR	Pressurised Water Reactor
PZ	Protected Zones
PZ	Protected zones
QAA	Quality of the Atmospheric Air
RAW	Radioactive Wastes
RAWPS	RAW Processing Shop
RBMP	River Basin Management Plan
REIA	Report of Environmental Impact Assessment
REM	Radio-Ecological Monitoring
RES	Renewable Energy Sources
RHM	Regional Historical Museum
RIEW	Regional Inspectorate for the Environment and Water
RNG	Radioactive Noble Gases
RPN	Radiation Protection Norms
RTI	Road Traffic Incident
RWCS	Reactor Water Cleanup System
SAGSCES	System for Accelerated Graphic Seismic Control of Equipment and Structures
SB	Sanitary Buildings
SCEWR	State Committee for Energy and Water Regulation
SD RAW-Kozloduy	Specialized Division Radioactive Waste
SE RAW	State Enterprise Radioactive Wastes
SFP	Spent Fuel Pond
SG	Steam Generators
SIASP	System for Industrial Anti-Seismic Protection
SMM	System for Meteorological Monitoring
SNF	Spent Nuclear Fuel
SP	Spray Ponds

STV	Specialized Transport Vehicles
SUNEA	Safe Use of Nuclear Energy Act
SWEP	Emergency service water pumps
SZ	Surveillance Zone (zone of 30 km, defined for the purposes of radio-ecological monitoring and coinciding with the Urgent Protective Action Planning Zone (UPAPZ))
TC	Training center
TLD	Thermoluminiscent dosimeter
UACEG	University of Architecture, Civil Engineering and Geodesy
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UPAPZ	Urgent Protective Action Planning Zone (zone of 30 km, defined for the purposes of emergency planning (on the basis of dose rates) and coinciding with the Surveillance Area (SA).
WA	Water Act
WFD2000/60/EU	Water Framework Directive
WHO	World Health Organization
WMA	Wastes Management Act
WSF	Wet Spent Fuel Storage Facility
WWER	Water-cooled Water-moderated Power Reactor
WWER	Water-cooled water-moderated power reactor
WWTF	Waste Water Treatment Facility
ZS	Zavodski stroezhi (company name)

INTRODUCTION

The present Terms of Reference on the scope and contents of the EIA for the **Investment proposal for Construction of a new nuclear unit of the latest generation at the site of Kozloduy NPP** are elaborated on the basis of art. 95, clause 2 of the Environmental Protection Act and art. 10, clauses 1-3 of the Regulation on the terms and conditions for performing an environmental impact assessment (State Gazette, No. 3/2006, modified and amended in State Gazette No. 94 dated 30.11.2012).

The investment proposal (IP) of Kozloduy NPP-New Build EAD foresees the construction of a new nuclear unit of the latest generation (Generation III or III+) with installed electric power capacity of approximately 1200 MW. Since the same is included within the scope of Appendix 1 to the EPA, item 2.2 Nuclear Power Plants and Other Nuclear Reactors, including dismantling or decommissioning of such plants and reactors, excluding installations for the production and processing of fission or enriched materials, the maximum power capacity of which does not exceed 1 kilowatt constant thermal load, the IP is subject to a compulsory EIA, the competent authority for making the decision on the EIA being the Minister of the Environment and Water**.**

The design for the nuclear unit shall comply with the European requirements, specified in the European Utility Requirements for LWR Nuclear Power Plants and in the Bulgarian Regulatory Norms in the field of nuclear power.

The new nuclear unit shall be a reliable and safe diversified energy source for provision of the required balance of electric power (production-consumption) for the Republic of Bulgaria and shall aid in the long-term aspect the following:

- → provision of a reliable source of electric power, guaranteeing the electric power balance of the country;
- → maximum economic effect and minimum risks for the supply of power resources;
- → diversification of the power sources;
- → maintenance of acceptable and stable prices for the electric power;
- → provision of a reliable source of electric power, which shall not emit greenhouse gas emissions into the environment;
- → possibilities for sales of quotas of greenhouse gas emissions to third countries;
- → possibilities for export of electric power.

The scope of the Terms of Reference is completely in compliance with the requirements of art. 10 of the Resolution on the terms and conditions for the implementation of an environmental impact assessment, and includes:

- the characteristics of the investment proposal, including: a description of the physical characteristics of the investment proposal and the required areas, a description of the basic characteristics of the production process, determination of the type and quantity of the expected wastes and emissions as a result of the operation of the investment proposal;
- Alternatives for the realization of the investment proposal;
- Characteristics of the environment, in which the investment proposal shall be realized and the estimate of the impact;
- Importance of the environment impact, determination of the unavoidable and permanent effects on the environment as a result of the construction, operation and decommissioning of the object of the investment proposal, which could come out to be significant, and which should be studied in detail in the EIA report;
- Cumulative effects;
- Risks from incidents;
- Monitoring;
- Trans-border impact;
- Structure of the EIA report with a description of the expected contents of the items included therein;
- List of the required appendixes, schedules, etc.;
- Stage, phases and terms for elaboration of the REIA;
- Other terms or requirements.

The main objective of the Terms of Reference is to determine the scope and contents of the REIA, including indicating the methodology to be used for the estimations and for the assessment of the individual components and factors of the environment, and the risks for human health from the construction of the new nuclear unit, taking into consideration equially two major technical and layout solutions ("kompanovka"[1]) for the reactor installations of the newest generation and of 4 potential sites for the construction of the new nuclear unit. In this context, **the specific aims of the present Terms of Reference on the scope and contents of the report of EIA** are as follows:

- to determine the existence and nature of the impacts, which the investment proposal could have on the environment during the construction, the operation and the decommissioning of the facility for each of the sites, and for each of the technical and layout solutions for the reactor installations;

[1] "kompanovka" (Russian) – layout of the separate sites, buildings and facilities and the process interfaces between them.

- to determine the cumulative effects upon realization of the IP with the existing operational facilities at Kozloduy NPP site and the expected trans-border impact of the IP;
- to determine the importance of the impacts based on criteria, which reflect the basic characteristics of all components and factors for the environment, on the movable and immovable cultural heritage and the risks for human health.

In compliance with the main objective and the specific aims, the Terms of Reference shall identify the components and the factors of the environment, which the realization of the IP could potentially impact, the possible accumulation of the impacts, the risks from incidents and the eventual trans-border impact, which shall be studied in detail and assessed in the EIA report. Studying equally the two main technical and layout solutions for the reactor installations of the latest generation and of the 4 potential sites for the location of the new nuclear unit, the main task of the assessment shall be to substantiate and motivate the most appropriate alternative solution, proposing measures for reducing, preventing or eventually fully eliminating the identified impacts on the environment and on human health.

The Terms of Reference for the determination of the scope, contents and format of the EIA for the investment proposal Construction of a new nuclear unit of the latest generation on the site of Kozloduy NPP takes into consideration the instructions, provided by the Ministry of Environment and Water (MoEW) on the basis of the submitted notification of the IP (letter outgoing ref. No. OVOS-220 dated 05.07.2012 of the MEW) and the additional information provided on the Notification by letter No. OVOS-220 dated 09.01.2013.

The elaborated Terms of Reference also take into consideration the requirements of the Bulgarian, European and International legislation on EIA in the transboundary context: EPA, the Regulation concerning the terms and conditions for implementing an EIA, Directive 85/337/EEC and its three amendments dated 1997, 2003 and 2009, transposed into Directive 2011/92/EU, the Convention on EIA in a transboundary context (Espoo Convention), as well as with the requirements of Appendix I of the Recommendations of the Commission dated October 11th, 2010 concerning the implementation of art. 37 of the EURATOM Treaty.

In the elaboration of the Terms of Reference concerning the scope and contents of the EIA report the outcome (comments and proposals) from the held consultations in accordance with the provisions of art. 95, clause 3 of the EPA with the specialized companies, authorities and representatives of the public are also fully incorporated.

In addition to the above, in the process of elaboration of the Terms of Reference the intermediate results and conclusions achieved in the course of currently implemented projects for carrying out feasibility study to justify the construction of a new nuclear unit at Kozloduy NPP site, and the study and determination of the location for the new nuclear unit at Kozloduy NPP EAD site were also taken into consideration.

The choice of the site for the project is the subject of a related design, which is executed in parallel to the present EIA for the IP for the NNU. The assessment in the report of EIA shall be made in accordance with the provisions of art. 25, item 1 of the Regulation on the provision of safety at nuclear power plants (2004), which specifies that the sites favorable for the construction of NPP's are the ones, which comply with the following terms: compliance with the legislation on environmental protection, the requirements on radiation protection, fire safety and physical protection.

INFORMATION ON THE CONTRACTING AUTHORITY

Legal entity:	**Kozloduy NPP-New Build EAD**
Executive Director:	**Lyuben Marinov**
Address:	3321 Kozloduy
Town:	Kozloduy
Municipality:	**Kozloduy**
Telephone:	+359 973 72104
Fax	+359 973 72422
Website:	http://www.npp-nb.bg/
e-mail:	newbuild@npp.bg
Contact person:	**Bilyana Simeonova**
GSM phone:	+359 886 40 20 08
Fax:	+ 359 973 72422
e-mail:	b.simeonova@npp-nb.bg

1 CHARACTERISTICS OF THE INVESTMENT PROPOSAL

1.1 HISTORY OF KOZLODUY NPP

The beginning of the nuclear energetics was laid on 15 July 1966 by signing the agreement for cooperation between Bulgaria and former Soviet Union for the construction of a nuclear power plant. Following a detailed feasibility study the site for the construction of the nuclear power plant was selected on the Danube river in the proximity of the town of Kozloduy. The groundbreaking ceremony for the Kozloduy NPP was held on 14-th October, 1969. The construction of the main building of Kozloduy NPP started on 6-th April 1970.

The official opening of the Kozloduy NPP was on 4-th September, 1974. The construction and the commissioning of the nuclear facilities of the Bulgarian nuclear power plant was executed in three stages:

- → Stage I: 1970 – 1975 - Construction and commissioning of units 1 and 2 with water-cooled water-moderated power reactors WWER-440, model B-230, with two independent trains of the safety systems;
- → Stage II: 1973 – 1982 - Construction and commissioning of units 3 and 4 with water-cooled water-moderated power reactors WWER-440, upgraded model B-230 with three-fold redundancy of the safety systems.
- → Stage III: 1980 – 1991 - Construction and commissioning of units 5 and 6 with reactors WWER-1000, model B-320 with containment and three-fold redundancy of the safety systems.

Following the commitments made by Bulgaria with regard to the country's accession to the EU, Kozloduy NPP stopped the operation of the first four units before the expiry of their design lifetime that is 30 fuel campaigns - **Table 1.1-1**: *Data on units 1÷4 of Kozloduy NPP*

TABLE 1.1-1: DATA ON UNITS 1÷4 OF KOZLODUY NPP

Unit	Reactor type and power capacity, MW	Year of connection to the grid	Closure of the units	Current fuel campaign	Electricity generated for the period, MWh
Unit 1	WWER-440	1974	31.12.2002	23	66 675 397
Unit 2	WWER-440	1975	31.12.2002	24	68 905 334
Unit 3	WWER-440	1980	31.12.2006	22	68 703 260
Unit 4	WWER-440	1982	31.12.2006	21	66 711 966

Electricity generation

For the last year (2002), of operation of all the six installed units, the nuclear power plant has generated an amount of electricity in its history – 20 221 719 MWh, with which it reached 47,3% share in the total electricity generation of the country.

In 2006, having four units in operation, Kozloduy NPP came close to its record achievement , by providing for the national electricity grid 19 493 219 MWh or 42,6% of the electricity generated in the country – **Figure1.1-1**: *Annual generation of Kozloduy NPP.*

Since the beginning of 2007, units 5 and 6 have remained in operation: reactors WWER-1000, model B-320, with containment and three-fold redundancy of the safety systems.

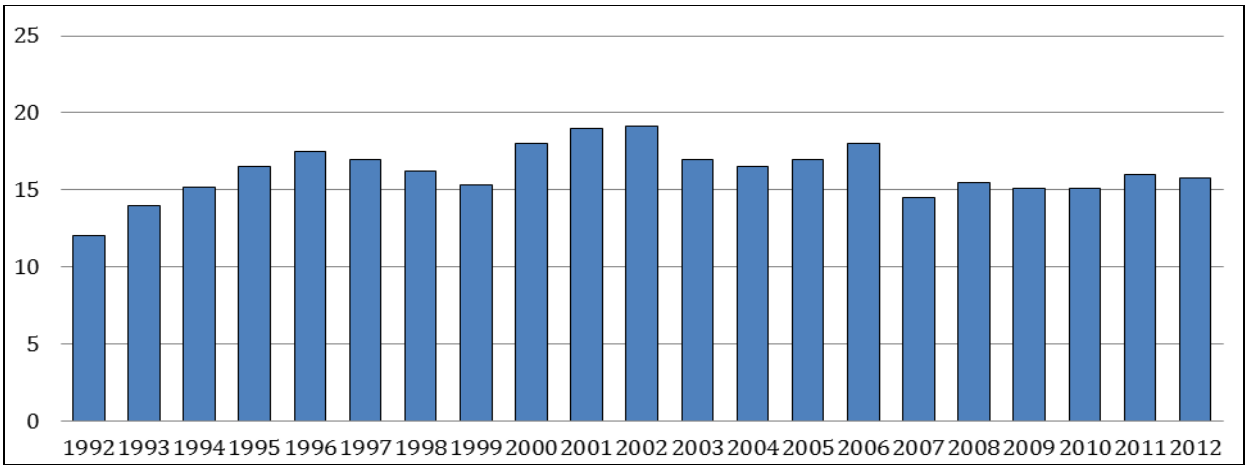

FIGURE1.1-1: *ANNUAL GENERATION OF KOZLODUY NPP*

For the year 2012, ***Figure 1.1-2:*** *Generation during the period January - December 2012* shows the annual generation of each of units 5 and 6.

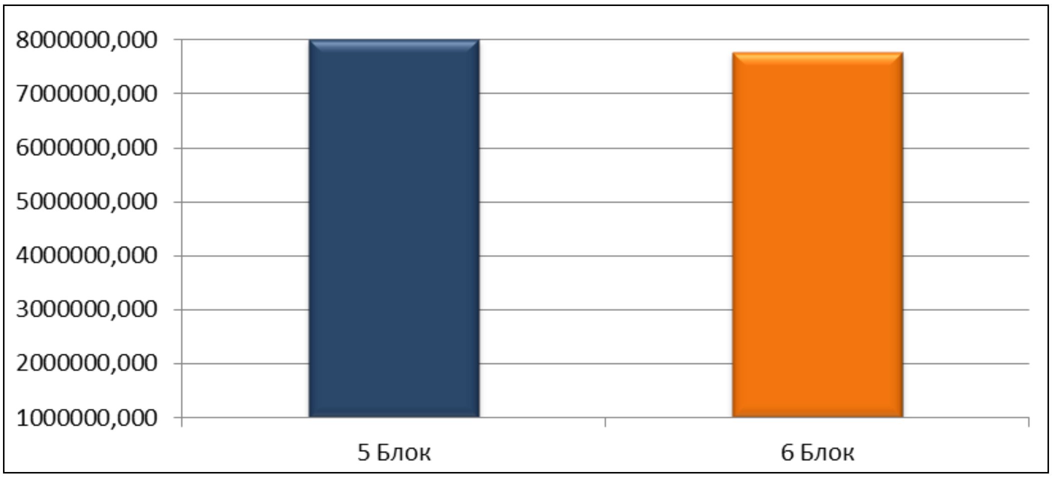

FIGURE 1.1-2: *GENERATION DURING THE PERIOD JANUARY - DECEMBER 2012*

Kozloduy NPP is one of the major factors for the sustainable development of the electricity generation in Bulgaria today, and is an element of particular importance for the country energy mix. The nuclear power plant has the largest share in the national electricity generation.

1.2 NUCLEAR FACILITIES AND GENERAL PLANT FACILITIES AT KOZLODUY NPP SITE

The site of the Kozloduy NPP is located in northwestern Bulgaria, within the territory of the district of Vratsa and the municipality of Kozloduy, mainly in the lands of the town of Kozloduy and the village of Harlets. The site is located at approximately 2.6 km to the southeast of the town of Kozloduy, at 3.5 km to the northwest of the village of Harlets, at 65 km to the north of the district center - the town of Vratsa and at 200 km to the north of the city of Sofia. It is situated on the second non-flooded terrace of the Danube River, with an absolute elevation of +35 m, at approximately 3.5 km from its right bank, where the river flows from the northwest to the southeast. To the north the site of Kozloduy NPP borders the Danube River plain, and to the south-southwest - the watershed plateau with an altitude of 90 m a.s.l.

There are no natural flow waters within the territory of Kozloduy NPP. The closest to the plant internal rivers within the territory of the Republic of Bulgaria are the Ogosta River and the Skat River to the east, and the Tsibritsa River to the west. Only the Danube River has a significant importance for the operation and security of Kozloduy NPP. The elevation of the site is formed on a considerable in its size sedimentation area, determined during the designing of the power plant with a reserve of non-flooding upon arrival of a 10 000 year high water wave along the Danube River.

Between the site of Kozloduy NPP and the Danube River there are constructed dikes, dimensioned for the flow of a 1000-year high wave along the Danube River with the reserves required by the regulations. The drainage systems in the area are dimensioned to drain surface water from intensive rainfall with varying duration and probability of the rainfall depth of 0.01 %.

The Danube River is a surface-flowing water body, of the river category with the name of DanubeRWB01 and code BG1DU000R001, defined by the RBMP for the Danube Region, which has been elaborated in accordance with the requirements of Directive 2000/60 of the EU and the Water Act, and has been approved as per Ordinance No. 293 dated 22.03.2010 of the Minister of the environment and water. The whole length of the Bulgarian stretch of the Danube River from the village of Novo Selo up to the town of Silistra is a receiving water body of category III according to Ordinance No. RD-272 dated 03.05.2001[2] of the Minister of the environment and water. It is defined as a strongly modified water body with a moderate ecological potential, and its chemical state is bad according to the RBMP for the Danube Region along our country and letter No. 3804 dated 08.01.2013 of the BDWMDR.

[2] During the process of elaboration of the present Terms of Reference, Regulation No. 7/1986 concerning the parameters and norms for determination of the quality of flowing surface waters, was repealed by the Regulation for the repeal of Regulation No. 7, published in State Gazette No. 22 dated 05.03.2013.

The constructed sites and facilities at Kozloduy NPP site (**Figure 1.2-1**: General Layout of Kozloduy NPP и разположение на предложените площадки на НЯМ

) currently include the following:

- Main building (reactor building and turbine hall) – the main buildings for units 1 and 2, as well as for units 3 and 4 are common (all 8 turbine generators for units 1÷4 are in a common turbine hall);
- Main building for units 5 and 6;
- Auxiliary buildings 1 and 2 (AB-1, -2) - servicing respectively units 1, 2 and 3, 4 of EP-1; Axiliary building 3 (AB-3) - servicing units 5 and 6 of EP-2;
- CWTF-1 (Chemical Water Treatment Facility) - servicing units 1÷4;
- CWTF-2 – servicing units 5 and 6;
- CPS-1 and 2 servicing units 1÷4, and CPS-3 and 4 servicing units 5 and 6;
- 2 DGS, servicing power units 1÷4 and 3 DGS, servicing units 5 and 6;
- Open Switchgear – consisting of three sections: 110 kV, 220 kV, 400 kV;
- Intake (Cold) channel (CC-1);
- Outlet (Hot) channels (HC-1,-2);
- Spray ponds for units 1÷6;
- Wet Spent Fuel Storage Facility (WSFSF);
- Dry Spent Fuel Storage Facility (DSFSF);
- Fuel and oil facility at EP-1 and fuel and oil facility at EP-2;
- Fire-fighting pumping station-2 (FFPS-2);
- Outdoor storage facility Enemona;
- Depot for non-radioactive household industrial wastes – DNHIW.
- Common Purpose Building (CPB-1) and Mechanical workshop (MW) – EP-1;
- Waste water treatment plant (WWTP) – EP-2;
- Sanitary buildings (SB–1,-2) - in EP-1;
- Engineering laboratory building (ELB) – in EP-2;
- Training center (TC);
- Information center;
- Administration buildings: NPP Management; EP-2 Division; Investments Division; Engineering building for D&M Directorate;
- Warehouses (within and outside the secured zone).

The construction zone of the Kozloduy NPP has an area of 4 471.712 daa . The following main areas are defined within this territory:

I. Electricity production-1 (EP-1), with units 1÷4, auxiliary buildings 1 and 2, and auxiliary subprojects. The territory of this area accommodates the Wet spent fuel storage facility (WSF) and the Dry spent fuel storage facility (DSFSF). Power units 1 and 2 were shut down in 2002, and unit 3 and 4 in 2006. At present, units 1÷4 are announced as radioactive waste management facilities - property of SE RAW;

II. Electricity production-2 (EP-2), with power units 5 and 6, auxiliary building 3 and auxiliary facilities. The territory of this area accommodates the company for treatment of radioactive wastes, property of the State Enterprise RAW;

III. Territory of the intake (cold) channel CC-1, outlet (hot) channels HC-1 and HC-2, as well as the facilities of the Riverbank pumping stations (RBPS) - all of which provide for the service water supply for the power plant.

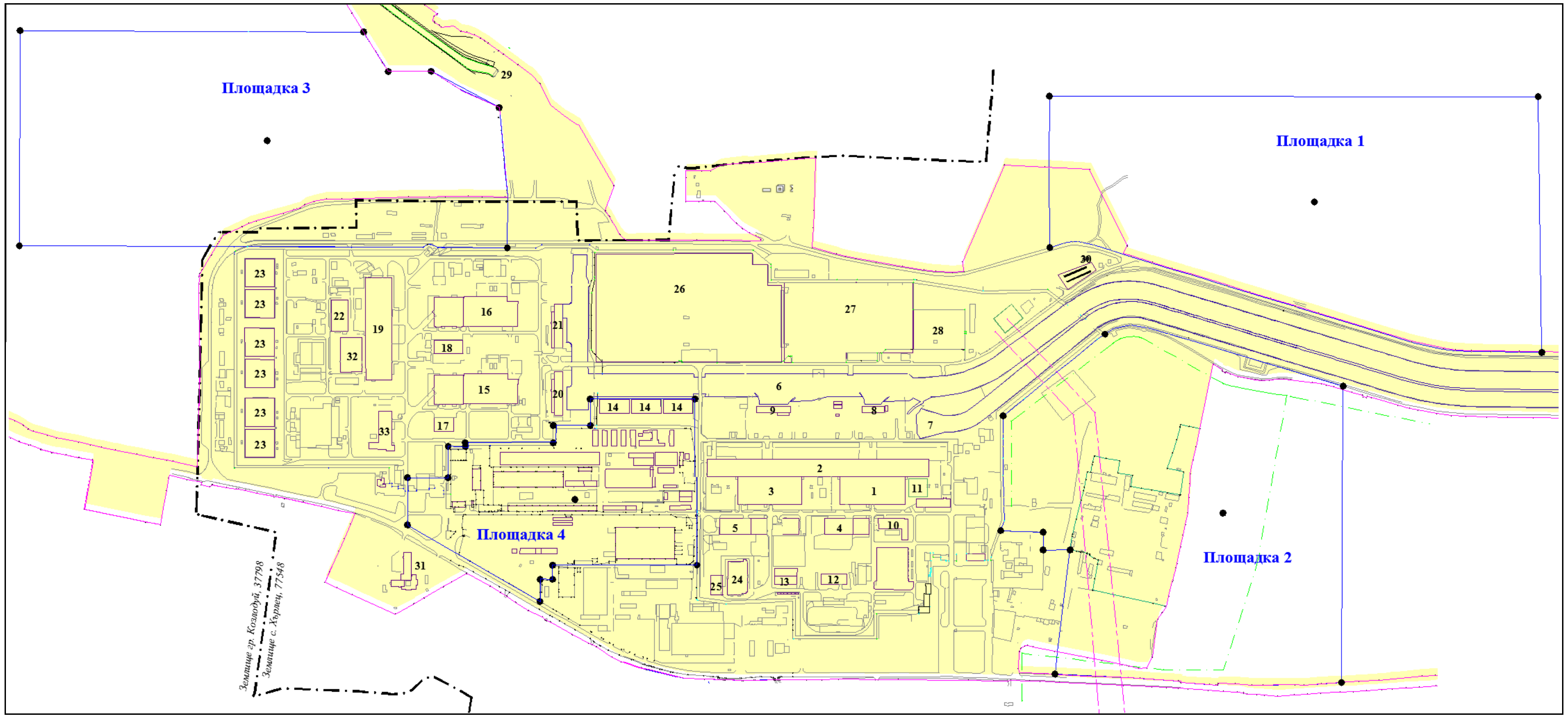

FIGURE 1.2-1: GENERAL LAYOUT OF KOZLODUY NPP И РАЗПОЛОЖЕНИЕ НА ПРЕДЛОЖЕНИТЕ ПЛОЩАДКИ НА НЯМ

Legend:

1. Reactor building Units 1-2.
2. Turbine hall Units 1-4.
3. Reactor building Units 3-4.
4. Auxiliary building 1.
5. Auxiliary building 2.
6. Intake (cold) channel 1.
7. Outlet (hot) channel 1.
8. Circulation pump station 1.
9. Circulation pump station 2.
10. Chemical Water Cleanup Facility.
11. Size reducation and decontamination workshop – project.
12. Diesel Generator Station 1.
13. Diesel Generator Station 2.
14. Units 3-4 Spray ponds.
15. Power Unit 5.
16. Power Unit 6.
17. Diesel Generator Station Unit 5.
18. Diesel Generator Station Unit 6.
19. Auxiliary building 3.
20. Circulation pump station 3.
21. Circulation pump station 4.
22. RAW Storage facility.
23. Spray ponds Units 5-6.
24. Wet Spent Fuel Storage Facility (WSF).
25. Dry Spent Fuel Storage Facility.
26. Open Switchyard – 400 kV.
27. Open Switchyard – 220 kV.
28. Open Switchyard – 110 kV.
29. Outlet (hot) channel) 2.
30. Depot for non-radioactive household and industrial waste – DNHIW.
31. Fire protection service.
32. Specialized Division RAW - SE RAW.
33. On-site Medical Center.

1.2.1 NUCLEAR FACILITIES

The following facilities are built at Kozloduy NPP site: 6 power units with a total electrical output of 3760 MW, equipped with presurized water reactors, spent fuel storage facility (WSF) and dry spent fuel storage facility (DSFSF). Other facilities and sites, property of SE RAW, are also classified within this category.

1.2.1.1 UNITS 1 AND 2

Units 1 and 2 were shut down on the 31.12.2002. By a Resolution of the Council of Ministers dated 20.12.2008, units 1 and 2 were announced as radioactive wastes management facilities, and, together with the required movable property, the same were transferred to the State Enterprise Radioactive Wastes, which is an independent business entity. On the 18.10.2010, the BNRA issued licenses to the State Enterprise Radioactive Wastes for the operation of units 1 and 2 as as radioactive waste management facilities, which are subject to decommissioning, and revoked the licenses of Kozloduy NPP for operation of the first two units in E mode of operation. No nuclear fuel is stored on the site of units 1 and 2.

1.2.1.2 UNITS 3 AND 4

Units 3 and 4 were shut dwon on the 31.12.2006. By Resolution of the CM No. 1038 dated 19.12.2012, units 3 and 4 of Kozloduy NPP EAD were announced as a RAW management facility, which are subject to decommissioning. Their property was transferred for management by the SE RAW. On the 26.02.2013, the BNRA issued licenses to the State Enterprise Radioactive Wastes for the operation of units 3 and 4 as radioactive wastes management facilities, which are subject to decommissioning, and revoked the licenses of Kozloduy NPP for operation of the two units in E mode of operation. No nuclear fuel is stored on the site of units 3 and 4.

At present, the spent nuclear fuel (SNF) of all four units has been removed from them and is stored at the spent fuel storage facility(SFSF).

Units 1÷4 have been transferred for management to SE RAW EAD, Sofia and are controled by specialized divisions, named "Decommissioning" and "Management of RAW – 3 and 4 units"

1.2.1.3 UNITS 5 AND 6

Units five and six are in operation, with unit five being in its 19th, and unit six in its 18th fuel campaign. Both units operate in basic mode at rated power in compliance with the terms and conditions of the licenses for operation.

Power units 5 and 6 of Kozloduy NPP were built with reactors WWER-1000 type B-320. The reactors are Russian - second generation, with pressurized water. According to the safety provision concept, the design characteristics and the structure of the units are analogical to the western designs of reactors of the PWR type. The units WWER-1000/B-

320 have been designed in compliance with the standards, specified in the "General Requirements on the Provision of Safety" (GRPS-73), later updated by the "Rules on Nuclear Safety for NPP" (RNS-04-74), "General Rules on Provision of Safety" (GRPS-82) and "Radiation Protection Norms" (RPN-76) of the former USSR. The main safety concept "Protection in Depth" is realized through design solutions, characterized by redundancy, diversity, independence, protection against failures and passive elements. Each WWER-1000/B-320 reactor has containment - protective lining, which is lined by steel and is mechanically pre-stressed, as in the western units. Both units are in the process of procedures for extension of their operational lifetimes, as well as for the uprating (increase of their power capacity).

The Company for Treatment of Radioactive Wastes, which is property of the SE RAW is built on the territory of this area, under the management of the Specialized Division RAW (SD RAW).

1.2.1.4 WSFSF

The wet spent fuel storage facility is located to the southwest of units 3 and 4 at Kozloduy NPP site. The WSF provides the possibility for underwater temporary storage of the SNF from the WWER-440 and WWER-1000 reactors for a 10-years period of operation of all the units of Kozloduy NPP, and for carrying out the transport and technological operations for its receiing, loading in the storage areas, storage and transport from the WSF in compliance with the requirements for provision of safety.

1.2.1.5 DSFSF

The site of the DSFSF is located to the north-northwest of the building of the WSF.. Kozloduy NPP used as technology for the storage in the DSFSF casks with air cooling according to the natural convection principles . The casks are of the type CONSTOR 440/84 with a capacity of 84 fuel assemblies from WWER-440. The DSFSF is located within the existing boundaries of Kozloduy NPP and expands the NPP activities performed till date – temporary storage of spent nuclear fuel in the WSF.

1.2.1.6 OTHER FACILITIES AND SITES, PROPERTY OF THE SE RAW

At present, according to the terms of the license issued by the BNRA to the State Enterprise Radioactive Wastes for the operation of a nuclear facility for RAW management via its specialized division (SD) Radioactive Wastes – Kozloduy, it is authorized to perform basic, auxiliary and service activities. The nuclear facility for RAW management of the SD RAW – Kozloduy, includes the following main facilities:

1. RAW Processing Shop (RAWPS) - main facility, designed to perform the activities related to the *preliminary treatment, treatment and conditioning of the* RAW generated by Kozloduy NPP;

   The basic assembly unit for forming the packages for the conditioned RAW is a reinforced concrete containers (RCC), which is manufactured and tested according to the terms of the permit issued by the BNRA.

The packages of conditioned RAW are stored temporarily in the DSCRAW, Site No. 1 and Site No. 2 (these should not be mistaken with the numbers of the sites for the construction of the new nuclear unit), which are subject to disposal without additional treatment.

The main systems of the RAWPS are:

→ Processing line for Solid RAW - sorting and processing by compacting the solid RAW for the purposes of reducing their volume and preparation for the consequent conditioning and storage;

→ Processing line for Liquid RAW - processing and conditioning of the liquid RAW. The Line for RAW Packing is a part of the Line for Liquid RAW.

2. Depot for storage of conditioned RAW (DSCRAW) - designed for temporary storage (until their disposal) of the conditioned RAW from Kozloduy NPP. It is a reinforced concrete building above the terrain surface, providing the required engineering barriers between the stored RAW and the environment and the personnel. It is built in the vicinity of the RAWPS;

3. Lime Storage Facility

The Lime Stiorage Facility site accommodates:

→ Trench depot for temporary storage of solid RAW [unprocessed and processed (compacted and secured in barrels)];

→ Depot for storage of processed solid RAW („baskets” with compacted and secured in barrels RAW);

→ Site No. 1 (not to be mistaken with the numbers of the sites for the construction of the new nuclear unit) for storage of solid RAW in Reinforced Concrete Containers (RCC) - (package RCC-1 or package RCC-2, according to the technical specification of the packages for conditioned RAW – see below);

→ Site No. 2 (not to be mistaken with the numbers of the sites for the construction of the new nuclear unit) for storage of solid RAW in Reinforced Concrete Containers (RCC) - (package RCC-2);

→ Site for storage of solid RAW in large capacity containers (LCC);

→ Depot for contaminated soil (DCS) - designed for storage of low radioactive soil masses.

The facilities outside of the layout of the nuclear units, which are planned for construction at Kozloduy NPP site are the following:

1. Plasma Melting Facility - at the stage of Detailed Design and developed ISAR;
2. Size reduction and decontamination workshop - at the stage of Technical Design,

3. National repository for short-lived low- and intermediate radioactive waste. The Radiana Site is not within the territory of Kozloduy NPP site, but it is close enough to take its impact into consideration in the development of the REIA. The national repository is an installation with multi-barrier protection for long-term storage of waste that has been preliminary processed, safeguarded and packed in reinforced concrete cube packages. The repository will be at the ground, trench type with a capacity of 138 200 m^3. The installation will consist of several reinforced concrete embedded structures (modules), and separated in chambers by internal partition walls. After the chambers are filled with packages, they are covered with a reinforced concrete plate and insulated from the atmospheric waters through a construction of a multi-layer soil fill. The facility is planned to be in operation, i.e. to be gradually filled up during the next 60 years. The detailed layout plan (DLP) – Plan for regulation and building (PRB) for the Radiana Site for the construction of the National Repository for Short-lived Low- and Intermediate-level Radioactive Waste (NR-SLI-RAW), has been approved as to date. Its commissioning is expected in 2015.

1.2.2 General plant sites and facilities

1.2.2.1 Open Switchgear

Kozloduy NPP is connected to the Electrical Grid (EG) of the Republic of Bulgaria by means of three installations, called Open Switchgear (OS) with voltage 400 kV, 220 kV and 110 kV. Connections between them are provided by auto-transformers. The 400 kV installation is realized according to the double sectioned busbar system, the 220 kV installation according to the double busbar system, and the 110 kV installation according to the double busbar system with a bypass busbar.

1.2.2.2 Drinking water supply

A very good water supply network for drinking domestic and service water needs has been built at Kozloduy NPP site. The drinking water for the NPP is provided from Ranney type wells – three drills, located on the terrace of the Danube River before the town of Kozloduy according to a contract with ViK (WS&S) EOOD - Vratsa. Reserve water supply is provided those for the villages of Harlets and Glozhene. A Permit for Water Intake was issued for these water intake structures of Kozloduy Municipality according to the WA by the BDWMDR. From the tanks of the town of Kozloduy, the water flows by gravity to reach the pumping station /PS/. The pumping station pumps the water to the tank of the power plant at elevation 93.0 m, with a volume of 2000 m^3 by means of a water mains with a length of 11 km, diameter of Ø500, with a maximum water discharge rate of 260 l/sec., from which it flows by gravity to the individual consumers. The water mains, supplying the power plant with drinking water after this tank is made of steel with a Ø500. The external water supply system of wells, pumping stations, water mains and other facilities up to the first distribution shaft are maintained by ViK[3] EAD - Vratsa. Kozloduy NPP EAD annually executes a contract with the WS&S operator for supply of water with drinking qualities. The consumed water quantities are measured by water meters. The external consumers of drinking water at the site of the power plant are supplied from the internal site water mains of the NPP, and the water they consume is measured.

The calculations on the mean monthly consumption of drinking water by the NPP consumers indicate that the actual quantity of drinking water amounts to approximately 35÷40 l/sec.

Balance of drinking water supplied to the consumers at Kozloduy NPP site:

1. Drinking water mains up to Kozloduy NPP - **Ø500** mm and capacity **260** l/s.
2. Consumers

Consumers	branch- Ø mm	consumption l/s
EP-1	315	73.00
EP-2	315	73.00
AER	150	17.50
ZS	60	5.00
INV.	57	3.40
MONTAZHI	100	8.00
FFPS-5 bl.	125	9.20
	TOTAL:	**189.10**

3. Reserve – **70.90 l/s.**

A shaft well in the Valyata area is used for the showers in EP-1 bathrooms. A Permit has been issued for this facility in accordance with the provisions of the WA by the BDWMDR.

1.2.2.3 SERVICE WATER SUPPLY

The service water supply provides cooling water (circulation – for the condensers of the turbines, and service – for the other facilities). It is provided by means of 3 riverbank pumping stations from the Danube River, as well as by means of 6 shaft pumping stations, located on the terrace of the Danube River - for emergency water supply of units 5 and 6. The service water for technological needs and for the fire-fighting system in BPS 1, 2 and 3 is provided from Ranney 5 well.

The water intake from the Danube River and the riverbank pumping stations are located at km 687 from the Danube River mouth, after the island at the town of Kozloduy. The water intake is in deep water. The constructed BPS-1, -2 and -3 provide the NPP with service water. The capacity of the cold channel is 180 m^3/s with proven maximum

[3] Water suply and canalization companies in Bulgaria.

capacity of 200m^3/s.[4]. Permits for water intake have been issued by the BDWMDR for the use of the water from the Danube River, as well as for the ground water sources.

Water from the Danube River is supplied to the power plant via the built hydro-technical facilities, which have a decisive importance for the normal operation of the power plant. The cold channel connects the outflow tanks of the BPS with the RPS-1 (Recirculation pumping station) with a length of 7023 m. At the end of curve 8 was built a long crosswise shoot up to elevation 29.25, providing for an emergency volume in case of blackout. With the consecutive construction of the nuclear units, it has been extended up to RPS-2 and later up to RPS-3 and RPS-4, where it was plugged. RPSs (the recirculation pumping stations) are located in front of the turbine halls of the respective power units. The supply cold open channel for the water from the Danube River has a bottom width of 19.50 m, slopes of 1:2 and a depth of 5.6 m.

The used water from the power units is returned to the Danube River by means of the discharge hot channel HC-1. The hot channel HC-1 starts at the outlet shaft of the low-pressure channels and ends next to the spillway of the bypass channel for discharging the hot waters into the Danube River. Its length is 6930 m. The capacity of the hot channel is 180 m^3/s with proven maximum capacity of 200 m^3/s and depending on the elevation of the spillway after the low-pressure channels and the elevation of the water in the Danube River. The discharge hot channel passes parallel to the cold channel CC-1 along the larger part of their route. The two channels have a common dike and form a double channel. Another hot channel HC-2 has also been built, designed for 110 m^3/sec., for the needs of power units 5 and 6.

A bypass channel has also been built, which is used for connection between HC-1 and the mainstream of the Danube River and for reducing the energy of the water flow. It has a rectangular cross-section with width of 35.00 m and vertical reinforced concrete enclosing walls. Its bottom is at elevation 27.40. A bridge - partition facility was built at its beginning with nine openings, equipped with sluice gates. The channel ends by a spillway and chute with a stilling basin, as well as a battery for hot water, which serves for supplying hot water from the HC-1 to the fore chambers of the BPS-1, -2 and -3 during the winter months. The purpose is to reduce the losses from over-cooling of the condensate of the steam from the turbines. The same consists of 6 pipelines with diameter of 1.20 m and is designed for a water discharge of 12 m^3/s The intake of hot water is provided by means of a channel which outflows before the spillway at the end of HC-1.

The route of the channels is crossed by the passing drinking water pipelines for the village of Harlets and for service water from the Valyata PS.

A benchmark monitoring system has been built to monitor the deformations along the double channel.

4 SRDI Energoproect - 1991 - Existing channels for service water supply of Kozloduy NPP.

44 drainage wells have been built around the channels (17 in the non-flooded terrace and 27 in the valley) for control of the ground waters. They are used for monitoring of the ground water table and for isotope measurements.

In addition to these HTF, spray ponds for cooling the water from the service water systems of EP-1 and EP-2 were built on the plant territory. For each of the units 5 and 6 3 SP were built (with dimensions 68 x 65 m and a depth of 3 m).

The service water consumers are united in two groups – safety related and not-safety related, according to their relation to the nuclear safety. The safety related ones are the consumers of the safety systems and the consumers of the normal operation systems, which are related directly to safety. In emergency situations, when the CC 1 is not capable of conveying water from the Danube River, service water from the fore-chambers of the RPS is conveyed only to the safety related consumers, its cooling being provided by the spray ponds. In such cases, the reserves of water is provided by the partition spillway in the area of curve 8. In the cases, when the water in the fore-chambers of the RPS is insufficient, it is possible to compensate the water losses in the SP (from evaporation and wind blowing) by other sources. For units 1÷6, these are 3 service water emergency pumps (SWTP), installed in BPS 2 and 3, which pump water from the Danube River to the fore-chamber of the RPS, and for units 5 and 6 – additionally from ground water sources (GWPS 1÷6).

Protection dikes have also been built along the Danube River in the area of the Kozloduy valley, which are also important for the safe operation of the power plant.

From the point of view of the service water supply, taking into consideration that the first four unit have been shut down, a free capacity exists of up to 100 m^3/sec, with the required conservative value of 60 m^3/s for the new power unit, according to letter No. 236 dated 11.03.2013 of Kozloduy NPP-New Build EAD. During the operation of the new nuclear unit no increase in the quantity of used water is expected for technological needs in excess to the provided for by the water intake permit.

The water supply system of Kozloduy NPP for service and industrial water, as well as for drinking water is well designed and reliable, being well maintained by the operating personnel.

TABLE 1.2-1: ANNUAL WATER DISCHARGE RATES, USED FOR SERVICE AND DOMESTIC WATER SUPPLY

Water intake location	Permitted discharge rate [thous. m^3]	Used discharge rate [thous. m^3]					
		2006	2007	2008	2009	2010	2011
Surface waters from the Danube River	5 000 000	3 334 722	2 323 800	2 629 876	2 593 459.52	2 564 530	2 660 788
Six shaft wells (GWPS 1÷6)	7 884	-	-	0	0	0	24.779
Ranney– 5 well	1 600	190	314	75	15.929	24.000	2.729
Valyata shaft well	788.4	291	183	204	192.27	193.000	216.700

Urban water mains	-	1 805	1 846	1 259			

Source: Annual report of Plant non-radiological monitoring of the environment for Kozloduy NPP, for the 2006-2011 period.

From the presented information (***Table 1.2-1:*** *Annual water discharge rates, used for service and domestic water supply)* it can be deduced that the water discharge rates applied for considerably exceed the water discharges used and, therefore, there will be no excessive operation from any specific water body, with sufficient water quantities being available for drinking, domestic and industrial water supply upon realization of the future investment proposal.

1.2.2.4 SITE SEWAGAGE SYSTEM

Kozloduy NPP has been provided with a built sewerage network to collect household-fecal wastewater, industrial and rain waters - mixed for EP-1 and separated for EP-2. It includes the whole territory of the power plant and takes in all types of waste waters.

The individual sewerage branches have been built at various times during the construction EP-1 and EP-2.

1.2.2.4.1 Non-radioactive waste waters

The non-radioactive waste waters from Kozloduy NPP site include the household-fecal wastewater, production and rain waters. They come from the administration buildings, the energy buildings, the sanitary personnel buildings, the auxiliary buildings, the Common Purpose Building, the engineering laboratory building, the CWTF, the fuel and lubrication facilities, the diesel-generator stations, rolling stock parks, etc.

The following main streams are formed at EP-2:

- household-fecal wastewater - from the sanitary facilities and laundries in the controlled area and the clean area, which are conveyed along separate collectors to the EP-2 WWTP;
- production waste waters - these comprise acid and alkaline waste waters from the CWTF, waters, contaminated by crude petroleum products and oils, which are conveyed along separate collectors to the built local waste water treatment facilities for the various types of waters;
- rain waters – from the drainage of the roofs, streets and greenery areas within the territory of the power plant, which are conveyed to the MSC via the rain water sewerage.

A stream of cooling non-contaminated waters from various sub-facilities is also arranged on this, which are conveyed into the rain water sewerage.

Aforementioned waste waters are discharged into the Main Sewage Channel (MSC) of the Kozloduy drainage and irrigation system, where the four streams of waste waters from the whole NPP site outflow, from which by means of a pump stations (PS) the waters from the MSC are conveyed into the Danube River:

Stream 1: Mixed from of household-fecal wastewater (untreated), industrial and rain wastewaters, conveyed to the MSC by means of a trapezoidal open channel (from the mixed sewerage of EP-1 - household-fecal wastewaters from the energy buildings of units 1÷4, Auxiliary buildings 1 and 2, DGS and other administration and staff buildings, part of which are the property of SD DC – a subsidiary of SE RAW; industrial waters from EP-1, excluding the installations in HC-1; rain waters from EP-1; part of the industrial, household-fecal wastewater and rain waters from the EP-2 site; household-fecal wastewaters from the office buildings and sites of Atomenergoremont PL (AER), Atomenergo-Stroyprogress EAD, Zavodski Stroezhi – Kozloduy AD (ZS), Energomontazh OOD, Energomontazh-KNPP AD; waters from the carwash of AESP EAD and rain waters – after treatment in the local sludge and oil retainer).

Stream 2: household-fecal wastewaters from the so-called clean area of EP-2, from SE RAW – Kozloduy and AESP EAD, discharged (without treatment) into the MSC by means of a collector of Ø300 mm during repair works, or in emergency situations.

Stream 3: Mixed flow of household-fecal wastewater from the controlled area and the clean area treated at the treatment facility of EP-2 (TF), industrial wastewaters from the TH, DGS and the fuel and oil facility (treated by the sludge and oil retainer at the TF), as well as rain waters from EP-2 and from SD RAW – Kozloduy, discharged into the MSC via collector of Ø1000 mm.

Stream 4: household-fecal wastewaters and rain waters, coming from the Open Switchgears, discharged into the MSC by means of a collector with an egg-shaped profile of 130/195 cm and an open lined channel.

A permit for discharge into the MSC was issued by the BDWMDR for these flows of waste waters.

In addition to above four streams, waste waters are discharged also into the Danube River by means of HC-1 and HC-2, for which a permit for discharge has been issued by the BDWMDR. This is primarily cooling water after the condensers and from the service water systems. Other waters, discharged via the HC, include:

→ treated water discharges from the Reactor Water Cleanup Systems (SVO-3, SVO-5, SVO-7), including the condensate from heating steam;

→ waters from the deminirelized water installations (after treatment in the neutralizing pits);

→ waters from the expansion vessels of the overflowing high-pressure deaerators (HPD) and from the expansion vessels of steam generators blowdown (SG);

→ water from the secondary circuit drainage tanks and from the condensate system flushing;

→ flushing water from the recirculation water filters.

Water treatment facilities

Various water treatment facilities have been built on the territory of the NPP for treating the waste waters coming from the individual sub-facilities.

Waste water treatment facility for EP-2

A Treatment Facility (TF) was build for the purification of the household-fecal wastewaters from EP-2. It consists of two plants – one for the waters from the Controlled Area (CA) and the other for the waters from the Clean Area (ClA). They are equipped with similar treatment facilities, which differ only as regards their capacity. The waste water treatment plant for the CA is designed for a mean daily water discharge of 106 m^3. It is equipped with an installation for dosimeter control. In case the radioactivity of the water exceeds the admissible values, it is returned to the CA for re-processing.

The treatment plant for the clean area is designed for 146 m^3 per day.

The treated waters from both areas are discharged via a collector of Ø1000 into the MSC of the Kozloduy drainage system.

The proper operation of the waste water treatment plants is ensured by instructions which state the requirements for normal operation mode in and in case of potential failures. In emergency situations or in case of repair works carried out, a possibility is provided to discharge the household-fecal wastewaters from the CA into the MSC without treatment.

Sludge and oil retainers

Immediately next to the TF a sludge and oil retainer was built for treatment of the production waste waters from TH, DGS and the fuel and oil facility. Its capacity is 50l/s The concentration of oil at its outlet is less than 0.5 mg/l. The treated waters from the sludge and oil retainer flow into a collector of Ø1000 of the sewerage, via which they are discharged into the MSC. It was commissioned at the end of 2011.

The existing earlier sludge and oil retainer (with a capacity of 14.0 l/sec.) is currently used for treating individual small quantities of waters, contaminated by crude petroleum products (e.g. from washing of various motors), delivered by tanker trucks.

A small sludge and oil retainer was built at the fuel and oil facility of EP-1. The sludge and oil retainer was built also for treating the waters from the carwash of Atomenergo-Stroyprogress EAD, before discharging them into the EP-1sewerage system.

Neutralization pits

The installations for chemical water treatment facility(CWTF) of Electricity production 1 (units 1÷4) and Electricity production 2 (units 5 and 6) of Kozloduy NPP EAD treat the water from the Danube River (raw water), using precipitation tanks, mechanical and ion-exchange filters. The waste waters from this treatment, as well as the solutions from the filters regeneration may contain sulfuric, hydrochloric and nitric acids, sodium hydroxide, calcimine, ferrous chloride.

The organization of the neutralization and the process technology are identical for EP-1 and EP-2. The waste waters are collected for neutralization in one of the two chambers (neutralization pits), where they are mutually neutralized. After the pH control (at values within the range of 6.5 – 8.5), they are discharged, as follows:

- → for units 1÷4 – into НС-1;
- → for units 5 and 6 – into РШ-1, and from there - into НС-1 or НС-2.

In case the waters do not satisfy the above requirement, they remain in the pits until they reach the required degree of neutralization.

The following permits have been issued by the MoEW/BDWMDR for the water intake structures along the Danube River, the water intake structures for ground waters, as well as for the discharge of the waste waters:

- → Permit No. 0562 dated 14.03.2005;
- → Permit No. 11590203 dated 30.05.2008;
- → Permit No. 11530128 dated 30.05.2008;
- → Permit No. 11530127 dated 30.05.2008;
- → Permit No. 13750001 dated 20.04.2007 with its subsequent amendments;
- → Permit No. 13120037 dated 22.11.2010.

Permit for water intake No. 11530127 dated 30.05.2008 from six shaft wells - SWPS 1÷6 regulates the water intake for reserve (emergency) service water supply for the spray ponds of units 5 and 6 at Kozloduy NPP. During normal operation, the losses of water in the spray ponds of units 5-6 are refilled from RPS 3 and RPS 4. A system for emergency service water supply was built to increase the level of safety, which provides water for the spray ponds in the cases, when it cannot be provided by the RPS. The emergency service water supply system was designed for a water discharge of 280 l/s and consists of 6 shaft well pumping stations (SWPS). The SWPS are located on the terrace of the Danube River at approximately 25 – 30 m to the south of the base of the state dike. They are equipped with 2 submersible pumps each.

By means of permit for water intake No. 11530128 dated 30.05.2008 the Ranney-5 well supplies service water - for process needs and for the fire-fighting system of the BPS-1, -2 and -3. The well has a diameter of 4 m and is located at approximately 1 200 m to the southeast of the BPS site. The design discharge rate of the pumping station is 116 l/sec, distributed, as follows:

- → for process needs – 46 l/se.; two pumps are installed, each with a discharge rate of 50 l/s (one operational, the second standby);

→ water for fire-fighting – two pumps are installed, each with a discharge rate of up to 140 l/s.

Permit No. 11590203 dated 30.05.2008 for water intake from the Valyata shaft well provides for the sanitary domestic water supply for units 1÷4 of Kozloduy NPP.

Whenever necessary, the issued permits for discharge, according to the WA for water intake and use of a water body for discharge, can be modified, in case during the realization and operation of the IP theye cannot comply with all the parameters and terms, specified therein. The prohibition for new discharges of waste waters into the irrigation drainage systems shall also be taken into consideration as per art. 6, clause 1, items 3 and 4 of Regulation No. 2 dated 08.06.2011 (State Gazette No. 47 dated 21.06.2011) concerning the issue of permits for discharge of waste waters into water bodies and determination of the individual emission limits for specific sources of contamination.

1.2.2.4.2 Radioactive contaminated waste waters

During the operation of the power units production radioactive waste waters are generated from:

→ nuclear reactors primary circuit leaks;

→ ponds and spent fuel storage facility;

→ decommissioning of equipment;

→ regeneration and flushing of ion-exchange filters;

→ laundry and Sanitary loops;

→ radio-chemical laboratories, etc.

These waters shall be processed (treated) in evaporation installations and ion-exchange filter complexes (Reactor Water Cleanup Systems SVO-3) in the Auxiliary buildings - 1, -2 and -3. The treated waters, called treated water discharges, shall be collected in intermediate tanks and after checking their radioactivity, they are discharged into HC-1 and HC-2, if they comply with the norms. Otherwise, they are returned for further treatment.

The purpose of the RWCS is:

→ SVO-3 – designed for purification of the floor drain from the Controlled Area (CA). The sources of such waters are the unorganized leaks in primary circuit, decontamination of equipment and systems, flushing and regeneration of filters, the SVO-3 itself - if the treated waters do not satisfy the NPP water chemistry standards or treated water discharges norms, etc.;

→ SVO-5 – designed for purification of the water from the steam generators blowdown - constant and periodical;

- SVO-7 – designed for purification of the radioactive waters from the laundries and hot showers;

The waters from the expansion vessels of the dearators are also treated water dscharges, as well as those from the steam generators blowdown. These waters are purified by means of ion-exchange filters and in case they cannot be used again in the process cycle, they are discharged (after dose metering control) into the HC.

The radioactive sludge from the RWCS is collected and stored in special tanks with evaporate concentrate. It is subjected to additional processing and disposal as RAW.

1.2.2.5 INTERFACES BETWEEN UNITS 1÷4 TO UNITS 5 AND 6 (STEAM, WATER, FIRE RING)

The process systems of the first 4 units (1÷4), on the one hand, and those of units 5 and 6 on the other hand, there are built interfaces, which provide for the supply of demineralized water, steam, water for fire-extinguishing in case of technological necessity:

- the fire-extinguishing systems for units 1÷4 and for units 5 and 6 are united in common fire rings, which are connected with each other and if required there is a possibility to transfer water for fire-extinguishing from one to another;
- the steam systems– for proper needs of units 5 and 6 are connected with those of units 1÷4 for the purpose of supplying steam for technological needs;
- the deminieralized water systems of units 5 and 6 are connected to those of units 1÷4, with a possibility to share demineralized water between the units, whenever necessary.

1.3 EMERGENCY PLANNING ZONES OF KOZLODUY NPP

On the basis of the performed design analyses of the maximum design based accidents and possible beyond design based accidents of the units WWER-440 (B-230) and WWER-1000 (B-320), and the radiological consequences, in compliance with risk categories I, II, III and the limit dose criteria according to the REGULATION on emergency planning and emergency preparedness in cases of nuclear and radiation accidents (Published in State Gazette No. 94 dated 29.11.2011) the following zones for emergency planning were determined according to Appendix 3.1-1 of the Emergency Plan for the Kozloduy NPP EAD):

- **On-site Emergency Planning Zone - *Protected Zone* No. 1**, for the site of Kozloduy NPP EAD);
- **Precautionary Actions Zone (PAZ) – Zone No. 2**, with a radius of 2 km and geometric center between the ventilation stacks of units 5 and 6. The area of the zone amounts to 12 566 daa, including 3 012 daa or 24% occupied by of Kozloduy NPP production site and the RAW storage and processing site of SD RAW Kozloduy. It was established on the basis of an ordinance of the Minister

of Regional Development and Public Works. Its purpose is to limit the exposure in case of emergencies.

→ **Urgent Protective Ation Planning Zone (UPAPZ)**[5] **– zone No. 3**, with a provisional radius of 30 kmaround Kozloduy NPP EAD and with an area of 284 874 daa. It was established on the basis of an ordinance of the Chairman of the BNRA. Its role is to perform the required control for the purposes of the radiation protection:

- ✓ Within the territory of the Republic of Bulgaria, this zone includes in whole the following municipalities: Kozloduy, Valchedram, Hayredin, Mizia and partially the municipalities of Lom, Byala Slatina, Oryahovo Boychinovtsi, Krivodol and Borovan. Within this zone there are no big Bulgarian industrial and military sites;
- ✓ Within the territory of the Republic of Rumania, this zone includes a total of 18 settlements of the Dolj and Olt regions.

  (Kozloduy NPP EAD is obliged to perform environment monitoring in case of emergency in the sub-zone of 12 km)

The Emergency planning zones are divided into 16 sectors of 22.5° each and are denominated by the first 16 letters of the Latin alphabet from the north clockwise (A, B, C, D, E, F, G, H, J, K, L, M, N, P, R and S) - ***Figure 1.3-1:*** *Layout plan*. Depending on the emergency status, actions of diverse nature are carried out for the protection of the personnel and of the public.

[5] The UPAPZ of 30 km is determined for the purposes of the emergency planning. The same zone of 30 km for the purposes of the radiation monitoring is called the Surveillance Zone (SZ)

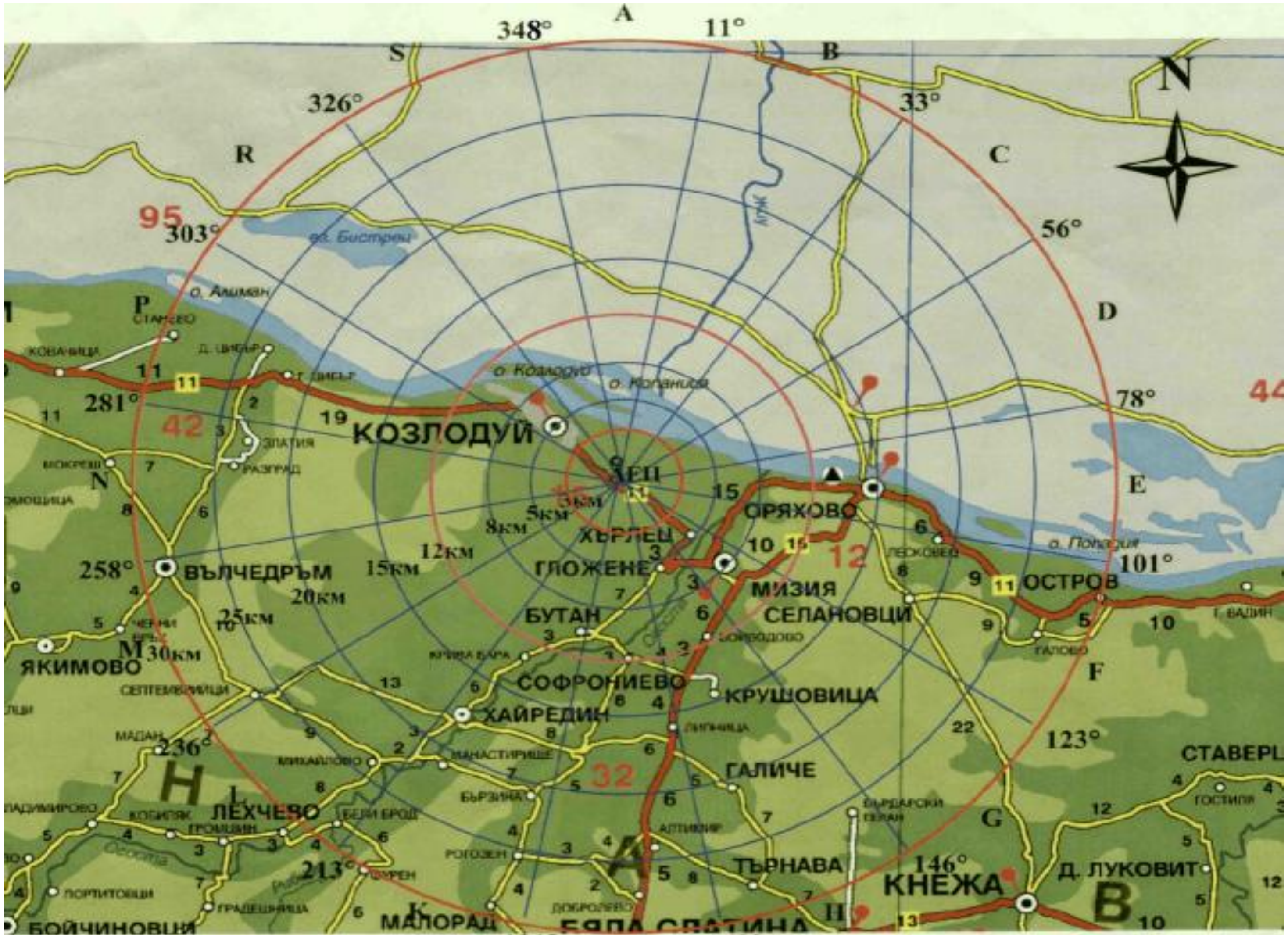

FIGURE 1.3-1*: LAYOUT PLAN*

1.4 RADIO-ECOLOGICAL MONITORING

The radio-ecological monitoring, performed at Kozloduy NPP, includes all the basic components of the environment (air, waters, soil, vegetation, etc.) in a radius of 100 km around the power plant on the Bulgarian territory.

The scope, range and controlled parameters are determined in a long-term program for radio-ecological monitoring during normal operation of the NPP, which has been agreed with the control and supervisory authorities of the country – the BNRA, the National Center for Radiobiology and Radiation Protection (NCRBRP) at the Ministry of Health (MH) and the Executive Environment Agency (ExEA) at the Ministry of Environment and Water (MoEW). The program fully complies with the national and European regulatory requirements in this field, including art. 35 of the EURATOM Treaty, Recommendations of the EU 2000/473/EURATOM and 2004/2/EURATOM.

The monitoring zone includes the territory of the NPP industrial site, the 2 kilometer Precautionary actions zone (PAZ), the 30 kilometer urgent protective action planning zone (UPAPZ) and the benchmark posts within the 100 kilometers radius around the nuclear power plant.

The definition of the zones with special status around Kozloduy NPP is related to the necessity of creating an instrument for the layout and management of the territory in compliance with the legal and regulatory system of the country and the pan-European standards for safety and protection, according to the requirements of art. 104, clause 1 of the Safe Use of Nuclear Energy Act (State Gazette No. 63 dated 2002, last am. in State Gazette No. 82 dated 2012).

1.5 RATIONALE OF THE NECESSITY OF THE INVESTMENT PROPOSAL

The reliable and successful operation of nuclear power reactors of the pressurized water type (PWR) at Kozloduy NPP since 1974 till to date indicates, that the Republic of Bulgaria owns the required scientific and technical engineering capacity to derive benefits from such a highly technological production, as the nuclear power generation. The logic of the investment proposal for the construction and commissioning of the new nuclear unit of the latest generation (Generation III or III+) with installed electric power capacity of approximately 1200 MW, is for the successful utilization of the whole capacity of Kozloduy NPP site, including the available infrastructure and the experienced and highly qualified personnel.

1.5.1 MAIN OBJECTIVES, PRINCIPLES AND SAFETY CRITERIA

The investment proposal foresees the construction of a new nuclear unit of the latest generation (Generation III or III+) with pressurized light-water reactor (of the type PWR – Pressurized Water Reactor), with an installed electric power capacity of approximately

1200 MW on one of the 4 potential sites and applying one of the two main technical and layout solutions for reactor installations of the latest generation.

The key advantage of the design for this generation of nuclear facilities, as compared to the designs for the second generation, which at present are operated throughout the world, including at units 5 and 6 of the Kozloduy NPP with reactors of the type WWER-1000/B320 is that it will include mainly passive safety systems, new design schemes for the structure of the containment and specific safeguarding provision, including the design scheme for the concept of corium catching in case of beyond design accidents, which considerably improve the safety of the nuclear unit.

With reference to the safety, the design for the construction of the new nuclear unit at Kozloduy NPP site shall take into consideration the requirements of the Bulgarian legislation in the field of utilization of the nuclear energy, the requirements of the IAEA, as well as the European requirements on safety, specified in the European Utility Requirements for LWR Nuclear Power Plants.

1.5.2 RATIONALE OF THE NEED FOR THE INVESTMENT PROPOSAL

The requirement to erect a new industrial nuclear reactor at Kozloduy NPP site is directly related to the provision for the energy balance of the Republic of Bulgaria, on the one hand, and on the other hand, for the provision of the required export, in this way also covering the growing deficit of electric power in the Balkan Region.

Since the planned construction of the new nuclear unit is designed for the generation of electric and low-potential thermal power, at present the Terms of Reference are focused on the determination of the scope and contents of the EIA with reference to the assessment of the necessity for the construction of the new nuclear unit. It is about proving that the IP will have its contribution to the society from the point of view of the energy balance with reference to the mentioned two types of energy while taking into account all the impacts on the environment and the risks to human health, as well as social and economic impacts.

The electric power in its end consumption point is environmentally clean (no hazardous emissions are produced during its use) and it has an universal application (i.e. it can be transformed into other types of energy). On the availability of electric power depends the functioning of all sectors of the economy and the lifestyle of the population. An eventual shortage, respectively failures/defects in the electric power supply affects the whole population, which fully justifies the strong public interest in the reliable supply of electric power.

According to the forecast energy balance of the country for the 2020 – 2030 period, which takes into consideration the development of the energy sector according to the current energy policy (the so-called basic scenario, elaborated and periodically updated for Bulgaria according to the order of the DG Transport and Energy of the European Commission), the consumption of electric power in the country is expected to grow by, respectively, 8% in 2020 and by 23% in 2030 as compared to the consumption levels, accounted in 2005.

Simultaneously with the forecast for the growth of energy consumption, the Bulgarian energy sector at present faces the necessity to cope with three basic challenges:

- → High energy intensity of the GDP: Notwithstanding the positive trends for improvements, the energy intensity of the national GDP is by 89% higher than the average for the EU (taking into account the parity of the purchasing power);
- → High dependence on the import of energy resources: Bulgaria provides for 70% of its gross consumption of energy resources by means of import. The dependence on imports of natural gas, raw crude petroleum and nuclear fuel is practically complete and has a traditional one-sided orientation towards the Russian Federation;
- → Necessity of environment considering development: The world faces challenges, related to climate changes, caused by the growing volume of greenhouse gas emissions. One of the main sources of the greenhouse gas emissions is the consumption of energy resources, such as the carbon intensity of the electric power, defined as a ratio of the total emissions of the power plants in relation to the total production of electric power in Bulgaria in 2008, which amounted to 555 kg/MWh.

In this context, the investment proposal is a considerable and reliable mechanism for overcoming all the mentions restrictions, for facing the growing energy needs of the country, as well for providing additional quantities of energy, destined for export.

According to the forecast energy balance of the country, the growing consumption of energy during the 2020-2030 period shall be fully guaranteed by domestic production, which shall grow at faster rates – respectively, by 13% in 2020 and by 32% by 2030. These expectations, however, are based on the forecast, that during the 2025 – 2030 period substitute power facilities shall be built fueled by lignite coal with technologies for catching and storing the carbon dioxide, as well as the commissioning of new nuclear power facilities on a national scale, which once again proves the logic and importance of the realization of the IP.

In this sense, the scope of the EIA shall include an analysis of the rationale of the selection of the IP; in order to back the necessity of the investment proposal with argument, an assessment of the state and development of the electric power mix in Bulgaria shall be performed, as well as an assessment of the contribution of the new nuclear unit for achieving the priorities, related to the transition to low-carbon energy production, reduction of the dependence on imported energy resources and improvement of the national rating according to the GDP energy intensity index.

This analysis shall provide conclusions as part of the EIA scope in the following aspects:

1. The new nuclear unit foreseen to be built at Kozloduy NPP site in the context of the state and development of the existing electric power generating facilities in the country

Bulgaria has a varied electric power production mix, including, in addition to Kozloduy NPP, thermal power plants and RES (hydroelectric, wind-powered and solar energy) power plants. The electric power is generated by power plants, separated in 2000 from NEC EAD, a part of which is currently included in the composition of the Bulgarian Energy Holding EAD (BEH EAD), while the rest remain the property of private companies.

The main challenges, related to the increase of the installed power capacity of the existing thermal power plants in the country are related, in the first place, to the operation of very depreciated electric power production capacities and, in second place, to the required considerable investments to bringingthem into compliance with the environmental protection norms. As long as one of the priorities of the Energy Strategy of the Republic of Bulgaria until 2020 is the efficient use of the local energy resources, from the point of view of security and sustainability it is focused on the protection and development of the coal industry. With reference to the above, it is foreseen to use the existing coal potential of Bulgaria to the maximum possible degree. The state shall support the coal-fueled power plants, by providing support for the full compliance with the ecological requirements, including the restrictions for the maximum admissible norms for hazardous emissions (sulfur, nitrogen oxides and dust), it will perform monitoring and will seek international aid for projects for the construction of new and/or substitute power facilities, operating on the basis of local coal, with compulsory utilization of contemporary highly effective and low-emission technologies with catching and storage of the carbon dioxide. Taking into consideration the environmentally friendly development of the national energy sector and in compliance with the Bulgarian and European legislation a time-schedule will be elaborated for the modernization or shutting down of power production facilities that are defined as highly polluting, and their owners shall be obliged to comply with the accepted ecological norms.

In the context of the above, the task of the EIA is to present a comparative analysis and forecast for the installed power capacity of the electricity generating facilities until the year 2030 as compared to the current status with 2 scenarios with and without the realization of the investment proposal for the construction of the new nuclear unit at Kozloduy NPP site.

2. Impact of the IP on the energy dependence index

The energy dependence shows the dependence of the country on imports of energy and resources (***Table 1.5-1:*** *Energy dependence of Bulgaria*)**.** Bulgaria provides for 70% of its gross consumption by means of imports.

TABLE 1.5-1: ***ENERGY DEPENDENCE OF BULGARIA***

	2005	2006	2007	2008	2009	2010
Energy dependence on coal, %	36.1	34.0	37.6	42.0	26.9	-
Energy dependence on crude oil, %	97.7	99.8	100.2	101.0	98.6	-
Energy dependence on natural gas, %	87.4	89.8	91.5	96.3	98.6	-
Energy dependence total, %	**47.4**	**46.0**	**51.7**	**52.5**	**45.6**	**40.4**

The data is from the Energy Balance for 2010 of the NIS

Coal

The structure of the coal yield is prevailed by the lignite coal at 93.6% (they comprise the main domestic energy resource), followed by the brown coal at 6.3% and black coal at 0.1 % (***Figure 1.5-1:*** *Yield of coal in 2011 according to type)*.

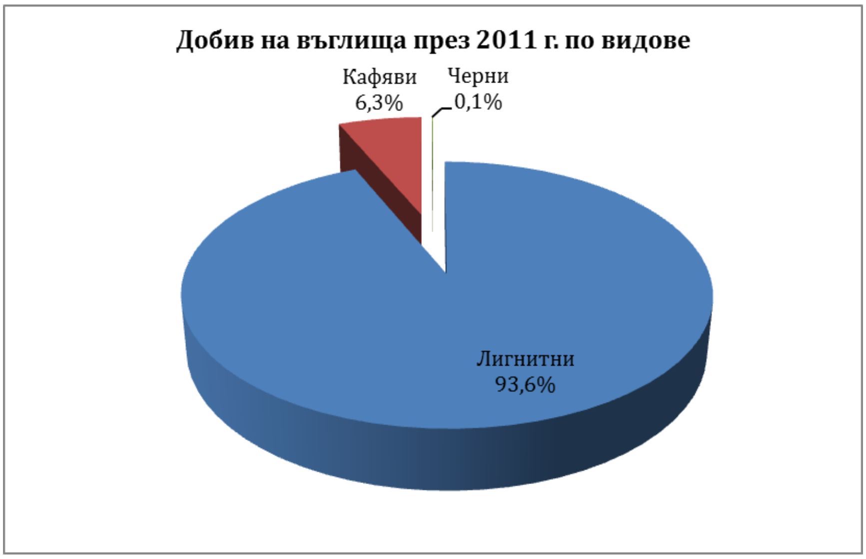

FIGURE 1.5-1*: YIELD OF COAL IN 2011 ACCORDING TO TYPE*

The total yield of lignite coal amounts to 34.5 mln tons, their main producer being the Maritsa Iztok Mines EAD with a share of 95.7%. The total yield of brown coal amounts to 2.3 mln tons, mined mainly at the Bobov Dol (0.99 mln tons) and Pernik (1.06 mln tons) basins. The total yield of black coal is insignificant (14.1 Ktons) and is realized mainly by the Balkan 2000 Mines EAD.

Natural gas

The imports of natural gas to Bulgaria for 2011 amounted to 2 811 mln m^3 (including 248 mln m^3 of fuel gas for the functioning of the transit system), which is by 6% more than in the preceding year 2010, and is imported from Russia - the sole supplier of this resource for Bulgaria. The local yield of natural gas in 2011 amounted to 443 mln m^3, realized by Melrose Resources S.a.r.l. and Oil and Gas Exploration and Production EAD. In comparison, the yield in 2010 was only 74 mln m^3. The considerable growth of the yielded natural gas in the country is due to the developed by Melrose Resources S.a.r.l. two new fields in Kaliakra and Kavarna. Notwithstanding the fact that the reserves of natural gas in the country are modest, they are of interest as a domestic source, which to a certain degree limits the growth of the prices of the imported natural gas.

Crude oil

The production of crude petroleum in the Republic of Bulgaria amounts to insignificant quantities at 22 Ktons in 2011. The same is performed by Oil and Gas Exploration and Production in the town of Dolni Dabnik, which belongs to a private company since 2004.

The domestic needs of petroleum are satisfied predominantly by imports. The main importer and petroleum processor is Lukoil Neftochim Bourgas EAD.

Uranium ores

The quantity and the potential of uranium ores are only estimates, while their mining was discontinued and the mines were closed down due to high costs, imperfect technologies and radioactive contamination.

In order to optimize the country's rating according to the energy dependence index, the Energy Strategy of the Republic of Bulgaria until 2020 provides for measures for the encouragement of energy production from renewable energy sources, as well as for starting projects for the construction of new facilities fueled by local coal and nuclear fuel. The nuclear energy is considered as a local source and in this sense, the IP will affect positively the energy dependence index in the long term, and in support of this statement, the EAI will present forecasts and analysis of the changes in the dependence from imports of energy resources as the result of the construction and commissioning of the new nuclear unit at Kozloduy NPP site.

3. The investment proposal in the context of the international trends

The population growth on a worldwide scale from 6,5 bln as of date to approximately 8.7 bln in 2050 will be accompanied by an energy demand growth by 1.7%, according to data from the International Energy Agency (IEA). No single source shall be capable of providing for all the energy needs of the future generations. In Europe, 1/3 of the produced energy is electric power, including 31% generated by nuclear power plants and 14,7% from renewable energy sources. Notwithstanding the fact that the contribution of RES has significantly grown since 1990, the demands for electric power cannot be satisfied without the contribution of nuclear power generetation worldwide. The new nuclear unit at Kozloduy NPP site will contribute to the validation of Bulgaria's position among the countries, which develop reliable and secure diversified energy sources based on contemporary nuclear technologies for providing the required balance (production - consumption) of electric power.

The scenarios for the future worldwide energy sources as of date are the subject of numerous studies and analyses. The scenario for the sustainable development of the IEA forecasts the progression, shown on ***Figure 1.5-2:*** *Scenario of worldwide energy sources for a sustainable future* below, in Gtpe (1 Gtpe = 1 Giga-ton petroleum equivalent = 11.63 MWh) for a growth of the worldwide population from 6.5 billion to approximately 8.7 billion in 2050. In order to provide for the grown demands of energy, all the available energy sources at present must increase their contribution. After the year 2030, when the contribution of solid fuels for primary energy is expected to drop, the nuclear sources, the sources using bio-mass, and other renewable energy sources (hydro-electrical, wind-powered, geo-thermal) will have to be used increasingly more. According to the forecast of the IEA[6], the demands for energy worldwide until 2030 and the related to emission of CO_2 will grow by 1.7% per annum.

It has to be taken into consideration, that the main renewable source of electric power is the hydraulic energy, the contribution of which cannot be increased significantly in Europe within the foreseeable future. The same applies to the geo-thermal energy sources. Notwithstanding the fact that a large number of wind-powered generators have been constructed in Europe since 1990 till date, at present it is difficult to forecast how this production will be capable of replacing the electric power, produced from gas, petroleum or coal or, respectively, nuclear energy.

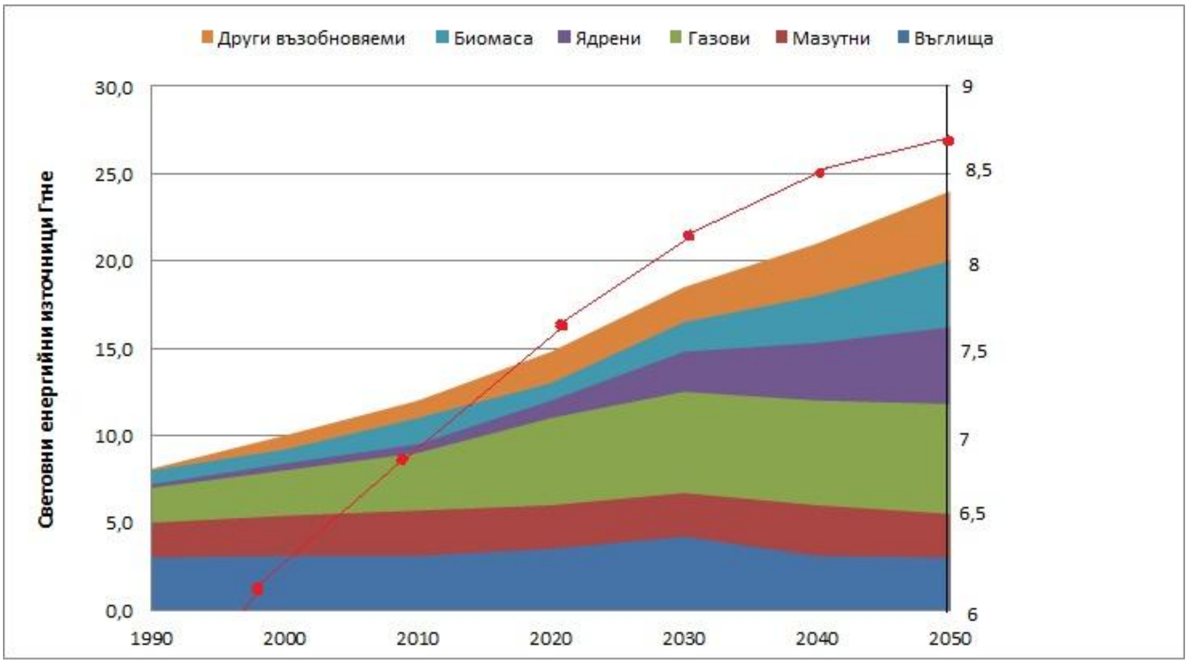

FIGURE 1.5-2: SCENARIO OF WORLDWIDE ENERGY SOURCES FOR A SUSTAINABLE FUTURE

The latest ambitious aim of the EU to reduce by 2020 the CO_2 emissions by 20% below the level of emissions for the year 1990 is based on a considerable reduction of the emissions in the transport sector, as well as by increasing the number and capacity of

[6] International Energy Agency

the photovoltaic and wind-powered poer plants. For example, the production of electric power from wind-powered plants must grow approximately 17 fold, in order to become equal to the production of electric power from the nuclear power plants. It is hard to forecast, how such growth will be provided by 2020, moreover, these calculations do not include the expected growth in the energy demands by 1.7% per annum. For that reason, notwithstanding the stimulations for the deveopment of RES, the achievement of the plan of the EU for reducing the CO_2 emissions depends in practice to a high degree on the generetation of electric power from nuclear power plants.

In Bulgaria, the share of greenhouse gas emissions from all energy production related activities included in the sectors of energy production, industry, transport, agriculture and households, represents 70% (according to the Energy Strategy of the Republic of Bulgaria until the year 2020, ***Figure 1.5-3:*** *Emissions of greenhouse gas by the various sectors of the Bulgarian economy, in mln tons of CO2 equivalent, for the 1990 – 2008 period****)***. The emission values for the energy production sector amount to 40% of the total greenhouse gas emissions for the country. The electric power plants and thermal power plants are the main source and emit more than 25 mln tons of CO_2 per annum, the quantities of emissions for the year 2009 only from the coal-powered plants amounts to 19.8 mln tons of CO_2.

FIGURE 1.5-3: EMISSIONS OF GREENHOUSE GAS BY THE VARIOUS SECTORS OF THE BULGARIAN ECONOMY, IN MLN TONS OF CO2 EQUIVALENT, FOR THE 1990 – 2008 PERIOD

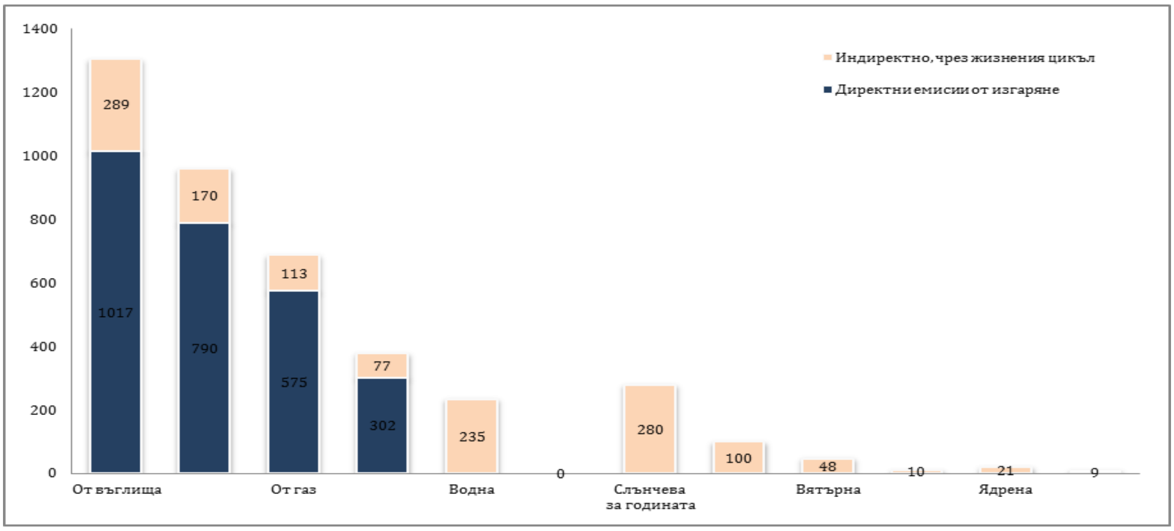

FIGURE 1.5-4: RESULTS FROM THE ANALYSIS OF THE LIFECYCLE OF CO2 EMISSIONS DURING GENERATION OF ELECTRIC POWER USING VARIOUS METHODS

The quantity of CO_2 emissions per 1 KWh produced electric power can be calculated as a sub-product of the analysis of the lifecycle. The obtained results depend on the studied electric power plant and are shown on ***Figure 1.5-4:*** , as coupled columns for each type of fuel.

As could be seen on the above figure, the burning of fossil fuels is the main contributor to the emissions, while the share of nuclear power generation is practically insignificant. The further growth of CO_2 emissions shall have a decisive impact on the life on the planet, with the fight against climate changes depending in the first place on the utilization of an energy cycle with the lowest possible emissions of CO_2. In the scenario of a similar cycle, the construction of a new nuclear unit at Kozloduy NPP site is fully justified, since the same shall ensure the production of an additional amount of energy without any CO_2 emissions. In that sense, the EIA scope shall comprise an analysis and a forecast of the impact of the IP on the emission intensity in the context of the international trends for restricting the greenhouse gas emissions and the fight against climate changes.

4. Impact of the IP on the compliance with the commitments undertaken by the Republic of Bulgaria with reference to the European energy policy

The starting point of the European energy policy lies in several priority areas:

→ mastering the negative climate changes;

→ reduction of the energy consumption rates of the economy and improvement of the energy efficiency;

→ limiting the dependence of the European Union on imported energy resources; and

→ encouraging the economic growth and employment, thus providing a reliable and accessible source of power for the consumers.

The sustainable energy sector development has been defined as the center of the energy policy and its achievement depends on the following long-term quantitative targets for the year 2020:

Target 1: 20 percent reduction of the greenhouse gas emissions as compared to 1990;

Target 2: 20 percent share of RES of the total energy mix and 10 percent share of energy from renewable sources in the field of transport;

Target 3: Improvement of the energy efficiency by 20%.

In compliance with the current European energy policy framework and the worldwide trends in the development of the energy technologies, the commitments of our country in this direction are incorporated in the Energy Strategy of the Republic of Bulgaria until the year 2020. The main priorities in the Energy Strategy can be summarized to the following five targets: guaranteeing the security of the power supply; achieving the targets with reference to renewable energy sources; improving the energy efficiency; developing a competitive energy market and policy, aimed at satisfying the energy needs, and protecting of the interests of consumers. These priorities also determine the vision on the development of the energy sector during the next few year, namely:

→ Maintaining a reliable, stable and secure energy system;

→ The energy sector must become a leader in the Bulgarian economy with a explicitly stated export orientation;

→ Accent on clean and low-emission energy production – nuclear and from renewable sources;

→ Balance of the quantity, quality and price of the electric power, generated from renewable sources, nuclear power, coal and natural gas.

The European energy policy is formed on the basis of two main strategic documents – the Green Book - European strategy for sustainable, competitive and reliable energy and the Communication of the European Commission concerning the Energy Policy of Europe, which is part of the so-called Energy package 2007. The European strategy for sustainable, competitive and reliable energy was published on March 8, 2008. Thereby, the Commission entrusts the Member states to implement the European energy policy, which should contribute to the overcoming of the main problems in the field of energy, namely: increasing dependence on imports of energy and energy raw materials, rising prices of petroleum and natural gas, climate changes, constantly growing energy consumption.

The energy policy of the EU according to the Green Book is based on three basic principles:

- Stability – combatting climate changes by means of encouraging the production of energy from renewable energy sources and improving the energy efficiency;
- Competitiveness – guaranteeing the efficiency of the European energy sector by creating a common energy market;
- Security of the supplies – improved coordination between the production and consumption of energy in the EU and on an international scale.

During the first half of 2007, the European Commission published the so-called Energy package as a continuation of the policies and priorities, reflected in the Green Book. This package consists of 9 interrelated documents, which comprise the new conceptual framework of the European energy policy for the next decade. Its main pillars are:

- Combat against climate changes;
- Reducing the dependence of the EU on imported energy supplies of petroleum and natural gas;
- Limiting by 2020 the greenhouse gas emissions of the developed countries by 30% as compared to 1990, with the EU undertaking unilaterally to achieve by 2020 a reduction of the emissions by a minimum of 20%.

The realization of the new nuclear unit at Kozloduy NPP ite fully complies with the national priorities in the field of the development of the electric power supply system of Bulgaria as a part of the common European energy strategy. In practice, the NNU in conjunction with the power capacities for production of energy from RES will ensure approximation to the goals for achieving an energy cycle without emissions, as well as providing for an optimum mix of energy sources.

5. Assessment of the logic of the investment proposal by using the internationally accepted energy indicators for sustainable development

In order to justify the logic of the investment proposal, the EIA scope covers conducting and presenting an assessment of the necessity for the construction and commissioning of the new nuclear unit at Kozloduy NPP site by using a complex of internationally accepted energy indicators for sustainable development (by using the methodology as per Energy Indicators for Sustainable Development: Directives and Methodologies dated April 2005). The criteria shall be used for the performance of an assessment and a comparison of the two basic scenarios: upon realization of the investment proposal and without its realization. The assessment of the scenarios shall be performed in 3 aspects: social, economic and ecological.

The *social aspect* assessment shall include:

- Analysis and forecast of the expenses for households in Bulgaria based on the assumption that both the prices of the main energy sources and the incomes of the households will grow;

- Safety analysis – as with any source of energy, the generation of nuclear energy is related to risks for the health, life and safety of the population. The assessment of the safety of the new nuclear unit shall be performed on the basis of a comparison of the risks and potential hazards for the human health, as compared to all the other energy sources;
- Analysis of the employment in the energy sector of the country according to both scenarios.

The *economic aspect* assessment shall include:

- Forecast and assessment of the final consumption of energy by the households and the various sectors of the economy;
- Assessment of the future state of the sources for the production of primary energy, including the rate of exhaustion of the local resources and forecasts on the dependence from imports of energy resources;
- Forecast on the development of the market and the prices of energy for the end consumers.

The *ecological aspect* assessment shall include an analysis of the contribution of the IP to the fulfillment of Bulgaria's commitment with regard to:

- Reduction of the CO_2 emissions;
- Protection of the atmospheric air and water resources;
- Sustainable management of the radioactive wastes.

1.6 DESCRIPTION OF THE PHYSICAL CHARACTERISTICS OF THE INVESTMENT PROPOSAL AND THE REQUIRED AREAS

1.6.1 LOCATION OF THE NEW SITES AND EXISTING INFRASTRUCTURE

The site of the Kozloduy NPP is located on the right bank (at the 694th km) of the Danube River. It lies at 3.7 km to the south of the river midstream and the state border with the Republic of Rumania. In a straight line, it lies at approximately 120 km to the north, and along the republican road network at approximately 200 km from the capital - the city of Sofia.

The site is located in the northern part of the non-flooded terrace of the Danube River (elevation +35.0 m according to the Baltic Altitude System) and has an area of 4471.712 decars (447.1712 hectars).

To the north, the site borders the Danube River valley. To the south from the site lies the slope of the watershed plateau with a comparatively high (100 - 110 m) altitude, to the north the altitude rises to approximately 90 m, and to the east it drops to 30 m above the sea level.

The closest settlements to Kozloduy NPP are: the town of Kozloduy - at 2.6 km to the southwest, the village of Harlets - at 3.5 km to the southeast, the village of Glozhene - at 4.0 km to the southeast, the town of Mizia - at 6.0 km to the southeast, the village of Butan - at 8.4 km to the south, and the town of Oryahovo - at 8.4 km to the east of the site.

The sites foreseen for installation of the NNU in the area of Kozloduy NPP are shown on ***Figure 1.6-1:*** *Layout of the sites for the IP.*

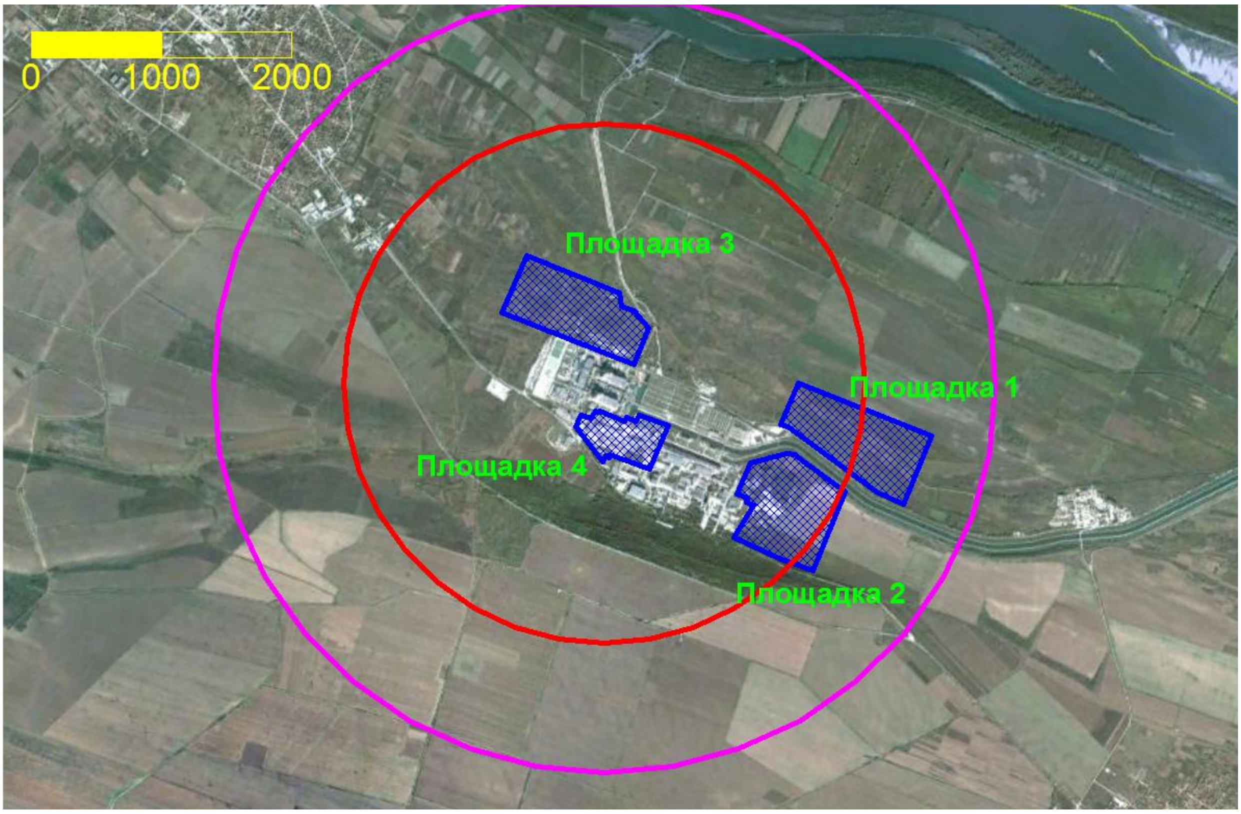

FIGURE 1.6-1*: LAYOUT OF THE SITES FOR THE IP*

(The red circle (▬) is the 2000 meters Precautionary action (PAZ), and the pink circle (▬) is the 3000 meters zone around the Kozloduy NPP)

Provisionally called site 1 - The site is located to the northeast of units 1 and 2 of the Kozloduy NPP, between the Open Switchgears and Valyata, in the vicinity of the constructed cold and hot channels - to the north of them. The area of the site amounts to approximately 55 ha. The terrain is comparatively flat with a slight slope from the southwest to the northeast. The area of the site takes in open drainage channels, which will have to be restructured. The humus loess layer will have to be removed in advance from the arable lands.

The expropriated land is used for growing agricultural crops.

Provisionally called site 2 - The site is located to the east of units 1 and 2 of Kozloduy NPP in the direction of the village of Harlets, to the south of the built cold and hot channels. The area of the site amounts to approximately 55 ha. The land is hilly with a considerable slope from the south to the north, more highly expressed in the southeastern part of the site. A former farm yard is located within the area of the site. The remaining area is used for growing agricultural crops.

Provisionally called site 3 – The site is located to the northwest of units 5 and 6 of Kozloduy NPP, in the vicinity of the bypass road of the existing power plant. The area of the plot amounts to approximately 53 ha. The terrain is flat with a slight slope from the south to the north. The area of the site takes in open drainage channels, which will have to be restructured. The humus loess layer will have to be removed in advance from the arable lands.

From the point of view of engineering utilization and connection to the electric grid a large number of activities and complex reconstruction works of the 400 kV overhead power transmission line route will be required.

The expropriated land is used for growing agricultural crops.

Provisionally called site 4 - The site is located to the west of units 3 and 4 of Kozloduy NPP and the WSF, to the south of the cold and hot channels. The available area amounts to approximately 21 ha, within the borders of the expropriated lands of Kozloduy NPP. The terrain lies within the existing built service facilities – the Equipment storage facility, the Vehicle Repair Workshop and the Assembly Facility. For the use of the site it is foreseen reconstruction and displacement of the main underground communications of the NPP, and deplanting and moving of these facilities.

None of the sites infringes upon any forest funds.

All the main and auxiliary buildings and facilities, the equipment, required for the operation, including the DSFSF, as well as all the local treatment facilities and WWTP shall be located within the borders of the proposed sites. The layouts with the elaborated layout solutions shall depend on the functional design of the buildings and of the facilities, and the respective areas shall be differentiated.

The site, chosen for the installation of the new nuclear unit, shall be fenced in and secured in compliance with the requirements of the Regulation for the Provision of Physical Security of Nuclear Power Facilities, Nuclear Materials and Radioactive Substances (State Gazette No. 44 dated 09.05.2008) and shall be established as a protected zone, PAZ and UPAPZ in compliance with the requirements of the Regulation on emergency planning and emergency preparedness in case of nuclear and radiological emergencies (Prom. SG issue 94 dated 29.11.2011).

The required areas according to the designed layout solutions shall be studied and analyzed in the REIA.

1.6.2 REQUIRED AREAS FOR THE REALIZATION OF THE IP

Due to the absence of specific data on the required areas for the various periods of the realization of the NNU, at the time of the elaboration of the present Terms of Reference, we have accepted provisionally the size of required areas according to the reference design, related to the construction of a similar power facility at Temelin, the Czech Republic, where for the realization of 2 units an area of approximately 83 ha is foreseen. Taking into consideration the fact that at Kozloduy NPP no cooling towers are foreseen the construction, the larger part of the required infrastructure is available (Open Switchgears', service buildings), as well as the areas for the necessary temporary works and the infrastructure for the same, related to the civil works process, the required area shall amount to approximately 60 ha depending on the selected alternative for the equipment of the two units and approximately 50 ha per unit.

According to information from Westinghouse, for a AP-1000 are required 28 ha for a pair of units, including 15 ha for temporary civil works site, with the required area for each unit amounting to approximately 7 ha.

During the elaboration of the report of EIA on the basis of the feasibility study for the NNU, which shall be provided by the Employer, the required areas for the realization of the NNU shall be specified more precisely.

1.6.3 REQUIRED AREAS FOR THE OPERATION OF THE NNU

Due to the absence of specific data on the required areas for the operation of the NNU, at the time of the elaboration of the present Terms of Reference, we have accepted provisionally the size required areas according to the reference design, related to the construction of a similar power facility at Temelin, the Czech Republic, where for the operation of the 2 units a required area of approximately 64 ha is foreseen. A similar design for 2 units AES-2006 shall be realized at the nuclear power plant Leningrad-II in the Russian Federation, where an area of 60 ha is foreseen.

Taking into consideration the design for the Belene NPP and the fact, that at Kozloduy NPP it is not foreseen the use of cooling towers, as well as that a large part of the required infrastructure is already existing (Open Switchgears' service buildings), it follows that the required area for the operation of the potential site shall amount to approximately 35 ha, depending on the selected alternative for the equipment.

According to information from Westinghouse, for a reactor AP-1000 approximately 6 - 7 ha.

During the elaboration of the report of EIA on the basis of the feasibility study for the NNU, which will be provided by the Employer, the required areas for the operation of the NNU shall be defined more precisely.

1.6.4 REQUIRED AREAS DURING DECOMMISSIONING

During the period of decommissioning of the NNU no additional, permanent or temporary occupation of any areas shall be required outside Kozloduy NPP site.

1.7 DESCRIPTION OF THE BASIC CHARACTERISTICS OF THE PRODUCTION PROCESS

1.7.1 TECHNOLOGY

The new nuclear unit foreseen to be build at Kozloduy NPP site shall be a highly technological energy project for the generation of electric power on the basis of a nuclear fuel process.

The parameters for the construction of such an energy project presuppose the existence of two basic groups of sub-sites and facilities:

→ nuclear power sub-sites and facilities, implementing the main technological process - generation of electric power, as well as those that are sources of radiation effects;

→ other production sub-sites and facilities, implementing auxiliary and/or concomitant technological processes, important for the support of the main nuclear power process and/or are sources of various types of non-radiation effects on the environment.

The technology, which shall be used for the generation of electric power using a nuclear source, shall be a reactor using pressurized light water (of the type PWR – Pressurized Water Reactor), with light water as moderator and coolant.

The technological diagram of the new nuclear unit shall consist of two circuits and shall include:

→ primary circuit - with recirculing radioactive medium, consisting of one power reactor and circulation loops. Each loop shall include a main coolant pump, a steam generator and coolant pipes;

→ secondary circuit - with non-radioactive medium, including the steam-generation part of the steam generator, the turbine and the auxiliary equipment of the turbine hall.

The new nuclear unit shall have:

→ high availability (more than 90%) and long operational lifetime – at least 60 years;

→ possibility for operation with quick changes of the loads within 80% – 100% of the rated power capacity, without worsening of the efficiency;

→ highly reliable systems, realizing the defense in depth approach in all operating modes, including passive safety systems;

- possibility to perform fundamental safety functions - reactivity control, heat removal from the core; retention of the radioactive substances within the defined limits in all operating modes and in emergency conditions;
- design, which uses the principle of diversity and self-diagnostics;
- design, which foresees technical facilities, helping to preclude the possibilities for human error or restrict the consequences thereby;
- high resistance to internal and external impacts, including earthquakes, aircraft crash, floods, etc.;
- in case of a fire - ensuring the performance and long-term maintenance of the safety functions and control of the state of the nuclear unit. The implemented fire-fighting measures shall ensure defense in depth by preventing the occurrence and expansion of a fire, the localization of an occurred fire and restriction of its consequences;
- technical provisions and solutions for management of severe accidents and minimizing their consequences, reduced probability fo core meltdown;
- higher discharge burnup, leading to a reduction of the fuel consumption and the waste amounts;
- combustible absorbers for extending the restlife of the nuclear fuel.

The most significant advantage of the design for the new nuclear unit as compared to the designs of the second generation designs lies in the fact that the design of the power capacity foreseen for construction **shall include passive and specific protection provisions**, including a core catcher concept, which considerably increase the safety of the nuclear unit.

The technology, foreseen in the present investment proposal, which shall be used for the generation of electric power from a nuclear source, shall be reactors using pressurized light water (PWR – Pressurized Water Reactor), with water as the moderator and the coolant. The technological diagram of the new nuclear unit shall include two circuits (***Figure 1.7-1:*** *Technological diagram of a WWER reactor*):

→ **The Primary circuit** is designed to remove the heat from the reactor core and to transfer to the secondary circuit. The most important components of the primary circuit are:

- ✓ reactor;
- ✓ main coolant loops;
- ✓ steam generators, which produce saturated steam;
- ✓ pressurizer;
- ✓ main coolant pumps (MCP).

The nuclear fuel, in the form of fuel assemblies, is placed in the reactor core. The primary circuit water circulates among the assemblies. It removes the thermal power generated during the nuclear reaction.

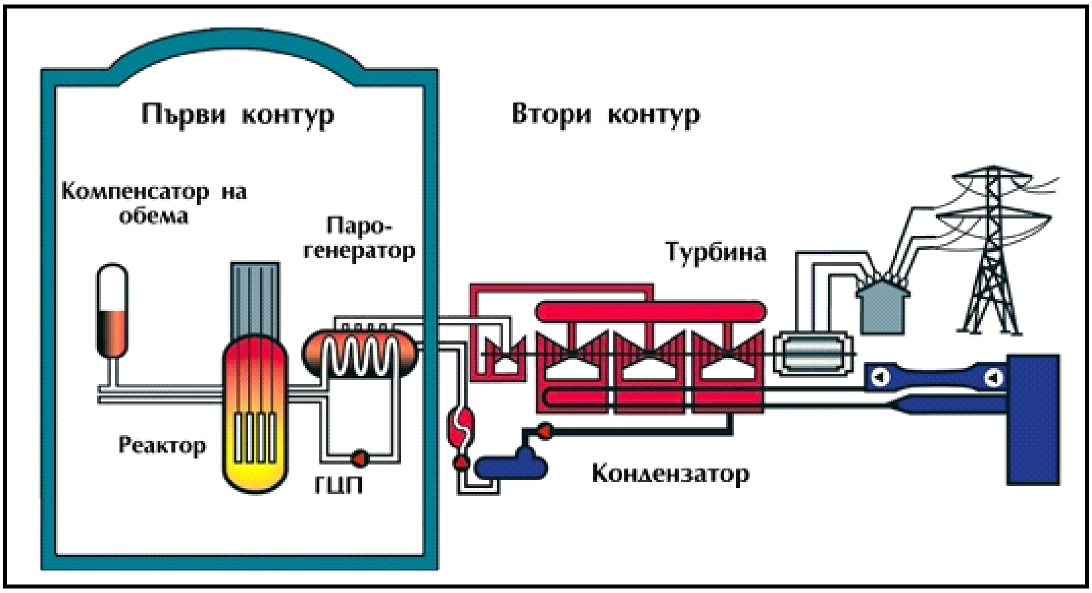

FIGURE 1.7-1*: TECHNOLOGICAL DIAGRAM OF A WWER REACTOR*

As a result of the forced circulation provided by the main coolant pumps, the primary circuit transfers the heat generated in the reactor core via the steam generators to the secondary circuit, so that the core and the primary circuit coolant are kept within a specified thermal range. At the same time, it provides sufficient natural circulation, required for obtaining the sufficient heat in the core to the steam generators, when the reactor is stopped and the main coolant pumps are not operating.

The primary circuit is designed in such a manner, as to perform the following functions:

- ✓ core cooling and heat removal from the core to the steam generators by means of:
  - control of the coolant temperature in the core;
  - control of the coolant pressure in the core;
  - control of the coolant flowrate in core;
  - control of the reactivity in the core,
- ✓ retention of the radioactivity by means of a second barrier (borders of the primary circuit).

The fuel asemblies of the reactor are fully immersed in pressurized water, so that its boiling temperature is higher than the normal operational temperatures. The fuel is a slightly enriched uranium dioxide (UO_2) or MOX (nuclear fuel, which contains more than one oxide of a fission material).

→ **Reactor** - The typical solution for the reactor set is shown on ***Figure 1.7-2:*** *Possible structural solution for a reactor of the type PWR.* It is a pressurized vessel, consisting of a reactor pressure vessel and an upper unit (head) of the reactor. The internals are located within the reactor pressure vessel (e.g. the core barrel, the neutron reflector, etc.), and the control rod drives are located on the reactor head.

A chain reaction of fission and transfer of the heat, resulting from this reaction, to the coolant takes place in the core. The core consists of fuel assemblies, located in most cases in square or hexagonal meshes. The fuel bundle consists of fuel rods, guide thimbles, spacer grids and top nozzles.

The fuel rods consist of fuel pellets, which are encapsulated inside tubes of special alloy, in most cases, based on zirconium. The purpose of this cladding is to maintain the geometry (shape) of the fuel rod, in order to allow the transfer of the heat from the fuel to the coolant and at the same time to retain the radioactive fission products in the fuel.

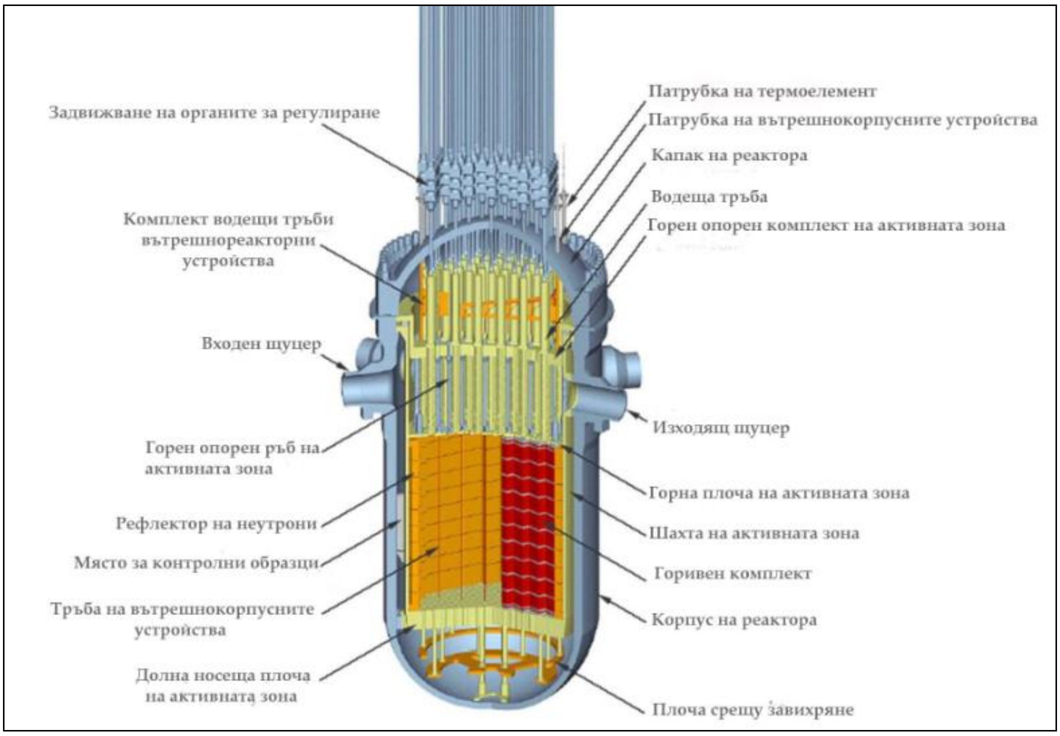

FIGURE 1.7-2: *POSSIBLE STRUCTURAL SOLUTION FOR A REACTOR OF THE TYPE PWR*

The guide thimbles form channels for the introduction either of a bundle of control rods or rods with burnable absorber. The measuring pipe is located in the central position and repreents a channel for the introduction of an internal neutron detector.

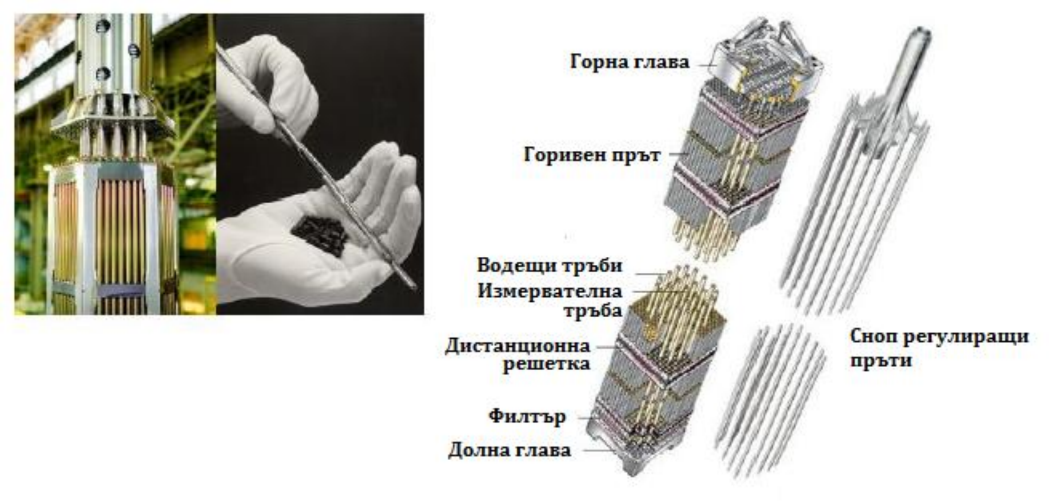

FIGURE 1.7-3: *FUEL PELLET, FUEL ROD AND FUEL ASSEMBLY*

The power capacity of the reactor is controlled by means of control rods (***Figure 1.7-3:*** *Fuel pellet, fuel rod and fuel*) and the Reactor control and protection system (acram).

Inside the reactor with the aid of a refueling machine, the fuel is placed according to the calculated optimized refueling scheme. The thermal-hydraulic design limits, such as, e.g. the maximum linear thermal power capacity of the fuel rod, the minimum margin up to a boiling crisis, the maximum temperature of the fuel and the cladding, shall be determined and checked within the framework of the preparation of each refueling in such a way, as to provide sufficient margins.

→ **Steam generator** - The steam generator is a pressure vessel with a horizontal or vertical design with a feed water and emergency feed water distribution system, a heat-exchange surface system, consisting of tubes and with a steam header. In the nuclear power plant with a pressurized water reactor (PWR), the steam generator serves as a heat-exchanger between the primary nd the secondary circuit. The heated coolant of the primary circuit enters the hot header, and then is conveyed to the heat-exchange tube bundles. When passage through these bundles, the coolant transfers heat to the feed water and after cooling goes to the cold header. After that, it is conveyed to the cold leg of the primary circuit and then back to the reactor. From the secondary circuit of the steam generator, the feed water is transformed into saturated steam, which is conveyed to the turbine.

→ **Main coolant pump** - The main coolant pump is generally a vertical centrifugal single-stage pump with a sealing unit on the shaft and asynchronous electric drive. It is equipped with a flywheel to provide for the required continuation of its movement in case of power failure. The main coolant pumps ensure the circulation of the required quantity of coolant in the primary circuit in compliance with the thermal power capacity of the reactor in various operating modes.

→ **Chemical and Volume Control System** - The chemical and volume control system includes a pressurizer, pressurizer relief tank, relief valves unit and pipelines, connecting the individual components to the connected systems. The pressurizer is a vertical welded vessel with an elliptic bottom. The pressurizer set includes electric heaters and a spray system. The chemical and volume control system serves to maintain the pressure and to restrict the pressure deviations in the primary circuit and to prevent uncontrolled pressure rise in emergency modes, as well as for providing for the smooth rising and dropping of the pressure during heating and cooling of the primary circuit. The pressure in the primary circuit is created and maintained by the heating of the water volume in the pressurizer by means of electric heaters. In case of high pressure, it is reduced by injecting a coolant from the primary circuit to the steam volume of the pressurizer. The relief valves unit is designed for reducing the undesired rise of the pressure in the primary circuit in abnormal modes.

→ **Primary circuit auxiliary systems**

- *Primary circtuit make-up and maintaining chemistry*

  For the long-term control of the fission reaction and for maintaining the required quality and quantity of the coolant, coolant make-up and draining systems and a coolant chemistry treatment system shall be installed.

  The systems perform the following functions:

  - the draining and the make-up serve for maintaining the required balance of the coolant in all operating modes of the unit;
  - control of the boric acid quantity in the coolant;
  - removing the fission products and radioactive products from the coolant;
  - dosing of chemical reagents into the coolant, for the purpose of control of the chemical regimes (pH of the coolant, degassing of the coolant).

  The boric acid quantity control in the coolant allows to increase the operational reactivity reserves of the reactor, required for the continuous control of the fission chain reaction.

- *RAW processing system*

  The system provides for the processing of the radioactive wastes in gas, liquid or solid form.

  Gaseous RAW occur mainly as a result of the continuous degassing of the coolant from gases generated by the radiolysis of the water in the reactor or as gas products of the fission. The gaseous RAW pass through dust filters, where the dust particles (aerosols) and moisture are retained, then the adsorption filters retain the radioactive aerosols. In this way, the whole radioactivity is reduced to solid or liquid form, and the purified air is exhausted via the vent pipe.

The liquid RAW are generated during the purification of the coolant of the primary cirction, decontamination of the equipment, regeneration of filters, etc. The radioactive liquid is evaporated in special evaporation installations, then the condensed steam is filtered, consecutively in mechanical and ion-exchange filters. When the purified water criteria are satisfied, it is discharged under control into the water flows. The exhausted ion-exchange resins and concentrated evaporated concentrate are transformed into solid form by means of fixing into another material (most often, cement, bitumen or glass).

The solid wastes are divided, eventually fragmentized and stored in steel barrels.

The solidified and solid wastes in the steel barrels are placed into concrete containers, which are then disposed in a specialized storage facility.

- *Fuel pond cooling and cleaning system*

The fuel pond cooling system provides for heat removal from the spent fuel during its long-term storage in the spent fuel pond, during the replacement of the fuel and in case of removal of the whole core of the reactor. The system also maintains a sufficient level of protection for the servicing personnel from the radioactive radiation of the fuel. The cleaning system maintains the required quality of cooling water. The consists of ion-exchange filters.

- *Ventilation systems*

The ventilation systems provide for the required parameters of the environment for the safe working conditions of the servicing personnel and for the proper functioning of the technological equipment during normal operation and in emergency conditions.

→ **Safety systems**

- *Emergency Core Cooling System*

The Emergency core cooling protects the core from thermal damages. It acts as the main emergency system in cases of LOCA[7] incidents, which are accidents involving loss of coolant in the primary circuit. In the case

[7] LOCA (Loss of Coolant Accident) – accident, which results in the loss of coolant from the first contour.

of such incidents cooling borated water is supplied to the reactor. A basin located in the containment is used as a cooling water tank with a sufficient capacity for this purpose.

- *Residual Heat Removal System*

  The Residual heat removal system removes the heat, occurring in the stopped reactor as a result of the radioactive fission of the fission products, located in the fuel and cools down additionally the reactor in normal operating conditions, abnormal conditions and in case of design based emergency conditions, retaining the leak-tightness of the primary circuit.

- *Safe Pressure Suppression System*

  The safe pressure suppression system is used for controllable pressure suppression in the primary circuit, required for the proper functioning of the emergency core cooling system, as well as for its protection from over-pressure.

- *Integrated (intermediate) cooling loops*

  These are closed cooling systems, providing for the heat removal from the primary circuit systems to the service water system. These systems are a protection barrier against radioactivity penetration into the service water system in abnormal modes.

- *Service Water Supply System for Safety Related Consumers*

  This system provides for the residual heat removal from all the important systems of the unit, which do not allow long-term absence of cooling. In case of an emergency, it removes the heat from the integrated (intermediate) cooling loops of the emergency core cooling system or theresidual heat removal system.

  The heat from the system is coneyed to the ultimate heat sink, which in most cases are the cooling towers or spray ponds.

- *Steam Generators Emergency Feedwater System*

  This system serves for supplying demineralized water to the steam generators in case of failure of the normal operation systems. Thus, it provides for the heat removal from the primary to the secondaty circuit in emergency situations without loss of coolant in the primary circuit.

→ **System of Protective Enclosures**

The system of protective enclosures consists of an internal containment (Primary Containment Vessel) and external containment. The containment consists of the actual structure and leak-tight units (penetrations, airtight locks). Inside, its internal space houses the temperature and pressure control systems inside the containment (e.g. passive heat removal, spray system, hydrogen combustion system, etc.).

During operating states and in emergency conditions related to radionuclides emission, including servere accidents, the design of the containment provides for restricts these emissions to the environment, so that the radiation effects will be acceptable. The construction and the system of the containment are designed so that the reactor, the primary circuit and all related facilities, important from the point of view of nuclear and radiation safety, located inside the containment, will be protected from external events, whose occurrence cannot be excluded to a sufficient degree of probability. The system of the containment also functions as a biological shielding.

→ **The secondary circuit** is non-radioactive. It is designed to take up the thermal energy from the primary circuit and to transform it into kinetic energy of rotation of the steam turbine. The steam generated in the steam generators is collected in a common steam header and is directed towards the turbine. In the condensers of the turbine, the exhausted steam condenses and is returned back to the steam generators. The secondary circuit:

- *Main steam supply system (steam lines)* – the function of the system is to transport the steam from the steam generators to the turbine within the discharge rates and pressures, which cover all operating modes from heating up the system up to the full load operation. The steam supply system includes the main steam lines, main steam isolation valves, safety devices and connection steam pipelines.
- *Turbine generator* - the functions of the turbine generator is to transform the thermal energy of the steam into electric power. The turbine generator does not perform any functions, related to the nuclear safety of the unit. The generator is coupled directly to the shaft of the turbine.
- *The lubrication equipment of the turbine and the generator* is installed in the turbine hall. This includes a tank, coolers, pumps, pipelines, valves and other equipment. The equipment is protected against oil losses in the system.
- *Main feed water supply system for the steam generators* - the functions of this system are to supply water with the required parameters to the steam generators. The supply station includes the main feedwater pumps and the auxiliary feedwater pumps (for start-up and stopping, as well as for the transients of the unit) and the connecting pipeline systems and valves. Thermal degassing also takes place in the supply tank (deaertor). The control valves, together with the feedwater pump,

ensure maintaining of the required level of feed water into the respective steam generator.

- *Secondary circuit auxiliary systems* - these are the systems for cooling in the turbine hall, the service water systems for non-safety related consumers, drainage system, heat-exchangers, etc. Some of the auxiliary systems support the whole unit, e.g. the chemical preparation of the water and a reserve of demineralized water.
- *Circulation system* - the system includes a pumping station for cooling water, channels, pipeline connections to the turbine hall, cooling of the condenser, piping connections to the cold and hot channels, etc. The condensers shall be cooled using water from the Danube River, which flows along the third circulation circuit and has no contact with the water from the secondary circuit. The water from the bank pumping station of the NPP is taken along channels to the nuclear power plant, from where the pumps of the circulation pumping stations shall feed the water to the condensers of the turbines in the new unit.

→ **Instrumentation and Control System** - The I&C systems, together with the other systems of the electric power plant, provide for the production of electric power, in strict compliance with the safety requirements. When implementing the I&C systems of the newly delivered facilities, the priority shall be given to using of commercially available digital technologies. Depending on the specific supplier, for some of the selected safety functions may be used facilities, using combined digital and analogue technologies, depending on the control philosophy. A high degree of automation shall be used, in order to minimize the effects of human factor and to restrict the consequences of a human induced error. Only proven equipment shall be used, taking into consideration the gathered experience.

The information and control systems shall be supported with equipment in such a manner, as to provide for the monitoring, measuring, recording and control of all operational parameters, which are important for the nuclear safety during normal operation and in emergencies conditions.

The design and the location of the alarms and control shall enable the servicing personnel to obtain continuously information on the operation of the nuclear facility and shall be capable to respond if necessary.

The control and information systems shall have visual and sound alarms, warning of the occurrence of operational states and processes, which deviate from the limits of the normal operation and may affect the nuclear safety.

The control and information systems shall record the values of the nuclear safety related parameters, periodically at certain intervals, as the need may be.

Upon occurrence of emergency conditions, the equipment shall provide:

- information on the current state of the nuclear facility, based on which protective actions could be carried out;
- basic information concerning the occurrence of the emergency and its recording;
- information that allows to forecast and characterize the emissions of radio-nuclides and radiation in the vicinity of the nuclear facility, in order to allow for the timely undertaking of measures for the protection of the population.

According to the requirements currently in place, the NNU shall also be equipped with equipment for monitoring the parameters for exceptionally low-probability accidents, related to fuel melt-down.

→ **Protection systems**

The nuclear facility, a part of which shall be nuclear reactor, shall be equipped with protection systems, which shall be:

- capable of recognizing emergency states and automatically activate the respective systems, in order to guarantee that the design limits will not be exceeded;
- capable of providing for „manual" activation of the protection, if needed.

The protection and the control systems shall be separated in such a way, so that a failure in the control systems shall not affect the ability of the protection system to perform its required safety function.

The protection systems shall be designed with high functional reliability by providing redundancy and independence of the trains, so that no simple fault could cause a failure of the protective functions of the system.

→ **Human-machine interface**

For the management and operation of the new facilities modern human-machine interface shall be used, which shall allow the servicing personnel of the electric power plant to respond properly and in due time to any and all states of the nuclear facility and of the power plant systems.

In order to aid the decisions of the servicing personnel information shall be provided and arranged in a suitable manner, so that the personnel shall have timely information on the state of the nuclear facility for the purpose of its safe and efficient operation.

The information on the operation and the signaling concerning the occurring operational situations or abnormal situations shall be arranged in such a way, as to minimize the load on the servicing personnel.

The reactors of the type WWER (PWR) are the most commonly used worldwide. The process of design, construction, commissioning and decommissioning of the new nuclear unit shall be carried out in compliance with the legislative requirements, specified mainly in the Safe Use of Nuclear Energy Act (SUNEA) and theregulations thereby related.

The design for the nuclear facility shall comply with the European requirements, specified in the European Utility Requirements for LWR Nuclear Power Plants.

1.7.2 Type and quantity of used raw materials and materials during the operation:

1.7.2.1 Non-radioactive

The following substances and mixtures are expected to be used during the operation of the new nuclear unit:

→ ***Liquid fuels*** - they shall be used for the operation of the diesel generators, which are reserve power supply sources for the power unit, for the needs of the road vehicles and the various shops and structural of Kozloduy NPP EAD. Certain quantities of diesel fuel shall be required, as well as gasoline, etc. The report of EIA shall indicate provisional quantitative and qualitative characteristics of the fuels and shall analyze the possibilities for their safe storage.

→ ***Lubrication materials*** - it is expected that during the operation of the new nuclear unit various types and quantities of oils and lubricants shall be used – machine oil and compressor oil, turbine oil, engine oil, various types of lubricants. Thee shall be accompanied by the respective certificates and other documents, such as safety data sheets, indicating the proper way for their storage, use and treatment.

→ ***Chemical substances and mixtures*** – in order to support the main technological process various types of chemical reagents, certified for use in the nuclear industry shall be delivered and used. The main and most important hazardous substances and mixtures shall be: ammonium, sulfuric acid, hydrochloric acid, nitric acid, sodium hydroxide, etc. When the chemical substances and mixtures are delivered, they shall be accompanied by safety data sheets, which shall specify their environmentally friendly storage and use. During the storage and use of hydrazine hydrate, ammonium and other substances and mixtures, in case of an emergency, there is a potential danger for the occurrence of bursts of emissions of dangerous toxic substances into the working environment and the natural environment.

In order to support the water-chemistries of the power reactors at the Kozloduy NPP EAD and for other production and auxiliary activities large quantities of chemical reagents shall be delivered and used, some of which are: boric acid, nitric acid, sulfuric acid, hydrochloric acid, potassium hydroxide, sodium hydroxide – technical, ferrous chloride, ammonium, hydrazine hydrate; hydrated lime, etc. The information concerning the used chemical substances and mixtures on the territory of the Kozloduy NPP is specified in ***Table 1.7-1:*** *Description of the used chemical substances* [8] .

TABLE 1.7-1: *DESCRIPTION OF THE USED CHEMICAL SUBSTANCES*

No.	Denomination	CAS No.	EU No.
Chemical reagents for the production of desalinated water, decontamination, etc.			
1.	Hydrochloric acid	-	231-595-7
2.	Calcium hydroxide (hydrated lime)	1305-62-0	215-137-3
3.	Sodium hydroxide	1310-73-2	215-185-5
4.	Ferrous trichloride	7705-08-0	231-729-4
5.	Boric acid	10043-35-3	233-139-2
6.	Nitric acid	7697-37-2	231-714-2
7.	Ammonium water	1336-21-6	215-647-6
8.	Sulfuric acid	7664-93-9	231-639-5
9.	Hydrazine hydrate	302-01-2	206-114-9
10.	Potassium hydroxide	1310-58-3	215-181-3
11.	Oxalic acid	144-62-7	205-634-3
12.	Citric acid	77-92-9	201-069-1
13.	Potassium permanganate	7722-64-7	231-760-3
14.	Detergents	-	-
Ion-exchange resins			
15.	Ion-exchange resin LEWATIT	-	-
16.	Ion-exchange resin type AMBERLITE	-	-
17.	Ion-exchange resin type Wofatit	-	-
Liquid fuels and maintenance of motor vehicles			
18.	Diesel fuel Euro-diesel	68334-30-5	269-822-7
19.	Car gasoline unleaded	68334-30-5	269-822-7

[8] EIA Report from the decommissioning of units 1÷4 at the Kozloduy NPP, 2013.

No.	Denomination	CAS No.	EU No.
20.	Antifreeze[9]	107-21-1	203-473-3
21.	Gas for lighting (kerosene)	106-97-8	203-448-7
22.	Extraction benzene	-	-
Oils			
23.	Turbine oils	-	-
24.	Engine oils	-	-
25.	Transformer oils	-	-
26.	Hydraulic oils	-	-
27.	General purpose mechanical oils	-	-
28.	Compressor oils	-	-
29.	Transmission oils	-	-
Greases and lubricants			
30.	Lubricants (К2, graphite, with MoS2, etc.)	74869-21-9	278-011-7
31.	Greases (Litol, Ciatim, graphite, with MoS2, high-temperature, etc.)	74869-21-9	278-011-7
Adhesives and sealing compounds			
32.	Sealants, pastes, adhesives (loctite, Univer, Proma), silicon, liquid metal, etc.[10]	-	-
Paints, primers, varnishes, thinners and cleansers			
33.	Paints non-water based (alkyd, oil, etc.)[11]	-	-
34.	Paints water based (facade paint, emulsion paint)[12]	-	-
35.	Thinners, diluters, rust converters, etc.	-	-
36.	Koresilin	-	-
37.	Primers	-	-
38.	Varnishes	-	-
39.	Alcohol/ethyl alcohol	64-17-5	200-578-6
Gas and gas mixtures			

[9] Hazard category, R and S – phrases are for the subtsance ethyleneglycol, the contents of which in antifreeze is > 90%.

[10] Due to the absence of information on the contents of the adhesives, sealants and silicons, their hazard phrase is quoted in the list as R 20/22 (Hazardous for breathing and swallowing).

[11] The hazard category, R and S – phrases are for the substance terpentine, the contents of which in the non-water based paints, varnishes and thinners varies within the range of 15 and 40%.

[12] The hazard category, R and S – phrases are for the substance ethyl glycol, the contents of which in the water based paints are < 1.5%.

No.	Denomination	CAS No.	EU No.
40.	Gaseous nitrogen	7727-37-9	2317839
41.	Liquid nitrogen	7727-37-9	2317839
42.	Oxygen	7782-44-7	231-956-9
43.	Hydrogen	215-605-7	1333-74-0
44.	Propane butane	74-98-6 106-97-8	200-827-9 203-448-7
45.	Argon	7440-37-1	2311470
46.	Cargon gaseous mixture (82% Ar and 18% CO_2)	7440-37-1 124-38-9	7440-37-1 2046969
47.	Crysal gaseous mixture (80% Ar and 20% CO_2)	7440-37-1 124-38-9	2311470 2046969
48.	Freon 22 (chlordifluormethane)	LD	LD
49.	Refenrece gaseous mixture Ar –CH_4 (90%-10%)	7440-37-1 74-82-8	2311470 200-812-7
50.	Carbon dioxide	124-38-9	2046969

The report of EIA shall be study the proposed possibilities for separation of the air and the capacity of the currently existing nitrogen-oxygen stations, and the degree to which they are capable of satisfying the needs of the NNU.

When the chemical substances and mixtures are delivered, the good practice shall continue and they shall be accompanied by safety data sheets, which specify the way for their environmentally friendly storage and use.

1.7.2.2 NUCLEAR FUEL (NF)

There are different types of nuclear fuel, one of them being the most widely used type, in which the uranium is included in the form of UO_2 and enriched by the isotope U^{235}. This type of fuel is used in reactors of the WWER or PWR reactors according to the western European abbreviation norms.

For all types of nuclear fuel as an initial raw materials is used natural uranium, mined according to varying methods.

Taking into consideration the fact that the fuel cycle is an important element of the operation of a new nuclear unit, it will be studied in all stages from the point of view of the environmental impact the assessment – supply of fresh NF, transport of fresh NF, operation of the NF, temporary storage of the spent nuclear fuel and transport of the spent nuclear fuel.

During the preparation of the assessment with reference to the transport of the fuel, the potential environmental impacts shall assessed for both normal conditions and for emerencies.

Any NF to be used must comply with the design bases for the maximum discharge burnup of the fuel, stipulated by the EUR. As regards the requirements for the nuclear fuel of the NNU, the report of EIA shall consider at least:

- During normal operation:
  - emissions of fission products in gaseous from the fuel pellets;
  - interaction of the fuel pellets with the fuel cladding;
  - compaction and expansion of the fuel pellets;
  - behavior of the spring inside the fuel rod.
- During emergency situations:
  - embrittlement of the fuel rods cladding;
  - generation of hydrogen;
  - fragmentation and melt-down of the fuel rods.

Storage conditions for the fresh nuclear fuel

During the design of the NNU, the following conditions shall be considered and analyzed with reference to the handling and storage of the fresh nuclear fuel, as a part of the REIA:

- ensuring possibility for incoming fuel inspection, technical servicing and performance of periodical inspections and testing of the safety related components;
- ensuring of control over the storage conditions;
- minimizing the possibilities to inflict damage;
- prevention of unauthorized access to the nuclear fuel;
- prevention of dropping and/or falling of the fuel assemblies hen transported;
- prevention of dropping and/or falling of heavy objects onto the fuel assemblies.

1.7.2.3 SPENT NUCLEAR FUEL (SNF)

The spent nuclear fuel is an inevitable technological product of the of nuclear power generation. It is irradiated nuclear fuel. The average composition of the SNF, as compared to the initial quantity of heavy metal (HM), includes 94-95% of uranium, approximately 1% of plutonium and approximately 4-5% fission products, the radioactivity of which accounts for 99% of the radioactivity of all the materials, used in the nuclear power sector and industry. The existence of fission uranium and plutonium radionuclides in the SNF fundamentally differentiates it from the radioactive wastes. On the basis of the commercial contracts between Kozloduy NPP and the Federal State

Unitary Company FEDERAL CENTER FOR NUCLEAR AND RADIATION SAFETY of Moscow, Russian Federation, our country disposes of considerable reserves of fission materials, which are stored on the territory of the Russian Federation. The ownership over the fission materials (Pu and U), produced after the processing of the SNF, is retained by the owner, according to the Euratom Treaty.

The contemporary scientific research elaborations indicate that the SNF can be processed and successfully utilized as nuclear fuel for fast breeder reactors. This possibility will render the SNF into a significant energy resource. The use of the SNF as a raw material, instead of its processing as a radioactive waste, will lead to considerable financial savings for the country. This policy with reference to the SNF is also followed by other small countries with nuclear power generation, such as the Czech Republic, Hungary, Finland, Slovakia, etc. The alternative for the management of SNF lies in its intermediate storage within the country for its future use as a resource.

The practices in the management of SNF in the Republic of Bulgaria are related to the storage of SNF at Kozloduy NPP site in by the reactor spent fuel ponds and in the Wet spent fuel storage facility, with subsequent transport of the SNF for technological storage and processing. The processing of the SNF reduces the volume of the stored wastes, which provides the possibility to use its energy resources in the future. The high level radioactive wastes (HLRAW) obtained after the processing of the SNF are rendered into a suitable form for their long-term storage and final disposal.

During the 1974–2009 period, the total quantity of SNF, generated by the operation of units 1 through 6, amounted to approximately 1880 tons of heavy metal (HM). During the 1980-2009 period, approximately 52% of this quantity was transported for processing and technological storage. The SNF from the operation of the units of WWER-440 and a part of the SNF from the WWER-1000 reactors (spent fuel assemblies from the WWER-1000 are stored in the by the reactor ponds for the first three years) has been transferred to the wet storage facility at the Kozloduy NPP. According to the current refueling schemes for units 5 and 6 of the power plant approximately 38.7 tons of HM are generated per annum. The dry spent fuel storage facility constructed on the site of the Kozloduy NPP, stages 1 and 1a, is foreseen for the storage of, respectively, 2800 and 2456 assemblies from the reactors WWER-440. The design rate of filling of the storage facility is 420 assemblies per annum. The second stage of the dry SFSF for 2508 assemblies from the reactors WWER-1000 is currenly at the stage of development of the technical design. In case the practice to return certain quantities of SNF for processing keeps on, then this stage should not be executed during the next 10 years, since the WSF is capable of taking in and storing safely the fuel from units 5 and 6 until the year 2030 at the current rates of refueling. It should be taken into consideration that the transport of the SNF from Kozloduy NPP for technological storage and processing is performed on the basis of long-term commercial contracts with the Federal State Unitary Company FEDERAL CENTER FOR NUCLEAR AND RADIATION SAFETY No. 08843672/70046-09Д, notified and approved by the Euratom Supply Agency under No. AGW/6221 and No. /6222 in 2007, the term of validity of which expires after the return of the last spent fuel assembly. The quantities of SNF, which have been transported for technological storage and processing since 1998 till the end of 2009 amount to approximately 225 tons of HM from the reactors WWER-440 and approximately 415.2 tons of HM from the reactors WWER-1000.

According to the existing contracts, the HLRAW from the processing of the SNF are subject to return to the Republic of Bulgaria 10 years after the specific volume is defined according to a Mothodology agreed between the countries in compliance with the international practices in this field. The HLRAW from the SNF, transported for processing until 1989, are not subject to return to the Republic of Bulgaria. According to the international practices, from the processing of 1 ton of SNF are produced approximately 70 liters of vitrified HLRAW or approximately 200 kg of vitrified HLRAW or the HLRAW comprise approximately 3-4% of the processed SNF. The vitrified HLRAW is encapsulated in 170 liter canisters in a matrix of 11-18% sodium-aluminum-phosphate glass, with a weight of approximately 450 kg. The transport of the HLRAW is performed by means of containers, which contain from 21 to 28 such canisters.

It is expected that from the SNF transported for processing during the period from 1998 till 2009, the HLRAW quantities which will be returned to the country after 2020 shall amount to approximately 128 tons. The precise volume with the respective qualitative and quantitative characteristics shall be defined upon the signing of the respective contracts.

As of 31.05.2010, approximately 925 tons of SNF heavy metal are stored at Kozloduy NPP site at the SFP and the WST (approximately 630 tons of HM from the reactors WWER-440 and approximately 295 tons of HM from the reactors WWER-1000). Since 2010 till the end of the design term of operation of units 5 and 6 of Kozloduy NPP, 2017 and 2021 respectively, approximately 495 more tons of SNF heavy metal (1136 assemblies from the reactors WWER-1000) are expected to be generated. In case of extension of their operational life by 15 years, until 2032 and 2036 respectively, during the 2017/21–2032/36 period another 595 tons of SNF heavy metal are expected to be generated at Kozloduy NPP (1364 assemblies from the reactors WWER-1000).

The processing of the SNF is considered as a necessary process, providing for the separation of the FP and simultaneous storage and possibility for use of the fission materials, property of Kozloduy NPP. The main advantage of this alternative is the relieve of Kozloduy NPP site the from SNF with financial means, which will be evenly distributed over a long period of time. In this case, the principle of non-encumbrance of the future generations is observed. The dry spent fuel storage facility provides the possibility for the storage of SNF for a period of 50 years. The long-term storage has certain advantages, the most important of which is the possibility to make the rightest choice in the future and to use the results from the currently performed research and development studies and elaborations. The disadvantage of this alternative lies in the fact that a large quantity of spent nuclear fuel shall be accumulated at Kozloduy NPP site. Notwithstanding all the safety measures, the existence of such quantities of SNF on the site presents a serious problem in the long-term, this being in fact a deferred solution and a transfer of the responsibility to the future generations. In order to comply with the task for non-encumbrance of the future generations with expenses for the processing or disposal of the SNF, upon expiry of the term for its long-term storage in dry storage facilities, in parallel to the construction and filling of the containers with SNF, the operator shall be obliged to deposit resources to manage the spent fuel and nuclear material, including activities related to the reprocessing of spent fuel and disposal of HLW from processing it at the expense of the fund "Decommissioning of Nuclear Facilities" (DNF). These funds shall be accepted as non-taxable expenses according to the accounting norms and shall be included in the cost price of the generated electric power.

The National Strategy for Management of the Spent Nuclear Fuel and Radioactive Wastes till 2030, approved as per resolution of the CM on January 5, 2011, elaborates a time-schedule for the resolution of the problems related to the high level radioactive wastes (HLRAW) on a national level.

Without refuting any alternatives for the possible technical solutions for the management of the HLRAW and category 2b RAW, for the purposes of protecting the political and economic sovereignty of the country, at this stage as the optimum decision is accepted the decision to construct above the ground long-term depot with a period of administrative control of not less than 100 years for the HLRAW and medium level RAW (MLRAW) of category 2b. This period of controlled storage of the HLRAW and category 2b RAW shall allow to obtain new data and technical solutions, which may significantly modify the methods for management of such wastes. In this way, we will be able to avoid big errors in the final disposal in stable geological formations.

In order to achieve this goal, it will be necessary to perform the following measures at Kozloduy NPP and SE RAW:

- *Continuation of the transport of the SNF for processing on the basis of economically favorable solutions and commercial contracts;*
- *Removing the SNF from the WSF and transporting it to the DSESF;*
- *Commissioning of stage 2 of the DSFSF for SNF from WWER-1000 after 2015, taking into consideration the possibilities for package transport of SNF from WWER-1000 as of 2011;*
- *Extension of the term of operation of the WSF by 10 years after 2014;*
- *Investigation of the possibilities to construct a depot for long-term storage of containers with HLRAW, resulting from the processing of SNF from Kozloduy NPP*

until 2022. The final resolution to the problem with the returned HLRAW from the processing of the SNF is based on a contract between the operator and the SE RAW;

- *Elaboration of a National Program for Geological Disposal of the HLRAW and MLRAW of category 2b by 2013, which is to be approved by the Council of Ministers;*
- *Continuation of the investigation of the possibilities for disposal of the HLRAW from the processing of the SNF in the country and/ or at international depots. Including for the term of validity of the present strategy, a site should be selected for the long-term isolation of HLRAW from the environment and such a facility should be built, provided its transportation to other countries is not economically feasible and possible, according to the requirements of the EC.*

1.8 Determination of the type and quantity of expected wastes and emissions during the operation

1.8.1 Wastes

1.8.1.1 Non-radioactive

During the operation of the new nuclear unit generation of domestic, industrial, construction and hazardous wastes is expected, since conditions for the generation of various types and quantities of non-radioactive wastes are created every year in the working premises and on the sites for the various operational activities, repair works, reconstructions of buildings and premises, etc. According to art. 7 of the WMA[13], the entities, whose activities generate wastes, and the owners of the wastes must treat them themselves or must submit them for collection, transport and treatment by the entities, authorized to perform such activities in compliance with the said law.

Construction wastes – they are generated by repair and maintenance works. They will be collected separately and will be handed-over to a specialized company in compliance with the requirements of the Regulation on the Management of Construction Wastes and on Utilization of Recycled Construction Materials[14].

Household wastes - the wastes from the protected zone shall be transported and deposited into the regulated depot - Depot for non-radioactive household and industrial waste (DNHIW) of Kozloduy NPP, after compulsory radiation control. The wastes from the sites outside this zone shall be transported to the Regional depot at the town of Oryahovo. With reference to the biologically degradable wastes, information shall be required on the method of their separate collection from the Municipality of Kozloduy, and they shall be handed-over for composting or anaerobic degradation.

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[13] Wastes Management Act, State Gazette No. 53 dated 12.07.2013.

[14] Regulation on the Management of Construction Wastes and the Utilization of Recycled Construction Materials, State Gazette No. 89 dated 13.11.2012.

Production wastes, which include:

- metal wastes, not resulting from the proper electric power generation activities, but are generated during repair and maintenance works and shall be stored at specified locations at the power plant and at a well organized outdoor temporary depot;
- sludge from the domestic waste water treatment plant for the new nuclear unit;
- sludge from the neutralization pits – facilities for the neutralization of the waste waters from the production of demineralized water.

Hazardous wastes – to be generated by exhausted fluorescent and mercury vapor lamps, sludge from the mud and oil retainers, laboratories and industrial chemical substances and mixtures with expired terms of validity, packages of fuel and lubrication materials, oiled rags, wooden shavings, etc. These shall be stored separately, in specially arranged depots on the site of the Kozloduy NPP. After certain quantities are accumulated, they shall be handed-over for subsequent treatment by the specialized companies, holding the relevant licenses in accordance with the provisions of the WMA.

***Table 1.8-1: Characteristics** of the non-radioactive wastes from the operation of the NNU* specifies the types of wastes, which are expected to be generated as a result of the operation of the new unit.

TABLE 1.8-1: CHARACTERISTICS OF THE NON-RADIOACTIVE WASTES FROM THE OPERATION OF THE NNU

No.	Denomination	Code as per Regulation No. 3 (*published in State Gazette No. 44 dd 25.05.2004, modified and amended in No. 23 dd 20.03.2012*)
Domestic wastes		
1.	Paper and cardboard	20 01 01
2.	Batteries and accumulators, different from the ones specified in 20 01 33	20 01 34
3.	Electrical and electronic equipment out of use, different from the ones specified in 20 01 21, 20 01 23 and 20 01 35	20 01 36
4.	Timber materials, different from the ones specified in 20 01 37	20 01 38
5.	Plastics	20 01 39
6.	Other fractions, not specified elsewhere (sludge from the cleaning of the cold channel and fore-chambers of the RPS)	20 01 99
7.	Bio-degradable wastes	20 02 01
8.	Soil and rocks	20 02 02

No.	Denomination	Code as per Regulation No. 3 (*published in State Gazette No. 44 dd 25.05.2004, modified and amended in No. 23 dd 20.03.2012*)
9.	Mixed domestic wastes	20 03 01
10.	Wastes from the cleaning of the sewerage systems	20 03 06
11.	Bulk wastes	20 03 07
Construction wastes		
12.	Concrete	17 01 01
13.	Excavated soil masses, different from the ones specified in 17 05 05	17 05 06
14.	Insulation materials, different from the ones specified in 17 06 01 and 17 06 03	17 06 04
15.	Mixed wastes from construction and demolition works, different from the ones specified in 17 09 01, 17 09 02 and 17 09 03	17 09 04
Production wastes		
16.	Chips, shavings, cuttings, pieces, timber material, pressed timber particle sheets and veneers, different from the ones specified in 03 01 04	03 01 05
17.	Shavings, turnings and cuttings of ferrous metals	12 01 01
18.	Shavings, turnings and cuttings of non-ferrous metals	12 01 03
19.	Paper and cardboard packages	15 01 01
20.	Plastic packages	15 01 02
21.	Metal packages	15 01 04
22.	Absorbents, filter materials, wiping cloths and protective clothes, different from the ones specified in 15 02 02	15 02 03
23.	Disused tires	16 01 03
24.	Components taken out of disused equipment, different from the specified ones in code 16 02 15	16 02 16
25.	Non-organic wastes, different from the ones specified in 16 03 03	16 03 04
26.	Organic wastes, different from the ones specified in 16 03 05	16 03 06
27.	Sharp instruments	18 01 01
28.	Wastes, whose collection and rendering harmless is not the subject of special requirements, taking into consideration the prevention of infections	18 01 04

No.	Denomination	Code as per Regulation No. 3 (*published in State Gazette No. 44 dd 25.05.2004, modified and amended in No. 23 dd 20.03.2012*)
29.	Sludge from physical and chemical treatment, different from the ones specified in 19 02 05	19 02 06
30.	Infiltrate from depots for wastes, different from the ones specified in 19 07 02	19 07 03
31.	Wastes from grates and sieves	19 08 01
32.	Sludge from treatment of waste waters from settlements	19 08 05
33.	Ferrous metals	19 12 02
34.	Non-ferrous metals	19 12 03
Hazardous wastes		
35.	Used grease and lubricants	07 06 99*
36.	Solutions of water based developer and activator	09 01 01*
37.	Fixing solutions	09 01 04*
38.	Non-chlorinated mineral based hydraulic oils	13 01 10*
39.	Non-chlorinated mineral based engine, lubrication and geared transmission oils	13 02 05*
40.	Non-chlorinated mineral based insulation and heat-transfer oils	13 03 07*
41.	Sludge from oil-retainer shafts (collectors)	13 05 03*
42.	Gas oil, boiler and diesel fuels	13 07 01*
43.	Other emulsions	13 08 02*
44.	Packing materials, containing residues of hazardous substances or contaminated by hazardous substances	15 01 10*
45.	Absorbents, filter materials, wiping cloths and protective clothing, contaminated by hazardous substances	15 02 02*
46.	Non-organic wastes, containing hazardous substances	16 03 03*
47.	Organic wastes, containing hazardous substances	16 03 05*
48.	Sludge from physical and chemical treatment, containing hazardous substances	19 02 05*
49.	Thinners	20 01 13*
50.	Fluorescent lamps and other wastes, containing mercury	20 01 21*

No.	Denomination	Code as per Regulation No. 3 (*published in State Gazette No. 44 dd 25.05.2004, modified and amended in No. 23 dd 20.03.2012*)
51.	Batteries and accumulators, included in 16 06 01, 16 06 02 or 16 06 03, as well as unsorted batteries and accumulators, containing such batteries	20 01 33*

(*) Wastes, containing hazardous substances (inflammable, irritating, hazardous, toxic, cancerogenic, corrosive, mutagenic, etc.), are classified as hazardous and are marked by the star symbol.

According to art. 8 of the WMA[15], the handing-over and taking-over of the production, construction and hazardous wastes shall be performed only on the basis of written contracts with entities, holding permits, complex permits or registration documents in accordance with the provisions of art. 35 of the WMA for the respective activity and a depot for wastes of the respective code, according to Regulation 3 (2004) as per art. 3 on the classification of wastes.

The report of EIA shall present a quantitative characteristic, as well as a description and analysis of the method of collection, temporary storage and treatment of the wastes, and shall also identify the specific measures for guaranteeing their environmentally friendly management[16,17,18].

1.8.1.2 RADIOACTIVE WASTES

The source for the formation of radioactive wastes (RAW) are the radionuclides, generated in the process of operation of the nuclear reactors. According to their origin, the radio nuclides are divided into two main groups:

- Fission products,
- Neutron activation products.

The accumulation of fission products and primary circuit coolant activation, inside the reactor vessel and the internals, can be provisionally called the primary contaminations.

Any other contaminations of the equipment, tools, rooms, special clothing, etc. are formed as a result of the migration and redistribution of the radionuclides, running differently - dissolving and crystallization, evaporation and condensation, sorption, diffusion and chemical reactions. These contaminations are defined as secondary contaminations. The radioactively contaminated objects, which cannot further be used

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15 Wastes Management Act, State Gazette No. 53 dated 12.07.2013.
16 Letter of Kozloduy NPP EAD, Safety and Quality Division, output ref. No. D„B&K“ 190 dated 08.02.13.
17 Recommendation of the Ministry of the Environment and Forests (Republic of Rumania), letter output ref. No. 3672 RP dated 18.10.2012.
18 According to the recommendations of the RIEW – Vratsa, letter output ref. No. B2975 dated 10.01.2013.

according to their design functions and are simultaneously contaminated by radionuclides above the regulatory norms (free release levels), are classified as RAW.

Sources of ionizing radiation are foreseen to be used in the new nuclear unit for the needs of metal control, for calibration of the dosing and radio-measuring equipment, in the fire-alarm installations, for technical measurements and control. After their disuse, they shall also be treated as radioactive wastes.

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management adopted by IAEA, as well as the Regulation on safety during radioactive waste management of the BNRA, define the international criteria and the national regulatory requirements for all the aspects of the activities, related to RAW. The BNRA Regulation dated 2004 define 3 (three) categories of solid RAW depending on their radioactivity - categories I, II and III, also referred to as low-, medium- and high-level radioactive RAW. The liquid RAW are classified depending on the characteristics of the solid RAW, which are expected to be obtained after their conditioning.

With reference to the processing of the RAW and in compliance with art. 5 of the Regulation on safety during radioactive waste management the following three categories of solid RAW are defined:

- → Category 1: transitional RAW, which may be free released after suitable treatment and/or temporary storage for a period of time not longer than 5 years, when their specific radioactivity will drop to the required level for free release,
- → Category 2: low- and medium-level radioactive wastes, containing radionuclides in concentrations which do not require special measures for the heat removal during their storage and disposal; the radioactive wastes of this category are additionally subdivided into:
  - ✓ category 2a - short-lived low- and medium-level radioactive wastes, containing mainly short-lived radionuclides (with a half-life period of shorter than or equivalent to the half-life period of ^{137}Cs), and long-lived alpha-active radio nuclides with specific radioactivity, lower than or equal to 4.106 Bq/кg for each package and lower than or equal to 4.105 Bq/кg for the whole volume of the RAW;
  - ✓ category 2b - long-lived low- and medium-level radioactive wastes, containing long-lived alpha-active radio nuclides (with a half-life period longer than the half-life period of ^{137}Cs) with specific radioactivity exceeding the limits, specified for category 2a;
- → Category 3: high-level radioactive wastes, with such concentration of radionuclides, that the heat removalmust be taken into consideration for the duration of their storage and disposal.

A complex RAW Management program is introduced at Kozloduy NPP for the management of RAW. The program covers the whole technological cycle from the occurrence of the RAW up to their delivery to SE RAW-Kozloduy, as well as the implementation of activities for their release by the regulation authority.

With reference to the particularities of the implemented methods for processing of the RAW and according to the contractual relations with SE RAW, in compliance with art. 7 of the Regulation on safety during radioactive waste management additional categories of RAW from Koloduy NPP EAD were introduced. The additional categories detail the provision of art. 5, item 2 of the Regulation and are related to the operationally measurable parameters within limits, specified by SE RAW, SD RAW-Kozloduy and are in compliance with the Procedure for accepting RAW in the facilities for management of RAW from Kozloduy NPP. The following main groups are specified:

→ Additional categories of solid RAW (category 2a);

→ Additional categories of liquid RAW.

The additional categories of **solid RAW (category 2a)** from Kozloduy NPP EAD are defined, as follows:

→ category **2-I** - with equivalent dose rate of gamma-radiation at a distance of 0.1 m from the surface of the wastes from 1 μSv/h to 300 μSv/h;

→ category **2-II** - with equivalent dose rate of gamma-radiation at a distance of 0.1 m from the surface of the wastes from 0.3 mSv/h to 10 mSv/h;

→ category **2-III** - with equivalent dose rate of gamma-radiation at a distance of 0.1 m from the surface of the wastes of more than 10 mSv/h.

The solid RAW of each of the above additional categories are characterized as compactible (textile, wool and wastes based on polyvinyl chloride, polyethylene and other plastics) and not compactible (metals, wood, construction wastes, etc.).

The additional categories of **liquid RAW** from the Kozloduy NPP EAD are defined, as follows:

→ category **2–H** - with radioactivity up to 3.7E+5 Bq/l;

→ category **2–C** - with radioactivity from 3.7E+5 Bq/l to 7.2E+7 Bq/l;

→ category **2–B** - with radioactivity of more than 7.2E+7 Bq/l.

The liquid RAW of each additional category, depending on their origin, can be characterized as:

→ liquid radioactive concentrate;

→ ion-exchange resins;

→ slurries and sludge;

→ oils.

1.8.1.2.1 Solid radioactive wastes

The solid RAW from the new nuclear unit shall be formed by the radioactive wastes, which are generated during the day-to-day operation of the unit, theya re expected to be predominantly category 2a. RAW of the same categoty are expected to be generated also during the decommissioning of the new nuclear unit. The technology for the processing of the RAW shall include compacting, immobilization in a cement matrix and packing into reinforced concrete containers (net volume of 5 m^3).

Depending on the processing technology, the generated wastes are divided into compactible and non-compactible.

The activities for the management of the RAW shall be performed on the basis of the established administrative structures with defined status between the operator company and SE RAW through defined functions and tasks and clear specification of the rights, obligations responsibilities of both operators on the site.

The solid RAW, which will be generated, shall be predominantly of categories 1 and 2a.

According to the requirements of the EUR, during the operation of such type of reactors, the generated solid radioactive wastes per annum, including the conditioned liquid RAW, shall not exceed 50 m^3 per 1000 MW installed power capacity. These quantities are determined for a dose rate limits of the packaged conditioned RAW of 10mSv/h. The quantities of RAW, generated during repair and maintenance works, expected to amount to not more than 100 m^3 per campaign (12-36 months), are not included in the above quantities. If observing the contemporary technologies for the management of RAW, the above limiting quantities could be considerably reduced.

1.8.1.2.2 Liquid radioactive wastes

In the process of operation of the new nuclear unit industrial radioactive waste waters from the primary circuit shall be generated as a result of equipment leakages, from the spent fuel storage facilities, from the facilities for decontamination of the equipment and for regeneration and flushing of the ion-exchange filters, special laundries for outfit and sanitary loops, radio-chemical laboratories, etc.

In compliance with the requirements of the Regulation on safety during radioactive waste management, the liquid radioactive wastes are categorized in compliance with the provisions of art. 5 of the Regulation, depending on the characteristics of the solid RAW, which are expected to be produced after their conditioning.

According to the requirements of the EUR, during the operation of such type of reactors, the maximum radioactivity released by the generated liquid radioactive wastes per annum shall not exceed 10 GBq (excluding tritium).

1.8.2 EMISSIONS INTO THE AIR

1.8.2.1 NON-RADIOACTIVE EMISSIONS

During the normal operation gas emissions are expected from transport activities, related to the project, along the Republican road network. The transport plan for delivery (equipment) and the transport of the wastes concerns the servitude territories of the stretches of the roads, used for the project. They are a linear source of pollutants.

The assessment of emission levels of various pollutants from the road transport is made using Tier 2[19] of the European Guide EMEP/EEA CORINAIR'2009 emission inventory for passenger cars (NFR code 1.A.3.bi), light-duty vehicles (LDV) <3 5 tons (1.A.3.b.ii) and heavy duty vehicles (HDV) > 3.5t and buses (1.A.3.b.iii), chapter Road Transport for the main pollutants:

- ✓ Precursors to ozone - CO, NO_X, NMVOC (non-methane volatile compounds);
- ✓ Greenhouse gases (CO_2, CH_4, N_2O);
- ✓ Acidification (NH_3, SO_2);
- ✓ Particulate matter (PM) - emission factors refer to PM2.5, as the coarse fraction (PM2.5÷10) is negligible in vehicle exhaust;
- ✓ Carcinogenic compounds:
  - PAH - polycyclic aromatic hydrocarbons (Benzo (α) pyrene, Benzo (b) fluoranthene + Benzo (k) fluoranthene, indeno (1,2,3-cd) pyrene - for unleaded petrol));
  - POP - Persistent Organic Pollutants
  - toxic substances (DIOX - Dioxins and furans (for unleaded petrol)
- ✓ Heavy metals.

The estimation not include emissions such as fuel evaporation from vehicles (NFR code 1.A.3.bv), tyre wear and brake wear (NFR code 1.A.3.b.vi), or road wear (NFR code 1.A. 3.b.vii).

The report on the EIA shall also assess the emissions from the diesel generators for emergency power supply of the safety systems on the basis of the combusted fuel.

1.8.2.2 EMISSIONS OF RADIOACTIVE PRODUCTS INTO THE ATMOSPHERIC AIR

The sources of organized gas-aerosol radioactive discharges into the atmosphere shall be the ventilation stacks of the new nuclear unit.

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[19] In determining the emission levels of greenhouse gases (GHGs) in IPCC, the methods of varying complexity are used. The level of complexity of the method is designated as Tier X, i.e. when X is higher digit, the method is more complex and more accurate.

As a result of the organized and unorganized leaks of the primary circuit coolant, in normal operating mode, radioactive substances are emitted in the reactor building compartments. Radionuclides shall be contained also in the air of the Auxiliary building compartments. The special ventilations are organized for exhausting the gases from the compartments, after passing through the special gas purification systems.

The radioactive gases and aerosols shall be treated by means of gas purification systems, equipped with equipment for retention of the RNG and tritium and for reducing their radioactivity before exhausting them into the atmosphere, as well as by means of equipment for purification of the gases from iodine isotopes and from the radioactive aerosols.

The radioactive emissions into the atmosphere shall be a mix of dozens of radionuclides, the most representative among them being more than 50 types with a half-life period from 30 s (^{106}Ra) to 30.2 years (^{137}Cs). The main radioactive emissions into the atmosphere shall be classified in three groups - radioactive noble gases (RNG), long-lived aerosols (LLA) and iodine 131 (J^{131}).

The limits for radioactive emissions into the atmosphere according to EUR for the normal operation and emergency operation modes are:

- For radioactive noble gases – 50 TBq;
- For long-lived aerosols and halogen elements – 1 GBq.

The above reference values are determined on the basis of 1500 MWe. They can be conservatively accepted for environmental impact assessment for the new nuclear unit, whereas the actual emissions from the various models of reactors are expected to be lower.

In all operating states of the NNU, the annual individual effective dose of internal and external exposure of the population, caused by the impacts of the liquid and gas emissions into the environment for all units and facilities (units 1÷6, WSF and the National Repository for RAW Disposal), which are located or are to be located at Kozloduy NPP site, shall not exceed 0.25 mSv (instructions by the BNRA by letter No. 47-00-171 dated 12.02.2013, according to the final provisions of § 3, clause 2, item 2 of the Regulation on the Provision of Safety for the Nuclear Power Plants (2004), for the existing nuclear power plants as of the date the Regulation enforcement).

1.8.3 EMISSIONS INTO THE WATERS

The main receiving water body for all types of waste waters from the NNU shall be the Danube River.

The Danube River is the second largest river in Europe, with more than 80 mln persons living along it. The river passes through 13 countries, provides for the river transport between them as the river transport corridor and provides fresh water for the economies of the said countries. A large number of HTF have been built, which use the hydro energy potential of the river, including NPP's, but also as a source of fresh water for their technological needs. It is also a receiving water body for the waste waters and heat. The quality of the water in the river is of utmost importance for everyone and for this reason the ICPDR (International Commission for the Protection of the Danube River) was established with head office in Vienna. The Republic of Bulgaria is its active member.

According to the Bulgarian legislation - WA and FDW 2000/60 of the EU, the RBMP elaborated for the Danube region basin management, the Bulgarian stretch of the Danube River is defined as a category river with the denomination Danube RWB01 and code BG1DU000R001. This water body is of the type „strongly modified water body" with moderate ecological potential and bad chemical state. The aims and targets of the RBMP require for these parameters to be corrected during the next planning years until a good state and a good potential are achieved. The Danube River and the whole Danube region for basin management of the waters in our country are defined as a sensitive zone with reference to anthropogenic pollution according to Ordinance No. RD-970 dated 28.07.2003 of the Minister of the Environment and Water, for which reason, the requirements on the users of the water bodies are stricter. These requirements are specified for the NPP in the permits for discharge of the waste waters from production activities into the receiving water body of the Danube River, issued by the MoEW/BDWMDR.

The waste waters from the NNU (New nuclear unit) shall be similar to those from the existing power plant (letter of the MoEW, Regional Inspection on the Environment and Water (RIEW) – Vratsa, output ref. No. V2975 dated 10.01.2013).

The sewerage network of the new nuclear unit shall be separate for the various types of waste waters. According to Regulation No. 2 dated 08.06.2011 concerning the issue of permits for discharge of waste waters into water bodies and determination of the emission limits of point sources of pollution as per art. 6, clause 1, item 3 and item 4, it is prohibited to discharge new waste waters and no permits are issued for the discharge of waste waters into the irrigation and drainage systems and of production waste waters into the drainage systems. The main receiving body for the waste waters shall be only the Danube River, in compliance with all the strict requirements of the environment related legislation.

1.8.3.1 NON-RADIOACTIVE CONTAMINATED WASTE WATERS

A.1. household-fecal wastewaters. They shall be formed at all administration, main and auxiliary buildings outside of the controlled area. They shall pass through the WWTP, which shall be dimensioned and with a contemporary technological scheme of the treatment in order to guarantee at the outlet of the plant the parameters defined in the permit for the receiving water body the Danube River - category III, according to ordinance No. RD-2728 dated 3.5.2001 of the MoEW and the permit for discharge of these waste waters issued in accordance with the provisions of the WA. The expected discharge quantity shall be justified according to the norms currently in force, determining the required quantity of drinking water according to the number of the consumers. The location and the capacity of the WWTP for the household-fecal wastewaters shall be in accordance with the layout scheme for the buildings on the site, as well as according to the vertical leveling design, providing the shortest possible route of the treated waste water to the main channel discharging all the waste waters into the receiving body.

A.2. Production waste waters – these are drained waters from the turbine hall, DGS, transformer beds, fuel and oil facility and other auxiliary activities, for which facilities are to be built on the territory of the new unit. These waters shall be conveyed to the treatment plant for petrol products, while local facilities are foreseen for catching the oils, such as separation shafts, oil retainer pits and other suitable facilities. For the waste waters from the CWT facilities for neutralization shall be foreseen before their discharge into the site sewerage for industrial waters. These waste waters are different as regards quality and quantity. The locations of the local treatment facilities shall be determined on the basis of the layouts of the main buildings and facilities, as well as by the design of the underground sewerage system, providing for the discharge of the treated production waste waters into the receiving body.

A.3. Rain waters. The expected quantity of rain waters shall be determined according to the method of limit intensity for a 5-minute rain and the drainage norm and shall depend on the layout of the buildings and the facilities, the vertical leveling design, the grassed areas, the areas covered by pavements, etc.

A4. The exhaust cooling waters, which shall be conveyed to the Danube River via HC-1 and HC-2.

A.5. The household-fecal wastewaters from the controlled area, after passing through the specialized treatment plant and the subsequent radiation control with strictly defined parameters, shall be conveyed for subsequent treatment with the remaining household-fecal wastewaters before their discharge into the sewerage network for conveying to the receiving water body.

1.8.3.2 RADIOACTIVELY CONTAMINATED PRODUCTION WASTE WATERS

The radioactively contaminated waste waters, which shall be generated at the NNU, shall be similar to those, discharged from the currently existing nuclear units.

During the process of operation of the nuclear reactors production radioactive waste waters shall be formed from:

- Leaks in the primary circuit of the nuclear reactors;

- The spent fuel ponds and storage facility;
- Dercontamination of the equipment;
- Regeneration and flushing of the ion-exchange filters;
- Laundries for special clothing and Sanitary loops;
- Radio-chemical laboratories, etc.

These waters shall be treated (purified) consecutively in evaporation installations and in filtering complexes (Reactor Water Cleanup SVO-3) in the Auxiliary building of the new nuclear unit. The treated waters, referred to as "treated water discharges", shall be collected in intermediate tanks and, after the control of their radioactivity, shall be transferred into HC-1, -2, if they comply with the norms. Otherwise, they will be returned for further treatment.

The design function of the RWCS is:

- SVO-3 – designed for treatment of floor drains from the controlled area (CA). The sources of such waters are the unorganized leaks from the primary circuit, decontamination of the equipment and the systems, the flushing and regeneration of the filters, the SVO-3 itself - if the treated waters do not comply with the norms for the water chemistry of the NPP or for the treated water discharges, etc.;
- SVO-5 – designed for treatment of the water from the the steam generators blowdown - constant and periodical;
- SVO-7 – designed for treatment of the radioactive waters from the laundries and the hot showers.

The waters coming from the expansion vessels of the deaerators and from the steam generators blowdown are also treated water discharges. These waters shall be treated by means of ion-exchange filters and, in case they cannot be used again in the technological cycle, they shall be discharged (after radioactivity control) into the HC.

The radioactive sludge shall be discharged into special tanks for evaporated concentrate. It is subject to treatment (cementing) at the SD RAW – Kozloduy, subsidiary of the SE Radioactive wastes.

1.8.4 CONTAMINATION OF THE SOILS

The wind is one of the elements, which directly affect the spreading of the emissions and the deposit of the radioactive elements onto the soil. The sites studied for the new nuclear unit are located in an area, characterized by prevailing winds from the west and the northwest throughout the year. The wind regime for a specific location is strongly affected by the local conditions. The hilly terrain leads to a redistribution and deformation of the wind flow, as a result of which the wind velocity is changed, as well as the frequency of the prevailing directions of the wind. The role of a large water body, such as the Danube River, which, in this case, can be defined as a large aeration channel, is equally important.

In order to assess the spread of the emitted radionuclides by the new nuclear unit and their concentrations close to the earth number of tasks will have to be resolved, including the development of models to describe the respective processes.

The main radioactive emissions into the atmosphere by the NPP fall into three groups - radioactive noble gases (RNG), long-lived aerosols (LLA) and iodine 131 (^{131}I). The main factor for the assessment of the probability of contamination of the soils as a result of the aerosol emissions have the long-lived radioactive aerosols - LLA (mainly the isotopes of: ^{134}Cs, ^{137}Cs, ^{89}Sn, ^{90}Sn,^{95}Zr, ^{59}Fe, $^{58,60}Co$, ^{54}Mn, ^{51}Cr, ^{110m}Ag). Their half-life period, as compared to the other two groups of radionuclides, existing in the radioactive emissions, is longer; therefore, they are of particular interest for the assessment of the impact on the soils, notwithstanding their smaller share in the emitted radioactivity of the NPP. According to the long-term monitoring of Kozloduy NPP (REIA Kozloduy, 1999), the maximum model values of the close to the ground-level concentrations of the LLA (3.2 $\mu Bq/m^3$ in 1994 and 1996 up to 1.06 in 1998) were measured around the borders of the Precautionary Action Zone (PAZ) of 2 km, mainly to the west of the NPP. These values are in good compliance with the emitted radioactivity of LLA by years. They drop sharply with the increase of the distance from the power plant.

It is not realistic to compare the values achieved via the models for the deposits of LLA, emitted from the ventilation stacks of Kozloduy NPP, with the experimentally achieved results by the Environmental Radiological Control Department of the NPP, as well as with the experimental data of the NCRBRP on the total beta-activity of the samples from the constantly controlled points within the supervised area, since the deposits of radioactive products, found in the form of aerosols in the atmosphere, are the result of both the emissions from the operation of the NPP, as well as caused by transmission from farther away. To have a better idea on the ration between the two components, an example could be provided with the registered average total beta-activity of atmospheric deposits in the town of Pleven and in the town of Lom in 1998, which amounted to approximately 0.35 Bq/m^2, similar, even higher than the one measured at the control point in the town of Berkovitsa. These values of are much higher than the deposits defined from the LLA emissions from the power plant, which indicates their insignificant effect on the radioactivity of the atmosphere in these regions.

In order to provide for the completeness of the studies, the report of EIA shall performe an assessment of the spread of the LLA emissions from the WSF, notwithstanding the fact that their share in the common flow of radionuclides emitted into the atmosphere by Kozloduy NPP is insignificant.

1.8.5 NOISE AND VIBRATIONS

Sources of environmental noise due to the project for construction and commissioning of the new nuclear unit at Kozloduy NPP site are the main and the auxiliary technological equipment and the transport servicing the operation. The noise emissions in the environment shall be determined on the basis of the passport noise characteristics data of the envisaged equipment. In case such data is not available, the Bulgarian legislation (Regulation No. 6 on the parameters for noise in the environment, considering the degree of discomfort during the different hours of the day, the limit values of the parameters for noise in the environment, the methods for evaluation of the noise parameters and the adverse effects from noise on the public health, MH, MoEW, State Gazette 58/2006, compliant to the European Directive 2002/49/EU) allows to use data from a similar project (if technology and equipment are similar to the investment proposal under consideration). The traffic attending the operation of the site shall also be considered as a source of noise, and the equivalent noise level, emitted by the vehicles shall be determined on the basis of the data on the forecast traffic intensity.

The design of the project ensures that the future technological equipment is not a source of vibrations in the environment. The vibrations are characteristic of large-scale machine parts, at high rotation speeds. In the electricity generation, these are mainly the turbines, located in the turbine halls. For the machinery and equipment, limiting the distribution of vibrations outside the source is achieved by compliance with special technical requirements to the installation: anti-vibration treatment of their foundations by means of rubber pads, insulation joints of vibration damping materials, removal of the rigid connection between the vibrating sites and the structural elements of the premises, etc. Vibrations in the industrial sites are solely factor of the working environment.

The transport vehicles, servicing the activities of the new nuclear unit, are not expected to become source of vibrations in the environment. They shall travel along the class II national road network, designed to comply with the respective road traffic category, which provides for attenuation of the vibrations from heavy vehicles within a short distance from the road.

Due to the mentioned considerations, the report of EIA of the project stage: Operation of the new nuclear unit, shall not study the technological and transport vibrations as a factor affecting the environment.

1.8.6 RADIATION

1.8.6.1 IONIZING RADIATION

The ionizing radiation occur to a large degree as a result of the nuclear reactions and the fission of the nuclei of the natural and artificial radionuclides. This radiation affects the living organisms by means of its ionizing component.

Radioactive materials are used almost along the whole chain of the technological process at the NPP. The main part them are operational (necessary for the technological process), such as the nuclear fuel and the radio-isotopes, used in the control and diagnostic equipment. The specific radioactive material - the spent nuclear fuel, product of the main technological process at the NPP, is stored, handled and transported in accordance with the regulatory requirements for nuclear and radiation safety at the NPP.

1.8.6.2 NON-IONIZING RADIATION

The main sources of MLF electric and magnetic fields (with industrial frequency of 50 Hz) in the working environment are the Open Switchgear (OS) of the transformer installations, the busbar systems, the circuit-breakers, the electric power transmission lines. Sources of MLF fields (mainly magnetic) can also be the turbine generators, the current rectifiers, the low-voltage power supply systems.

Sources of radio frequency and (microwave) MHF electromagnetic emissions at Kozloduy NPP can be found in:

- → the security systems;
- → the mobile communications systems;
- → the emergency public address systems

2 ALTERNATIVES FOR THE REALIZATION OF THE INVESTMENT PROPOSAL

2.1 ALTERNATIVES AS REGARDS THE LOCATION

According to the Terms of Reference, the subject of the assessment are the four alternatives as regards the location - ***Figure 2.1-1:*** *View from the air of the four alternative sites for the NNU*.

Site 1 – located to the northeast of units 1 and 2 of Kozloduy NPP, between the Open Switchgears and the Valyata area, in the vicinity of the built cold and hot channels (to the north of the same). The area of the site amounts to approximately 55 ha. The land is flat, with a slight slope from the southwest to the northeast. For the purposes of the site development the construction of a fill is foreseen to raise its elevation. In the area of the site there are located open drainage channels, which shall have to be restructured. A part of the site is used for growing agricultural crops;

Site 2 - located to the east of units 1 and 2 of Kozloduy NPP in the direction of the village of Harlets, to the south of the built cold and hot channels. The area of the site amounts to approximately 55 ha. The land is hilly, with a considerable slope from the south to the north, more expressed in the southeastern part of the site. For the purposes of the site development some excavation works will be necessary. Aa former farmyard is located within the area of the site. The remaining area is used for growing agricultural crops;

Site 3 – located to the north of units 5 and 6 of Kozloduy NPP, in the vicinity of the plant bypass road. The area of the site amounts to approximately 53 ha. The land is flat, with a slight slope from the south to the north. For the purpose of the site development a fill to raise the elevation has to be foreseen. Within the area of the site there are located open drainage channels, which will have to be reconstructed. The site is used for growing agricultural crops;

Site 4 –located to the west of units 3 and 4 of Kozloduy NPP and of the Spent Fuel Storage Facility of Kozloduy NPP, to the south of the cold and hot channels. The available area on the site amounts to 21 ha, within the borders of the expropriated lands of Kozloduy NPP. The site is located on the existing service facilities – Equipment storage facility, Vehicle Repair Workshop and Assembly facility. For the purposes of the site development it will be necessary to foresee the reconstruction and displacement of the main underground communications of Kozloduy NPP and of its service buildings.

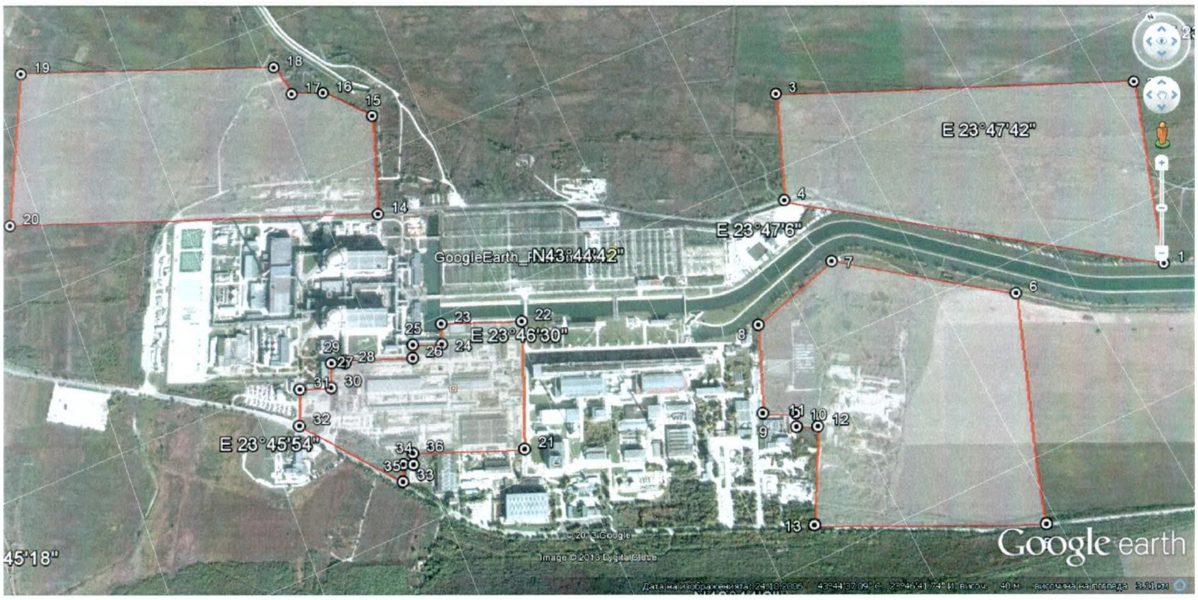


FIGURE 2.1-1: VIEW FROM THE AIR OF THE FOUR ALTERNATIVE SITES FOR THE NNU

2.2 ALTERNATIVES FOR THE ASSOCIATED INFRASTRUCTURE DURING CONSTRUCTION AND OPERATION

Before commencing the major construction works, earth foundation improvement methods should be applied on the proposed site to ensure that its load-bearing capacity complies with the loading and the settling does not exceed the allowed limits.

The proposed site should be furnished with provisional land lots intended for storage of bulk materials, finished steel, concrete and ferro-concrete, metal, and other structural components, fuel and lubricants, and for the establishment of provisional offices, provisional housings to accommodate the workforce coming from a greater distance, provisional community and health centres, water-supply network and drainage network to take away household-fecal wastewaters to the treatment stations municipal, equipment to take away rain water, and a ground water level lowering system. Such organization of the construction site will be possible with sites 1, 2, and 3, while for site 4, additional terrains will have to be provided.

The vertical planning of the proposed site will be consistent with the working level of the existing power plant site, which is +35.00 m according to Bulgarian Standard. This is determined by the fact that they will have to be connected to the existing cold channel (CC) and hot channel (HC). Thus, for instance, choosing site 1 or 3 will require shifting or reconstructing of the drainage channels passing through them during the preparatory construction stage, while choosing site 4 will require demolishing and shifting of the available service buildings and their moving to a new terrain. Choosing site 3 will also require shifting of the 400 kV overhead power line (OPL) route.

All sites feature appropriate engineering options for the supply of drinking water from the available power station water mains.

All sites feature appropriate options for providing access for the required vehicles through forks of the available road infrastructure.

Liquid radioactive waste, which will be generated during the operation of the power unit from the primary circuit as a result of equipment leakages, by the equipment decontamination and ion-exchange filter regeneration and flushing facilities, the special clothing laundries and the Sanitary loops, the radio-chemical laboratories, and the like will be processed on the territory of the respective site according to the requirements of the Regulation on safety during radioactive waste management.

According to the European Utility Requirements (EUR), the solid radioactive waste generated by the operation on an annual basis, including conditioned liquid RAW, should not exceed 50 m^3 per 1000 MW of installed capacity.

The generated solid RAW will be mostly of category 1 and 2a.

The activities related to RAW management will be performed based on established administrative structures with definite status between the operator of the New Nuclear Unit (NNU) and the SE RAW, through defined functions and tasks and clear allocation of the rights, obligations, and responsibilities.

2.2.1 ELECTRICAL PART – LAYOUT SOLUTIONS

In the Environmental Impact Assessment Report (REIA), assessment will be made of the overall layout of the NNU on the site, including the connection with the National Energy System according to Regulation No. 4 of May 05, 2001 on the scope and contents of investment projects and Article 2. para. 1, point 1 of Regulation No. 6 of June 9, 2004 on the connection of electricity producers and consumers to transmission and distribution electrical networks, which is to satisfy the Rules for electric power system management, issued based on Article 21, para. 1, point 7 of the Energy Act by the Chairman of the State Committee for Energy and Water Regulation, Appendix to point 1 of Decision No. П-5 of June 18, 2007, as promulgated the SG issue 68 of August 21, 2007.

- *Connection to the electrical grid of the Republic of Bulgaria* – The connection to the electrical grid of the country will be implemented by one detached 400 kV overhead transmission line to Open Switchgear - 400 kV (Open Switchyard) of Kozloduy NPP, which is currently connected to the electrical grid by eight 400 kV power lines (two of them are intersystem lines) and one 400/220 kV autotransformer. The backup houseload power supply will be provided by one 220 kV overhead line, also from the Open Switchgear-400 kV of Kozloduy NPP. Thus, in case of possible external or internal failures of the electric power network, the backup power supply thus established will provide to minimize the disturbances in the reactor's normal operation. The heat removal system and the safety related consumers and consumers essential for the NPP's operation will be power-supplied by two different sources (own generator and electric power system grid).

- *Working power supply* – The working houseload power supply source will be the working houseload transformers. The connection of the working transformers will be implemented by a branch between the generator switch and the unit step-up transformer.

- *Backup power supply* – The backup houseload power supply for each of the units will be provided by groups of two backup transformers. These transformers will be power-supplied by Open Switchgear-400 kV of Kozloduy NPP. The backup sources will be used in normal and emergency operating modes, as well as in emergency conditions in the case of partial or complete loss of working power supply.

- *Emergency power supply* – The safety related systems will be supplied by reliable power supply systems. The emergency systems will be switched on automatically by connecting to emergency power supply-sources and/or accumulator batteries.

2.2.2 SERVICE WATER SUPPLY

Regarding service water supply, the following alternatives are available:[20]

2.2.2.1 SITE 1

2.2.2.1.1 Service water supply facilities

The facilities located on the site and providing service water supply using fresh water from the Danube river and taking the hot processed (used) water comprise:

→ Connections with the cold channel and hot channel,

→ Fore chamber,

→ Circulation Pumping Sration (CPS),

→ Power control building,

→ Discharge pipes,

→ Filter compartment,

→ Low-pressure channels.

The connection of the NNU with CC-1 and HC-1 will be possible through a supply and bypass cold water channel and low-pressure open hot water channel. The bypass will be necessary in case the connection will be established while the channels are operating, whereat the water amount in the channels will have to be limited during cut-in. The site development will require large earth fillng activities to reach the „0" level of the NPP's major site and reconstruction and/or shifting of the available open drainage channels.

2.2.2.1.2 Auxiliary facilities

Generally, the auxiliary facilities will be intended to provide and fill-up the conventional stock required to run the normal and design operating modes, as well as to protect the environment from various waste products from the technological process and to provide for the required amounts of drinking water.

These will comprise:

→ Water-preparation installation – Chemical Water Treatment Facility (CWTF);

[20] Feasibility Study for the construction of a new nuclear unit using the equipment supplied for the *Belene* NPP, *Energoproekt* NIPPIES (*Energoproekt* Scientific-Research and Project-Survey Institute for Energy Construction).1999.

- Treatment stations for household-fecal wastewaters from „controlled” and „clean” area cand for industrial water, as well as various local treatment facilities;
- DGS and fuel supply;
- Other common and auxiliary facilities;
- Connection with the existing water mains for drinking water on the major site will be possible at an appropriate place;
- A new split sewer system, taking away waste water from the site to the water receiving body, the Danube river, after it was treated and a discharge license was under the terms of the Water Act for the IP.

2.2.2.2 Site 2

2.2.2.2.1 Service water supply facilities

The facilities located on the site and providing service water supply using fresh water from the Danube river and taking the hot processed (used) water comprise:

- Connection with the cold channel and the hot channel,
- Fore chamber,
- Circulation Pumping Station (CPS),
- Power control building,
- Discharge pipes,
- Filter compartments,
- Low-pressure channels.

Here, the connection of the equipment providing service water supply of the NNU will not differ in principle from that of Site 1, the difference being that a cold water sag pipe (Düker) from CC-1 and a hot water bypass channel from HC-1 will be constructed. It will be also possible to implement the connection while the double channel is operating by limiting water amount in the channels during cut-in.

2.2.2.2.2 Auxiliary facilities

Generally, all of these will be intended to provide and fill-up the conventional stock required to run the normal and design operating modes, as well as to protect the environment from various waste products from the technological process.

These will comprise:

- Water-preparation installation – Chemical Water Treatment Facility(CWTF);
- Treatment stations for household-fecal wastewaters „controlled” and „clean” area and for industrial water, as well as various local treatment equipment;
- DGS and fuel supply;
- Other common and auxiliary facilities;
- Connection with the existing water mains for drinking water on the major site will be possible at an appropriate place;
- A new split sewer system, taking away waste water from the site to the water receiving body, the Danube river, after it is treated and discharge license is issued under the terms of the Water Act for the IP.

2.2.2.3 SITE 3

2.2.2.3.1 Service water supply facilities

The equipment located on the site and providing service water supply using fresh water from the Danube river and discharging hot processed (used) water comprises:

- Connection with the cold channel and hot channel,
- Fore chamber,
- Circulation Pump Station (CPS),
- Power control building,
- Discharge pipes,
- Filter compartments,
- Low-pressure channels.

Here, the connection may be implemented without disturbing the operation of the other units, if an additional CC-2 is constructed. After units 1÷4 were shut down, fresh service water from the Danube river amounting to about 100 m^3/s will be available for use. This secured reserve does not require construction of additional service water supply equipment, i.e. CC-2, therefore, another technical solution will be required for connection with the available CC-1.

2.2.2.3.2 Auxiliary facilities

Generally, all of these will be intended to provide and fill-up the conventional stock required to run the normal and design operating modes, as well as to protect the environment from various waste products from the technological process.

These will comprise:

- Water-preparation installation – Chemical Water Treatment Facility (CWTF);
- Treatment stations for household-fecal wastewaters from the „controlled" and „clean" area and for industrial water, as well as various local treatment equipment;
- DGS and fuel supply;
- Other common and auxiliary facilities;
- Connection with the existing water mains for drinking water on the major site will be possible at an appropriate place;
- A new split sewer system, taking away waste water from the site to the water receiving body, the Danube river, after it is treated and a discharge license is issued under the terms of the Water Act for the IP.

Here, construction and assembly works will be required, related with reconstruction and/or shifting of the available open drainage channels from the irrigation and drainage system of the Kozloduy low-land, which is of significance for the NPP site. Large earth-filling activities to reach the „0" level of the NPP's major site and a new engineering solution for service water supply will be required.

2.2.2.4 SITE 4

2.2.2.4.1 Service water supply equipment and auxiliary facilities

Placement of the major and auxiliary equipment will require demolition of all buildings, equipment, and their pertaining communications to be found on the site. New terrains will be required for their restoration.

It will be possible to supply the power units with service water from the fore chamber of power units 5 and 6 through a sag pipe (Düker). The sag pipe will cross the major output mixed sewer collector and the low-pressure channels of units 5 and 6. The discharge pipings of the circulation water supply will join into the low pressure channels of units 5 and 6 or unit 4:

- Connection with the existing drinking water supply network at an appropriate place of the major site.
- For waste water, a new split sewer system, taking away all waste water to the water receiving body, the Danube river, after it is treated according to the license under the terms of the Water Act for the IP.

When developing the Environmental Impact Assessment Report (REIA) based on the Feasibility Study (FS) for the New Nuclear Units (NNU), which will be provided by the Employer, the technical solutions for the connection of the existing facilities providing service water and process cooling water discharging equipment for the NNU will be specified and assessed for each individual alternative site.

2.3 ALTERNATIVE CONSTRUCTION OPTIONS FOR THE NEW NUCLEAR UNIT

In the field of nuclear energy, the units of the III, respectively III+ generation, represent the best state-of-the-art technology. These are the newest of nuclear power plants designs which, compared to the older generations, show better technological, economical, and safety features.

The step-by-step development of nuclear energy is shown in the next Figure 2.3-1*:*

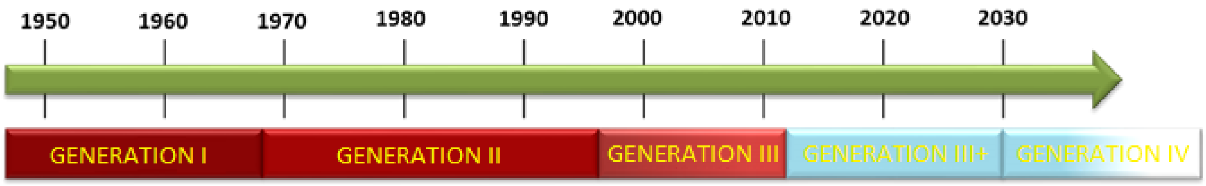


FIGURE 2.3-1: DEVELOPMENT OF NUCLEAR ENERGY BY REACTOR GENERATIONS

Currently, the power plants of the IIIrd generation use the best available technologies based on the proven IInd generation types. The main differences compared to the IInd generation are:

- → Standardized design which reduces the required time for licensing of the individual power plants, the required investment costs, and construction time;
- → Simplified, but nevertheless solid design, providing for easier servicing and increase of operational reserves;
- → Higher availability (90 % and more), higher net effectiveness (up to 37 %) and longer service life (60 years as a minimum);
- → Lower risk of accidents with significant core damage (considerably less than 10^{-5}/year);
- → Higher resistance to external impacts;
- → Possibility for higher fuel burn-up (higher fuel use up to 70 GWd/tU) and reduction of the amount of the generated waste;

→ Extension of the core residence time of the fuel by usingof burnable absorbers (up to 24 months).

Generation III+ was developed immediately after the IIIrd generation. It involves reactors with improved operational economics. Of the reactors of the PWR type, examples of reactors pertaining to generation III+ are the EPR units built by the Finnish company *Olkiluoto* or the French company *Flamanville*, or the new Russian reactor AES-2006 (with trade name MIR-1200) belonging to the WER development series, the Japanese EU-APWR, or the reactors with AP1000 units of the *Westinghouse* company. The reactor (respectively, the power plant) subject to this Investment Intention will belong to this generation.

According to the Employer's Terms of Reference for the implementation of the Investment Proposal (IP), two options for the construction of the new nuclear unit with reactor of the latest generation, complying with the modern requirements for safe operation are possible, as follows:

→ **A-1**: (Hybrid) Maximal use of the equipment from the nuclear island, ordered for the *Belene* NPP and turbine island from another provider;

→ **A-2**: An entirely new design.

Both options envisage the use of Pressurized Water Reactors (PWR) of the latest generation (Generation III or III+), with installed electrical capacity of about 1200 MW. Below variants of different models of reactors for both alternatives are presented.

2.3.1 DESCRIPTION OF A-1 (HYBRID)

The *Belene* NPP has been designed for Water-Cooled Water-Moderated Energy Reactor (WWER) of the WWER-1000/V466B type with four circulation loops, based on a standard design for a WWER AES-92 power plant, which in 2006 passed successfully all analysis stages for compliance with the European power facilities requirements, supported by the major European energy companies for the next generation of NPPs with light pressurized water (Figure 2.3-2: General layout of AES-92 (V-466B - Belene)*)*.

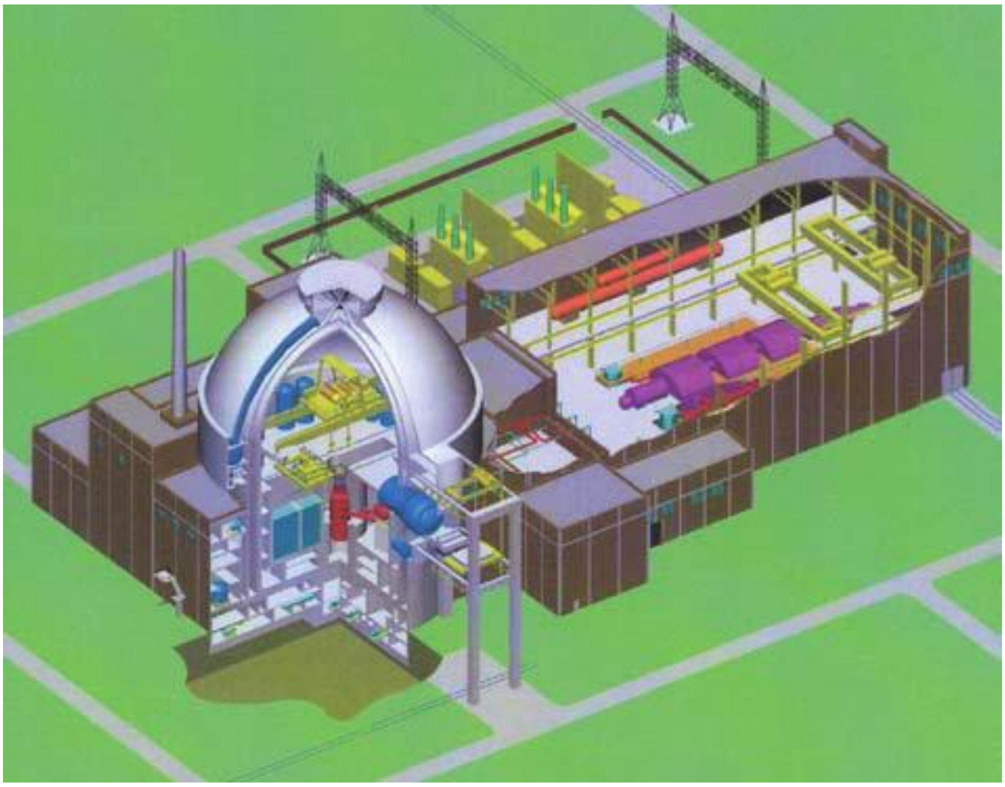


FIGURE 2.3-2: GENERAL LAYOUT OF AES-92 (V-466B - BELENE)

The major differences between this desing and the previous designs for NPPs with WWER of the previous generation are, as follows:

- Quick interruption of the nuclear reaction in the core using two completely independent reactivity control systems;
- Residual heat removal and maintaining the reactor in safe condition through a combination of active and passive systems, which do not require operator intervention or external power supply;
- Double containment intended for a wide range of internal or external events: the primary (inner) containment with leak-tight envelop is made of prestressed reinforced concrete with steel liner and the outer containment is made of reinforced concrete.

Essential improvement of the leak-proofness has been made, providing maximal barrier for the emission of radioactive products into the surrounding environment. It has been designed as a double-containment structure where the primary containment is made of prestressed reinforced concrete with leak-tight metal lining, and the external containment is made of non-prestressed reinforced concrete. The external containment has been designed to withstand external forces, such as a airplane crash of a big passenger or military airplane, external explosion waves, tornados, snow, extreme temperatures, and earthquakes. The inner containment has been designed to withstand by seismic impacts and all security systems comply with the seismic safety requirements. The *Belene* NPP has been designed to withstand Safe Shutdown Earthquake a^{max} = 0.24 g and probability of occurrence 1 in 10^4..

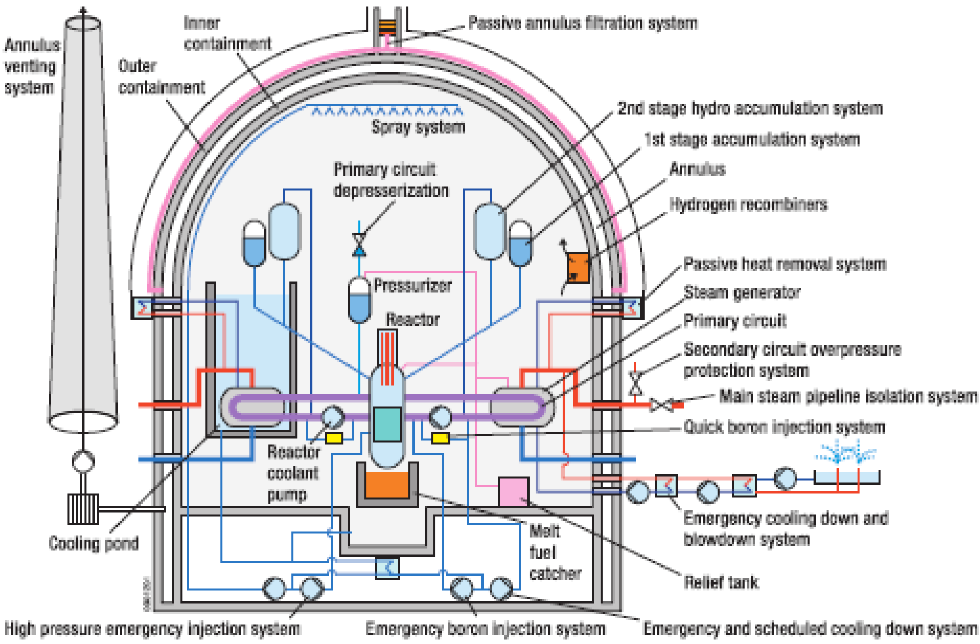


FIGURE 2.3-3: DIAGRAM OF AES-92 (V-466B - BELENE)

The *Belene* NPP design (Figure 2.3-3: Diagram of AES-92 (V-466B - Belene)) is distinguished by an unique combination of active and passive safety systems, which ensures higher NPP protection level, inclusive by using corim catcher.

The major technical parameters of the *Belene* NPP design V-466B (AES–92) are as follows:

General data

Output, gross [MWe]	1068
Output, net [MWe]	1000
Thermal power output [MW]	3000
Efficiency [%]	33.1
Operating mode	Basic and load-following
Design service life [years]	60
Availability [%]	85 or > 90 (target)

General data	
Construction period [months]	60
Core damage frequency, 1/year	<6.1 x 10^{-7}
Early large emissions frequency, 1/year	<1.77 x 10^{-8}
Residual heat removal systems	4 trains – active and passive
Feed systems	4 trains – active and passive
Corium catcher	Yes
MDE [g]	0.24
Primary circuit	
Number of main circulation loops	4
Primary circuit flow [m^3/s]	23.9
Operating (rated) pressure [MPa]	15.7
Secondary circuit	
Steam flow under rated conditions [kg/s]	1633
Steam temperature/pressure [°C/MPa]	278.5 / 6.27
Reactor core	
Core height [m]	3.53
Core equivalent diameter [m]	3.16
Number of fuel assemblies	163
Fuel assembly	Hexagonal
Maximal fuel enrichment [%]	4.28
Number of bundles with absorption elements	121
Average discharge burnup [MWd/kg]	54.6
Fuel	UO_2
Duration of the fuel campaign [м]	12÷18
Fuel quantity [t UO_2]	79.8
Reactor pressure vessel	
Internal diameter of the cylinder vessel [mm]	4195
Wall thickness of the cylinder vessel [mm]	195
Total height [mm]	11185
Main coolant pumps	
Number	4
Rated flowrate [m^3/h]	21500
Pressurizer	
Total volume [m^3]	79
Design pressure [MPa]	17.3

General data

Steam generators	
Number	4
Type	horizontal U-shaped pipes
Maximal external diameter [mm]	4490
Total length [mm]	13820
Primary containment	
Make	reinforced concrete
Volume [m^3]	63000
External containment	
Make	ferro-concrete

Apart from the large water inventory in the secondary circuit, this type of reactors are equipped with 8 additional two-stage hydro-accumulators with water inventory of 120 m^3 each, as well as an expanded spent fuel pond, which provides much greater additional time reserve for fuel cooling in case of accident. A distinguished feature of the WWER design is the location of the spent fuel pond (SFP) inside the containment.

The safety systems include: protection, localization, support, and control systems. The protection systems perform functions related with emergency core cooling and residual heat removal. They have active and passive parts. Each safety system has four independent trains; the trains' efficiency has been chosen based on the “single failure” principle. The safety systems trains are physically separated.

2.3.2 Description of A-2

The second option considered for the construction of a new nuclear unit is an entirely new PWR design of generation III or III+ reactors, with 1200 MW output. Generation III and III+ are advanced reactors, which have been developed based on the experience with the operation of second generation reactors.

The design will comply with the basic Safety Fundamentals Safety and Requirements of the International Atomic Energy Agency (IAEA).

The reactor models under review should comply with the safety criteria determined by the Bulgarian legislation, the IAEA documents and the European Utility Requirements (EUR) for LWR Nuclear Power Plants (requirements of the European NPP exploiting organisations with light water reactors). The WWER/PWR types of reactors were chosen based on the following considerations:

- → This type of reactors (WWER) have been successfully operated in Bulgarian since 1974;

→ Utilising the highly qualified staff at Kozloduy NPP site, who possess knowledge of many years on the respective technology;

→ The proposed technology is the most widely used one worldwide for electricity generation from nuclear source and approximately 80% of the reactors are precisely of that type.

Currently, over 430 nuclear power reactors with total installed capacity of about 370 GW_e are operating worldwide. A few dozens nuclear power plant units are in different construction phases – ***Figure 2.3-4****: Share of the PWR NNU which have already been constructed or are under construction by countries during the period 2004-2010.*

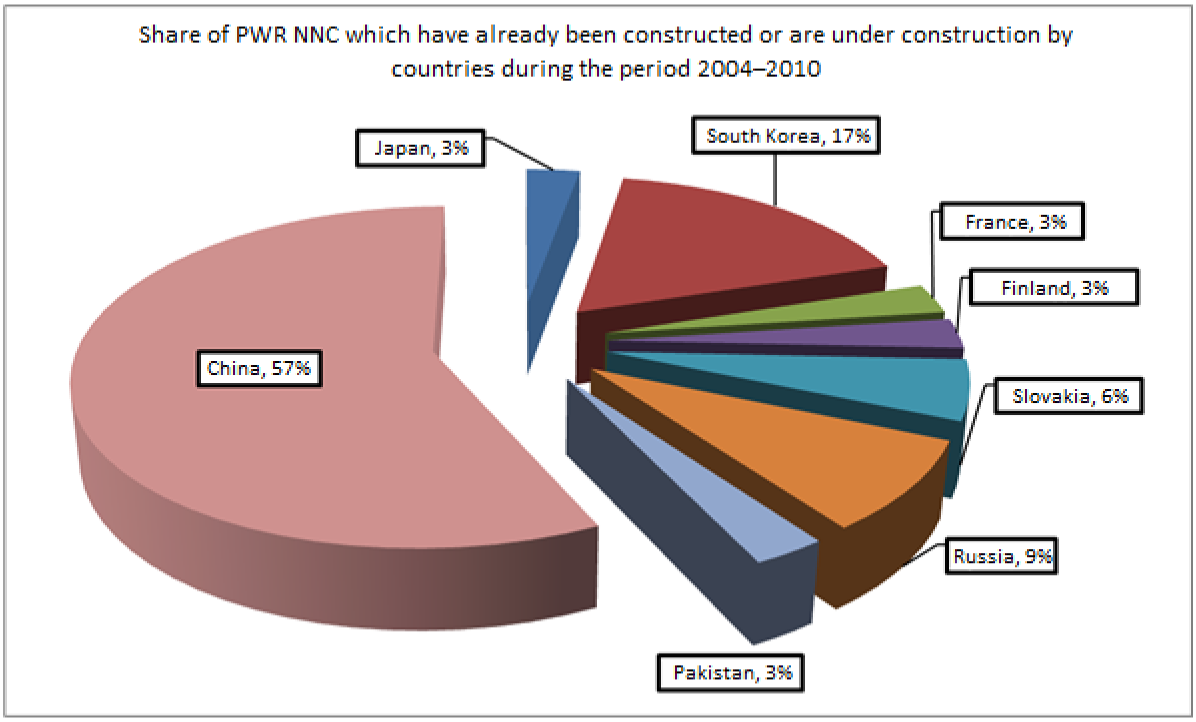


Figure 2.3-4: *Share of the PWR NNU which have already been constructed or are under construction by countries during the period 2004-2010.*

In parallel with the EIA project, a project for "Techno-economic analysis to justify the construction of a new nuclear power at the site of NPP" Kozloduy" (TEA) is carried out. With regards to alternative A-2 (a brand new project), there is a technical requirement in the TEA that the installed electric power be around 1200 MW. This requirement is defined by the fact that a number of normative documents recommend that the unit installed capacity does not exceed 10% of the total installed capacity in the country. Currently, the total installed capacity in Bulgarian is around 12200 MW. The emergency shutdown of a single power unit greater than 1200 MW would threaten the integrity of the electrical energy system of the country.

Considering that in recent years there have been nearly no new NUCLEAR POWER PLANT of III and III+ generations, the construction of the given type of reactor at the moment is considered an advantage.

According to the interim results of the "Techno-economic analysis to justify the construction of a new nuclear power at the site of NPP" Kozloduy ", a summary of currently available on the market models of PWR/WWER reactors, generation III or III + is shown on ***Error! Reference source not found.***

TABLE 2.3-1: REACTORS OF THE III OR III+ GENERATION

Model	EPR	EU-APWR	APR1400	AES2006	ATMEA1	AP1000
Manufacturer	Areva France	Mitsubishi Japan	Kepko Korea	Atomstroy-export Russia	Areva + Mitsubishi	Westing-house USA
El.capacity *(Gross)*	1770 MW	1700 MW	1455 MW	1170 MW	1200 MW	1200 MW
El.capcity *(Net)*	1650 MW	1620 MW	1400 MW	1082 MW	1150 MW	1117÷1154 MW
Certificate	EUR; URD-in progress	EUR-in progress; URD-in progress	URD-in progress	Design complying with the EUR requirements	Design complying with the EUR requirements	URD; EUR
Licese	France; iDAC; NRC-in process	NRC-in progress	KINS; NRC-pending	Rostehnadzor	In progress	NRC; iDAC
Construction	France Finalnd China	No	Corea UAE	Russia	No	China USA

Legend: EUR-European Utility Requirements; URD-Utility Requirements Document (US); iDAC – Interim Design Acceptance Confirmation (UK); NRC – Nuclear Regulatory Commission (US); KINS – Korean Institute for Nuclear Safety

In view of the objectives set out in the terms of reference for the techno-economic analysis, there are several nuclear reactors available on the market that meet the above requirements.

In the ToR for EIA of investment proposal "Construction of a new nuclear power of the latest generation of NPP " Kozloduy " the following two models of reactors are considered as examples:

- ✓ AES-2006;
- ✓ AP-1000.

The Atomstroyexport AES-2006 model is an evolutionary project of the AES-91/92 project, which was developed for NPP "Belene" as well. The AES-02 project has passed

EUR compliance asessments. Currently, the AES-2006 is constructed in Leningrad, Novovoronezh and Kaliningrad.

The Westinghouse AP-1000 has passed assessments for compliance with EUR and a license from NRC. Currently, it is constructed in China (4 units foreseen to be put into exploitation until 2015) and USA (14 units have received combined license for construction and exploitation from NRC)

These different engineering solutions are options of the Investment Intention which will be subject to environmental impact assessment. The environmental and safety requirements for all reactor types are identical and their impact will be assessed for their maximal potential values.

For the purposes of the REIA, the so-called conservative approach has been chosen whereas throughout the assessment values which result in the least favourable environmental effects will be considered.

2.3.2.1 REACTOR AP1000

Westinghouse AP1000 (Figure 2.3-5: AP1000 *Layout)* has been designed following the conventional configuration of a primary system with 2 circuits and 2 steam generators, with improvement some details (Figure 2.3-6: AP1000 *Primary circuit*).

AP1000 has been designed for thermal power output of 3400 MW_t and, depending on the specific conditions, rated power of 1117 MW. It was licensed in the USA and China, and it is currently being licensed in Europe by the British nuclear supervision authorities. Currently, the first four units are under construction in Sanmen and Haiyang, China.

FIGURE 2.3-5: AP1000 LAYOUT

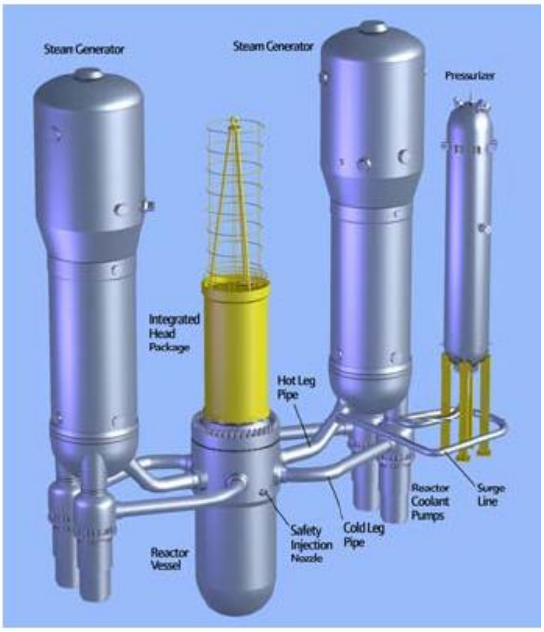


FIGURE 2.3-6: AP1000 PRIMARY CIRCUIT

The core contains 157 fuel assemblies similar to those in Doel-4 and Tihange-3, Belgium. AP1000 has systems for passive emergency cooling of the active zone and for cooling of the containment. This means that the active systems in AP1000, required only for the purpose of removing design basis emergency conditions, have been replaced by less complex passive systems, which are driven by gravitation, compressed gases, or natural circulation instead of using pumps. Moreover, AP1000 does not need high security class alternate current sources. The power needs during events of low probability, when the passive emergency system should be activated, are provided for by class 1E accumulators.

Compared to a standard power plant with identical production capacity, AP1000 has 35 % less pumps, 80 % less high safety class pipings, and 50 % less valves of safety class ASME. There are no high safety class pumps. This makes the AP1000 power plant much more compact compared to the older designs. Since the equipment and pipings have been reduced, the greater part of the safeguarding equipment is assembled within the containment. Therefore, AP1000 has approximately 55 % less pipe connections to the containment compared to the power plants of the current generation. The construction volume at earthquake class 1 is by about 45 % less compared to older designs for commensurate capacities. AP1000 features a relatively larger pressurizer, which allows it to adapt easier to different modes.

The passive core cooling system of AP1000 (Figure 2.3-7: AP1000 *Passive core cooling system)* uses core make-up tanks with boron water which have been designed so as to discharge into the reactor vessels and at various points of the primary circuit.

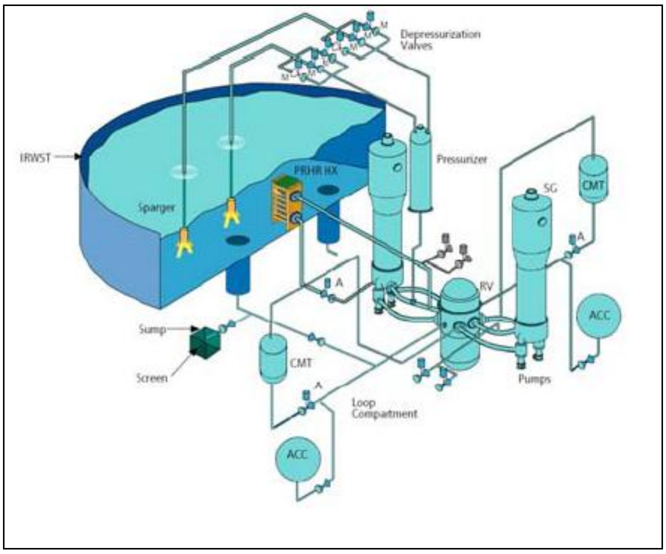


FIGURE 2.3-7: AP1000 PASSIVE CORE COOLING SYSTEM

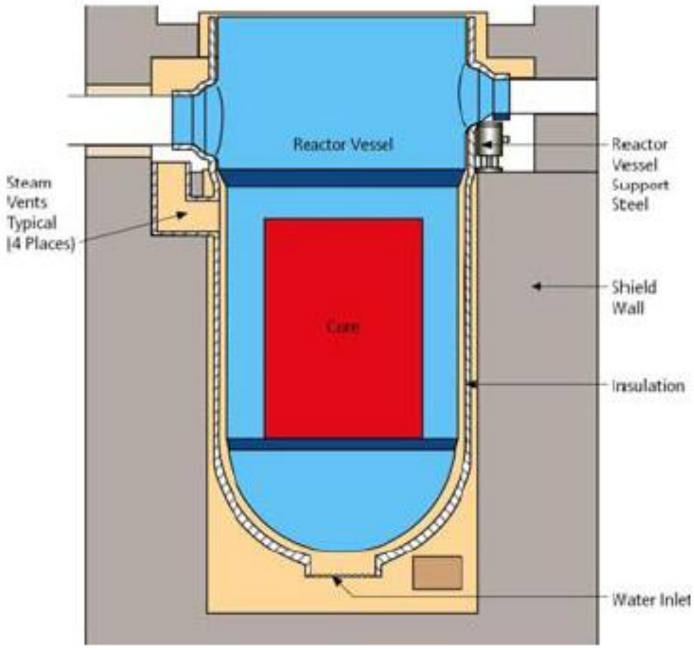


FIGURE 2.3-8: AP1000 INTERNAL VESSEL COOLING DESIGN

AP1000 has been designed to retain pieces from the molten core within the reactor vessel, so that no corium can penetrate the bottom of the reactor vessel. In case of severe accident, cooling water from the large reserve water tank used during refueling may be used to flood the reactor cavity and to cool the reactor vessel on the outside. The device is shown in Figure 2.3-8: AP1000 *Internal vessel cooling design*. The special-design insulation of the reactor vessel forms a ring which allows the cooling water to come in direct contact with the vessel. Vents have been provided allowing the steam to get out of the ring.

The vented steam condenses on the containment walls to be directed afterwards back to the cavity (Figure 2.3-9: AP1000 *Containment passive cooling*).

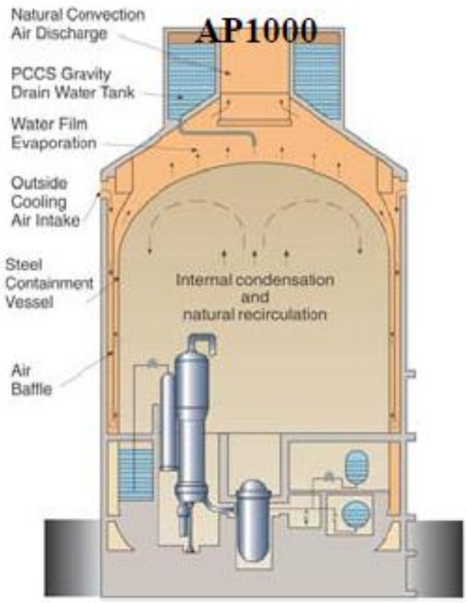


FIGURE 2.3-9: AP1000 CONTAINMENT PASSIVE COOLING

The major technical parameters of the *AP1000* design are as follows:

General data

Output, gross [MWe]	1200
Ouput, net [MWe]	1117÷1154
Thermal power output [MW]	3400
Efficiency [%]	33÷34
Operating mode	Basic and load following
Design service life [years]	60
Availability [%]	> 93
Construction period [months]	54
Core damange frequency, 1/year	5.11 x 10^{-7}
Early large emission frequency, 1/year	5.94 x 10^{-8}
Residual heat removal systems	Passive
Feed systems	Passive
Corium catcher	Yes, in the vessel
MDE [g]	0.3
Primary circuit	
Number of main circulation loops	2 hot / 4 cold

General data	
Primary circuit flowrate [m^3/s]	19.87
Operating (rated) pressure [MPa]	15.5
Secondary circuit	
Steam flowrate under rated conditions [kg/s]	1886
Steam temperature/pressure [°C/MPa]	272.78 / 5.76
Reactor core	
Core height [m]	4.267
Core equivalent diameter [m]	3.04
Number of fuel assemblies	157
Fuel assembly	Square
Maximal fuel enrichment [%]	4.8
Number of bundles with absorption elements	69
Average discharge burnup [MWd/kg]	60
Fuel	UO_2 or MOX
Duration of the fuel campaign [m]	18÷24
Fuel quantity [t UO_2]	95.97
Reactor pressure vessel	
Internal diameter of the cylinder vessel [mm]	4038.6
Wall thickness of the cylinder vessel [mm]	203
Total height [mm]	13944
Main coolant pumps	
Number	4
Rated flowrate [m^3/h]	17886
Pressurizer	
Total volume [m^3]	59.5
Design pressure [MPa]	17.1
Steam generators	
Number	2
Type	vertical, with U-shaped pipes
Maximal external diameter [mm]	6096

General data	
Total height [mm]	22460
Primary containment	
Make	steel
Volume [m³]	58333
External containment	
Make	reinforced concrete

2.3.2.2 REACTOR AES-2006

AES-2006 is a water-cooled water-moderated 1200 MW power reactor. This is the latest project of the Russian company *Atomstroyexport*, owned by the Russian State company *Rosatom*. This design is based on the design and operational experience of the WWER-1000 reactors and it develops further AES-92. The AES-2006 design is licensed in Russia. Currently, these units are under construction on the sites of the Novovoronezh, Leningrad, and Baltic power plants.

The safety functions of AES-2006 have been improved compared to the AES-92 power plants. With the AES-2006 power plant, both the active and passive systems are used to perform safety functions. Moreover, AES-2006 is furnished with severe accident control systems. The rated service life of the power plant is 60 years. With AES-2006, the structural protection against large aircraft crash is concentrated in the external containment and the fresh fuel storage facility.

A power plant with AES-2006 reactor type comprises the following major equipment and systems:

- Pressurized water reactor with thermal power output of 3200 MW with primary circuit coolant pressure 16.2 MPa, where the water with boron acid acts as a coolant and moderator in the reactor. The concentration of boron acid varies during operation. Slightly enriched uranium dioxide is used as a fuel;
- Four horizontal steam generators of the PGV-1000MKP type with pipe arrays, placed at great distance and forming a corridor. Each steam generator produces (1602+112) t/hour of dry saturated steam with pressure of 7.0 MPa;
- Four sets of main coolant pump of the GTsNA-1391 type;
- Main coolants pipe with nominal diameter Dn 850;
- Pressure compensation system;

- → Concrete reactor containment equipment;
- → Safety systems.

The safety systems of AES-2006 (B 491) consist of four completely independent trains. The power, the quick activation, and other line characteristics have been chosen based on the condition for providing nuclear and radiation safety with all initial events, envisaged in the design. Due to the fact that the safety system trains are located in separate bodies, high degree of physical separation is achieved. Each safety system trains is separated from the others by fire-proof physical barriers located along their whole length, including the connections from one compartment to another (FIGURE 2.3-10: AES-2006 (B 491) *Physical separation of the safety trains)*. No direct connections between the different safety trains are permitted. The safety systems are provided with physical protection against unauthorized staff access.

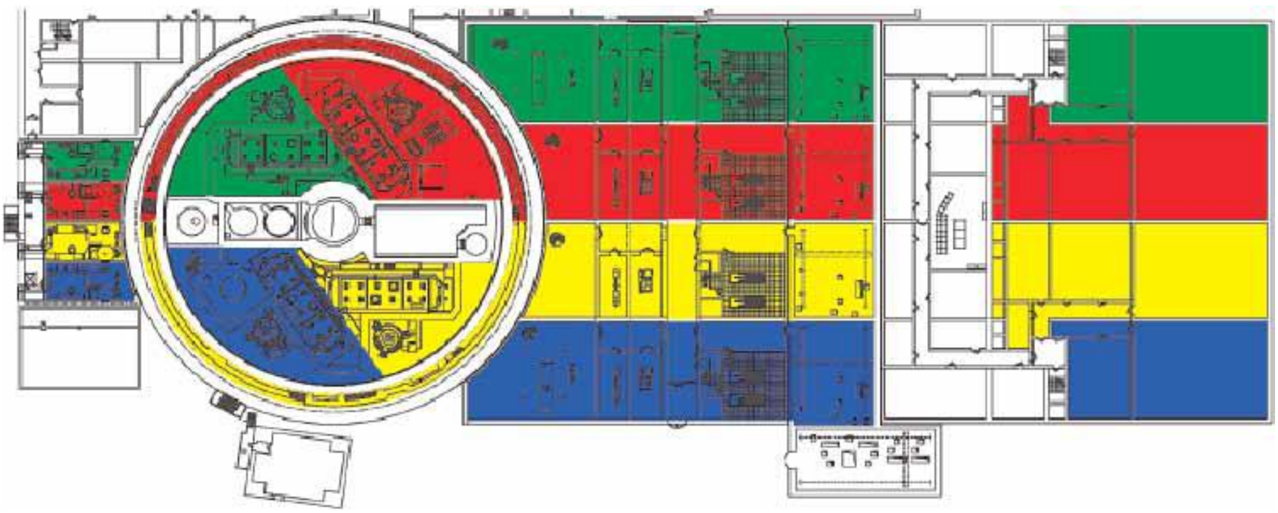


FIGURE 2.3-10: AES-2006 (B 491) PHYSICAL SEPARATION OF THE SAFETY TRAINS
(each shown in different color)

The technical solutions used in the AES-2006 design with WWEP-1200 preclude the occurrence of any severe beyond design basis accidents in case of occurrence of several single failures and subsequent failures of the safety system components. Such accidents may occur only in case of failure of several safety system trains, which is a rare event.

The localization systems are intended to prevent or restrict the spread of radioactive substances (as a result of accidents) within the NPP and their release into the surrounding environment. In principle, the primary containmentis is a cylinder made of prestressed reinforced concrete, with semi-spherical upper part and reinforced concrete plate as a basis. On the inside, it is lined with welded carbon steel sheets to ensure leak-tightness. The external container is a cylinder made of ferro-concrete, with semi-spherical upper part. The inlets of all pipings are firmly fixed to the walls of the inner body and are welded to the steel lining. All inlet pipes are equipped with localization valves (Figure 2.3-11: Containments AES-2006).

FIGURE 2.3-11: CONTAINMENTS AES-2006

The basic data for AES-2006 are as follows:

General data

Output, gross [MWe]	1170
Ouput, net [MWe]	1082
Thermal power output [MW]	3200
Efficiency [%]	34
Operating mode	Basic and load-following
Design service life [years]	60
Availability [%]	> 90
Construction period [months]	54
Core damange frequency, 1/year	< 1×10^{-6}
Early large emission frequency, 1/year	< 1×10^{-7}

General data

Residual heat removal systems	4 channels – active and passive
Feed systems	4 channels – active and passive
Corium catcher	Yes
MDE [g]	0.25
Primary circuit	
Number of main circulation loops	4
Primary circuit flowrate [m^3/s]	23.9
Operating (rated) pressure [MPa]	16.2
Secondary circuit	
Steam flowrate under rated conditions [kg/s]	1780
Steam temperature/pressure [°C/MPa]	286 / 7
Reactor core	
Core height [m]	3.73
Core equivalent diameter [m]	3.16
Number of fuel assemblies	163
Fuel assembly	Hexagonal
Maximal fuel enrichment [%]	5
Number of bundles with absorption elements	121
Average discharge burn-up [MWd/kg]	60
Fuel	UO_2
Duration of the fuel campaign [м]	12÷24
Fuel quantity [t UO_2]	87
Reactor pressure vessel	
Internal diameter of the cylinder vessel [mm]	4250
Wall thickness of the cylinder vessel [mm]	200
Total height [mm]	11185
Main coolant pumps	
Number	4
Rated flowrate [m3/h]	21500
Pressurizer	

General data	
Total volume [m^3]	79
Design pressure [MPa]	17.6
Steam generators	
Number	4
Type	Vertical, with U-shaped pipes
Maximal external diameter [mm]	5100
Total length [mm]	13820
Primary containment	
Make	Stressed concrete with steel lining
Volume [m^3]	74169
External containment	
Make	reinforced concrete

2.3.3 Spent Nuclear Fuel (SNF)

According to the project, each of the considered nuclear unit alternatives is furnished with a spent fuel pond. The fuel resides in such ponds for 3 to 5 years after which it may be transported outside the facility. The spent fuel pond (SFP) provides space for placing of fuel assemblies during unit outage works and for underwater storage of activated components. The safety requirements for the SFP involve provision of subcriticality of 5% in normal operating mode and in case of design basis accidents. This requirement is implemented through:

- limiting the space between assemblies of the assemblies storage areas;
- controlling the location of the SNF assemblies and restricting the possible displacements during transportation on the site, SNF handling and storage under normal operation conditions and under external impacts;
- controlling the system (component) parameters which affect nuclear safety during SNF management.

Data about the spent fuel ponds envisages in the NNU designs are presented on Table 2.3-2 -2 Spent fuel pond

TABLE 2.3-2 SPENT FUEL POND

Model	Location of the SNF pond	Number of fuel assemblies in the core	Capacity of the SNF pond (number of fuel assemblies)	Duration of the fuel campaign and part of the core to be refueled	Approximate total capacity	SNF pond cooling system	Additional cooling system	Cooling system under beyond design basis conditions
AP1000	**Auxiliary building outside the containment**	157	889	18 months 1/3 of the core	17 x 1/3 of the core	Passive	Active cooling and filtering system	Yes
AES-92 Hybrid	**In the containment**	163	580	12 months 1/3 of the core	10,7 x 1/3 of the core	Active	Sprinkler system in the containment	See previous
AES-2006	**In the containment**	163	(*)	18 months 1/3 of the core	approx. 10 years	Active	(*)	(*)

(*) No data available so far

The management strategy of the Republic of Bulgaria for the spent nuclear fuel and radioactive waste envisages an *open fuel cycle*/*once-through fuel cycle*. Essentially, this solution is not a cycle. After the fuel has been used, it is deposited in storage facilities, without any further processing other than packaging to provide better insulation for the radioactive substances from the biosphere. This is the preferred method for six countries: the United States, Canada, Sweden, Finland, Spain, and South Africa. Some countries, in particular Sweden and Canada, have designed such storage facilities to provide for future use of the nuclear material in case of need, while other countries plan permanent disposal in a geologic depot. In the Republic of Bulgaria, spent nuclear fuel is considered a usable resource, which may be processed to benefit the country. The Strategy envisages storing the SNF in intermediate storage facilities, using dry storage as preferred technology.

The availability of a dry spent fuel storage facility for fuel from the proposed models is important, especially until a storage facility is provided or if a decision for a *Wait and See* strategy has been made.

The considered NNU alternatives propose different solutions for SNF storage:

With **AES–92,** the dry storage facility is a separate building with capacity covering 20-year service life of one unit (72 containers). In the existing WWER-1000/V466B designs, the facility is common for the two units, whereas it has been assumed that it may be expanded furtheron to provide sufficient capacity for the entire service life.

In the by the reactor pools, the fuel is placed in CASTOR1000 containers which are then transported to a dry storage facility.

AP1000 is furnished with conceptual desings for dry storage facilities covering the full service life of the nuclear unit, whereas specifically for UK generic design assessment, Westinghouse proposes an underground storage facility with fuel storage in HI-STORM 100U containers developed by *Holtec International*. In one case or other, different dry storage systems are available on the market.

2.4 ZERO ALTERNATIVE

Taking into account the Governmental decision to renounce the *Belene* NNP Project and to erect NNU at Kozloduy NPP site instead, using the nuclear equipment produced for the *Belene* NNP Project, as well as the Decision of the Council of Ministers adopted by Protocol No.14 of April 11, 2012 for consent in principle to undertake actions required for the erection of a new nuclear unit at *Kozloduy* NNP, the zero alternative turns to be a practically impossible option.

In this context, the following two options are theoretically available:

- To look for another site in the country where to erect the required nuclear unit;

- To end completely the research and actions aimed at the erection of a new nuclear unit in the country.

The first option may be considered purely theoretically. *Kozloduy* NNP is the only operating licensed site, where the greater part of the associated infrastructure, required for the implementation of a new nuclear unit has already been built.

Actually, the *"Zero"* alternative, or the decision to not undertake any actions for the implementation of this Investment Intention at *Kozloduy* NNP site, means refusal to erect in the foreseeable future a new nuclear unit in the country. Such decision contradicts the objectives laid down in the country's National Energy Strategy for launching of new nuclear capacities and increase of the share of electric energy generated by nuclear power plants by 2020.

Of the two options mentioned above, the actually possible one is the second option, but only if considered detached from the country's energy needs. From the viewpoint of the electric energy sector, the dropping out of the possibility to erect a new nuclear unit means to erect another new non-nuclear 1000–2000 MW electricity generation unit. Taking into account the country's energy resources, the required new energy capacity will most probably have to be provided by thermal power stations, which will be located elsewhere. This will require making survey of a new site and new planning, technical works, preparation of the site and construction according to the accelerated time schedule, in view of erecting a thermal power station with output of 2000 MW.

"Zero" alternative environmental effects

The erection of a new unit replacing *Kozloduy* NNP, in case of dropping off the option for the erection of nuclear unit, could theoretically be implemented following different choices, the most probable of which is a new thermal power station, taking into account the energy resources and the fuel-energy balance of the country.

The erection of a new thermal power station with an output of 1000–2000 MW will cause problems in the energy sector at least in two aspects:

→ A new thermal power station with the mentioned capacity means a new large combustion plant (LCP), which should comply with the requirements of Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants. A more practical and cost-effective choice for the country is to erect a thermal power station (TPS) on lignite coal, but the research revealed that, with such fuel, the running TPSs exceed the allowed emission limit. Therefore, it is not practical and possible to erect a new lignite-coal TPS with such capacity, since such a project would not comply with the Directive's requirements. One could hardly believe that a TPS with such capacity based on import good-quality coal or based on import gas might be an economically preferable solution;

→ The erection of a new LCP – a lignite-coal TPS with capacity of 1000–2000 MW means increase of the gas emissions causing greenhouse effect and reduction of Bulgaria's chances to fulfil its obligations under the UN Framework Convention on Climate Change and the Guide of the Intergovernmental Panel on Climate Change (IPCC), and other international agreement and programs for protection of the environment.

For the purposes of analysing the environmental consequences of these two aspects, it would be expedient to present some world and national data.

On the one hand, it should be emphasized that the energy needs and installed power capacity worldwide are expected to increase during this century. This will result in abrupt increase of burnt conventional fuels, which will aggravate further the global negative effects related to greenhouse gases and climate change.

Against this background, the minimization of environmental impacts and, in particular, the economy of greenhouse gases with each new power capacity becomes essential, especially on the continental/regional and national scale. The latter will be specifically emphasized, taking into consideration the obligations under the UN Framework Convention on Climate Change, the Kioto Protocol and others.

In this context, the effects from electric power generation by TPS and NNP will be compared.

The controlled nuclear fission reaction produces vast amounts of electrical power out of small amounts of uranium fuel, with relatively small amount of generated radioactive waste. Compared to the waste from the stations using coal, the volume of NPP waste is more than 30 000 times less than the volume of TPS waste.

The effect of the large-scale use of nuclear energy on emission reduction becomes particularly evident, if we compare the generated national product per unit of emitted carbon dioxide. The data about 6 countries worldwide, which account for over 60 % of world economy and in which nearly half of the world's population lives, show that the amounts of CO_2 emissions are inversely proportional to the relative participation share of nuclear power in the relevant national energy sector. Moreover, the experience of the greatest emitter of carbon dioxide in the world, the USA, shows that more than 75 % of the entire amount of "economized" emissions during the production of electrical energy are due to nuclear power, and less than 1 % - to solar and wind energy.

These examples of the role of nuclear energy in the "power engineering – environment" system, as well as the numerous related publications of a number of international organizations, such as the IAEA, Euratom, the World Nuclear Association and more are indicative of the environmental impact correlations and the conclusions derived therefrom are greatly applicable to each country.

With respect to nowadays conditions in our country, the commitments of the Bulgarian Government in the field of power engineering and environment relating to the closure of Chapter *Environment* and the negotiations on the preparation for Bulgaria's accession to the European Union, and more specifically, the transposition into national law of Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants should be emphasized. On the other hand, the erection of a new 2000 MW capacity is related with certain time limits under the *Minimal Cost Development Plan for the Electrical Energy Sector of the Republic of Bulgaria during the Period 2004–2020*.

To compare the environmental impacts of a new TPS on lignite coal erected in our country of commensurate capacity to the one proposed by the Investment Proposal for the erection of *Kozloduy* NNP, the actual impact parameters of the greatest TPS running in the country, *Maritsa–Iztok 2* TPS, will be used, notwithstanding that its installed capacity of 1587 MW is by about 24.4 % greater than the envisaged 1 200 MW for *Kozloduy* NNP site.

The conducted national-scale research regarding the possibility to apply Directive 2001/80/EC shows that the *Maritsa–Iztok 2* TPS is the number one energy source of SO_2 emissions and number four source of NO_X emissions, generating accordingly 44 % and 11 % of these emissions in the country. Obviously, from this point of view, it is not acceptable to erect in the country yet another emitter with such capacity, especially in view of Bulgaria's commitments to reduce SO_2 emissions.

To assess the "greenhouse gas emission economy" effect from the operation of *Kozloduy* NNP compared to a lignite-coal TPS with equal capacity, only one example with the *Maritsa–Iztok 2* TPS will suffice:

The installed electrical capacity of *Maritsa–Iztok 2* TPS is 1450 MW, and the thermal power capacity is 2420 MWth. During the period 1996–2000, the TPS has had 6.995 mill. tons of average coal consumption from the *Maritsa–Iztok* coal-field. With average thermal generation capacity of the coal of 6.12 kJ/g and C=18.4 %, the calculated average annual CO_2 emissions amount to about 4.724 mill. tons. These emissions account for 38 % of the greenhouse gas emission reduction required by the Kioto Protocol for Bulgaria – 12.4 mill. tons of CO_2-equivalent. Obviously, from this point of view as well, it is not acceptable to erect in the country yet another emitter with such capacity, which will result in approximate increase of 4.7 mill. tons of annual CO_2 emissions from Bulgaria.

Therefore, it could be summarized that, from the viewpoint of greenhouse gas, SO_2, NOx, dust, and other emissions, the *"zero"* alternative of replacing the new nuclear unit at *Kozloduy* NNP site, which does not emit into the atmosphere such harmful substances, by a TPS with equivalent and even smaller capacity, is not advisable.

3 CHARACTERISTICS OF THE ENVIRONMENT IN WHICH THE INVESTMENT PROPOSAL WILL BE IMPLEMENTED AND ESTIMATE OF THE IMPACT

3.1 CLIMATE AND ATMOSPHERIC AIR

3.1.1 CLIMATE

The considered region surrounding the *Kozloduy* NNP is located in the western part of two climatic regions according to Bulgaria's climatic zoning – the North and Middle climatic region of the Danube hilly plain of the Moderate-Continental climate subzone.

The climate in this region is characterized as pronouncedly continental for the abrupt contrast between winter and summer thermal conditions. The average annual air temperature amplitude is between 24.5°C and 26°C – the highest for the country. The climate's continental nature is also confirmed by the precipitation regime in the region. The annual precipitation is between 540 mm and 580 mm, whereas the maximum is in June and the minimum – in February. The difference between the precipitation total for the three summer months and the three winter months is between 70 mm and 120 mm, i.e. 15% - 20% of their annual total. The absolute maximum 24-hour precipitations are in summer, reaching about 100 mm – 130 mm. Summer precipitations, however, are concentrated around certain dates and, especially during the second part of summer, droughts are quite often to occur. In both summer and autumn there are 4-5 periods without precipitation, with duration of over 10 days and average duration of 16-20 days. In some years, even longer draught periods are observed.

In the parts of the region westward of the Ogosta river, the influence of the Stara Planina mountain can be felt. It is expressed in the annual precipitation distribution, whereas the seasonal precipitation totals are almost identical, without abrupt extremities, which results from the relative increase of winter precipitations and decrease of summer precipitations.

The dynamics of air transport in the surface layer is characterized by the wind rose. The indented relief and proximity of the Danube river, which is considered as a big aeration channel, have significant effect on the local climate. It results in the appearance of material inhomogeneities in the meteorological element fields and, particularly such ones as the minimum temperatures and ground wind, which are pronouncedly sensitive to the form and location of the terrain. The establishment of these inhomogeneities is of great significance for many meteorological tasks and, in particular, for the spread of pollutants in atmospheric air.

Until 1997, the climatic characteristic of the region was based on data determined using statistics of the regular climatic observations of the *Kozloduy* station, performed during the period 1970–1982, as well as observations from the *Lom* station. After 1997, real meteorological data were used, obtained from three meteorological stations, corresponding to class III, which were united in Automated Meteorological Monitoring System (AMMS). The first of them was installed on an external radiation control site, representative of the observed region (Automatic Measurement Station – External Radiation Control [AMS–ERC]), and the other two are located in the *Blatoto (The Swamp)* locality and in the village of Harlets.

To assess microclimate in the region, report on tasks assigned by the Central Office of the consortium "*Meteorological Systems and Equipment* will be mostly used, as well as official publications which have been published on the Internet.

3.1.1.1 CLIMAT PARAMETERS

3.1.1.1.1 Air temperature

The mean annual air temperature in the studied region for 2009, 2010 and 2011[21] is about 13°C.

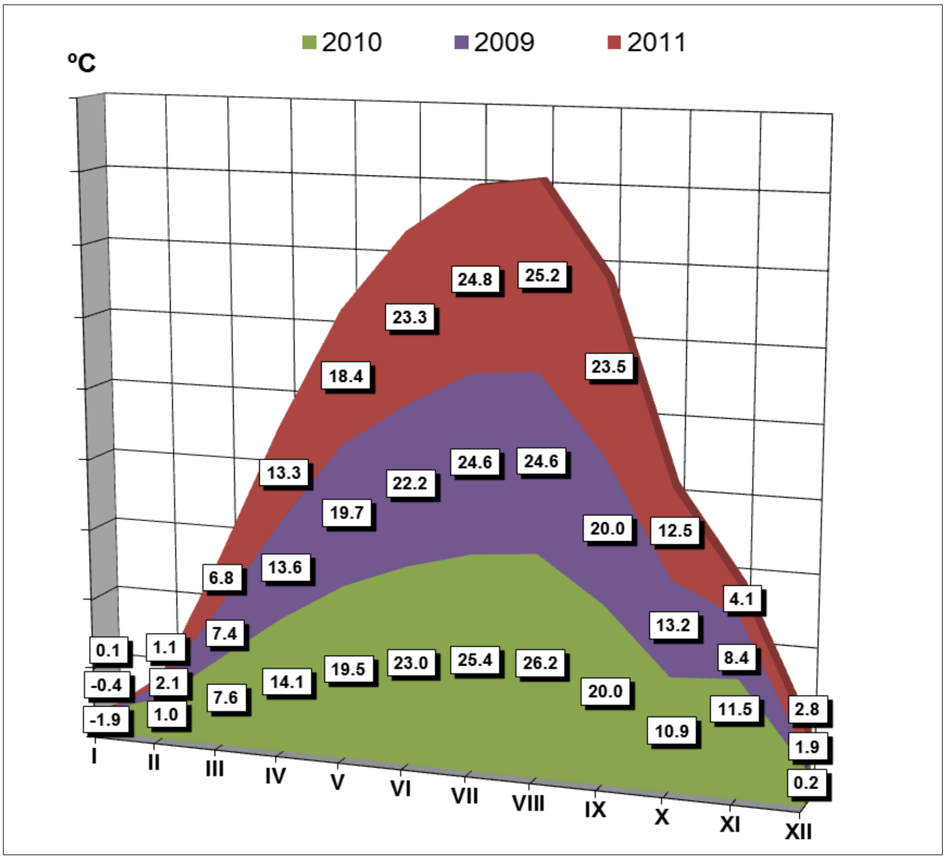


FIGURE 3.1-1: MEAN MONTHLY TEMPERATURES FOR THE PERIOD 2009÷2011

The annual course of the mean monthly temperatures displays a maximum in July (from 25.2°C to 26.2°C) and a minimum in January (from 0.1°C to minus 1.9°C). For the three

21 Reports on: Local Meteorological Conditions in the Region of *Kozloduy* NPP, 2009, 2010 and 2011.

years, the mean temperatures for the winter season are about 0.8°C, and for the summer season – 24.4°C. The mean temperatures for winter and spring are 13°C (*Figure 3.1-1: Mean monthly temperatures for the period 2009÷2011)*. In *Figure 3.1-2: Temperature roses in gradation for 2009, Figure 3.1-3: Temperature roses in gradation for 2010* and *Figure 3.1-4: Temperature roses in gradation for 2011,* the temperature frequency in gradation, spaced at 10 degrees, over the 16 sectors of wind direction for the period 2009÷2011, or the so-called "temperature roses in gradation", is presented.

The greatest percent falls to temperatures in the interval (+5°C to +15°C) with north-northeast and south wind (above 3% individually). Positive temperatures (above 0°C) exceed 80%, and the mean monthly temperature during the warmest month (July) from the three years is lowest for 2009 - 24.2°C (see Figure 3.1-1: Mean monthly temperatures for the period 2009÷2011).

In 2010, the greatest percent falls to temperatures in the interval (+15°C to +25°C) with west-southwest winds (3.7 %). Positive temperatures (above 0°C) exceed 86 %, which shows that 2010 was much warmer than 2009. The mean monthly temperature during the warmest month (July) is highest - 26.2°C (Figure 3.1-1: Mean monthly temperatures for the period 2009÷2011).

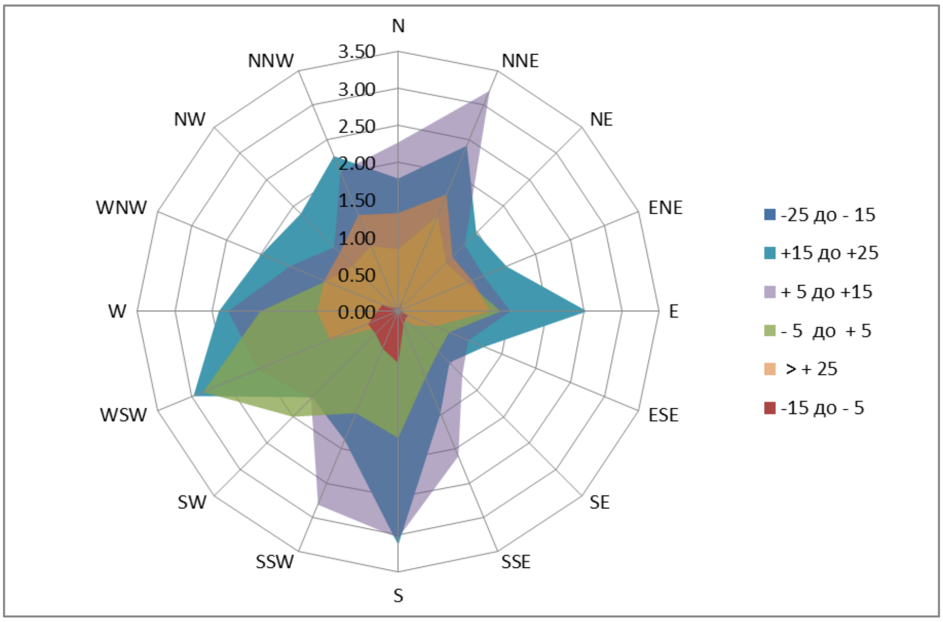


FIGURE 3.1-2: TEMPERATURE ROSES IN GRADATION FOR 2009

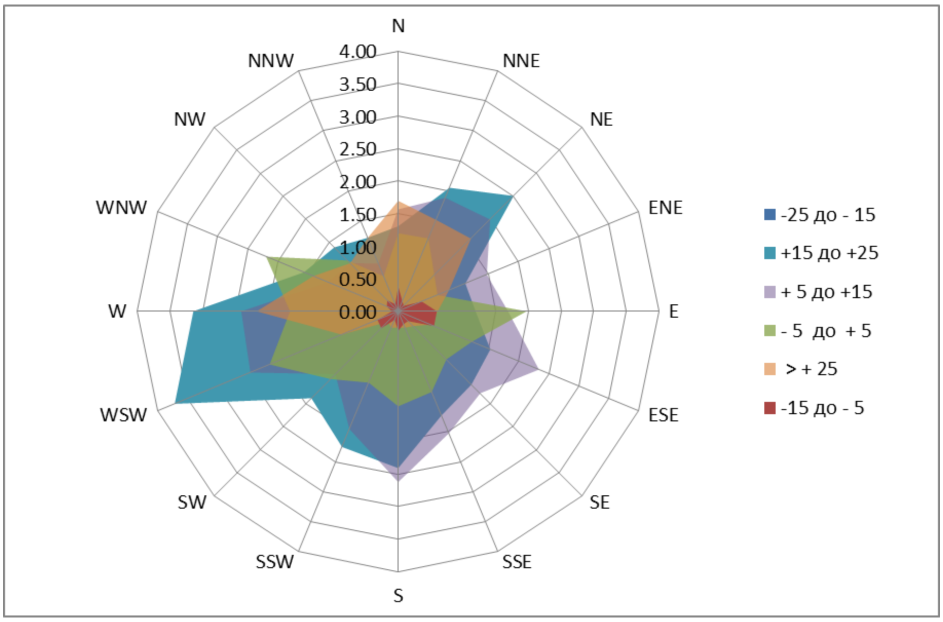


Figure 3.1-3: *Temperature roses in gradation for 2010*

In 2011, many cases of temperature in the interval (+15°C to +25°C) with purely south winds (4.7 %) are observed, but nevertheless, the positive temperatures (above 0°C) are only 75 %.

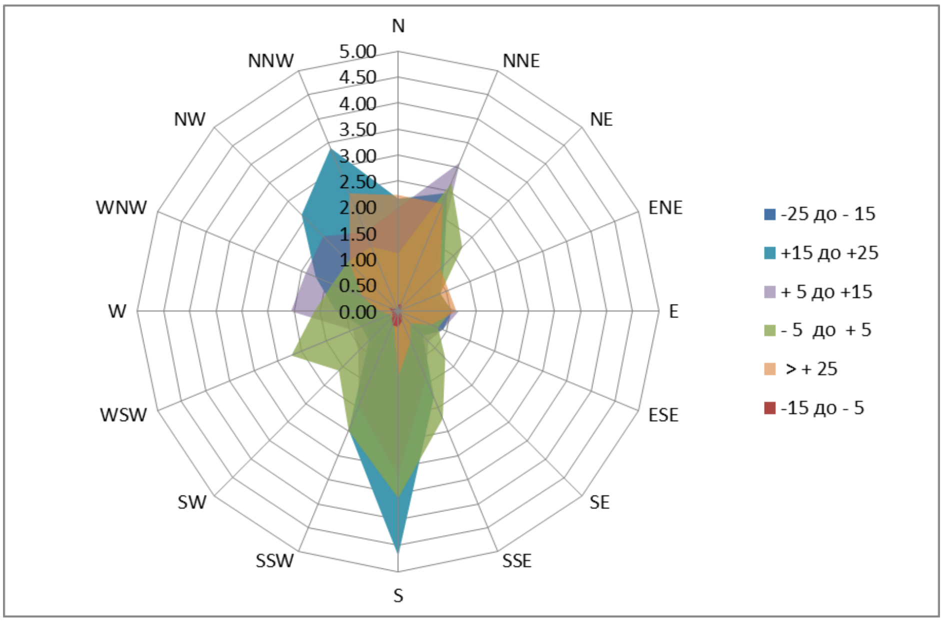


Figure 3.1-4: *Temperature roses in gradation for 2011*

Table 3.1-1: ***Extreme temperatures for 2009, 2010 and 2011***, shows the extreme temperature values in the region of *Kozloduy* NPP for 2009, 2010 and 2011. In the column "Date [hour:min]", the date and the exact time of their recording are shown.

Table 3.1-1: *Extreme temperatures for 2009, 2010 and 2011*

T [°C]	Minimum°C	Date [hour:min]	Maximum °C	Date [hour:min]
2009	-16.3	05.01.2009 [08:24]	38.8	24.07.2009 [17:50]
2010	-19.3	26.01.2010 [00:41]	39.8	28.08.2010 [16:50]
2011	-11.7	26.01.2011 [07:28]	38.9	16.07.2011 [15:23]

3.1.1.1.2 Precipitations

Table 3.1-2: ***Annual precipitations (mm) for a period of 8*** , shows the annual precipitation totals over a period of 8 years - 2004÷2011, based on the reports ***Local Meteorological Conditions for the Region of Kozloduy NPP*** for these years.

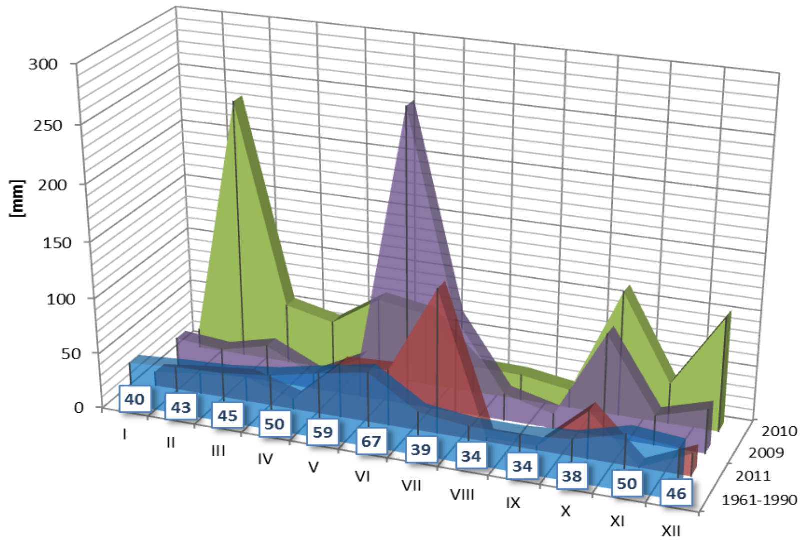
Table 3.1-2: *Annual precipitations (mm) for a period of 8 years*

Year	Amount mm	Year	Amount mm
2004	305.5	2008	422.2
2005	532.8	2009	676.7
2006	234.0	2010	801.8
2007	518.8	2011	363.2

The averaged annual precipitation total for the period of 8 years is 481.9 mm, which is below the climatic norm (1961–1990)[22] for the precipitations in the region - 545 mm.

Figure 3.1-6***: Deviations of the monthly precipitation totals from the climatic norm for the period 2009÷2011***, shows the deviation of the monthly precipitation totals from the climatic norm.

22 The World Meteorological Organization (WMO) has defined the climatic norm as the average value of a given climatic element for a fixed baseline period of 30 years. The baseline periods adopted so far are 1901-1930, 1931-1960, 1961-1990.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1961-1990	40	43	45	50	59	67	39	34	34	38	50	46
2011	12.9	18.4	22.3	9.3	48.4	50.5	129.6	3.8	3.8	43.2	0.5	20.5
2009	26.7	22.9	33.3	13.3	35.4	263	85.4	24.1	13.3	92.7	26.7	39.9
2010	17.6	233.4	54.1	44.5	72.4	65.6	23.8	22.8	16.2	112.2	36.4	102.8

Figure 3.1-5: *Precipitations for the period 2009÷2011 and climatic norm for 1961-1990*

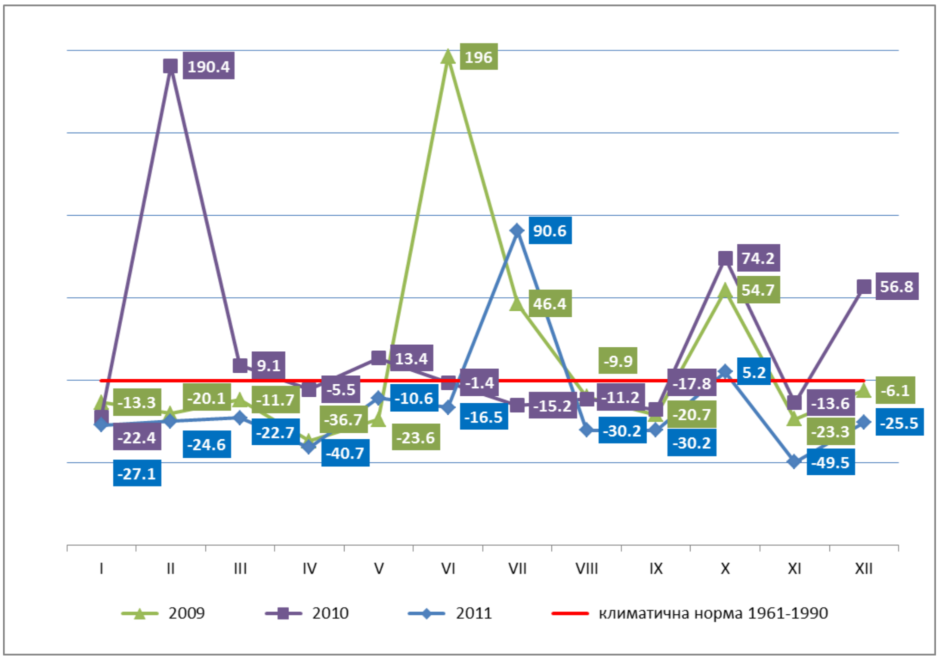
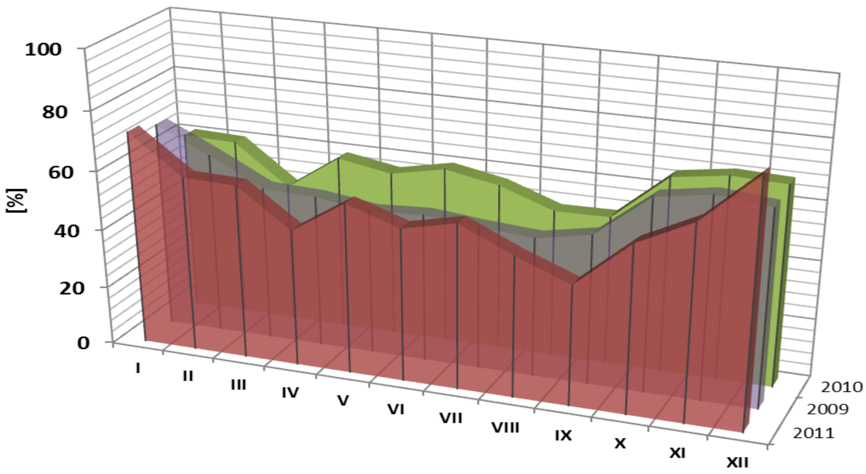


Figure 3.1-6: *Deviations of the monthly precipitation totals from the climatic norm for the period 2009÷2011*



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2011	72.7	59.7	59.2	46.5	57.9	52.0	56.1	47.9	41.0	56.9	66.0	82.8
2009	69.7	61.4	52.4	51.7	49.3	50.3	48.6	47.4	50.9	65.5	68.5	66.8
2010	60.9	60.3	47.2	59.1	56.1	59.8	56.5	50.2	50.5	66.0	68.7	68.1

Figure 3.1-7: *Relative humidity for the period 2009÷2011*

3.1.1.1.3 Relative humidity

Relative humidity above 60 % is observed in winter months and in the last 2 autumn months. Maximum of relative humidity was observed in December 2011 (above 82 %), notwithstanding that the average relative humidity for this year was lower than the average relative humidity for 2009 (Figure 3.1-7***: Relative humidity for the period 2009÷2011***)

In August, the frequency of the rush-ins of fresh and moist Atlantic air is relatively low, therefore, namely at this time, the lowest values of relative humidity are observed.

3.1.1.1.4 Wind

The dynamics of air movements in the surface layer is characterized by the wind rose – the wind speed and wind direction, measured in 16 directions: The wind at a given place is one of the meteorological elements, which depend strongly on local conditions and, especially, on relief form. The hilly relief results in redistribution and deformation of air flow resulting in change of both wind speed and the frequency of the prevailing directions. For a region as the considered one, the closeness of a large water basin, such as the Danube river (aeration channel), also exerts some impact.

In Figure 3.1-8***: Wind rose for 2009***, Figure 3.1-9***: Wind rose for 2010*** and Figure 3.1-10***: Wind rose for 2011***, the wind roses for wind speed gradations for 2009, 2010 and 2011 are shown. The coloured area for each wind speed range indicates in percents the speed share for this interval in all wind cases throughout the year.

The percentage of "calm conditions" (the cases of wind velocity below 1 m/s) is 8.8%, 5.2% and 7.7%, accordingly.

In 2009, the greatest component was the southern one at low wind speeds between 2 and 2.9 m/s (their share in all speeds being 29.6%), and in the interval between 3 and 4.9 m/s, the greatest frequency was the frequency of northeast winds (Figure 3.1-8***: Wind rose for 2009***). The wind share in the interval 1÷7 m/s amounts to 97.8% of the cases.

In 2010, the greatest component was the western one at wind speeds between 3 m/s and 4.9m/s (their share in all speeds being 30.4 %) and between 5 m/s and 6.9 m/s (Figure 3.1-9***: Wind rose for 2010***). The wind share in the interval 1 m/s ÷7 m/s amounts to 96.9 % of the cases.

In 2011, the greatest component was the southern one at wind speeds between 1 m/s and 1.9 m/s (their share in all speeds being 31%) (Figure 3.1-10***: Wind rose for 2011***). The wind share in the interval 1 m/s ÷7 m/s amounts to 97.9% of the cases.

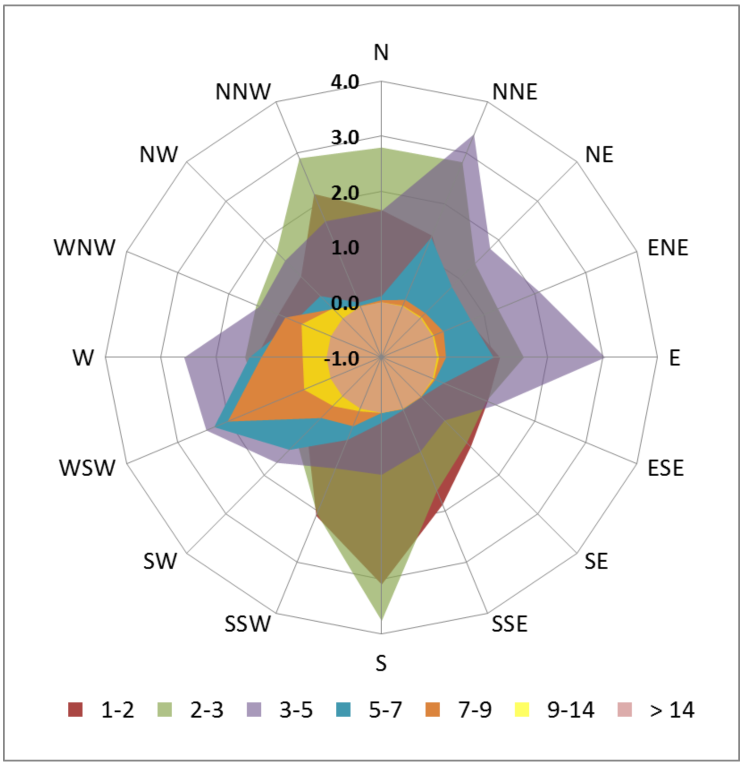


Figure 3.1-8: *Wind rose for 2009*

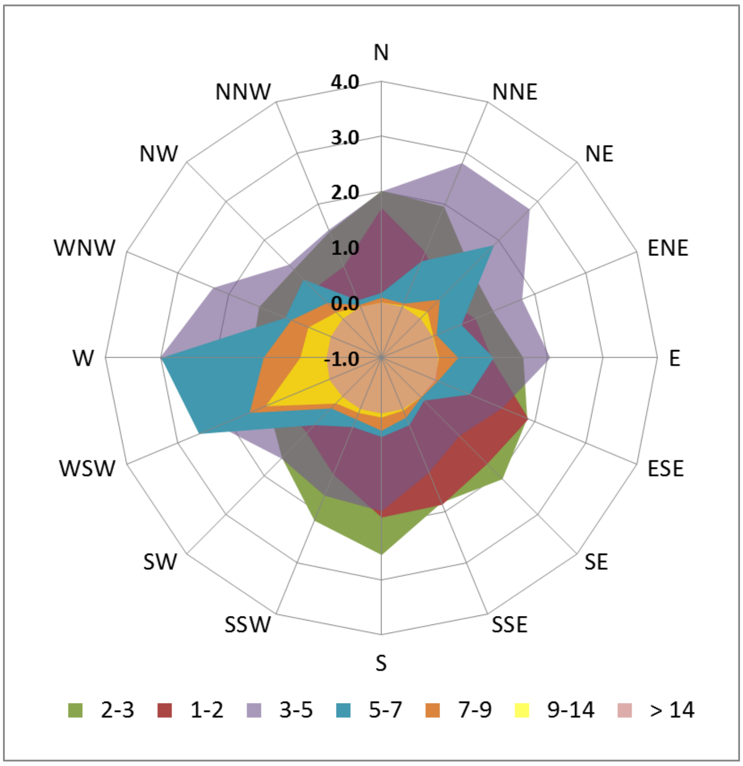


Figure 3.1-9: *Wind rose for 2010*

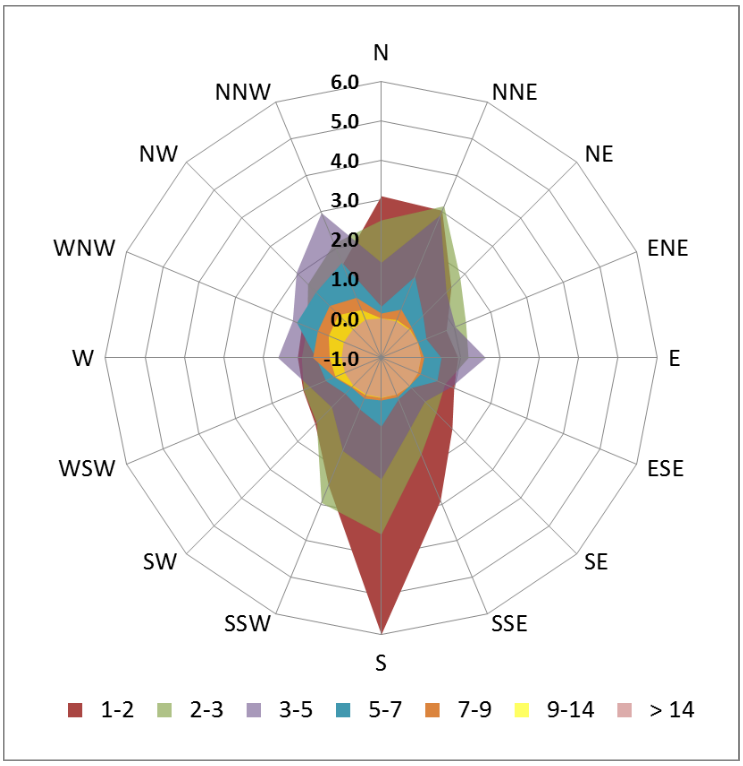


Figure 3.1-10: *Wind rose for 2011*

The extreme values for wind speed are presented in Table 3.1-3***: Extreme speeds for 2009, 2010 and 2011*** It is worth noting that, apart from these three years, they always came from the north[23].

Table 3.1-3: *Extreme speeds for 2009, 2010 and 2011*

	Maximum	Date [hour:min]
2009	34.6 m/s from direction 357º (north)	21.03.2009 [12:10]
2010	26.0 m/s from direction 357º (north)	09.12.2010 [22:35]
2011	23.5 m/s from direction 357º (north)	28.11.2011 [14:58]

3.1.1.1.5 Annual characteristics of Pasquill atmospheric stability classes for the region of Kozloduy NPP

For the purpose of calculating the radiation exposures in the region of *Kozloduy* NPP, one should have information about the state of atmospheric turbulence, which determines the possibility for spread of impurities in atmospheric air. The major part of the diffusion models most oftenly use the Pasquill atmospheric stability classes. There are 6 atmospheric stability classes: ***A – very unstable***, ***B – unstable***, ***C – slightly unstable***, ***D – neutra***, ***E – slightly stable*** and ***F – stable***.

Under unstable atmospheric conditions (classes **A**, **B** and **C**), the pollutants diffusion takes place very quickly because of the strong turbulence in the vertical direction, which results in quick vertical mixing of the pollutants with the ambient air masses. Although these conditions are favourable for the pollutants diffusion, single occurrences of large ground concentrations may be observed near the source at small wind speeds in the early hours of the day in sunny weather.

Under stable atmospheric conditions (classes **E** and **F**), the lack of or too weak turbulence prevents the spread of impurities in the vertical direction and transports them in the horizontal one but, on account of the too weak or lacking winds, the pollution may stay for a long time in the region around the source. Such conditions occur in the presence of inversions in the late evening hours or at night.

The neutral atmospheric condition (class **D**) is observed in cloudy weather or on sunny days in the hours between the break-down of the inversions formed at night (increase of

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23 Reports on: Local Meteorological Conditions in the Region of *Kozloduy* NPP, 2004, 2005, 2006, 2007 and 2008.

temperature with height) and the development of the unstable daily conditions. Then, lower ground-level concentrations are observed.

Figure 3.1-11: Rose of Pasquill atmospheric stability classes for 2009, Figure 3.1-12: Rose of Pasquill atmospheric stability classes for 2010 and *Figure 3.1-13: Rose of Pasquill atmospheric stability classes for 201,* show the roses of the stability classes for 2009, 2010 and 2011, accordingly. The coloured area for each stability class indicates in percents the share of the relevant class in all classes observed during the year.

In 2009, the greatest share was that of slight atmospheric stability (class **E**) - 54.15%, the frequency of southern winds being highest – 6.8% - *Figure 3.1-11: Rose of Pasquill atmospheric stability classes for 2009* The share of the neutral conditions – class **D** is 32.5%, the frequency of west-southwest winds being highest – 4.8 %. The unstable atmospheric conditions (class **A**, **B** and **C**) feature a share of only 8.7% in the cases.

In 2010, the greatest share was that of slight atmospheric stability (class **C**) - 28.6%, the frequency of western winds being highest – 3.4% - *Figure 3.1-12: Rose of Pasquill atmospheric stability classes for 2010* Then follows class **E** with share of 27.8%. The share of the neutral conditions – class **D** is 22.1%, the frequency of west-southwest winds being highest – 3.4 %. The unstable atmospheric conditions (classes **A** and **B**) feature a share of 11.3% in the cases.

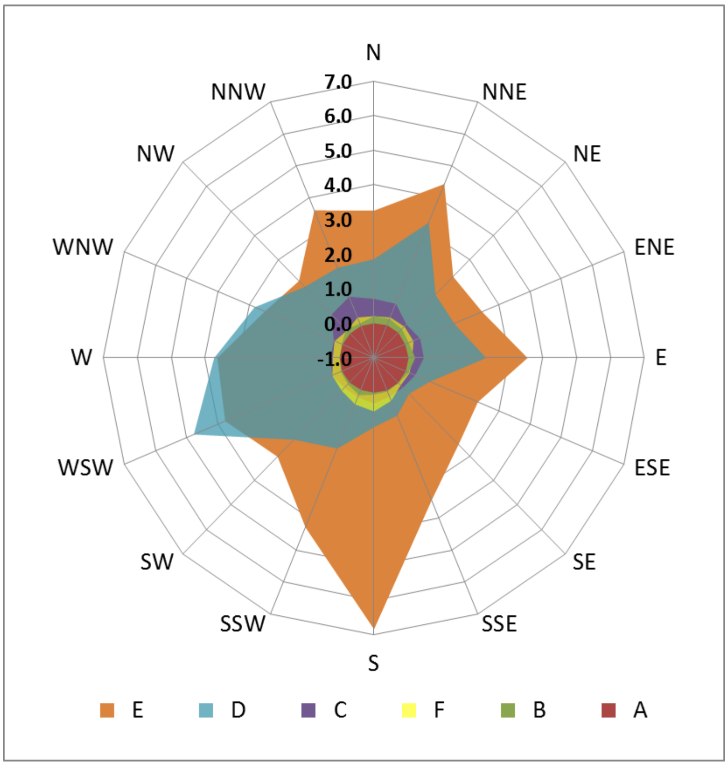

Figure 3.1-11*: Rose of Pasquill atmospheric stability classes for 2009*

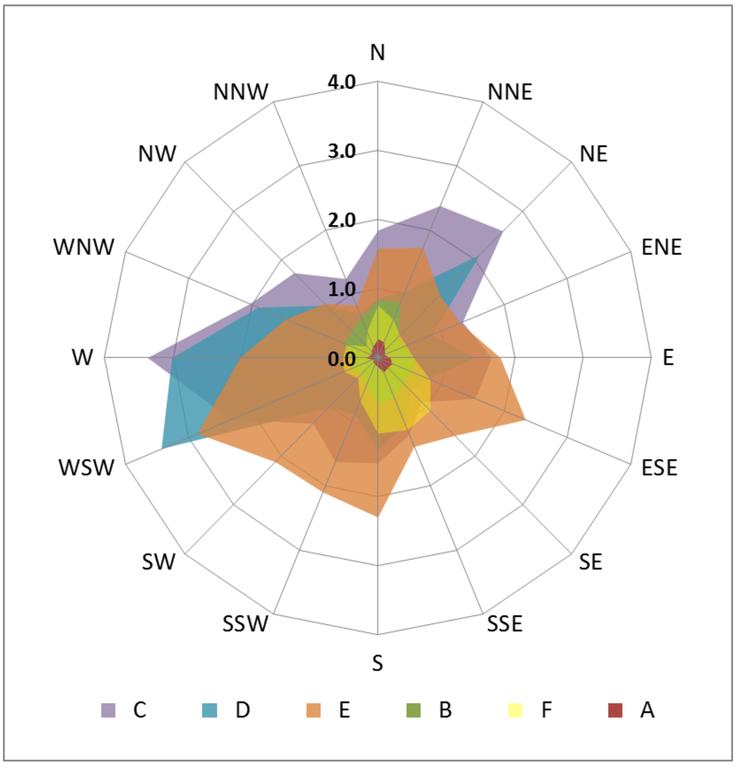

Figure 3.1-12: *Rose of Pasquill atmospheric stability classes for 2010*

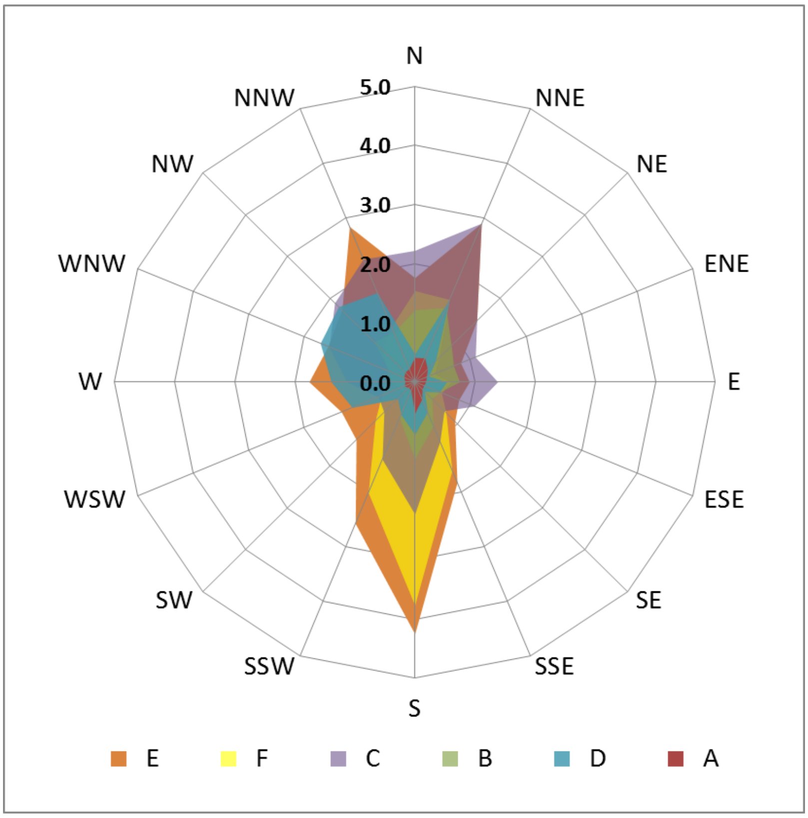

Figure 3.1-13: *Rose of Pasquill atmospheric stability classes for 2011*

In 2011, the greatest share was that of slight atmospheric stability (class **E**) - 28.8%, the frequency of southern winds being highest – 4.2% - *Figure 3.1-13: Rose of Pasquill atmospheric stability classes for 201*. Next comes class **C** with share of 23.7%. The share of the class of the neutral conditions – class D, amounts to 14%, the frequency of the winds from the north-western quarter of the horizon being highest. The unstable atmospheric conditions (classes **A** and **B**) have a share of 15.9% in the cases.

3.1.1.1.6 Cloudiness

The amount and type of cloudiess is determined by the nature of the barric systems and their interaction with relief. The annual cloudiness course for the region is determined by the annual circulation course, the humidity course, and air layer stratification. From the middle of autumn to the end of winter the amount of low and total cloudiness increases due to the increase of atmospheric stability and the decrease of the height of condensation level. The maximum of the total cloudiness is observed in December – 7.4 clear and the number of „gloomy" days (with cloudiness of 8-10 clear) – 17 days on average. During the cold half of the year the cloudiness is greatest in the morning hours and lowest in the evening ones.

The annual minimum of total cloudiness is in August when anticyclone weather prevails. Cloudiness is mostly convective. In the considered region the mean total cloudiness for August is 2.4-2.8 clear. At the same time, a maximum of the clear days is also observed (cloudiness of 0-2 clear), which make about 50% of the days in the month. In August, the monthly number of cases with clear skies is smallest (about 15) in the noon hours, and greatest in the morning or evening hours (20-25).

3.1.1.1.7 Fogs

The data from *Lom* and *Oryahovo* stations regarding the number of foggy days (

Table 3.1-4*:*) are quite close, which may provide grounds to assume that they are close to the values typical for the region and for *Kozloduy* NNP in particular.

Table 3.1-4*: Number of foggy days by months and annually*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Lom	7.7	6.2	3.5	0.6	0.4	0.1	0.1	0.1	1.0	5.6	6.4	9.8	41.3
Oruahovo	7.8	7.0	3.4	1.2	0.7	0.7	0.5	0.3	0.7	4.7	7.3	10.1	44.5

The typical thing about fog duration is that, in Lom, throughout the year, fogs most often last less than 24 hours. January is the only month during which 7 % of the fogs lasted 1-2 days, and only 1% of them lasted up to 2-3 days. In October, only 4% of the fogs lasted 1-2 days. The duration of fogs during the other winter months is within the same range. In Oryahovo, the percentage for January is somewhat different - 80% of the fogs lasting up to 1 day, 14% lasting 1-2 days, 5% lasting up to 2-3 days, and only 1% lasting more than 3 days.

The mentioned noticeable differences lead to the conclusion that there are no grounds to assume that fog data from the adjacent stations are characteristic of regions, such as *Kozloduy* NPP. Therefore, observations of the fog regime on the NPP's site should be carried out. This holds for horizontal visibility, too.

3.1.1.1.8 Snow cover

Regarding the climatic characteristics of the *snow cover* in the region of *Kozloduy* NPP, conclusions may be drawn from the data from the climatic stations of the NIMH-BAS, located in the region. The results from the climatic processing of these data are presented most completely in the *Climate Directory for the People's Republic of Bulgaria*, volume 2 (1979) - Table 3.1-5: *Climatic characteristics of snow cover.*

Table 3.1-5: *Climatic characteristics of snow cover*

Snow cover (SC) parameter	Lom	Oryahovo
Average SC height cm	XII – 5÷9; I – 9÷12; II – 8÷12; III – 3÷6;	XII – 2÷6; I – 6÷7; II – 10
Average number of days with SC	XII–5; I–20; II–16; III–3	XII–7; I–16; II–14; III–4
Average monthly SC height cm	XII–13; I–25; II–25; III–11	No data available
Maximal monthly SC height (cm)	XI-27; XII–70; I–111; II–104; III–81; IV-8	No data available
Monthly number of days with SC height cm: **a) 10÷20** **б) 20÷50** **в) ≥ 50 cm**	 XII–4; I–11; II–9 I–6; II–6 Not available	No data available

3.1.1.2 METEOROLOGICAL PHENOMENA

3.1.1.2.1 Hail phenomena

The greatest hail frequency with damages of the studied region is observed in July (about 36%), followed by June (32%) and May (17%) – *Climate of Bulgaria*, 1991. Their frequency is negligible in April, September and October. The 24-hour course of the beginning of hail precipitation displays maximum in the interval 14:00-18:00 o'clock local time. Night hails between 22:00-24:00 and 00:00-04:00 are also possible, which fall along cold atmospheric fronts. On the overall, it may be said that, from statistical point of view, hails are a strongly expressed random phenomenon due to their large spatial and time variations. This accounts for the small annual materialization probability of the mentioned climatic characteristics.

3.1.1.2.2 Icing of ground-level objects and equipment

The geographical location and the climate specifics of the country provide relatively favourable conditions for icing and frosting of ground-based objects or wet snowfall in winter. Ice formation on ground-based objects – accumulation of wet snow and ice depositions, characteristic of the non-mountainous parts of the country, has been poorly studied in our country as climate elements. The most probable temperature-wind-humidity combinations during the process are: temperature between 0°C and minus 2°C to minus 4°C, wind speed between 3 m/s and 5 m/s, and relative humidity along the Danube river valley between 95% and 100%. During the period between November and March, and mostly, during the months December and January, these meteorological conditions provide to also make long-term weather forecast for the icing process, accounting for the prevailing direction of ice-carrying wind.

3.1.1.2.3 Dust storms

No data about observed dust or sand storms in the region of *Kozloduy* NPP site are available. Table 3.1-6*:* (Ivanov and Latinov, 1993), shows the number of the recorded dust storms by years for the entire country and the two meteorological stations closest to the region of *Kozloduy* NPP – *Lom* and *Oryahovo*.

Table 3.1-6: *Number of cases with dust storms by years*

	1964	1970	1971	1972	1975	1976	1977	1978	1980	1983	Total
Lom	-	-	1	-	1	-	-	-	-	-	2
Oryahovo	-	-	1	1	3	2	-	-	-	-	7
the country	3	1	3	1	14	10	3	1	1	5	42

As shown in the study, these phenomena are conditioned by both the current synoptic conditions, as well as by the preceding climatic conditions – below-the-norm monthly total of precipitations for a given point. The probability for occurrence of dust storms obviously depends on soil character, as well as vegetation cover.

3.1.1.2.4 Snow storms

This phenomenon occurs as a result of moderate or strong wind (with speed above 5 m/s) in the presence of strong snowfall (it is called general snowfall and comprises the entire subcloud layer) or in the case of blowing away and transfer of freshly fallen "dry" snow (comprises ground air layer with height up to several meters – „ground snow storm" or up to several dozens of centimetres – „low snow storm"). The phenomenon creates difficulties for land transport and other activities due to the snow-drifts formed by the snow's blowing away. Snow storms in our country are observed mostly during the period December–February. They are manifested most intensely and most often in North-East Bulgaria, whereas snow transfer usually takes place from North and North-East (depending on wind direction) of the order of about $10m^3$ per linear front meter. Snow storms are observed most often in synoptic circumstances related with Mediterranean cycles from south and Siberian winter anticyclone crest from north-northeast.

3.1.1.2.5 Tornado

Though rarely, in circumstances characterized by meso-scale convective storms, tornadoes (or local tornadoes) may be formed in our country, most often above rugged mountainous terrains or above the sea aquatoria[24]. Tornado is often mistaken for the so-called "falling" or squall-like wind.

The typical synoptic circumstances favouring the development of tornado above our country are a deep valley or a separate cyclonal whirlwind located westward of Bulgaria, where the flow in the middle troposphere in the frontal part of the cyclone or the valley is directed from south-west to north-east. Strong convective systems are formed, whereas Coriolis's force facilitates the development of tornado in them.

Under such synoptic circumstances, the tornadoes described in positions 1, 3, 5A and 5B from Table 3.1-7***: Number of tornado cases during the period 2006-2009*** were formed. Near to the NPP, 2 cases were recorded during this period – at about 20 km southward of the NPP, near the village of Hayredin (case 5A), and at the village of Turnava, about 35 km south-southeastward, which occurred on the same day. These two are the only cases observed over a period greater than 100 years.

Table 3.1-7: *Number of tornado cases during the period 2006-2009*

No.	Affected region	Date	Start	Duration (min)	Direction of tornado movement	Precipitation area (km^2)	Precipitation intensity (mm)	Diurnal precipitation total (mm)	Maximal size of hail grains (cm)	Damages caused by the tornado (USD)
1	**Bobeshino**	02.04.2006	05:20	31	W-E	200	64	3-11	1.5	80 000
2	**Kalekovets**	21.05.2007	13:20	10	NE-SW	232	45	6-40	6.0	110 000
3	**Kostandenets**	22.05.2008	13:55	80	SW-NE	320	237	2-14	6.0	640 000
4	**Kyustendil**	08.07.2008	16:02	12	NW-SE	500	100	2-24	3.0	68 000
5A	**Hayredin**	02.06.2009	15:58	75	SW-NE	600	225	14-32	9.0	134 000
5B	**Tarnava**	02.06.2009	13:35	75	SW-NE	600	225	14-32	7.5	225 000

24 Analysis of Strong Convective Storms Related to the Development of Tornadoes in Bulgaria during the period 2006–2009, Petar Simeonov, Ilian Gospodinov, Liliya Bocheva, Rangel Petrov.

On average for the entire country, the possibility for the occurrence of tornado is estimated to ~ 10^{-6} cases in a year.

3.1.1.3 UNFAVOURABLE METEOROLOGICAL CONDITIONS FOR IMPURITIES DIFFUSION INTO THE ATMOSPHERE

3.1.1.3.1 Temperature inversion

Temperature inversion in a specific region is observed when the low atmospheric layer is in strong stable equilibrium. Characteristic property of such layers is the suppression of air movements originated in them, which leads to attenuation of the dynamic turbulence and thermal convection determining the dispersion of air pollutants. In the cases with ground-level inversions (starting from the earth's surface), the low situated pollutant sources are of essential importance. Conclusions regarding the presence of a phenomenon of this type may be drawn from the aerological sounding from the period September 1967 - August 1968, performed in the region of the Kozloduy NPP (Nikolova, 1972)[25].

Table 3.1-8: ***Characteristics of the temperature inversions in the region of Kozloduy NPP by aerological sample collections during the period September 1967 – August 1968,*** shows the number, thickness ***d***, and mean vertical temperature gradient γ obtained from the one-year period of single-time (at 8 a.m.) aerological sounding of the layer to a height of 2 km. The inversions have been observed in 30 % of the cases, this percentage being about 37 % during the cold half-year and about 22 % during the warm half-year. There have been ground-level inversions in 15 % of the cases, their frequency being much lower during the warm half-year – about 7 %, whereas in the cold season it is about 23 %.

Table 3.1-8*:* *Characteristics of the temperature inversions in the region of Kozloduy NPP by aerological sample collections during the period September 1967 – August 1968*

Observation period	Ground inversions							High inversions									
	Number of cases with thickness, m				Total number of cases	Mean temperature gradient, °C/100m	Average layer thickness	Number of cases with thickness, m					Total number of cases	Average height H1, m	Mean temperature gradient γ	Number of performed sample collections	Number of days with inversion
	$200 \le d_1 \le 300$	$301 \le d_1 \le 500$	$501 \le d_1 \le 1000$	$d_1 > 1000$				$100 \le H_1 \le 150$	$151 \le H_1 \le 250$	$251 \le H_1 \le 500$	$501 \le H_1 \le 1000$	$H_1 > 1000$					
Warm half of the year	-	2	5	1	8	-0.29	757	-	5	8	4	2	19	462	-0.29	121	27
Cold half of the year	3	5	14	10	32	-0.62	801	1	3	6	9	6	25	720	-0.51	140	52
Total for the year	3	7	19	11	40	-0.46	779	1	8	14	13	8	44	591	-0.40	261	79

[25] Nikolova N., Assessment of the weather conditions in the region of NPP "Kozloduy" in connection with the project to build a nuclear power plant, Institute of Hydrology and Meteorology, Vol. XIX, 1972

Although for a one-year period and single-time sounding, there is some notion given also for the atmospheric stability categories of the boundary layer above the Kozloduy station according to the Pasquill's classification. The stabilitry classes are determined according to ground-level data (radiation balance and wind speed) and in accordance with the values of the vertical temperature gradient in the lower 200-meter air layer, γ [deg/100 m]. In the cited investigation it is shown, that for the year as a whole highest frequency is observed for the following classes

Although for a one-year period and single-time sounding, there is some notion given also for the atmospheric stability categories of the boundary layer above the Kozloduy station according to the Pasquill's classification. The stability classes are determined according to ground-level data (radiation balance and wind speed) and in accordance with the values of the vertical temperature gradient in the lower 200-meter air layer **γ** [deg/100m]. In the cited study it is shown, that for the year as a whole highest frequency is observed for the following classes:

- **D** (neutral conditions) – 0.5 deg / 100 m $\le \gamma \le$ 1 deg / 100 m – in about 40 % of the cases;
- **E** (slightly stability) – 0.5 deg / 100 m $< \gamma <$ 0.5 deg / 100 m – in about 30 % of the cases;
- **C** (slightly instability) – 1 deg / 100 m $< \gamma \le$ 1,5 deg / 100m – in about 25 % of the cases;
- **B** (moderately unstable) - $\gamma >$ 1.5 deg / 100 m and **F** (moderately stable) - $\gamma \le -$0.5 deg /100 m feature small frequency of the order of 5 % – 8 % of the cases.

Based on the data and the performed assessment, the following conclusions can be made about the processes and phenomena of interest for *Kozloduy* NPP site, in relation with its specifics:

- Due to the prevailing low winter speeds (between 2 m/s and 5 m/s), the wind field potential for pollutants transportation to long distances is low, i.e. there is no immediate danger of trans-border pollution of Romanian territories;
- The precipitations are below the climatic norms, the potential for pollutants purification (wetting and raining down) in the atmosphere is small;
- Icing of ground facilities in this part of the Danube river lowland may occur under combination of the following meteorological parameters: air temperature between 0°C and minus 2°C to minus 4°C, wind speed between 0 m/s and 3 to 5 m/s, and relative humidity between 95 % and 100 %;
- Damage-causing hailstorms in North-West Bulgaria were observed during the period 5 May – 31 July, but specifically with respect to *Kozloduy* NPP, from

statistical point of view, they constitute a marked occasional event, on account of their great spatial and time variations;

→ The possibility for occurrence of snow storms is much lower than in the North-East part of the Danube plain;

→ On average for the country, the possibility for occurrence of tornadoes is of the order of 10^{-6} cases annually;

→ Fogs are annually observed on average on about 45 days with a maximum of 120–140 days. They last up to 1 day in about 80 % of the cases in January.

3.1.2 ATMOSPHERIC AIR QUALITY (AAQ)

3.1.2.1 NON-RADIOACTIVE POLLUTANTS

The Kozloduy region comprises the Municipalities of Kozloduy, Oryahovo, and Mizia. With respect to these municipalities, it is not required to prepare a pollutant level reduction program, since according to Articles 30 and 31 of Regulation No. 7 on the assessment and management of atmospheric air quality, the measured concentrations of harmful substances are not only lower than the admissible norm, but they are also lower than the upper and lower assessment thresholds.

As a rule, the quality of ground atmospheric air layer in the region is determined by the operation of *Kozloduy* NPP, industrial activity, road transport, and municipal sources.

The more significant sources of atmospheric air emissions on the territory of the Municipality of Kozloduy are: the concrete production unit with sifting facility in the village of Butan of *Putstroy Engineering* AD *(Road Construction JSC)*, town of Vratsa, Atomenergostroyprogress, *Zavodski Stroeji (Plant Construction)*, and *Mehanizatsiya i Transport (Mechanization and Transport)*[26]. These are locally active dust sources. Transport is the greatest source of carbon oxide, carbon hydrogen, nitrogen oxide and other emissions. The roads in the municipality are characterized by relatively high traffic intensity. In the peak hours, though for a short while, conditions for increase of road transport emissions are created.

The Municipality of Vulchedram falls within the Montana district, whereas the major emission sources are concentrated in the district central town and are outside the 30 km Precautionary Action Zone (PAZ).

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26 Appendix 3 – References and input data: Hand-Over Protocol 15 of February 26, 2013.

3.1.2.1.1 Emissions from industrial combustion and production processes by municipalities.

By data from the National Statistical Institute, ***Regions, Districts, and Municipalities in the Republic of Bulgaria, 2006, 2007, 2008***[27], analysis of the emissions from industrial and combustion and production processes for the Municipalities of Kozloduy, Mizia, and Hayredin has been performed – Table 3.1-9***: Emissions from combustion and production processes (in Ktons) for the municipalities in the region of Kozloduy NPP during the 2006÷2009.***

Table 3.1-9: *Emissions from combustion and production processes (in Ktons) for the municipalities in the region of Kozloduy NPP during the 2006÷2009 period*

EKATTE /classifier/	Statistical regions, districts, and municipalities	Sulphur oxides	Nitrogen oxides	NMVOC	CH_4	CO_2	CO	N_2O
		thousand tons						
		2006						
VRC20	Kozloduy	4.894	2.971	62.066	59.719	0.537	2120.974	0.277
VRC28	Mizia	7.072	0.988	5.637	13.358	0.319	448.349	0.071
VRC35	Hayredin	9.979	1.277	0.753	0.253	0.547	406.426	0.046
		2007						
VRC20	Kozloduy	6.873	2.793	21.176	12.184	0.811	1619.163	0.029
VRC28	Mizia	0.238	0.075	4.386	6.594	0.004	112.149	-
VRC35	Hayredin	3.620	0.368	0.386	0.012	0.007	206.876	0.036
		2008						
VRC20	Kozloduy	4.434	32.336	21.325	8.194	2.985	12026.426	0.309
VRC28	Mizia	0.146	0.046	0.539	6.363	0.002	68.858	-
VRC35	Hayredin	0.736	0.045	0.256	0.002	0.001	37.038	0.007

Figure 3.1-14: *Emissions from combustion and production processes* presents the data from *Table 3.1-*, whereas it can be seen clearly that the Municipality of Kozloduy features the best developed production activity, which accounts for the greatest share of combustion emissions. They are not caused by the NPP itself, since nuclear production generates no conventional pollutant emissions. The above emissions are related to both auxiliary production activities at the NPP, as well as with the favourable business environment in the municipality, which contributes to the development of small productions related to combustion processes, whose produce is intended mainly for the NPP – asphalt facility, concrete production units. In calculating the above emission amounts, the statistics has not taken into account municipal fuel burning.

27 The data up to 2008 are used because since 2009, emission data for combustion and production processes for the each municipality are confidential and are not accessible according to the Statistics Act, Article 22.

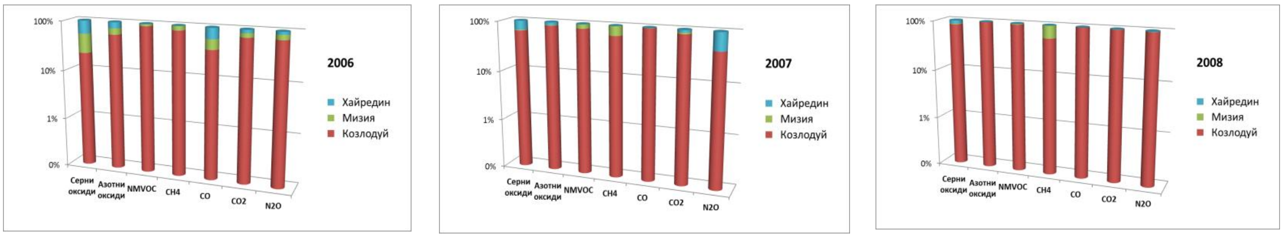

Figure 3.1-14: *Emissions from combustion and production processes*

3.1.2.1.2 Emissions from navigation along the Danube river

River traffic along the Danube river bordering the region around the NPP (national and international) is a source of emissions from ship engines. Diesel engine (compression-ignition engine) emissions into atmospheric air along inland water ways (IWW[28]) are regulated by MARPOL 73/78, Appendix VI, where the emission restrictions for certain pollutants depend on the engine class (cylinder working volume).

The assessment of emissions into the air is based on river traffic (number and type of passed ships) in the lower stream of the Danube river (the Bulgarian section of the river) published in EUROSTAT[29] where the total amount of goods (in tons), transported on an annual basis along inland water ways, as well as the national, international, and transit transportations are given in the form of "ton-km" (Tkm) – Table 3.1-10***: Freights transported along inland water ways in lower Danube***. This provides to apply emission factors in the dimension grams of harmful substance emitted per ton-kilometre (g/Tkm)[30] in emission calculations.

Table 3.1-10: *Freights transported along inland water ways in lower Danube*

Year	Ton	ton-km	km
2004	4 406 369	697 414 292	158
2005	5 270 366	756 837 254	144
2006	5 705 895	721 810 965	127
2007	6 622 307	1 010 837 176	153
2008	10 956 000	2 890 000 000	264
2009	17 104 000	5 436 000 000	318
2010	18 372 000	6 048 000 000	329
средно	**9 776 705**	**2 508 699 955**	**213**

28 IWW – Inland Water Ways

29 http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database, upon registration

30 Van Essen et al. Emissions of pipeline transport compared with those of competing modes -Case I.Antwerp-Cologne, Delft Nov 2003

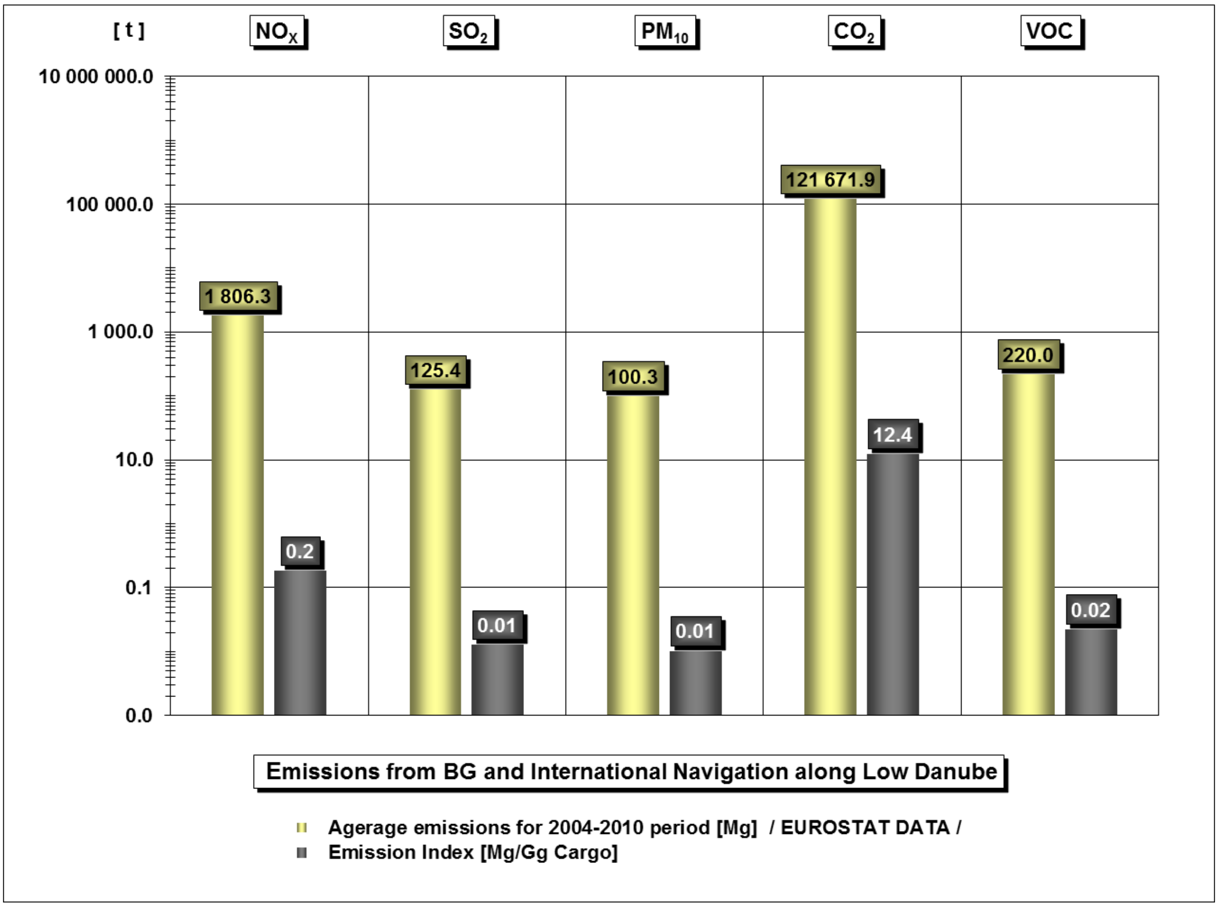

Figure 3.1-15: *Emission levels averaged over the period 2004-2010 and emission index of a given pollutant from the navigation along lower Danube*

Figure 3.1-15***: Emission levels averaged over the period 2004-2010 and emission index of a given pollutant*** *the navigation of lower Danube*, shows the annual levels of navigation emissions, as well as the emission index of a given pollutant averaged over the period, calculated in accordance with the requirements of MARPOL 73/78, Appendix VI.

The obtained emission indices (***Figure 3.1-16:*** *Emission levels averaged over the period 2004-2010 and emission index from a given pollutant from the navigation along lower Danube*) for a given pollutant are below the common values of the same indices; for instance, for the Varna Port, they are several 10 times higher. It will be taken into account that the indices for the Varna Port are for a small area (the area of the port), while the indices for the Danube river cover the entire length of the river, therefore at a certain distance from the river (such as, along the NPP's length) they will be even lower.

3.1.2.1.3 Emissions from the DNHIW of the Kozloduy NPP

The Depot for Non-Radioactive Househole and Industrial Waste (DNHIW) receives non-radioactive waste from the protected zone of *Kozloduy* NPP. The depot is a source of greenhouse gases: methane (**CH_4**) and carbon dioxide (**CO_2**) and small amounts of other volatile organic compounds.

Landfill gas[31] is generated in the body of a given depot at temperature by about 10-20°C higher than the temperature of the surrounding air, and its speed and quantities depend on the following waste characteristics:

- → Morphological composition – the larger the organic component in the waste, the greater amount of landfill gas is released,
- → Age,
- → Presence of oxygen – methane generation starts only after the oxygen amounts in the water body are depleted,
- → Moisture content – moisture content accelerates the biological decomposition process. The optimal moisture content is 40% - 50%,
- → Temperature – in summer the released gas quantities increase, and in winter they decrease.

After the landfill gas is generated in the cell's body, it is emitted into the atmosphere through:

- → **diffusion** – the gases shift from places with high concentration to places with low concentration;
- → **convection** – places with higher pressure push out the gas to the surface;
- → **solubility** – methane is soluble in water and it is also released in small quantities through the produced infiltrate.

The waste amounts accepted at the until 2011 are shown on

Table 3.1-11: Received waste amounts at the DNHIW

TABLE 3.1-11: RECEIVED WASTE AMOUNTS AT THE DNHIW [32]

Years	Amount of received waste [m³]	Amount of received waste with accumulation [m³]	Time of filling [years]
as of 31.XII 2001	7 298	-	1

31 When landfill gas is cleaned of some admixtures (such as, sulphur) it turn into biogas which can be used as a fuel.

32 Plant non-radiation monitoring of the Depot for Non-radioactive Household and Industrial Waste, 2011.

as of 31.XII 2002	5 397	12 695	2
as of 31.XII 2003	4 690	17 385	3
as of 31.XII 2004	4 267	21 652	4
as of 31.XII 2005	4 690	26 342	5
as of 31.XII 2006	5 153	31 495	6
as of 31.XII 2007	4 421	35 916	7
as of 31.XII 2008	4 836	40 752	8
as of 31.XII 2009	5 519	46 271	9
as of 31.XII 2010	4 747	51 018	10
as of 31.XII 2011	4 949	55 967	11

The emissions (total: from diffusion, convection, and dissolved in infiltrate) from the depot's body are calculated after the **LandGEM**[33] model of the US Environmental Protection Agency (EPA).

The model is based on the (bacteriological) decomposition of the organic component of municipal waste linear equation. The input parameters are the starting year of deposition, the depot's capacity, and the amounts of deposited waste by years (Mg). Based on the capacity of a given depot, the model may also calculate the year until which it will be available for deposition. Since in the document for the DNHIW own monitoring it is stated that 85% of the capacity is filled at Stage I, the model calculated that, with 9% increase of the deposited amounts, Stage I may be used until 2016.

Figure 3.1-16: Emission levels from the DNHIW with deposition until 2016, shows the emission evolution of some gases from the depot with 50 % (voluminous %) methane content in landfill gas.

[33] http://www.epa.gov/nrmrl/appcd/combustion/cec_models_dbases.html

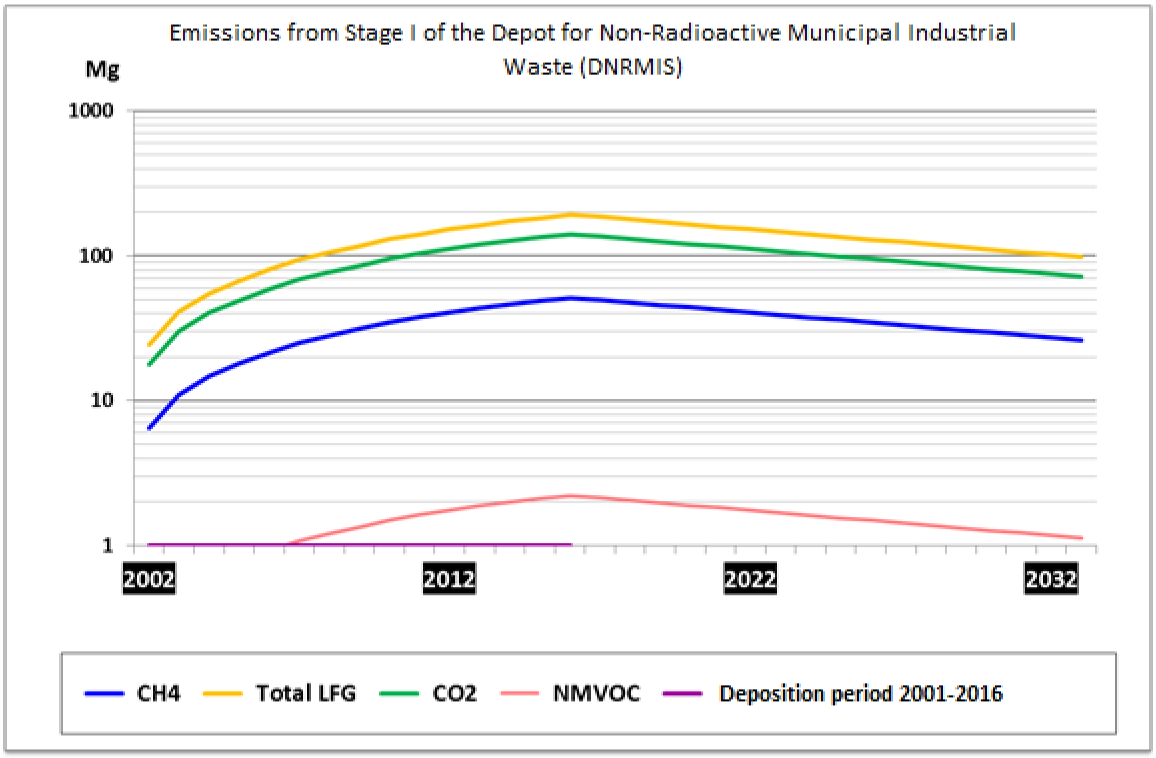

FIGURE 3.1-16: EMISSION LEVELS FROM THE DNHIW WITH DEPOSITION UNTIL 2016

The inventory of the emission amounts from the Depot's body in 2012 is shown in ***Table 3.1-12*****: Amounts of gas (tons) emitted from the from the *DNHIW* in 2012**

Table 3.1-12: *Amounts of gas (tons) emitted from the from the DNHIW in 2012*

CH_4	CO_2	NMVOC	Landfill gas
40.76	111.83	1.75	152.6

3.1.2.1.4 Emissions from car traffic on second class road II-11

The site of *Kozloduy* NPP is connected with the republican road network through a second class two-way traffic, asphalted and well-marked. This is road II-11, section Oryahovo-Mizia-Kozloduy-Lom, which runs southward of *Kozloduy* NPP and the site of the National Repository for RAW (NDRAW), through the non-flooded terrace of the Danube river. It provides to take away inter-settlement passenger traffic, including transit freight traffic.

The emissions from the regular traffic around the region of the NPP have been evaluated by data about the mean-24-hour annual intensity of the car traffic for 2010, as measured at the counting sites of the Road Infrastructure Agency for road II-11 of the Republican road network: at additional counting point (ACP)-205 in the Kozloduy-Lom section and at ACP-496 in the Mizia-Kozloduy section[34].

Table 3.1-13: Mean-24-hour annual intensity of car traffic – diagnosis for 2010 and forecast for 2015 and 2020, presents the data about the mean-24-hour intensity of car traffic for the 6 major car classes are shown: Cars, Light-Duty Cars, Medium-Duty Cars, Heavy-Duty Cars, Buses (out-of-town) and Heavy-Duty Cars with Trailers. The forecast intensity for 2015 and 2020 has been made based on traffic increase between 10% and 18% for the different types of car classes.

TABLE 3.1-13: MEAN-24-HOUR ANNUAL INTENSITY OF CAR TRAFFIC – DIAGNOSIS FOR 2010 AND FORECAST FOR 2015 AND 2020

Year	Counting point	Cars	Buses	Light-Duty Cars	Medium-Duty Cars	Heavy-Duty Cars	Heavy-Duty Cars with Trailers & Tow Trucks with Semi-Trailers	Total of freight cars	Total number of vehicles
2010	**ACP-205**	798	17	267	24	13	38	342	1 157
	ACP -496	6 185	252	964	166	48	150	1 328	7 765
2015	**ACP -205**	938	20	314	28	14	45	401	1 359
	ACP -496	7 266	295	1 134	195	53	177	1 559	9 120
2020	**ACP -205**	1 102	24	369	33	16	53	470	1 597
	ACP -496	8 535	346	1 333	229	59	208	1 830	10 711

The assessment of emission levels of various pollutants from the road is made using Tier 2[35] of the European Guide EMEP/EEA CORINAIR'2009 emission inventory for passenger cars (NFR code 1.A.3.bi), light-duty vehicles (LDV) <3 5 tons (1.A.3.b.ii) and heavy duty vehicles (HDV) > 3.5t and buses (1.A.3.b.iii), chapter Road Transport for the main pollutants:

- Precursors to ozone - CO, NO_X, NMVOC (non-methane volatile compounds);
- Greenhouse gases (CO_2, CH4, N2O);

[34] Appendix 3 – Letter No, ЦИ-0167-0158 of February 04, 2013.

[35] In determining the emission levels of greenhouse gases (GHGs) in IPCC, the methods of varying complexity are used. The level of complexity of the method is designated as Tier X, i.e. when X is higher digit, the method is more complex and more accurate.

→ Acidifying substances (NH3, SO2);

→ Particulate matter (PM) - emission factors refer to PM2.5, as the coarse fraction (PM2.5÷10) is negligible in vehicle exhaust;

→ Carcinogenic compounds:

  - PAH - polycyclic aromatic hydrocarbons (Benzo (α) pyrene, Benzo (b) fluoranthene + Benzo (k) fluoranthene, indeno (1,2,3-cd) pyrene - for unleaded petrol));
  - POP - Persistent Organic Pollutants

→ • Toxic substances (DIOX - Dioxins and furans (for unleaded petrol)

→ • Heavy metals.

The estimation not include emissions such as fuel evaporation from vehicles (NFR code 1.A.3.b.v), tyre wear and brake wear (NFR code 1.A.3.b.vi), or road wear (NFR code 1.A. 3.b.vii).

Table 3.1-14: Available emission loading in kilograms per 1 kilometer of the respective road section (kg/km), shows the emission loading in kilograms per 1 kilometre of the respective road of the Republican road network is shown.

TABLE 3.1-14: AVAILABLE EMISSION LOADING IN KILOGRAMS PER 1 KILOMETER OF THE RESPECTIVE ROAD SECTION (KG/KM)

Year	point	CO	NMVOC	NOx	N2O	NH3	Pb	PM2.5	Ideno Pyrene	B(k)F	B(b)F	B(a)P	CO2	SO2	benzene	tCO_2eq
2010	**ACP-205**	1.665	0.159	0.978	0.009	0.016	2.36E-06	0.036	6.38E-07	7.78E-07	9.50E-07	5.25E-07	301.87	0.00384	0.0048	**0.31**
	ACP-496	10.847	1.051	5.890	0.058	0.112	1.50E-05	0.193	4.12E-06	5.21E-06	6.24E-06	3.37E-06	1985.80	0.02621	0.0315	**2.03**
2015	**ACP-205**	1.956	0.186	1.144	0.011	0.018	2.77E-06	0.042	7.49E-07	9.09E-07	1.11E-06	6.17E-07	354.28	0.00451	0.0056	**0.36**
	ACP-496	12.741	1.234	6.900	0.068	0.132	1.76E-05	0.226	4.84E-06	6.10E-06	7.31E-06	3.96E-06	2330.78	0.03078	0.0370	**2.38**
2020	**ACP-205**	2.298	0.219	1.339	0.013	0.022	3.25E-06	0.050	8.79E-07	1.06E-06	1.30E-06	7.24E-07	415.85	0.00530	0.0066	**0.42**
	ACP-496	14.964	1.449	8.084	0.080	0.155	2.07E-05	0.266	5.68E-06	7.15E-06	8.57E-06	4.65E-06	2735.84	0.03615	0.0435	**2.79**

3.1.2.1.5 Measured concentrations

The National Environmental Monitoring System (NEMS), which performs the atmospheric air control on the territory of the country, does not have at its disposal a fixed measurement station for the region of Kozloduy Municipality.

In 2011, after the approved operation schedule for the Mobile Automatic Stations (MAS) which perform additional measurements in regions where stationary points are lacking or restricted in number, the Mobile Automatic Stations (MASs) performed Assessment and Control of Atmospheric Air Quality (RACAAQ) measurements in the North/ Danubean Regions (Agglomerations) for the Municipality of Kozloduy for 52 24-hour periods, which were carried out by the Pleven Regional Laboratory.

Within the Environmental Impact Assessment (EIA), an analysis will be made of the mean-24-hour parameters from the protocols of the measured pollutants' mean-24-hour concentrations and they will be compared with their relevant mean-24-hour norms (M24HNs).

The EIA Report will also contain assessment of diesel fuel combustion emissions in the Diesel Generator Station (DGS), based on the consumed fuel.

3.1.2.2 ATMOSPHERIC RADIOACTIVITY

Aerosols **–** atmospheric air radioactivity is examined on a weekly basis at 11 control posts within a 100 km Surveillance Zone (SZ) around the NPP. The summarized data from the performed aerosol monitoring during the period 2009–2011 (*Results from the Radio-Ecological Monitoring of Kozloduy NPP, Annual Report, 2011*), show that the results are within the normal limits and the operation of *Kozloduy* NPP, as a potential source of ground air pollution with radioactive substances, **has not resulted in change of the radiation gamma background** and the atmospheric radioactivity.

The data for the total beta-activity in ground air (Figure 3.1-17***: Гама-спектрометричен анализ на 137Cs и 7Be в приземен въздух (mBq/m3) from the region of Kozloduy NPP, Post-9 (village*** of Harlets), 1992–2011*)* feature normal values typical for this geographic region within the range 0.50 to 0.68 µBq/m^3. The results are commensurate in narrow limits throughout the years. The content of ^{137}Cs between 0.8 µBq/m^3 and 10 µBq/m^3, or average value of 2.8 µBq/m^3, falls within the minimal detectable activity limits of the analysis method, 10^6 times lower than the norms for the country according to the *Regulation on the basic norms of radiation protection, 2012*.

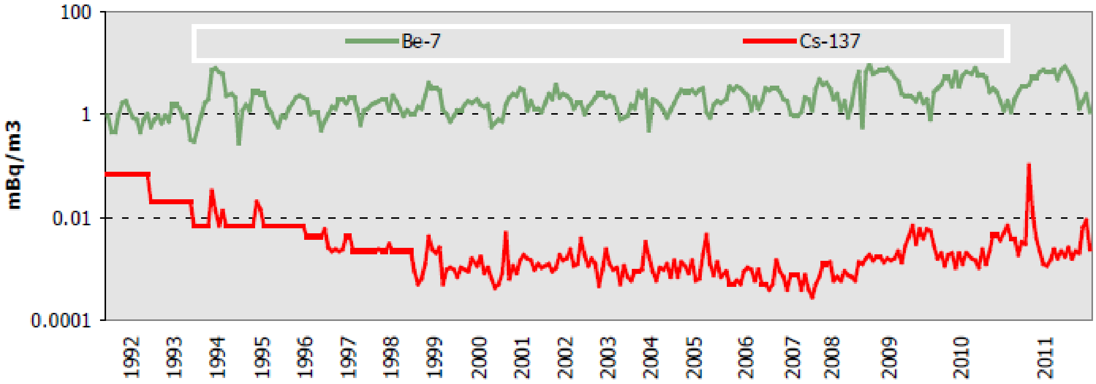

FIGURE 3.1-17: ГАМА-СПЕКТРОМЕТРИЧЕН АНАЛИЗ НА ^{137}CS И ^{7}BE В ПРИЗЕМЕН ВЪЗДУХ (MBQ/M^3) FROM THE REGION OF KOZLODUY NPP, POST-9 (VILLAGE OF HARLETS), 1992–2011

The monitoring data evidence of relative increase of long-lived beta-activity in the aerosol filters of part of the control posts mainly in the winter months, which is due to the snowfalls during this period.

No significant negative impacts are expected.

Atmospheric fallouts **–** atmospheric fallouts are controlled on a monthly basis at 33 of the 36 control posts within the 100 km observed area around the NPP. Slightly expressed seasonal dependence has been established, with maximal values during the spring-summer period, which is due to the intensive precipitations and self-cleaning of the atmosphere resulting in reduction of aerosol activity and, accordingly, increase of fallout activity.

The controlled total activity of atmospheric beta-depositions varies within the interval 0.058 Bq/(m^2.d) ÷ 1.96 Bq/(m^2.d), with average value of 0.43 Bq/(m^2.d). The results are commensurate with the preceding multi-annual measurements and constitute typical-for-the-region natural values. The results for ^{90}Sr in atmospheric depositions display a stable reduction tendency due to the atmosphere's self-cleaning from the Chernobyl ^{90}Sr.

On the overall, the conclusion is made that the radioactivity of atmospheric fallouts, within the 100 km Surveillance Zone is within the normal limits and is not affected by the NPP's operation.

Gamma background radiation – In 2011, a total of 1551 measurements of the gamma background radiation at the control posts and the routes were made, using portable dosimetric devices and statically positioned thermo-luminescent dosimetres. Of them, 1299 measurements were made, using portable dosimetric devices at a total of 77 checkpoints of the 100 km Surveillance Zone. For independent passive control of the gamma background radiation, a total of 63 TLD-4 (accordingly, 70 pieces of UD-802AS) thermo-luminescent dosimeters were used, which were used for a total of 252 measurements performed. The summarized data and results for 2011 and their comparison with those for the period 2007–2010 show, as follows:

- → The gamma background radiation at points of the NPP's fence and at the checkpoints and settlements within the 100 km Surveillance Zone is completely commensurate with natural background radiation, falling between 0.05 µSv/h ÷ 0.15 µSv/h;
- → The radiation situation in the region are stable and have not been changed by the operation of *Kozloduy* NPP.

3.1.2.3 PREDICTION OF THE IMPACT

Regarding the non-radioactive pollutants, during construction, operation, and decommissioning, the report of EIA will assess the expected concentrations into atmospheric air, both on Bulgarian, as well as on Romanian territory in 30 km zone (Ministry of Environment and Forests, Republic of Romania, Outgoing No. 3672 RP October 18, 2012) from respective activities in those stages. The cumulative traffic effect of the regular traffic along the Republican road network will be also assessed.

3.1.2.3.1 Modeling of non-radioactive pollution

AERMOD **Model**

To assess the dispersion of emissions from sources during the construction of each of the 4 sites, a model used by the U.S. Environmental Protection Agency (EPA) ***ISC-AERMOD*** (Industrial Source Complex) will be applied. Windows interface of the model is developed by Canadian software company *Lakes Environmental.*

The ***AERMOD***[36] model can simultaneously simulate many sources with different shapes, ground or elevated, buoyant), emitting one or more pollutants. ***AERMOD*** also accounts for the vertical non-homogeneity in the structure of the boundary atmospheric layer by using the meteorological parameters' vertical profiles. The vertical mixing of the pollutants with the ambient air is restricted in case of stable stratification (positive change of temperature with height). Dispersion under unstable thermal conditions (strong convection) is not of the Gaussian type, but it is physically described by turbulent convective flows which generate higher pollutant concentrations near the source.

AERMOD consists of three modules:

- → Atmospheric dispersion module (AERMOD),

36 http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod

→ Terrain pre-processor (AERMAP), which is used in the presence of a complex terrain to describe the height of each receptor,

→ Meteorological pre-processor (AERMET), which is used to prepare meteorological data input for simulation by the dispersion module.

AERMOD requires two types of hourly meteorological data: one, referring to the suface values of meteorological parameters, and another one, describing their vertical profiles.

Based on the ground characteristics of the underlying surface: ruggedness height, albedo and Bowen ratio (moisture amount which depends on the surface type – urban, rural, forest, water and so on, and varies depending on the season and wind direction), ***AERMET*** calculates the parameters of the surface boundary layer, which account for its development and which affect the pollutants dispersion. These parameters include surface friction velocity (measure of velocity that relates shear between layers of flow); surface heat flow (thermal energy vertical transport); mixing layer height at day; mixing layer height at night, and more.

In the ***AERMET*** model, the stable atmospheric condition is determined based on Monin-Obukhov's length which is a measure of heat transfer near the earth's surface. The relationship between Monin-Obukhov's length and the 6 atmospheric stability classes of Pascal-Gifford is the following:

L values		Atmospheric conditions	Stability class
Small negative	$-100\ m < \mathbf{L} < 0$	strong instability	A
Big negative	$-10^5\ m \le \mathbf{L} \le -100\ m$	instability	C
Very big (- or +)	$\lvert \mathbf{L} \rvert > 10^5\ m$	neutral conditions	D
Big positive	$10\ m \le \mathbf{L} \le 10^5\ m$	stability	E
Small positive	$0 < \mathbf{L} < 10\ m$	strong stability	F

AERMOD includes several improvements compared to the standard Gaussian jet models with respect to description of turbulence, dispersion under convective and stable conditions, effective lifting of the jet above the physical height of the source, pollution diffusion in urban environment accounting for a complex terrain[37].

The final results are the concentrations of a given pollutant at some previously chosen calculation grid points (so-called receptors) or the deposition of an amount of polluting substance on the earth's surface (dry, wet, or a total of dry and wet).

Modeling rationale

37 http://www.epa.gov/ttn/scram/7thconf/aermod/aermod_mfd.pdf

The extraordinary dust emissions during construction are due to earth excavation works, dust material processing, and wind erosion of the open earth mass embankments, as well as gas emissions from transport and construction equipment (internal combustion engines).

Input data for dust emissions

In calculating the quantitative emission values for all sources, the dust emissions will be taken into account, calculated based on the emission factors of the US Environmental Protection Agency (EPA) for work in open dust areas, as well as the internal combustion engine (ICE) emissions of the equipment working on the site, obtained after the emission inventory methods EMEP/EEA, 2009, Chapter: ***Stationary construction equipment***.

The action of each source has been accounted for in a time schedule (i.e. they are function of time), whereas the data have been input into the so-called HOURLY EMISSION RATE FILE (HOREMIS – Hourly Emission), which is an hourly action schedule for each individual source.

Input parameters for the modeling process

The first step is to develop a new model by indicating the precise coordinates and boundaries of the model of the 4 sites by introducing a precise terrain map in appropriate format. In this specific case, shapefile will be used. Later on, using the software module ***AERMAP*** to calculate topography, precise data will be assigned for the altitude of all objects, including pollution sources and the receptors for the specific project.

The next step in the modeling process is the introduction of the so-called receptor grid at a given height (in this case, the ground), in the nodes of which the expected ground concentrations are also calculated. After the data introduction, the model's completeness is verified, which is followed by starting the software program and preparation of the disperse models, in which each of the considered 4 alternative sites is a pollution source.

Input meteorological parameters – data for 2012

For the needs of the model, a ground and a profile meteorological parameter file (.SFC and .PFL, accordingly) are also prepared, using the software product ***AERMET***, representative of the 4 sites. During the preparation of this file, the terrain specifics (arable area, coniferous forest, deciduous forest, water area and so on) is accounted for, whereas the primary meteorological data for them, prepared using the synoptic model **MM5,** are purchased from the ***Lakes Environmental Software*** for a point with coordinates representative of the region.

TRAFFIC ORACLE **Model**

To determine pollution, according to European norms and the applicable Bulgarian law, the *Method for determination of the diffusion of harmful substance emissions from transport vehicles and their concentration in the surface atmospheric layer,* the software product ***TRAFFIC ORACLE***, ***DIFFUSION*** module will be used. It produces statistical or type evaluations for the pollution levels of a certain pollutant.

Brief description

The DIFFUSION module is based on the jet Gaussian model and it calculates the pollution from linear or surface sources in the atmospheric ground layer through the following type evaluations:

- Calculation of the expected maximally single concentrations of harmful substances,
- Calculation of the expected climatically mean (monthly-mean or annual-mean) concentrations using the respective "wind rose",
- Calculation of the expected averaged-by-period (hourly-mean, 24-hour-mean, monthly-mean or annual-mean) concentrations using the respective hourly meteorological file,
- Calculation of the maximum possible single pollution under the respective most unfavorable meteorological conditions.

The values of the harmful substance emissions from motor vehicle engines are presented in g/(m.s) or g/s with linear or area source, respectively, and their concentrations in the ground atmospheric layer are presented in mg/m^3.

It is assumed that pollution from transport vehicles during their movement along road sections could be approximated as continuously acting linear sources.

Modeling rationale

With respect to air pollutant emissions, the cumulative impact is due mainly to the gas emissions from transport activities related to the national and municipal road network project – delivery of raw materials and materials, earth masses, and transportation of workforce.

The objective of the modeling is:

- To evaluate in quantitative terms the share in available pollution of construction-related pollution caused by the mean-24-hour intensity of car traffic along a used section of the Republican road network related with the delivery of raw materials and materials,
- To evaluate pollution in the settlements through which traffic passes.

With respect to the generated **gaseous radioactive emissions,** the technical aspects will be analyzed – envisaged annual output amounts, origin, composition, and physico-chemical forms, control, release methods and paths. Modeling of the distribution of waste fluids into the atmosphere, surface deposition, and a second suspension generation will be made.

It is necessary to describe the requirements for monitoring of the releases – release sample collection, measurement and analysis undertaken by the operator or the competent bodies, fundamental characteristics of the monitoring equipment.

3.1.2.3.2 MODELING of radioactive pollution

The assessment of the environmental radiation impact in case of radionuclide contamination during normal operation will be performed using a software product based on the EU-adopted methodology CREAM (Consequences of Releases to the Environment Assessment Methodology) Radiation Protection 72 – Methodology for assessing the radiological consequences of routine radionuclide releases into the environment.

→ To assess the radiation exposure of the population within the 30 km Urgent protective action planning zone (UPAPZ) to gas aerosol releases - the LEDA-CM software program adapted to the geographic and meteorological characteristics of the region of *Kozloduy* NPP will be used. The methodology accounts for both the external and the internal impact of radioactive releases and evaluates the individual effective dose, the annual individual equivalent dose, and the critical group dose, as well as the collective population dose by age groups.

After the model is prepared and the analysed, the output data for the annual effective doses for the population for the area with radius of 30 km around *Kozloduy* NPP will be derived.

3.2 WATER

3.2.1 SURFACE WATER

3.2.1.1 CURRENT STATUS

Several rivers from the basin of the Ogosta river and the rivers westward of it flow through the region of the existing *Kozloduy* NPP site, namely:

→ 10 km to 30 km southward and southeastward – the Ogosta river with water body code BG1OG100R014 and the Ogosta river – the Skat river with water body code BG1OG307R013;

- 10 to 30 km eastward and southward – the Skat river with water body code BG1OG200R008;
- 20 km to 30 km westward – the Tsibritsa river – two water bodies with codes BG1WO800R016 and BG1WO800R017;
- in the immediate vicinity of the NPP and of greatest significance to it, northward of the site, the flows Danube river with the name of „Danube river RWB01" and code BG1DU000R001.

With respect to these rivers, all requirements of the Water Basin Management Plan (WBMP) are in effect, as well as the measures to it, as addressed in Program 7.1.5, Program 7.1.6, Program 7.1.7, Program 7.1.8, according to Letter No. 3804/January 08, 2013 of the Basin Water Management Directorate – Danube Region (BWMD-DR), aimed at: emission regulation through prohibition of the introduction of pollutants from point sources, prohibition of the introduction of pollutants from diffuse sources, prevention of water pollution with priority substances, and prevention or reduction of the impact of emergency pollutions. These requirements will have to be observed during the implementation of the Investment Proposal (IP) for the New Nuclear Unit (NNU).

The water body of the BGTR7 type, with code BG1OG100R014 – the Ogosta river, is 3.175 km long (part of the Ogosta river water subject), it is strongly modified and it has been qualified in the Water Basin Management Plan (WBMP) as being in good chemical condition and moderate ecological condition, but it has also been assessed as a water body „at risk" for the achievement of the ecological objectives. During the erection of *Kozloduy* NPP, the mouth of the Ogosta river was modified to provide service water supply from the Danube river to the NPP. It was shifted eastward, under the Bank Pump Stations (BPSs).

Small dams have been constructed in the region, which are run by the respective municipalities, as well as dams which are run by the *Napoitelni Sistemi* EAD (*Irrigation Systems* Sole-Owner EAD). On the Ogosta river, near the town of Montana, the *Ogosta* dam has been constructed which is on the List of Large and Complex Dams in the Country from Appendix 1 to the Water Act. It impacts greatly the river's flow regime. Apart from the *Ogosta* dam, another such dam near *Kozloduy* NPP is the *Shishmanov Val* (*Asparuhov Val*) dam, 10 km away from the NPP. This water basin was constructed for the needs of the irrigation system of the same name. The water basin is fed by the Danube river through a floating pump station; its capacity is 7 mill. m^3. The dam is defined in the Water Basin Management Plan (WBMP) as an artificial water body with code BGW0900L017 and its registered area is 2 km^2.

Due to the constantly high level of underground water on a large area of the lowlands in the region of *Kozloduy* NPP, a system of drainage canals and equipment has been constructed, which includes slope water running down the north slopes of the plateaus.

These systems protect the region in case of abundant precipitations and prevent bogging of the lowlands. The drainage systems include three types of canals: drainage, collector, and main. The water from the main canals is transferred to the Danube river over the embankments by pump stations (PSs). These drainage facilities are essential for the protection of agricultural land in the area and the existing infrastructure.

The main drainage canal is collector of the four flows of NPP wastewaters (household-fecal wastewaters and rain water) of NPP: by EP-1 and EP-2 (two stream) as well as from Open Switchgear. Drainage systems by the EP-1 and Open switchgear are mixed, and the sewerage system by the EP-2 is a separate. In the sewerage system of the EP-1 have been discharged and a small quantity of industrial waste water from the EP-2. Rainwater from electric convertors sites pass through oil-retainers. Household-fecal wastewaters from the EP-1 and Open Switchgear is discharged without treatment. For household-fecal wastewaters from the EP-2 is built a treatment equipment.

The Danube river plays the most important and essential role with respect to the existing *Kozloduy* NPP site and all proposed new alternative NNU sites.

The Danube river is used for circulation and service water supply to all consumers at *Kozloduy* NPP site. The total area of the international Danube basin is 817 000 km^2, and its total length is 2 857 km. The river is an international water transport corridor. In relation to the threat to the river water's ecological state as a result of the intensified man-induced impact on the banks and the transport traffic, established by the countries along the river, as well as for the purpose of preserving a number of protected areas and habitats, affected by its water, in 1992, the decision was made to establish an International Committee for Preservation of the Danube River (ICPDR). The Republic of Bulgaria has ratified the Convention for Protection of the Danube River. The first Management Plan for the entire Danube basin is in effect in the Republic of Bulgaria, as well as the Basin Management Plan for the Danube region. In this Plan, the river is classified as a river named Danube RWB01, with code BG1DU000R001. It has been defined as a strongly modified water body of moderate ecological state and poor chemical state. An Action Program aiming to achieve good chemical condition and good ecological potential during the next planning periods until 2021 and 2027 has been prepared and is being implemented. These requirements will be applicable with respect to the ecological commitments during the implementation of this Investment Proposal (IP). The river is subject to control physico-chemical monitoring and operative monitoring under a special National Monitoring Program for major physico-chemical indicators, priority and specific pollutants, and hydro-morphological quality elements, according to the Program of the International Committee for Preservation of the Danube River (ICPDR) which is included in the National Environmental Monitoring System (NEMS) implemented by the National Environment Agency (NEA) and the Regional Laboratories (RLs). Under the same Program, control and operative hydro-biological monitoring is also performed. To implement the Monitoring Program for the Danube river, as well as monitoring of the condition of the Ogosta river, Order No. РД-715/August 02, 2010 of the Minister of Environment and Water is in effect.

Kozloduy NPP EAD has arranged and carries out on a regular basis mandatory own non-radiation waste waters monitoring according to the conditions in the licenses for discharging - at the discharge points of the above mentioned four waste water streams into the MDC, as well as at the HC-1 and HC-2 discharge points in the Danube River. The temperature and the physico-chemical parameters of the water in CC-1, fed by the Danube river, are also monitored. Additional intra-institution monitoring and control is also performed of all points of discharge into the Main Drainage Channel (MDC), HC-1 and HC-2, the Danube river, and the quantity and quality of waste waters collected in the sewer network, which originates from external users on the territory of the NPP. *Kozloduy* NPP also performs hydrological monitoring of the Danube river, as well as quantitative and chemical monitoring of underground water in the site's region at the water collection points specified in the relevant licenses, inclusive of underground water on the territory of external establishments, such as the *Decommissioning* Specialized Division and the *Radioactive Waste* Specialized Division of SE RAW. Summarized statements of the conducted monitoring are submitted periodically and once a year to the Basin Water Management Directorate – Danube Region (BWMD-DR). Automated equipment is used to that end, as well as manual portable equipment. For the purpose of performing the monitoring, Annual Non-Radiation Monitoring Programs and Annual Reports on the performed monitoring are prepared. The control monitoring of all points of waste water discharge on the territory of the NPP is performed by the bodies of the Ministry of Environment and Water (MEW) at the Executive Environment Agency (EEA) and the Regional Laboratory (RL) – Vratsa (Letter of the MEW, Regional Inspectorate for Environment and Water (RIEW) – Vratsa, Outgoing No.B2975/January 10, 2013).

The Plant Non-Radiation Monitoring Program implemented by *Kozloduy* NPP, accounts for the work of the existing Waste Water Treatment Stations (WWTSs) and the local treatment facilities. The monitoring of non-radioactively wastewater shows slight organic pollution. Incidentally there is measured the presence of oil products and boron. Waste water containing oil products is generated at the Turbine Hall of EP-1 and EP-2, the Fleet park, the Fuel and Oil Facility, the Diesel Generator Stations (DGS) of EP-2, etc. Though of negligibly small amount compared to the other waste water, they may yet have certain impact. The slight waste water organic pollution is expressed in single cases of minimal exceeding of the IEL for organic indicators and biogenic elements, such as BOD_5 (Biological Oxygen Demand), total phosphorus (such as PO_4) and total nitrogen. These recorded and reported cases of exceeded values are largely due to the operation mode of the WWTF for municipal waste containing faecal matter for EP-2 (low organic loading and high hydraulic loading, i.e. dilution with water not containing organic pollutants, such as, rain water), which disturbs the biological treatment process. During the recent years, this tendency has been removed, as a result of which the performance of the WWTFs has improved. Measures have been taken to reduce the amount of input waste water. There is a persisting tendency for non-observance of the IEL for the indicator „boron in waste water discharged into the Main Drainage Channel (MDC)". The reason for that is the increased boron content in the potable water – below the norms pursuant to Protocol № 1-E/24.01.2012, but higher than the Individual Emission Limits stated in the permit. The control of the IEL's observance with respect to physico-chemical waste water pollution and the Danube river is performed by the External accredited laboratory (RL-Vratsa (Regional Laboratory at the ExEA), whereas during the last couple of years, over 100 samples have been collected, accompanied by protocols of the performed tests for the individual indicators.

The water amounts used in 2011, compared to the allowed amounts, are shown in **Table 3.2-1**: *Water amounts used in 2011,*

Table 3.2-1: *Water amounts used in 2011, compared to the allowed amounts*

Water-extraction point	Allowed amount, [m^3]	Used amount, [m^3]
Surface water from the Danube river	5 000 000 000	2 660 788 000
Shaft well "Valyata"	788 400	216 700
Well "Ranney–5"	1 600 000	2 729
Six-off shaft wells (SPS 1÷ 6) [Shaft Pump Stations]	7 884 000	24 779

The amount of used water from the Danube river is about 53.21% of the allowed amount, and the amount of underground water – only 2.38 % of the allowed amount.

Waste water amounts

The amounts of waste water generated in 2011, as measured by the *Hydro-Technical Facilities and Building Structures* Department. Table 3.2-2***: Waste water flows and amounts from the Kozloduy NPP in 2011*** compares them to the allowed ones.

Table 3.2-2: *Waste water flows and amounts from the Kozloduy NPP in 2011*

Flow	Water origin	Allowed amount, m^3	Generated amount, m^3
Flow No. 1 (TC – MDC) (Trapezium Channel – Main Drainage Channel)	Industrial, household, and rain water from EP-1	3 900 000	680 000
Flow № 2 **(Ø300 –MDC)**	Household water after the treatment complex/EP-2	450 000	16 000
Flow No. 3 **(Ø1000 – MDC)**	Treated industrial water from the Turbine Hall (TH), the Diesel Generator Station (DGS), the Fuel and Oil Facility (FOF), etc.	6 600 000	1 895 000
Flow No. 4 (Open Switchgear – MDC)	Household wastewaters from Open Switchgear	1 095	1 000
Flow No. HC-1 – Danube river	Cooling and industrial waste water from EP-1 and EP-2	1 050 000 000	2 114 288 000
Flow No. HC-2 – Danube river	Cooling and industrial waste water from EP-1 and EP-2	2 230 000 000	507 647 000

Note: The amount of waste water discharged through HC-1 exceeds the maximum of the allowed one, but the total amount of waste water discharged through HC-1 and HC-2 does not exceed the maximum of the allowed amount for both channels, which is 3 280 mill. m^3. During the reported period, the amount of discharged waste water is less than the allowed one.

Summarized results from the physico-chemical tests of waste water

In 2011, the waste water samples were selected and analysed by an accredited laboratory – the Regional Laboratory (RL) at the Executive Environment Agency (EEA), town of Vratsa, and the laboratories of *Kozloduy* NPP – Engineering Chemistry (EC) section, Testing and Calibration Laboratory, and *Physico-Chemical Control* Laboratory.

The following waste water samples have been selected and analysed:

1. Regional Laboratory (RL) at the Executive Environment Agency (EEA), town of Vratsa

→ 2 samples from Open Switchgear during I-st and II-nd quarter;

→ 12 samples from TC during I-st, II-nd, III-rd and IV-th quarter;

→ 5 samples from Ø1000 during I-st, II-nd, III-rd and IV-th quarter;

→ 10 samples from HC-1 during I-st, III-rd and IV-th quarter;

→ 11 samples from HC-2 during II-nd, III-rd and IV-th quarter.

2. *Physico-Chemical Control* Laboratory - Engineering Chemistry (EC) section

→ 3 samples from Open Switchgear during I-st and II-nd quarter;

→ 15 samples from TC during I-st, II-nd, III-rd and IV-th quarter;

→ 18 samples from Ø1000 during I-st, II-nd, III-rd and IV-th quarter;

→ 11 samples from HC-1 during I-st, II-nd, III-rd and IV-th quarter;

→ 10 samples from HC-2 during I-st, II-nd, III-rd quarter.

3. Testing and Calibration Laboratory – Engineering Chemistry (EC) section

→ 3 samples from Open Switchgear during I-st and II-nd quarter;

→ 12 samples from TC during I-st, II-nd, III-rd and IV-th quarter;

→ 13 samples from Ø1000 during I-st, II-nd, III-rd and IV-th quarter;

→ 9 samples from HC-1 during I-st, II-nd, III-rd and IV-th quarter;

→ 12 samples from HC-2 during I-st, II-nd, III-rd and IV-th quarter.

Note: Because of the low water level and weak water flow conductivity, in 2011, no samples from Ø 300 were selected.

Discharging of the Trapezium Channel (TC)

All recorded values are below the individual emission restrictions specified in the license for this flow, but for the results for the „boron" indicator, for which the restriction reads „not allowed" and "undissolved substances" (***Table 3.2-3*****: Recorded emission values exceeding the individual emission restrictions at the TC's discharging *point***).

Table 3.2-3*: Recorded emission values exceeding the individual emission restrictions at the TC's discharging point*

Indicator	Number of analysed samples	Number of exceeded values	IELs, [mg/dm^3]	Mean value, mg/dm^3	Maximal value, mg/dm^3
Boron	6	6	Not allowed	0.04	0.04
Undissolved substances	9	1	50	-	56

Discharging of Ø 1000

Exceeding of the Individual Emission Limits (IELs) has been observed for the „boron" and "phosphates" indicators.

All recorded values are below the Individual Emission Limits (IELs), specified in the license for this flow, except for the results for the „boron" indicator, for which the restriction reads „not allowed" and "phosphates" (**Table 3.2-3***: Recorded emission values exceeding the individual emission restrictions at the TC's discharging* ***point*****).**

Table 3.2-1*: Recorded emission values exceeding the individual emission limits (IELs) at the Ø 1000's discharging point*

Indicator	Number of analysed samples	Number of exceeded values	IELs, [mg/dm^3]	Mean value, mg/dm^3	Maximal value, mg/dm^3
Boron	15	13	Not allowed	0.05	0.09
Total phosphorus (such as PO4)	12	1	2	-	2,45

Discharging of waste water from the Open Switchgear

All recorded values are below the Individual Emission Limits (IELs), specified in the license for this flow, except for the results for the „boron" indicator, for which the restriction reads „not allowed" and "undissolved substances" (**Table 3.2-4***: Recorded* *emission values exceeding the individual emission limits (IELs) at the Open Switchgear discharging point*).

Table 3.2-4: *Recorded emission values exceeding the individual emission limits (IELs) at the Open Switchgear discharging point*

Indicator	Number of analysed samples	Number of exceeded values	IELs, [mg/dm³]	Mean value, mg/dm³	Maximal value, mg/dm³
Boron	3	1	Not allowed	0.11	0.11
Undissolved substances	9	1	50	-	56

Hot (outlet) channels (HCs)

HC-1

No cases of exceeded Individual Emission Limits (IELs), specified in the license for waste water discharging, have been observed for this flow.

HC-2

No cases of exceeded Individual Emission Limits (IELs), specified in the license for waste water discharging, have been observed for this flow.

Taking into account the analyses results it could be summarized that only for the waste water discharged into the Main Drainage Channel (MDC), some not too big values of the „boron" indicator have been recorded, however, they are within the limits of the values recorded for the drinking water of the town of Kozloduy and the water in the Danube river (Protocol No. 1-E/January 24, 2012).

Annual Programs and Annual Activity Reports are prepared for the implementation of radioecological monitoring which includes laboratory radioactive analysis of samples from major ecological site components within the 30 km Urgent Protective Action Planning Zone (UPAPZ) and within the 100 km zone around *Kozloduy* NPP.

The radio-ecological monitoring scope complies in full with the national and European regulatory requirements, including Article 35 of the EURATOM Agreement, EU Recommendations 2000/473/EURATOM and 2004/2/EURATOM. Subject to this monitoring are natural water catchments, drinking, underground, and waste water. The sample selection sites are 7, whereas natural water (catchments, drillings, water catchments, and bottom sediments) – at 4 points along the course of the Danube river, and at the Ogosta river, the Tsibritsa river, and the Kozloduy dam are analysed. Monitoring of underground water from about 80 boreholes (piesometres) alternated after a scheme, water from 10 spray ponds, and the drainage collectors for rain and waste water. Analyses for total beta-activity, strontium-90, tritium, and radionuclide composition are performed.

The monitoring comprises:

- periodic control of the gamma background radiation on the site and within 100 km from the NPP, laboratory radioactive analysis of samples from major ecological components on the site and within 100 km from the NPP,
- automated radiation monitoring of the settlements gamma background radiation within the 30 km Urgent Protective Action Planning Zone (UPAPZ).

The monitoring of the industrial site, the gas-aerosol and liquid radioactive releases, the mains water, the service and waste water from the NPP, and the monitoring in the region of Specialized Division *Radioactive Waste–Kozloduy*, are regulated by separate documents.

The total beta-activity of the water of the Danube river, the Ogosta river, the Tsibritsa river, and the *Shishmanov Val* dam varies between 0.012 Bq/l and 0.15 Bq/l, which is about 30% of the control level (0.5 Bq/l, Regulation No. H-4/2012[38]). The maximal measured value for the water of the Danube river is 0.087 Bq/l, according to the Annual Report of *Kozloduy* NPP EAD for 2011. Tritium content in surface water samples is somewhere about the minimal detectable activity – up to 8.0 Bq/l. The total beta-activity measured for the drinking water sources in the region varies between 0.024 and 0.088 Bq/l. These values are much lower than the allowed drinking water norms under Regulation No. 9/March 16, 2001.

A detailed Annual Radio-Ecological Monitoring Report containing analysis of all the results for the relevant year is submitted to the Bulgarian Nuclear Regulatory Agency (BNRA), the National Radiobiology and Radiation Protection Centre (NRRPC) at the Ministry of Health (MH), and the Executive Environment Agency (EEA) at the Ministry of Environment and Water (MEW).

Hydrological data about the Danube river

No rivers flow through the NPP's territory. The Bulgarian inland rivers closest to the NPP are the Ogosta river and the Skat river. The natural topographic conditions and the remoteness of these rivers exclude the possibility for them to have any impact whatsoever on the NPP's state. No direct impact on these open currents is possible, either.

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38 Regulation for the Characterization of Surface Water, prom. SG No. 22 of March 05, 2013.

The Danube river is the only one of decisive significance for the operation and security of *Kozloduy* NPP. The NPP's site is located on the terrace of the Danube river. The site's level is formed on a washed site of considerable size, designated during the NPP's design and having a non-floodability reserve in case a 10 000-year high wave along the Danube river is generated.

Between the NPP's site and the Danube river, dikes have been erected which are sized to withstand a 1000-year high wave along the Danube river with the required normative reserve. The drainage systems in the region have been sized to carry away surface water from intensive rain of different duration and 0.01 % provision of the precipitation height.

In relation to the assessment of the NPP's state on the part of theIAEA during the period 1991-1992, a cycle of hydrological, hydrogeological, and hydraulic calculations and studies for assessment of the NPP's selection and site elements has been carried out. Part of these results have been analysed and assessed in the EIA for the *Kozloduy* NPP, 1999, and major conclusions are presented hereunder in these Terms of Reference. After this mission, no interrelated hydrological study has been assigned or carried out. Individual studies have been carried out which do not cover the same period, so the results therefrom have been used without the possibility to be subject to a completely reliable assessment or interpretation.

The mentioned EIA Report pays serious attention to the maximal and minimal flow characteristics of the Danube river. In this respect, in Bulgaria, official results from only one study of the maximal flow have been published (Zh. Nikolov, BAS-1981). For the purposes of the design of various facilities along the Danube river, different studies have been carried out at the University of Architecture, Construction, and Geodesy (UACG), the National Institute of Meteorology and Hydrology (NIMH), the Institute of Water Problems (IWP) of the Bulgarian Academy of Sciences (BAS)[39] and *Energoproekt* AD, which differ in the amount and analysis of the information about the maximal flow and probabilistic assessments. Actually, in Bulgaria, there are no official publications on the use of stochastic models to determine the maximal sizing water amounts for the section from the town of Silistra to the town of Novo Selo.

Routine observations of hydrological elements are carried out on a daily basis by the Executive Agency for Maintenance and Study of the Danube River (EAMSDR), town of Rousse (water constructions, water amounts, water temperature and ice phenomena). Measurements and observations of these elements during various time periods have also been carried out by *Energoproekt* AD, *Kozloduy* NPP EAD, etc. Measurement expeditions for hydrological elements have been carried out by the NIMH, the UACG, Stefan Modev ET (Sole Trader Company). For the purposes of the mentioned EIA, available data from the following sources have been used:

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39 IWP – former Institute of Water Problems, BAS, which merged into the NIMH.

- The main hydrometric stations in the section of Oryahovo- ^{km}678 and Lom- ^{km}749.3,
- Observations of the water stands at ^{km}704 (Executive Agency for Maintenance and Study of the Danube River [EAMSDR]) and ^{km}678 (*Energoproekt* AD),
- Data from field measurements during the period 1978–1991.

In the section of the *Kozloduy* NPP, regime water level observations are carried out, as follows:

- ^{km}678 – Oryahovo Hydro-Meteorological Station (HMS) (Executive Agency for Exploration and Maintenance of the Danube River [EAEMDR], town of Rousse),
- ^{km}687.50 – Bank Pump Station (BPS) (*Kozloduy* NPP),
- Data from field measurements during the period 1978–1991.

The conducted studies comply with the requirements of the IAEA for processing of the “entire available hydrological information, while checking the same for available systematic mistakes, as well as technical errors”. The requirement “It is expedient to store this information in a hydro-meteorological database...” is addressed as recommendation to the *Hydro-Technical Facilities* Department of *Kozloduy* NPP, which is currently organizing this activity.

The report’s requirement reading that “...particular attention should be paid during the clarification of the natural hydrological characteristics and the hydro-morphological characteristics of the river bed and the river terrace, roughness characteristics, etc., and the multi-annual peculiarities of the river-bed processes should be clarified ...” has been fulfilled in accordance with the available information and the conducted studies. The lack of updated batimetric or topographic map of the river bed for the section of the Danube river located in the region of *Kozloduy* NPP does not provide to make complete hydraulic assessment of the flow capacity of the river bed at low and high water.

The performed study concludes that the *Zhelezni Vrata (Iron Gates)* water-power systems do not regulate flow during periods greater than 1 week because of the lack of regulating amounts. Therefore, their impact on the monthly and annual river flow is insignificant.

The variation of the Danube river flow has been determined to be greatest during low-water months (August – January). The river flow is most stable during the high water period (February – July). The annual river flow is determined with 95% provision of over 4300 m^3/s.

Accounting for the results from the study performed for the needs of the EIA[40], the authors have determined that when *Kozloduy* NPP operated at its full capacity (3760 MW – with six running reactors and capacity of the cold (intake) channel of 180 m^3/s with proven maximal capacity of 200m^3/s), even in a strongly low water year (security of 99%), the Danube river water consumed by the NPP was very small – only 4.5 % of the river flow.

In normal operating mode with average annual output of 2500–3000 MW, the required water amount for the NPP's cooling system is about 2.7 % – 3.5 %. Such operating mode would be commensurate with the currently running power units 5 and 6 plus the NNU.

The irrecoverable water losses at *Kozloduy* NPP have been estimated to 0.00092% of the Danube river flow and 0.044 % of all water used by the NPP, whereas the reasonable conclusion has been made that the *Kozloduy* NPP does not affect the Danube river's flow.

Ice phenomena have been considered in the EIA Report for *Kozloduy* NPP in 1999, insofar as they create or might create a risk for the NPP's operation or security.

Observations of the ice regime of the Danube river have been carried out since the end of the last century. The major recorded parameters are the dates of occurrence and disappearing of ice phenomena (ice drift and complete freezing), as well as their intensity. No systematic observations of ice thickness or ice blocks size during ice-break have been carried out. Most often, ice build-up phenomena have been presented only descriptively.

The section of the Danube river located in the region of *Kozloduy* NPP pertains to Lower Danube (from Turnu Severin to the Black Sea). The climatic conditions and the complex morphology of the river bed favour the generation of ice phenomena. The most unfavourable form in which these phenomena are manifested is ice build-up. With them, as a result of the building-up of ice blocks, river zones or sections with significant water retention are formed.

Earlier studies (St. Modev, 1991) show that water level retention in the area of the Bank Pump Station (BPS) at low water may reach up to 3.60 m, and at high water – up to 1.50 m. The probability for the formation of water retentions as a result of ice build-up phenomena at Oryahovo is once in 10 years, and water stands reached after water retention correspond to water stands with recurrence of 0.5%, i.e. once in 200 years. So far, no studies have been carried out regarding the chances of ice build-up at higher water, and the probability for the occurrence of such phenomena has been neither evaluated.

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 EIAR for *Kozloduy* NPP, 1999.

3.2.1.2 *PREDICTION OF THE IMPACT*

The forecast for the impact of the Investment Proposal (IP) will reflect the expected impact on surface and underground water and will evaluate the need of new water amounts for drinking and household needs according to the recommendation of the Municipality of Kozloduy, stated in Letter No.73 00-128/1 of January 03, 2013 on the great number of workers during construction and the servicing staff of the NNU during its operation. This evaluation will be valid for all proposed alternative sites, irrespective of their location. The evaluation of the need of fresh water for service and industrial needs will be single-option, i.e. one source and one water-extraction system for all sites. The assessment of the different inclusion options and their environmental impact will be made. The estimation for the impact of the discharging of non-radioactive household-fecal wastewaters, industrial and rain water, will consider in detail each alternative site, namely: the location of the envisaged treatment facilities, their capacity, and the treatment effect of the envisaged new underground infrastructure – sewer system, facilities leading to collector, and discharging facilities.

When estimating the impact of the Investment Proposal (IP), emphasis will be placed on the assessment of the ecological state and the chemical state of the water receiving body collecting all waste water from *Kozloduy* NPP and the NNU to the Danube river. Its ecological potential and ecological state will be assessed as pertaining to a body of moderate ecological potential and poor chemical state. The available knowledge and the adopted standards for assessment of chemical state quality (Directive 2008/105 Appendix 1) regarding the priority substances and assessment of the contribution to the organic pollution receiving waters according to the regulatory norms will be applied. According to the Water Basin Management Plan (WBMP), the Danube river has been qualified as a water body at risk of achievement of the ecological objectives. The results from the National Monitoring System will be considered and the possible impact from discharging of waste water and radioactively polluted water will be accounted for. The report of EIA will analyse and assess in detail each site with respect to the possibility of building-up and migration of radionuclides depending on its characteristics as regards the design characteristics related to the maintenance of acceptable risk level. The possibility for the sites' flooding by a high river water level, increase of underground water, destruction of the Hydro-Technical Facilities (THF) erected along the Danube river, and other combinations of natural and technogenic phenomena will be analysed and assessed.

The EIA Report will consider in detail and comprehensively the expected impact of the IP's construction and operation on the ecological state of the Danube river water body in the Bulgarian section and also, in the trans-border aspect (Letter of the Ministry of Environment and Forests (Republic of Romania) with Outgoing No. 3672 RP 18.10.2012).

The following basic criteria for assessment of the impact of the construction and operation of the NNU on the proposed alternative sites may be formulated:

- Criteria related to the location, which will assess the considered sites with respect to the impact of the IP's construction and operation on the available infrastructure, which is useful for the region or for the available NPP, and the physical impact of the IP's construction and operation on surface water;
- Criteria related to the possibility for providing service water supply using water from the Danube river and other available water sources from the constructed infrastructure, the transfer of the whole processed water and the whole waste water to the receiving waters;
- Criteria related to the security and safe operation of the new nuclear unit in view of the risk of natural phenomena – flooding by river high water, or technogenic risk – break-up of a dam wall above the site's region;
- Criteria related to the impact caused by the introduction of polluting substances into the water environment and their migration, including the thermal impact.

The thermal pollution of the Danube river will be considered in point 3.9.4. Harmful physical factors.

3.2.2 UNDERGROUND WATER

3.2.2.1 CURRENT STATUS

According to the Water Basin Management Plan (WBMP), the site of *Kozloduy* NPP and the pertaining boundary territories overlay parts of the following water bodies:

- Underground Water Body (UWB) defined by code BG1G0000QPL023 – porous water in the Quaternary – between the Lom river and the Iskar river. The site of *Kozloduy* NPP falls entirely over this water body, which occupies area of 2890 km^2. This is the first water-carrying surface horizon. Collectors of porous types of underground water are gravels of various sizes with sandy-clayish filler, at some places - with sand streaks covered by loess depositions. Normally, underground water in not pressurized. The following characteristics of the water body have been determined: average thickness of the Underground Water Body - 25 m, average water transmissibility - 13 m^2/d, average filtration coefficient - 2 m/d, average module of the underground flow - 1.1 l/s.km^2, area of the feeding zone - 2888 km^2, natural resources - 2310 l/s. The direction and rate of exchange with surface water has been qualified as embarrassed. According to the performed risk assessment of the chemical and quantitative state, the UWB has been qualified as **not being at risk**. According to the Danube Water Management Plan (DWMP), the protective action of the covering layers is distributed into 90% favourable and 10% medium;

→ Underground Water Body (UWB) defined by code BG1G0000QAL005 - porous water in the Quaternary – the Kozloduy lowland. Falls within the в east-northeast part of the site of *Kozloduy* NPP and the boundary territories. Occupies area of 39 km^2. Collectors of the porous type of underground water are gravels, sands, clays, and sandy clays covered by sandy clays and clays. Normally, underground water in not pressurized. The following characteristics of the water body have been determined: average thickness of the Underground Water Body - 13 m, average water transmissibility - 1155 m^2/d, average filtration coefficient - 89 m/d, average module of the underground flow - 4 l/s.km^2, natural resources - 160 l/s, area of the feeding zone - 39 km^2. The direction and rate of exchange with the Danube river is direct. According to the performed risk assessment of the chemical and quantitative state, the UWB has been qualified as **being at risk**. There is detected pollution with Fe and Cl from anthropogenic impacts in the UWB chemical state. According to the Danube Water Management Plan (DWMP), the protective action of the covering layers is distributed into 10% medium and 90% poor;

→ Underground Water Body (UWB) defined by code BG1G0000QAL005 - porous water in the Neogene – Lom-Pleven depression. The site of *Kozloduy* NPP falls entirely over this water body lying under the Quarternery water-carrying horizon. It occupies area of 3065 km^2. It is represented by an upper and a lower layer, as follows:

- ✓ Collectors of fresh, porous-type underground water, not pressurized, in the upper layer – gray-greenish clays, sandy clays, and clayish sands alternating with low-power coal lenses covered by sandy clays and loess. The following characteristics have been determined for the upper layer: average thickness of the Underground Water Body - 70 m, average water transmissibility - 140 m^2/d, average filtration coefficient - 2 m/d, average module of the underground flow - 0.8 l/s.km^2, area of the feeding zone - 618 km^2. The direction and rate of exchange with surface water is embarrassed. According to the performed risk assessment of the chemical and quantitative state, the UWB has been qualified as being at risk with respect to the chemical state and as not being at risk with respect to the quantitative state. NO_3, Mn and other pollutions resulting from agricultural activities have been identified. According to the Danube Water Management Plan (DWMP), the protective action of the covering layers is distributed into 10% medium and 90% poor;

- ✓ In the top of the lower layer there are clays (water impermeability), under them come sands of various grain sizes (water-carrier) with small-power clayish streaks. Pressurized nature. The following characteristics have been determined for the lower layer: average thickness - 100 m, average water transmissibility - 2500 m^2/d, average filtration coefficient - 25 m/d, natural resources - 1730 l/s. No exchange with surface rivers aws established. According to the performed risk assessment of the chemical and quantitative state, the UWB has been qualified as not being at risk with respect to the chemical and quantitative state. According to the Danube Water Management Plan (DWMP), the protective action of the covering layers is distributed into 95% favourable and 5% medium.

During the outlining of the underground water bodies, the criteria applied in the Dutch approach, *Strengthening of the capacity and enhancement of the national groundwater monitoring system of Bulgaria towards implementation of the Water Framework Directive 2000/60/EC*, have been taken into account, as implemented by a team from the *Hydrogeology* Department of the Institute of Geology at the Bulgarian Academy of Sciences (BAS) based on a contract signed with the Dutch company ARCADIS EUROCONSULT BV. Their identification was performed by the Executive Environment Agency with the help of the Basin Directorate. The major materials used were geological map (GIS, vector, M 1:100 000), hydrogeological maps (GIS, M 1:500 000 scalar, M 1:200 000, for certain, more water-abundant regions of the country, to scale M 1:25 000).

The characterization of the water bodies is a requirement of the Water Framework Directive 2000/60/EC, based on expert criteria for the objectives of the loading and impact assessment, adopted at national level (IMPRESS review). They have been taken from the criteria developed by the International Commission for the Protection of the Danube River (ICPDR) and have been adapted to the national conditions. In performing the assessment, the Guide on Application of the Framework Directive on Water developed under Twining Project BG 03/IB-EN-02 has been used as well.

The assessment of the protective action of the cover layers of the Underground Water Bodies (UWBs) has been performed based on expert assessment of the characteristics of the geological units. The analysis is based on the rate of revealing of the UWB on the Earth's surface and the anthropogenic loadings on the revealed parts of the bodies. Three UWB classes have been isolated – with favorable, medium, or unfavorable action on the cover layers.

The three water bodies on which the territory of *Kozloduy* NPP falls have been qualified as water-protection zones, from which water for human consumption is drawn, with average 24-hour capacity of above 10 m^3 or which are used for water-supply of more than 50 people, according to the requirements of Article 7, point 1 of Directive 2000/60/EC and Article 119 of the Water Act.

The drinking water protection zones for underground water bodies have been determined based on issued water-extraction licenses for drinking and household water supply and established Sanitary Protection Zones (SPZs) around the water-extraction equipment under the terms of European legislation transposed into the Water Act and Regulation No. 3/October 16, 2000 on the terms and conditions for investigation, design, approval and operation of Sanitary Protection Zones (SPZs) around the water-extraction equipment for drinking and municipal water supply and around mineral water sources used for healing, prophylactic, drinking, and hygienic needs.

The water from the Underground Water Body (UWB) defined by code BG1G0000QPL05 – porous waters in the Quarternery – Kozloduy lowland is characterized by total beta activity and content of natural uranium below the admissible values according to Regulation No. 9/March 16, 2001 on the quality of water for drinking and household purposes, and the specific activity of the studied radionuclides (^{40}K, ^{137}Cs, ^{54}Mn, ^{109}Cd, ^{226}Ra, ^{232}Th, ^{214}Pb, ^{214}Bi) is below the maximal admissible values, according to the Regulation on the basic norms of radiation protection, 2012.

According to provided information from the water management Basin Directorate – Danube region, Pleven, by Letter with Outgoing No. ЗДОИ-380/February 11, 2013, on the territory of the water body, one monitoring station is kept a track of, namely shaft well (SW)-P2 BC Kozloduy, which has been assigned to perform major monitoring of the physico-chemical indicators of the I-st and II-nd group and specific pollutants of the I-st group of metals and metalloids and II-nd group of organic substances.

The results from the analysis of the performed monitoring show that all observed indicators are within norm according to the quality standards regulated by Regulation No. 1 (2007) on the investigation, use, and preservation of underground water, as amended and supplemented the State Gazette (SG) issue 15, 2012.

The multi-annual studies of drinking water originating from *Kozloduy* NPP under environmental monitoring program show that the values for the total beta activity are considerably lower than the maximum admissible values according to the requirements of Regulation No. 9/March 16, 2001 on the quality of water for drinking and household purposes, and the content of technogenic ^{90}Sr и ^{137}Cs is several ten times lower than the norms according to the Regulation on the basic norms of radiation protection, 2012.

To implement the recommendations of the report of EIA of 1999 and the conditions of Decision No. 28-8/2001 on EIA, proper non-radiation monitoring (PNM) is carried out at *Kozloduy* NPP.

On the territory of the industrial site of *Kozloduy* NPP, a total of 181 boreholes (piesometres) have been drilled. Of them, 76 are located on the territory of EP-1, 52 – on the territory of EP-2, and 53 in the region of the Spent Fuel Storage Facility (SFSF) and the Lime Production Facility.

Since the commissioning of the Radioactive Waste Processing Shop (RAWPS) in 2001, exploration of 26 new piesometres has started.

Under the Underground Water Radioactivity Study Program, at the industrial site of *Kozloduy* NPP, sample collection from 115 boreholes is carried out. Of them, 27 are located on the territory of EP-1, 29 - on the territory of EP-2, 26 are in the region of the RAWPW and the RAW storage depot, 25 in the regions of the WSF, the Lime Production Facility, and the site for temporary outdoor storage of solid RAW, and 5 – on the waste depot.

In August 2004, sample collection and analysis of three new reference drillings located at the input and output of the water-carrying horizon, in the immediate vicinity of the industrial site, was initiated.

Water samples from the boreholes have been analysed four times in a year for total beta-activity and tritium content.

The European requirements regarding the application of Article 35 of the EURATOM Agreement for monitoring of environmental radioactivity levels for the purposes of assessment of the dose exposure of the population as a whole are regulated by Recommendation 2000/473/Euratom of June 08, 2000 of the European Commission. This Recommendation is of major significance for the standardization and unification of the applied practices in the field of radioecological monitoring of EU member-states. The terms and the general requirements for monitoring types, monitoring and sample collection (dense or spaced) networks, control periodicity, monitoring amount, and the requirements for sample collection and analysis of the major controlled environmental features have been defined. Furthermore, the amount of sample-accompanying information, and monitoring data management and transfer have been regulated.

The institutional environmental radiation monitoring is regulated by a long-term environmental radiation monitoring program of *Kozloduy* NPP. The Program is based on the regulatory requirements in the field, as well as on the good international practice and operating experience of the *Radioecological Monitoring* Department. The Program has been coordinated with the Ministry of Environment and Water (MEW), the Ministry of Health (MH), and the Bulgarian Nuclear Regulatory Agency (BNRA) and complies with the international recommendations in the field, including Article 35 of the EURATOM Agreement and Recommendation 2000/473/Euratom. To provide independent control, radiation monitoring programs are implemented by the controlling authorities: the Executive Environment Agency (EEA) at the Ministry of Environment and Water (MEW) and the National Radiobiology and Radiation Protection Centre (NRRPC) at the Ministry of Health (MH).

To localize and assess the potential impact of *Kozloduy* NPP on the environment and the population, 2 control zones of different radius around the NPP have been designated: Precautionary Action Zone (PAZ) - 2 km, and Urgent Protective Action Plannig Zone

(UPAPZ) - 30 km. Subject to monitoring is also the territory of the industrial site itself. For comparison, sample collection and measurements are carried out at reference points located within up to 100 km from the NPP, where no impact from the NPP's operation is expected. Laboratory and automated control of the environmental components is carried out.

Practice shows that the results from the radioecological monitoring feature much lower values than the values established by the normative documents. Therefore, most often, comparison of the current results with results from previous years of operation and prior to the NPP's commissioning is used. This approach provides to record and analyse even the slightest tendencies for change in radioecological circumstances. The pre-operation measurements in the region of *Kozloduy* NPP were carried out during the period 1972–1974 by the National Radiobiology and Radiation Protection Centre (NRRPC) (then bearing the name Scientific Institute for Radiology and Radioactive Hygiene [NIDDH]).

The available environmental water radioactivity data at *Kozloduy* NPP during the pre-operation period 1972–1974 show the following contents: Cesium-137 – 10.0 mBq/l ± 6.0 mBq/l; Strontium-90 – 7.0 mBq/l ± 6.0mBq/l; total beta-activity – 420 mBq/l ± 170 mBq/l.

During the implementation of the modern monitoring program, particular attention is also paid to drinking water sources in the region of the NPP. The drinking water for the town of Kozloduy, village of Harlets, *Kozloduy* NPP, and the town of Oryahovo has been tested on a monthly basis for beta-activity and tritium. ^{90}Sr и ^{137}Cs are determined twice in a year and for the water mains of the town of Oryahovo – four times in a year.

The results are identical with those from previous years and are many times lower than the statutory norms, which shows that the radiation state of drinking water sources in the region has not been affected by the operation of *Kozloduy* NPP and complies completely with the sanitary norms.

On the industrial site itself, about 115 boreholes are controlled to assess possible pollutions on a local scale. The control is carried out on a quarterly basis.

Out of 115 boreholes measured for total beta-activity in 2011, with 110 of them, the total beta-activity throughout the year has not been even a single time greater than 0.75 Bq/l, according to Regulation No. 1/2007 on the investigation, use, and preservation of underground water.

According to the Environmental Radiation Control Program, the water from boreholes with total beta-activity greater than 1.5 Bq/l has also been subject to gamma-spectrometric testing to find out its radionuclide composition.

With the gamma-spectrometric measurements, minimal technogenic ^{60}Co activity has been recorded only in two drillings, and traces of ^{137}Cs – in one drilling. The values of 0.3 ÷ 0.5 Bq/l are commensurate with the Maximal Admissible Values (MAV). Increased tritium content has been measured only in some drillings on the industrial site. These are but local sections, located in the immediate vicinity of equipment with radiation potential – dedicated bodies, RAW storage and processing equipment. Tritium activity varies from background levels in most drillings to a maximum of 12 kBq/l in the region of AB-3 of EP-2. Total beta-activity varies within the range from typical background values to 3 Bq/l in the region of the RAW storage facility.

The radioactivity from the other drillings on the site and the reference drillings is very low (below or about the MAV), which evidences that the water-carrying horizon in the region has not been affected by the operation of the NPP.

The underground water within the 2 km Precautionary Action Zone (PAZ) outside the site of *Kozloduy* NPP has been tested at 8 exploration boreholes (piesometres). Five of them are located in the region of the Depo for Non-Radioactive Household and Industrial Waste (DNHIW). A total of 4 of these 8 piesometres are reference ones and are used for comparison and global assessment of the impact on the water-carrying horizon in the region around the site. Sample collection and analysis is performed on a monthly basis. Tritium activity and total beta-activity of the samples is tested, and at the reference drillings, gamma spectrometric analysis is also performed.

In 2011, the results for the total beta-activity of underground water around the site of the DNHIW vary between <0.055 and 0.39 Bq/l, with average value of 0.11 Bq/l. These results are within the normal limits for underground water, lower than the underground water norm (1 Bq/l, Regulation No. 1 of October 10, 2007 on the investigation, use, and preservation of underground water).

The analyses for tritium in underground water show activity of <4.2 to 60.3 Bq/l, with average content of 13.3 Bq/l. All results are below the MAV, except for one piesometre from the DNHIW. These are very low values, even below the norm for drinking water (100 Bq/l, Regulation No. 9 of March 16, 2001).

On the overall, the radiation characteristics of the water-carrying horizon at the site's input and output are not affected by the operation of *Kozloduy* NPP. The radiation indicators are within the limits of the admissible norms.

3.2.2.2 PREDICTION OF THE IMPACT

For the purposes of the REIA, an Estimate of the impact will be prepared based on an assessment of the effectiveness of the performed actual studies, including the results from underground water monitoring in 2012 and current studies from 2013. The implementation of the following mandatory activities under the project, ensuring unbiased assessment of the impact of the Investment Proposal (IP) on underground water will be analysed in detail:

→ The prepared conceptual model of the hydrogeological circumstances will be assessed, in order to analyse the established underground water feeding sources and the drainage zones. The localized vulnerable zones of the industrial site will be analysed and the protective action of the underground water bodies' covering layers will be assessed based on expert assessment related to the characteristics of the geological units, thickness of the water-carrying layer, and restrictive beds. The prepared and assessed models for underground water flow, quality, transmissibility, and retention coefficient will be assessed. The criteria for the preparation of a conceptual model should comply with *Guide No. 26 A. Conceptual Model for Underground Water to the General Strategy for Application of the Framework Directive on Water*;

→ The filtration and migration characteristics of the hydrogeological environment for all sites will be defined, which will be used in the investment project to forecast radionuclide migration[41]. The methodology of the forecast – forecasts for radionuclide migration, in the studies so far has been made using the computer codes: MODFLOW – in the analysis of hydrodynamical characteristics, and MT3DMS – in the forecast of pollutant migration;

→ The impact estimation will be subject to the following criteria:

✓ Assessment of underground water regime, including water level behaviour and capacity change in the part of the considered water body on which the Industrial Site (IS) falls. The assessment criteria are defined in Regulation No. 1 of October 10, 2007 on the investigation, use, and preservation of underground water, in effect since October 30, 2007 issued by the Ministry of Environment and Water (MEW), the Ministry of Regional Development and Public Works (MRDPW), the Ministry of Health (MH), and the Ministry of Economy and Energy (MEE), as promulgated the SG issue 87 of October 30, 2007, as amended the SG issue 2 of January 8, 2010, as amended and supplemented the SG issue 15 of February 21, 2012.

✓ Assessment of the properties of underground water. The criteria for assessment of the chemical state of underground water are:

- the underground water quality standards determined pursuant to Article 135, para. 1, point 2 of the Water Act;

- the underground water pollution thresholds determined under the terms of Article 118b of the Water Act.

41 Clarification of the dispersion characteristics of soil and water environment in the region of *Kozloduy* NPP for the purpose of analyzing the possible migration routes of the radionuclides from the NPP into the soil and the hydrosphere, 1991, Aquater partnership, Leader: Prof. M.Galabov, 1992

- ✓ Assessment of the impact of the IS on the water protection zones, including the underground water properties used for Drinking and Municipal Water Supply (PMWS). The criteria for assessment of the chemical state of the underground water used for PMWS are the requirements of Regulation No. 9 of March 16, 2001 on the quality of water intended for drinking and municipal needs, as promulgated the SG issue 30 of March 28, 2001, as amended the SG issue 87 of October 30, 2007, in effect since October 30, 2007, as amended and supplemented the SG issue 1 of January 4, 2011, as amended the SG issue 15 от February 21, 2012, in effect since February 21, 2012;
- ✓ Assessment of the hydrogeological environment. Emphasis will be placed on the possibility for harmful impact of underground water as a result of the utilization of the IS, the possibility for the occurrence of suffosion, diffusion, subsiding, mixing of water-carrying horizons with different properties.
- ✓ Assessment of the ecosystems depending on the regime and properties of underground water. The assessment criteria have been defined in the Water Framework Directive (WFD), in effect since December 22, 2000. Its purpose is to establish a water protection framework (for surface, underground, coastal, or international water). By the WFD, the EU member-states undertake to protect from future deterioration and to improve the quality of water ecosystems. The major objective is to achieve “good ecological status” by 2015. The natural state of water ecosystems (flora and fauna) is used as criteria.

→ In carrying out of the investigations linked with the investment project, assessment of the hydrological circumstances will be made, which will include:

- ✓ the expected concentration of the radioactive material in underground water at the closest point of the region from which water for drinking and municipal purposes is taken;
- ✓ the characteristics of radionuclide retention in the soil;
- ✓ the transfer routes and the arrival times of the radioactive material from the point of release to the consumption source;
- ✓ the transfer capacity of the surface flow, the intermediate flow and the drainage into underground water;
- ✓ the pollution susceptibility of the water-carrying layer at different levels; and

- ✓ time and spatial distributions of radioactive material concentrations in underground water as a result of emergency release from the NPP.

→ To assess the hydrochemical and radiological examination of underground water, the investment project will provide analysis of the results from the monitoring program implemented over the years prior to the accomplishment of the Investment Proposal (IP), its effectiveness, the manner of interpretation of the results, and its applicability to the Investment Intention (II). A task of utmost importance will be to make a comprehensive survey and interpretation of the performed analyses of water samples during the period 2007–2012, preparation of graphs illustrating the concentration of the examined elements and their joining in a single information system for all monitoring programs. Seasonal isoline maps will be prepared, indicating water level behaviour and pollutant concentration in water. The assessment criteria have been defined in Regulation No. 1 (2011) on water monitoring;

→ Assessment will be made of the location of the erected monitoring stations, their technical condition, depth, structure, and the information obtained from them regarding the examined water and the water body they refer to. Where needed, new monitoring stations will be proposed in the NNU construction zone.

→ The available information does not contain any data of drawn seasonal hydrodynamic and hydrochemical underground water maps. Under the investment project, seasonal hydrodynamic maps will be drawn, evaluating the filtration depression zones.

→ For the purposes of the EIA, the possible releases into underground water during normal and emergency operation of the NPP will be assessed, which might affect the quality of underground water, directly or indirectly, through soils and surface water:

- ✓ Indirectly – through infiltration of surface water which has been polluted with radioactive material released by the NNP or infiltration of radioactive liquids from storage tanks;
- ✓ Directly – average on the NPP which may allow radiation material to penetrate into underground water. The protection of underground quality from such events will be taken into account in the safety analysis of emergency states and the need of a geographic protective barrier will be assessed.

3.3 LANDS AND SOILS

3.3.1 LANDS

3.3.1.1 CURRENT STATUS

The Investment Proposal (IP) includes 4 sites whose main characteristics are presented in

Table 3.3-1: Main characteristics of the alternative sites for location of NNU *.*

Table 3.3-1*: Main characteristics of the alternative sites for location of NNU*

Site	Total area, dka	Land	Municipality	Property
1	550	Harlets	Kozloduy	NPP – 24.7 dka; pubic organizations and state and private property – 525.3 dka
2	550	Harlets	Kozloduy	NPP-202.7 dka; GBC-ECM AD-68.6 dka; private plots – 278.7 dka
3	530	Harlets	Kozloduy	NPP-66.5 dka; private agricultural land – 463,5 dka
4	210	Harlets, town of Kozloduy	Kozloduy	NPP-161dka; Enemona AD-49.0 dka

On

Table 3.3-1: Main characteristics of the alternative sites for location of NNU , the four sites by type of property are presented.

In Figure 3.3-2*: NPP Kozloduy project sites by type of property*, the four sites by the way of sustainable land use are presented. As can be seen, none of the four sites falls within forest area.

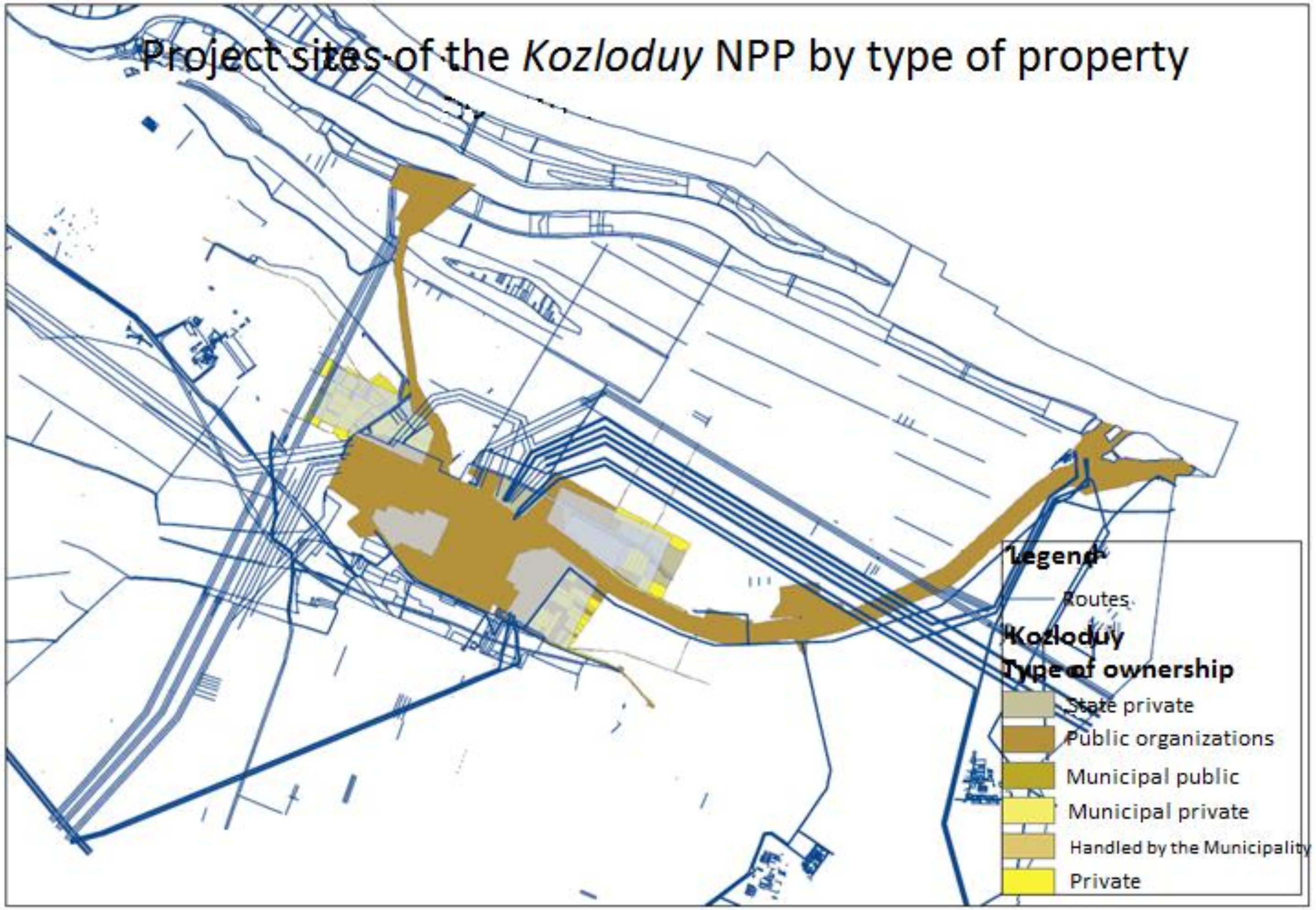


Figure 3.3-1: *NPP Kozloduy project sites by type of property*

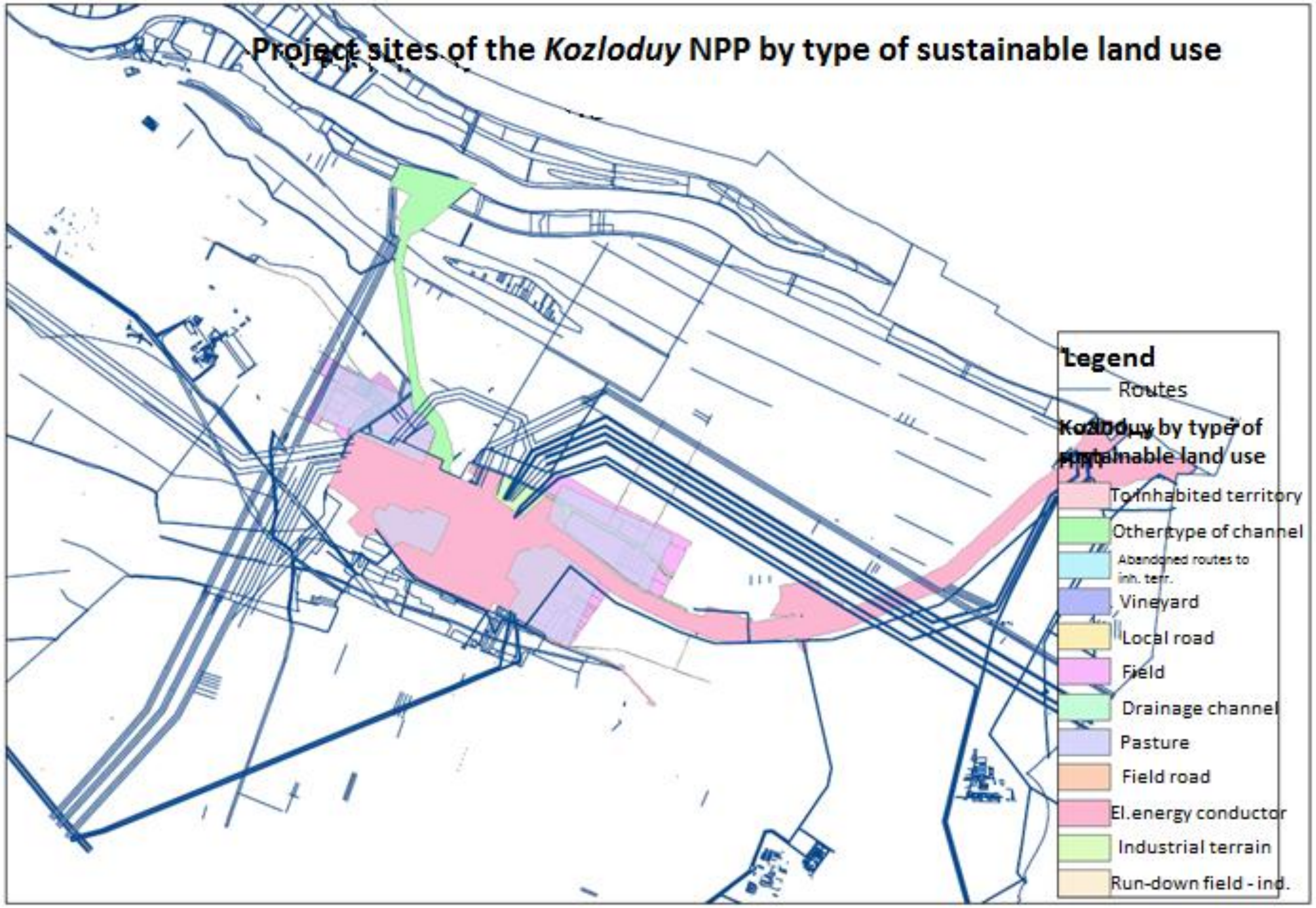


Figure 3.3-2*: NPP Kozloduy project sites by type of sustainable land use*

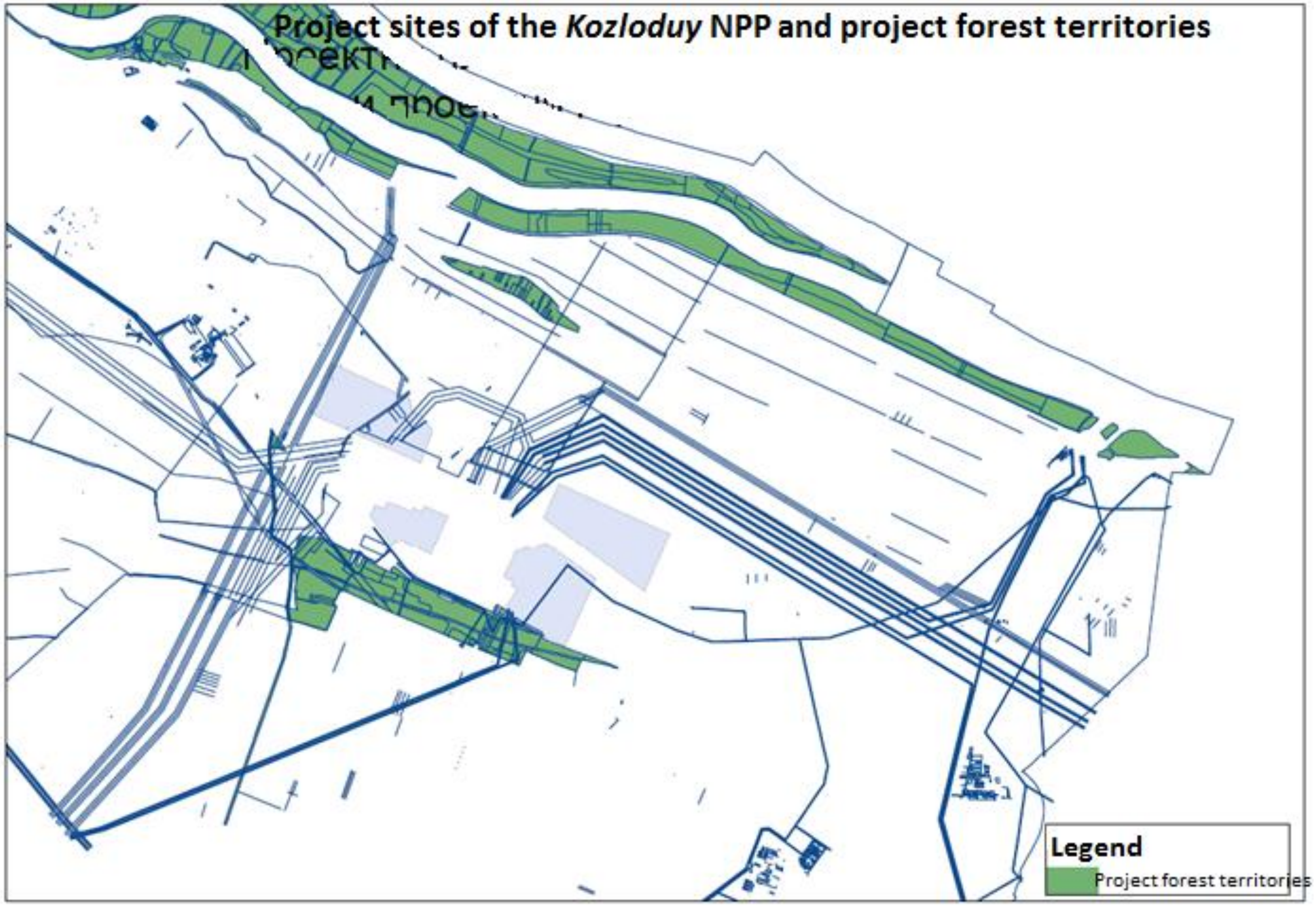


Figure 3.3-3: *Project sites of Kozloduy NPP and project forest territories*

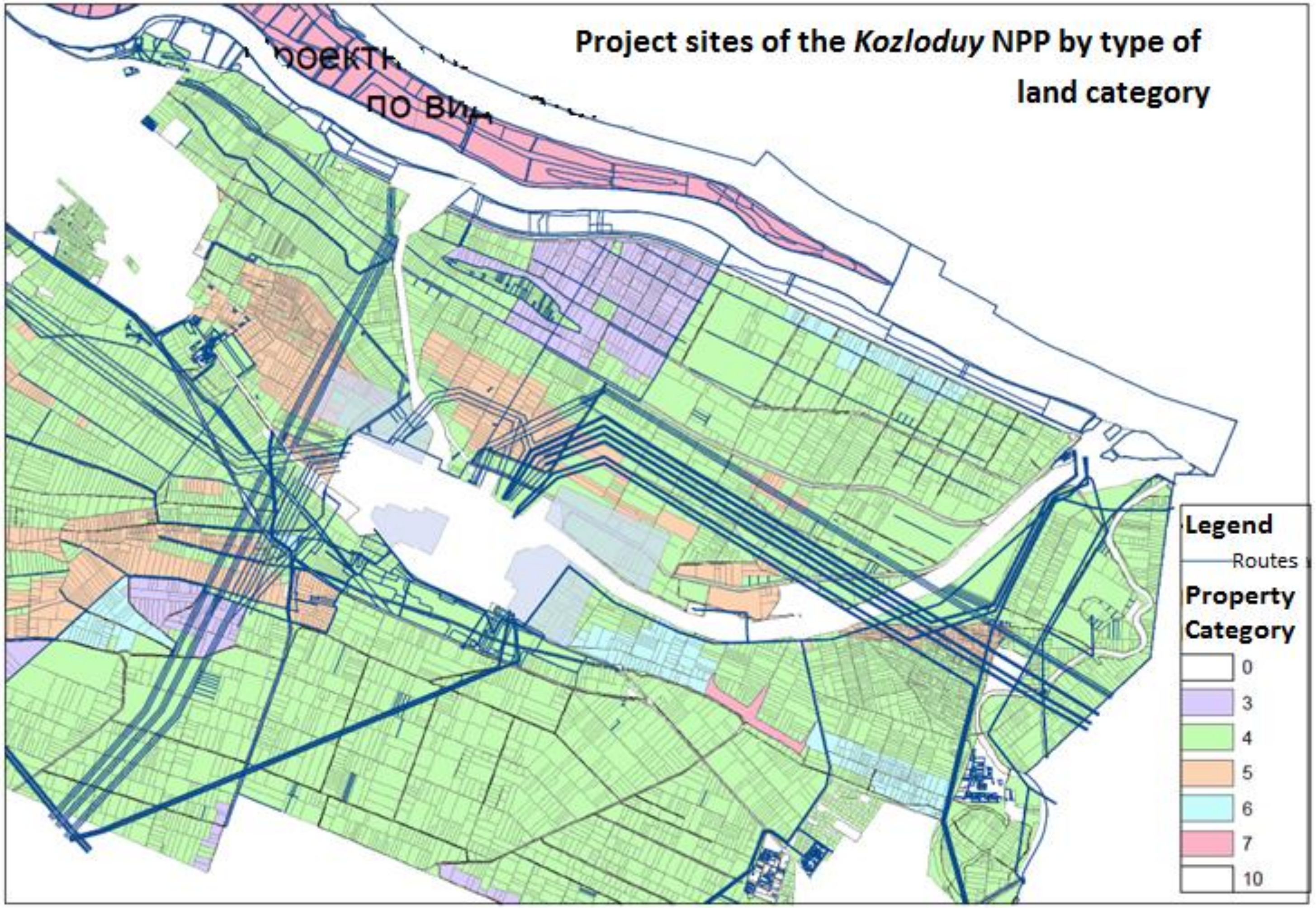


Figure 3.3-4: *Project sites of Kozloduy NPP by type of land category*

Figure 3.3-3*: Project sites of Kozloduy NPP and project forest territories* **shows the four sites and the p**

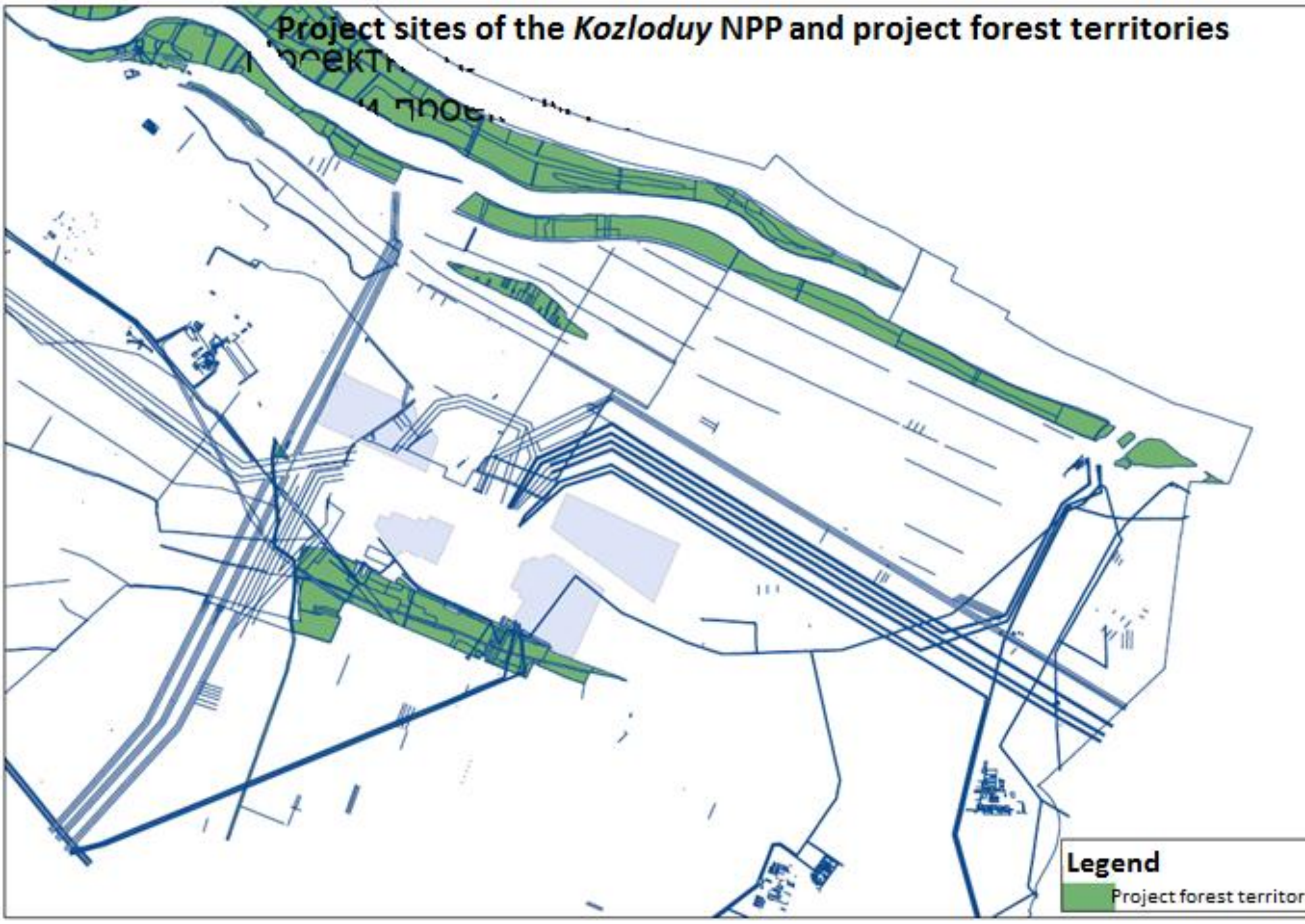


Figure 3.3-3***: Project sites of Kozloduy NPP and project forest territories*** roject forest territories nearby. The project forest territories are for example self-afforested deserted plots or ones which have turned from bush-planted plots to forests.

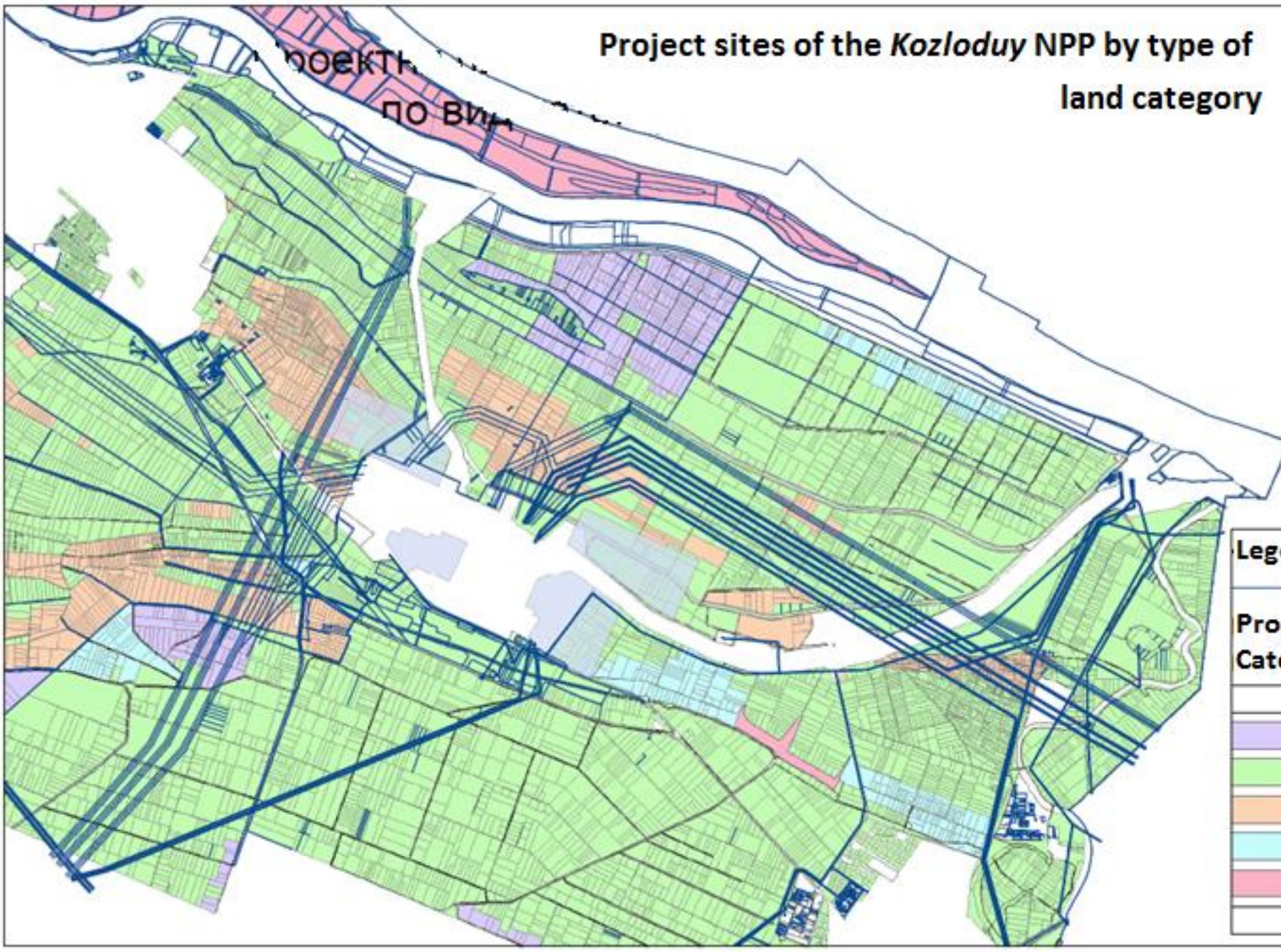


Figure 3.3-4: Project sites of Kozloduy NPP by type of land ***category*** presents the four sites by land category. Agriculture state within the region of *Kozloduy* NPP has been defined on the basis of information about the structural cover and the land productivity, as well as on the basis of the manner of agricultural land permanent use.

Available data on the distribution of arable land by groups of cultures in the zone of interest show that arable land (52.109 %) is mainly used for grain crops, 8.831 % for technical crops, 3.012 % for vegetables, 2.529 % are for vineyards.

The Report of Environmental Impact Assessment (REIA) will provide a survey of the use of agricultural land, the effect on forest areas and settlement territories within the 30 km Urgent Protective Action Planning Zone (UPAPZ) around the NPP. Within the scope of the Terms of Reference, attention is mainly focused on agricultural land for which specific data is available.

According to the Ecological Assessment of the Specialized Detailed Site Development plan (SDSDP), about 12 566 dka lie within in the Precautionary Action Zone (PAZ) of radius of 2 km around *Kozloduy* NPP, of which 3 012 dka have been allocated for the industrial site of *Kozloduy* NPP and the site for storage and processing of radioactive waste of the SD *RAW-Kozloduy*, and the rest is arable land, planted each year with different agrarian cultures. The summary conclusion to be made is that plant growing in the region is focused on grain production but technical cultures and orchards and vineyards are also important. Livestock–breeding is poorly developed and domestic animals are raised in household farms. On the territory of *Kozloduy* NPP, the main type of land affected by various-purpose activities is agricultural land, which in intended for growing of agricultural crops, part of it being swampy plots, for construction sites, etc. Besides the existing facilities and the operting units of *Kozloduy* NPP, some privatized buildings are located here. The New Nuclear Unit of the NPP is to be constructed on this territory, too. Four sites are proposed for that purpose. Register of the New Nuclear Unit site border points specifying the owner and the land area is provided in Letter No. 45/ January 29, 2013 of *Kozloduy* NPP EAD Legal Division, Appendix 3 to the Letter (Appendix 3 to the Terms of Reference).

SITE 1 – 55 ha

The site is located to the northeast of units 1 and 2 of *Kozloduy* NPP, between the Open Switchgear and the *Valyata* locality, in the vicinity of the constructed cold and hot channels –northward of them. The area of the terrain to be expropriated is about 55 ha (NPP – 24.7 daa ; public organizations and state and private property – 525.3 daa), first category, irrigated area located on the first flood terrace of the Danube river. The soils are of the *Alluvial-meadow* type. The terrain is plain, with slight gradient from northwest to northeast. To provide for the site development, an embankment is envisaged which will raise the level by a volume of about 3.5 mln. m^3. Half of the area is bush-grown.

Open drainage channels fall within the site area, which will be reconstructed.

The available connection to Cold Channel -1 and Hot Channel-1 is an advantage, but the terrain is halved by the drainage channel.

The fact that the site is located on the flood terrace of the Danube and in cases of high water level, there is real danger of floods and damages, is a disadvantage.

The humus layer loess of the arable land should be taken off in advance. The terrain to be expropriated is currently used for growing of agricultural crops.

SITE 2 – 55 ha

The site is located eastward of units 1 and 2 on the site of *Kozloduy* NPP in the direction of the village of Harlets, southward of the constructed cold (intake) and hot (outlet) channels. The area of the terrain to be expropriated is approximately half of the 55 ha, first category, irrigated area (NPP – 202.7 dka; GBS-ECM AD – 68.6 dka; private land – 278.7 dka). The site lies 3 km away from the village of Harlets and 4 km away from the town of Kozloduy. Statement of the buildings for properties and cadastre units within part of the territory of Site 2 has been provided in Letter No.45/January 29, 2013 of

Kozloduy NPP EAD Legal Division, Appendix 1 to the Letter (Appendix 3 to the Terms of Reference).

The terrain is at elevation of 37-38 m, hilly, greatly inclined from south to north, better expressed in the southeast part of the site. The soils are of the *Alluvial-meadow type*. Excavations are envisaged to provide for the site development.

A former farmyard happens to be within the site region, which is currently used as auxiliary production facility of enterprises servicing the NPP. The rest of the terrain is used for growing of agricultural crops.

Two power transmission lines cross the site over its farthest part which do not leave room for any new construction. As the channels are nearby and the connection with them is very good, the site turns out to be a good option for the erection of NNU from the viewpoint of excavation and backfilling works and saving agricultural land.

SITE 3 – 53 ha

The site is located northward of units 5 and 6 of the *Kozloduy* NPP, near the bypass road of the existing plant. The locality of the site is plain, its altitude varying between +26-28.0 m. The lowland and the site are protected by an embankment reaching absolute elevation of +30.40 m. To the north, the site is limited by the flood plain of the Danube river, lying 3.7 km away from the midstream of the №222000014/19.04.2012г.of the site are: the town of Kozloduy -2.6 km to the north, the village of Harlets - 3.5 km to the southeast, the village of Glozhene - 4.0 km to the southeast, the village of Saraevo - 6.0 km to the southeast, the town of Mizia - 6.0 km to the southeast, the village of Butan - 8.4 km to the south; the town of Oryahovo - 8.4 km to the east.

The site is located on plain terrain, slightly inclined to the north, and represents with area of about 53 ha and the following ownership: NPP – 66.5 daa ; private agricultural land – 278.7 daa . For the purposes of the site development, an embankment of at least 10 m is envisaged to raise the elevation. Currently, it is rather a swamp than agricultural land. Evidencing of this are the open drainage channels which should be reconstructed. The soil is of the *Alluvial meadow* type, very boggy.

The humus layer and the loess of the arable land should be taken off in advance. According to previous information submitted by the *Energoproekt* AD, the terrain to be expropriated is used for vineyards, fruit trees and other cultures. During the inspection of the terrain in January no such thing was established.

The site's disadvantage is that it is boggy in some parts of the terrain and that large area of private agricultural land will have to be expropriated and paid additionally in order to change its intended use.

SITE 4 – 21 ha

The site is located westward of units 3 and 4 of *Kozloduy* NPP and the Spent Fuel Storage Facility of the NPP, southward of the cold and hot channels. The available area is about 21 ha within the boundaries of the expropriated terrains of the NPP. Statement of the buildings for properties and cadastre units within part of the territory of Site 4 has been provided in Letter No.45/ January 29, 2013 of *Kozloduy* NPP EAD Legal Division, Appendix 1 to the Letter (Appendix 3 to the Terms of Reference).

The terrain coincides with the land on which the existing constructed servicing facilities – Equipment storage facility, Car Repair facility, Assembly facility and Enemona are located. For the purposes of the site development, reconstruction and shifting of basic underground NPP communications are envisaged, as well as moving these businesses to other locations.

The soil is of the *Calcareous chernozem* type, sealed in its major part, strongly affected by human activity and degraded. The site is sealed with asphalt and is built up.

The advantage is that no change in the intended use of the land will be required.

The disadvantage is the small area and the fact that there is a great number of buildings to be demolished.

From the analysis of the advantages and the disadvantages of the reviewed sites it becomes clear that the site of least disadvantages is the second site which also has a number of positive economic advantages.

3.3.1.2 PREDICTION OF THE IMPACT

The erection of the facility, including the associated and the auxiliary facilities is related with change in the intended use of the land, certain impact on some of the soils which will stay covered for a period of more than 70-80 years, change of the balance of the types of land use and more.

The Report of Environmental Impact Assessment (REIA) will assess the capacity of the land around and in the region of the NPP to undertake the assumed impacts during the erection and operation of the Investment Proposal and the cumulative effect on it. Subject to assessment and analysis will be the following:

→ Land status within the scope of the sites, subject to assessment;

→ Violation or change of land category;

→ Existing land users and their adaptation to the sites and the facility routes;

→ Violations and changes of land resulting from the implementation of the Investment Proposal;

- → Setting up criteria for ranking and site selection for the location of new nuclear unit;
- → Occurred violations and changes in land and soil;
- → Land and soil pollution in cases of accidents and incidents.

To finalize the procedures related to change in the intended use (except the cases under Article 73, para. 1, item 5 of the Forest Act) when establishing right to construction or servitudes, another procedure will be applied, related to the issuance of administrative acts and agreement conclusion. The REIA will describe according to the procedures that lands:

- → Subject to change of the territory's intended use pursuant to Article 73 of the Forest Act;
- → For which servitude will be established pursuant to Article 61 or Article 64 of the Forest Act;
- → For which right to construction will be established without change in the territory's intended use pursuant to Article 54 of the Forest Act;
- → Which will be rented pursuant to Article 43 of the Forest Act;

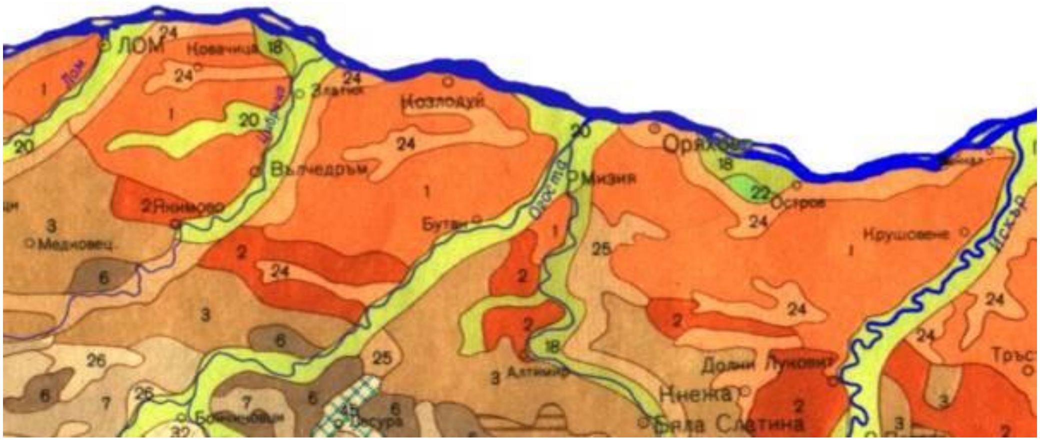
3.3.2 SOILS

3.3.2.1 CURRENT STATUS

According to soil geographic regioning, the Municipality of Kozloduy is located in the soil geographic region of the *Chernozem* (black earth) Danubean subarea, Middle Danubean province and the agro-ecologic region is also the region of *Chernozem* soils. In the erosion aspect, it lies within the region of plain and hilly regions with non-erosion soils. The soils of , the Municipality of Kozloduy appear to be heavy soils in the lowlands – mainly *Calcareous* chernozem and *Alluvial* (*Delluvial*) *meadow* soils. (Koinov, V., Iv. Kabakchiev and K. Boneva, 1998[42]). More detailed description of soils is shown in ***Figure 3.3-5:*** *Typical Soils in the Region of Kozloduy Municipality.*

Most widely spread in the 30 km zone around *Kozloduy* NPP are the ***Chernozems.*** The soils observed most often around them are Calcareous chernozems loamy, Chernozems typically loamy, Eroded Calcareous chernozems. and Chernozems typical leached heavy loamy.

42 Koinov, V., Iv. Kabakchiev and K. Boneva, 1998. Atlas of Soils in Bulgaria. Zemizdat. Sofia.



15 km

FIGURE 3.3-5: TYPICAL SOILS IN THE REGION OF THE MUNICIPALITY OF KOZLODUY[43]

Legend:

1 – Calcareous chernozems	20 – Alluvial and alluvial-meadow soils
2 – Typical chernozems	22 – Meadow and Peat-boggy soils
3– Leached chernozems	24 – Eroded calcareous and typical chernozems
6 – Dark grey forest soils	25 – Eroded leached chernozems
7 – Grey (lesive) forest	26 – Eroded grey forest soils
18 – Meadow chernozems	32 – Grey forest soils

Calcareous chernozems have good general physical properties and structure, they do not have great plasticity and are easy to process. The water regime of these soils is not very good due to the continuous drought in summer and the considerable non-productive evaporation of moisture. Regarding their sustainability to pollution they are of a high class due to the great quantity of carbonates and the relatively great quantity of humus.

The *Typical chernozems* occur relatively less frequently in the region, being located southward of the *Calcareous chernozems,* and because of the hilly relief, part of them are also eroded.

The *Leached chernozems* are formed mostly on loess, loam loess and loess-like sandy clays. Unlike the previous soils, they are notable for being better formed and featuring stronger humus horizon and soil profile.

The active soil acidity is within the weak alkaline spectrum of 7.4 pH – 8.4 pH. Lower values are rarely met – in the region of Krushovitsa, (pH=6.0), Manastirishte (pH=5.5) and other.

43 Koinov et al. Soil Map of Bulgaria, 1968

The buffer capacity of the *Chernozems* is great. Their physical and chemical characteristics show that the buffer capacity is provided mostly by the dissolution of calcium carbonate and the buffer capacity of such soils is great. A region where wind erosion is strongly manifested – first class, is the *Zlatiyata* plateau form. Regarding the texture class and humus content indicators which define the susceptibility of the soil to erosion, the *Calcareous chernozems* are assessed as having a total grade value of 6, i.e. they are of high susceptibility to wind erosion.

The ***Alluvial and Alluvial-meadow*** soils are located in flood and over-flood terraces of the Danube, at the rivers of Tsibritsa, Ogosta and Skat that flow into it and their tributaries. They are formed on alluvial deposits under the impact of meadow vegetation and near-by underground waters in the winter-spring period.

The ***Alluvial soils*** distribution in the reviewed 30 km zone around *Kozloduy* NPP occupies the flood terrace of the Danube river and the islands in it.

The ***Alluvial-deluvial*** soils are available in the locality of the villages of Rogozen and Selanovtsi. Their capacity is 115-160 cm, they have low alkaline reaction and average loamy mechanical composition.

The ***Meadow-boggy soils*** available near the described site are hydromorphic soils which have been formed under the impact of the meadow process and at high underground waters. Usually water is at a depth of 50 cm – 100 cm, but depending on the humidity of the year, it flows deeper or higher. The ***Overmoisturized and boggy soils*** are available northward of the NPP, in the *Blatoto* locality. These degradation processes occur due to both natural and technogenic causes. The depth of underground water which is directly connected to the level of the Danube river provides conditions for soils to become boggy.

Anthropogenic soils. They prevail on the territory of *Kozloduy* NPP, as well as in the 30 km zone surrounding it. At the site of *Kozloduy* NPP, they occur because of the construction activity related to the erection of the NPP.

As a receiver–accumulator and filter, the soil cover accumulates in the soil substrate, alongside with the useful chemical compounds, many hazardous chemical compounds, which are in most cases poisonous to the plants, the animals and the humans, as a result of the industrial and agricultural human activities – through the atmospheric air, precipitations and irrigation water, mineral fertilizers and chemical preparations for protection of plants from weeds, diseases or insects. Most of the heavy metals, such as the microelements, are closely related to soil fertility. Both the shortage as well as the excess of these elements affects the quantity and quality of yield production.

To characterize the components of the environment in a wide geographic region that is assumed to be potentially affected by the operation of the future nuclear unit, it is expedient to assume as a baseline natural and technogenic radioactivity.

In compliance with the requirements of the legislative base for monitoring and control of the pollution around and in the industrial enterprises in Bulgaria within a radius of 100 km and, more particularly, within a radius of 30 km around *Kozloduy* NPP, own monitoring of soils was carried out, as well as control on behalf of the state authorities. Greater attention was paid to radiation monitoring. Four independent institutions implemented a large-scale program for monitoring the radioactive pollution of soils – internal bodies (the Environmental Radiation Monitoring) (ERM) of *Kozloduy* NPP, the National Centre of Radiobiology and Radiation Protection (NCRRP), subdivisions of the MoEW (Regional Inspectorate for Environment and Waters [RIEW]), town of Vratsa) and the *N. Pushkarov* Institute of Soil Science.

In accordance with the international requirements for radiation monitoring, reference and checkpoints for monitoring have been established around *Kozloduy* NPP. Their selection has taken into consideration the specific meteorological and geographic conditions in the region and is representative for obtaining reliable and comprehensive information.

During the whole operation period of *Kozloduy* NPP, the content of the two most hazardous radionuclides in the biological aspect – ^{90}Sr and ^{137}Cs has been systematically determined. Some of the institutions have traced the levels of other radiotoxic elements, such as Co-60, Am-241, Ag-110^{m}, the isotopes of U, Ra-226 and in the recent years, also Pu-238, 239+240.

In 2002, when all 6 units of *Kozloduy* NPP were operating and the environmental impact was greater, the data from the soil monitoring[44] showed that the values for ^{90}Sr were within the limits: 0.23 Bq/kg - 1.86 Bq/kg a.d.w, and the average annual content for all 36 checkpoints was 1.01 Bq/kg a.d.w. These are results within the normal limits for this geographic region, characteristic of the deposits caused by the nuclear experiments to the atmosphere and the average at the *Chernobyl* NPP and the Earth surface. The values are close to the measurements from previous years, with slightly expressed trend of self-cleaning of the upper soil layer. Before the commissioning of the *Kozloduy* NPP in 1972-1974, the average content of ^{90}Sr was 5.0 ± 0.4 Bq/kg a.d.w.

The content of ^{137}Cs in the examined soils varies from 0.4 Bq/kg to 70,3 Bq/kg a.d.w, with average value of 18.7 Bq/kg a.d.w for 2002. During the past years, the activity varied within close limits reaching up to 114 Bq/kg a.d.w in 1996. For some of the checkpoints, the content of ^{137}Cs was considerably lower than the average. This is valid for the industrial site of *Kozloduy* NPP where, as a result of active construction work, the uppermost soil layer has been taken off or replaced by soil from deeper layers. Inhomogeneity in the content of radio cesium is also registered at other checkpoints of the zones of special status defined at that time (2002): the 3 km Sanitary Protection

44 Environmental Impact Assessment Report (EIAR) of Kozloduy NPP; Environmental Impact Assessment Report (EIAR) on Dry Spent Fuel Storage Facility of *Kozloduy* NPP, September 2005

Zone (SPZ) and the 30 km Monitoring Zone (MZ) (checkpoints 11, 15, 21 and 24).

On the overall, the content of ^{90}Sr and ^{137}Cs in the soil from the region of Kozloduy is lower than that measured in other regions of the country. This is because of the insignificant rainfalls in North-East Bulgaria in May 1986, and accordingly, lower quantity of deposited technogenic radionuclides.

In 2002 (and also, in the recent years), in the soils of some of the checkpoints for monitoring of the industrial site (3 and 31?34) or in their immediate vicinity, ^{60}Co has been detected.

According to data for 2011 of the Laboratory on Radioecology and Radioisotope Studies at the *N. Pushkarov* Institute of Soil Science, Agrotechnologies and Plant Protection, the content of ^{137}Cs in the surface soil layer of 0 cm - 5 cm (air dry soil) for North Bulgaria is 13 Bq/kg ± 10 Bq/kg (from 0.6 Bq/kg to 46 Bq/kg) and ^{90}Sr - 2.2 Bq/kg ± 0.9 Bq/kg (from 0.6 Bq/kg to 4.2 Bq/kg).[45], [46], [47], [48]

The content of natural radionuclides ^{238}U, ^{226}Ra, 2^{32}Th is within the limits of the natural values for the soils in the region, and the content of man-made ^{90}Sr and ^{137}Cs in the surface soil layer does not differ considerably from their content in the whole of North Bulgaria and results from the residual pollution caused by Chernobyl. Their permanent content is a proof for the lack of local additional deposits from the operation of the *Kozloduy* NPP. The content of ^{137}Cs varies within the interval 1.53 Bq/kg ÷ 48.5 Bq/kg a.d.w., of ^{90}Sr - between 0.37 Bq/kg ÷3,51 Bq/kg a.d.w., as defined at 36 check points within the 100 km zone around the plant according to data from the results of the 2010 radioecologic monitoring of *Kozloduy* NPP.

According to the Program for Protection of the Environment of the Municipality of Kozloduy for the period 2004–2010г.[49] in the site's region no pollution with heavy metal and metalloids has been established. Local spill of oil products has been established on *Kozloduy* NPP site near the Fuel and Oil Facility and not so heavy pollution with oils, oil

45 Maier D. & Scholl W. ^{90}Sr-Bestimmung in böden und pflanzlichen material (Determination of ^{90}Sr in soils and plants), *Landwirtsch. Forschung., 1082,* 35(3-4):269-274

46 Najdenov M., Content of Men-made Radionuclides in Soils from the region around "Kozloduy" NPP, Collection "Scientific Reports and Announcements", Sofia, Agricultural Academy: 1986, pp. 50-68

47 Ivanka Yordanova, Lidia Misheva, Martin Banov, Donka Staneva, Tsvetanka Bineva "Radioactivity in Virgin Soils and Soils from some Areas with closed Uranium mining Fasilities in Bulgaria" European Geosciences Union – General Assembly, Vienna, Austria, session SSS9.1, Radioactive Chemical Species in Soil: Pollution and remediation., 2012

48 Ivanka Yordanova, Donka Staneva, Lidia Misheva, Tsvetanka Bineva, Martin Banov, "Radioactivity in Bulgarian Soils and Behavior of Some Man-made Radionuclides in Different Soil Types", International Symposium on Managing Soils for Food Security and Climate Change Adaptation and Mitigation,. Vienna, Austria, Synopses, 2012, 171-172.

49 After data from Terms of Reference for Scope and Content of the Environmental Impact Assessment Report (EIAR) of the Investment Proposal for erection of National Radioactive Waste Storage Facility. 3.01.04-004.ToR/03, page 195 / 410

products and others has been recorded near the gas field in the village of Butan, the landfills in the villages of Harlets and Kriva Bara, near former agricultural facilities.

3.3.2.2 PREDICTION OF THE IMPACT

The implementation of the Investment Proposal is not expected to cause any soil pollution exceeding the maximum acceptable concentration (MAC), due to the plant's operation or the operation of other power units, in accordance with the established principles and rules for safe control of the facilities and with the requirements of the nuclear legislation and the recommendations of the International Atomic Energy Agency (IAEA)[50]. In the process of construction impact is related to the removal of the soil layer. The REIA shall analyze and assess the impact on the soils in the region during the construction, operation and decommissioning of the NPP.[51].

More specifically, the REIA will make an assessment of the possibility for the soils to assume the supposed impacts during the construction and operation of the Investment Proposal. Subject to analysis and assessment will be:

- → Soil state within the scope of the sites, subject to assessment;
- → Change in soil fertility;
- → Violations and changes resulting from the implementation of the Investment Proposal;
- → Measures for prevention of incurred violations and changes;
- → Required radiological monitoring of soils;
- → Measures for cleaning the land and soils during operation;
- → Measures for cleaning soils in cases of accidents;
- → Characterization of the soil state during the decommissioning of the facilities;
- → Information about the content of natural radioactivity and the main technogenic radionuclides (Cs-137 and Sr-90) in soils within the 30-km zone around the NPP and of each individual site will be provided. The techniques applied for assessment of the radiological pollution of soils, waters and plant cover are provided in Annex No. 2; [52], [53], [54], [55]

50 International Atomic Energy Agency (IAEA). The world's centre for co-operation in the nuclear field
51 IAEA, Vienna, TRS No 207, 1981
52 Methodology for low background determination of natural and technogenic gamma-emitters in soils, water, and agricultural facilities, 2009
53 Methodology for radiochemical defining of strontium -90 in soils, waters and agricultural facilities, 2009
54 ISO 18589-2,3:2007; Part 3: Measurement of gamma-emmiting radionuclides

→ Comparative analysis will be made for other regions of the country, as well as for the changes over a period of 20 years.

3.4 GEOLOGY AND UNDERGROUND NATURAL RESOURCES

3.4.1 GEOLOGY

3.4.1.1 CURRENT STATUS

Geological studies (including more than 50 deep boreholes) and geophysical prospecting for oil and gas were carried out during the second half of the past century in the part of Northwestern Bulgaria where the potential new build sites are located. Reports from these prospecting works are kept in the Geofund of the Ministry of Environment and Waters. The reports have been analyzed and summarized in connection with designing of nuclear facilities at Kozloduy NPP[56, 57, 58] .

The sites area has been subject to geomorphological investigations summarized by Evlogiev (2006)[59] and in the Research Base of Geotechnics (2012)[60].

The engineering-geological and hydrogeological environment of the potential sites shall be analyzed and assessed in this report of EIA on the basis of results from investigations carried out specially for the purpose[61].

For appraisal of the environment on Sites 2 and 4 located on the first non-flooded Danube terrace have been considered also investigations carried out by Energoproekt AD during the period 1967-1999 in connection with designing of nuclear reactors 1÷6 and other nuclear facilities at the Kozloduy NPP. Results have been used also from

55 ISO 18589-2,3:2007; Part 2: Guidance for the selection of the sampling strategy, sampling and pre-treatment of samples;

56 Investigations and activities for security improvement on the Kozloduy NPP site – series of reports in connection with fulfilment of recommendations by IAEA, Geophysical Institute, 1991-1992.

57 Assessment of geological conditions for long-term storage of radioactive wastes on the site of and round the Kozloduy NPP and complex analysis and feasibility appraisal of possibility for long-term storage of conditioned radioactive wastes on and close to the Kozloduy NPP, Geological Institute, 2003.

58 Study of possibilities for erection of deep geological depository. Analysis and division of the Bulgarian territory into regions, establishment of potential accommodating geological block for deep burying of radioactive wastes, Geological Institute at Bulgarian Academy of Sciences (BAS) under contract of Risk Engineering AD with SE RAW, 2010.

59 J. Evlogiev, Pleistocene and Holocene in the Danube Plain, Doctor's dissertation, 2006.

60 Research base in geotechnics of the Geological Institute at BAS. 2012. Elaboration of geology-hydrogeological profiles of the plateau through the Radiana site to the Danube. Contract with SE RAW.

61. Investigation and fixing the location of NNU on the Kozloduy NPP EAD, 2013.

studies for the design of Radiana National Disposal Facility for low and intermediate waste[62].

Further to data by Energoproekt AD, information has been used also supplied by Vodproekt from investigations for drainage of Kozloduy Lowland[63] .

Authentic information is available for both deep and close to the surface aquifers that, according to the Basin Directorate "Danube Region", are within the range of the following underground water bodies:

- → pore water in Quaternary – Kozloduy Lowland, code BG1G0000QAL005;
- → pore water in Quaternary – between the Lom an Iskar rivers, code BG1G0000QPL023;
- → pore water in Neogene – Lom-Pleven Depression, BG1G00000N2034.

3.4.1.1.1 Methods for drawing up the geological section of the REIA

Thereport of EIA geological section shall be drawn up through application of the following principles and approaches:

- → Environment impacts shall be treated in terms of two aspects:
  - ✓ New unit impact on the geological medium components on various sites, and
  - ✓ vice versa, what may be the effect of geological medium and processes of geological hazard mostly on safe and long-term functioning of the new nuclear unit wherefrom adverse consequences for the environment may evolve.
- → Analysis and assessment of geological data from geology-geophysical prospecting for oil and gas conducted after 1960 in the region. Information about deep geological structure required for report of EIA was obtained from data from the numerous deep boreholes. The other main source of information are reports by Energoproekt AD from engineering-geological investigations carried out during the period 1967-1999 in connection with the construction of Kozloduy NPP.
- → Analysis and assessment of the latest results from investigations in the region of potential sites for the new unit.
- → Consideration of the experience of nuclear countries in the European Union:

[62]. Report on results from geological, geophysical, engineering-geological, hydrogeological, hydrological and laboratory investigations on project „Confirmation of Radiana Site for erection of National Depository for Radioactive Wastes, Geotehnika ABC OOD and the Geological Institute at BAS, 2009.

[63] Elaboration of geology-hydrogeological profiles of the plateau through Radiana Site to Iskar River, Contract with SE RAW, Research base in geotechnics of the Geological Institute at BAS, 2012.

- ✓ Use only of results obtained through methods and technological capacities of modern geology reconciled with Bulgarian Standards, standards of IAEA and latest scientific achievements.
- ✓ Preference of facts to interpretations – superiority is given to data from immediate measurements and tests against argumentative results and findings, obtained by analogy with excessive model simplifications, through logical conclusions or conclusions deducted intuitively.

3.4.1.1.2 Geomorphology at the Sites regions

The geomorphological conditions in the thirty-kilometer zone of sites shall be reviewed in the REIA. The structure and geomorphological positions of old abrasion-accumulative level (OAAL), of river terraces from T_6 to T_0 and other relief formations shall also be described therein. A map of spatial location of levelled areas and terraces as well as dating of such relief formations shall be submitted. The above information shall be used for more comprehensive clarification of local geomorphology, assessment of neotectonic conditions, and to forecast river erosion hazard and other unfavourable processes.

3.4.1.1.3 Geological structure of the region of Sites: tectonics and neotectonics

The deep geological structure, tectonic and neotectonic conditions shall be assessed in the report of EIA in terms of long-term safety of new unit. The main information sources are the following reports:

- Investigation and activities intended to improve security on the Kozloduy NPP Site, series of reports in connection with fulfillment of IAEA recommendations, Geophysical Institute (1991, 1995);
- Study of possibilities for construction of deep geological repository. Analysis and division of the Bulgarian territory into regions, establishment of potential accommodating geological block for deep burying of radioactive waste, Geological Institute at Bulgarian Academy of Sciences (BAS) under contract of Risk Engineering AD with SE RAW, 2010;
- Identification and revision of active fractures in the region of Kozloduy NPP, Geological Institute at BAS (2013);
- Report of Environmental Impact Assessment (REIA) of investment proposal for construction of National Depository for low and intermediate waste (ND RAW) in the Radiana area in the lands of Harlets village, Kozloduy Municipality, Vratsa District (2011).

The following geological elements described in these reports shall be analyzed and assessed:

- → Lithology-stratigraphy of rocks in the geologic bed to a depth down to 1000 m. Neogene, Paleogene, Cretaceous and older sediments are found in depth. Cretaceous and Neogene sediments in the area of the Site are characterized by platform type horizontal layer arrangement, indicating calm geodynamic conditions whereat these deposits were formed. Furthermore, the lithologic-stratigraphic structure does not suggest availability of unfavourable processes like karstification, diapirism, depth suffosion of soluble rocks, etc.

- → Structure of Quaternary sediments in the area appurtenant to the Site: Eolic, lake, Alluvium and Diluvium deposits.
- → Tectonics, geodynamic and neo-tectonic development in the Site regions with stress on Quaternary (last 2.5 million years).

The potential sites for the new nuclear unit, like the existing facilities of Kozloduy NPP, are located in the western part of the Moeizia Platform and more exactly in the eastern part of the Lom Depression. That structure has been stabilizing for 2.5 million years, following rather intensive (with negative sign predominantly) fluctuating movements during the Neogene. During the quaternary the region under consideration underwent slow rise. Old, already damped faults are observed at greater depth. Recent capable faults in the Bulgarian section of the thirty-kilometer zone of Kozloduy NPP have not been established.

Analyses and assessments of geology-tectonic structure shall be supplied with figures and enclosures: map, profiles, tables, etc.

3.4.1.1.4 Engineering-geological environment on the potential sites

Additionally to the above reports, the requirements defined in Ordinance No. 1/1996 for raft foundations designing, Chapter III of Ordinance of the Bulgarian Nuclear Regulatory Agency (NRA) of 2004 for ensuring safety of nuclear plants and applicable international regulatory documents (IAEA) shall be considered for analysis and assessment of the engineering-geological environment.

Potential sites shall be examined in pairs according to location thereof and similarity of conditions (2 and 4, 1 and 3) with common features of relevant pair to be examined first and then the features in particular.

Sites 2 and 4 are located on the first non-flooded terrace - T_1 on the Danube with surface on elevation 35 m - 38 m. Three sediment complexes are distinguished in the terrace geological profile: loess, alluvium and lake (Brusarska suite). The loess complex is 12 m - 14 m thick. Loess in the terrace is underlain by alluvium consisting of sand in the upper section and gravel in the lower section. The alluvium top is at average elevation of 22 m - 24 m with irregularities on elevations 21 m and 25 m. The terrace toe at elevation from 15 m to 18 m is cut in Pliocene clay of the so-called Brusarska suite.

From engineering-geological point of view of greatest interest are the loess deposits studied thoroughly by Energoproekt through field and laboratory methods in connection with the building of of units 1÷6 of Kozloduy NPP. The most important feature of loess is its susceptibility to subsidence following wetting.

According to the Ordinance for raft foundation designing (1997) the subsidence capacity of loess may be either type 1 or 2. Loess bed of the 2nd type under the effect of dead weight thereof subsides by more than 5 cm when wetted and subsidence may reach up to 1 meter depending on the loess thickness. It is a dangerous earth bedding, but it does not occur on the potential sites for the new nuclear unit.

Loess bed of the 1st type, as the bed at sites 2 and 4 is, is subsiding practically under additional load of facilities only and subsidence under dead weight following wetting is less than 5 cm. Elimination of the bed subsidence capacity is not a heavy problem for foundation works.

The loess subsidence capacity at units 1÷4 of Kozloduy NPP has been overcome through deepening of pits to non-subsiding loess and building a silt-concrete pad[64] (Minkov, Evstatiev, 1975). All loess and the upper sandy-clayey section of alluvium were stripped off to gravel at units 5 and 6 where loading by foundations is greater. Then a ballast and silt-concrete pads were erected to the foundation elevation.

Problems related to foundations have not been established during the long-term operation of Kozloduy NPP. Continuous geodetic monitoring displays that actual subsidence coincides with the forecast one and ranges averagely from 5.0 cm to 10.0 cm. The silt-concrete pad is proved to act as a security barrier to radio nuclides spreading to underground waters.

Sites 1 and 3 are located on flood terrace T_0 of the Danube with elevation 26 m - 28 m. The terrace foot on elevations from 13 m up to 15 m at Site 3 is formed of Pliocene clay (Brusarska suite) and in Miocene sand (Archarska suite) at Site 1. Terrace bed depressions to elevation 10 m have been established. Alluvium, with average thickness of about 13 m, has a two-layer structure: gravel-sandy in the bottom section and clayey-sandy in the top section. Alluvium deposits are characterized by high heterogeneity both in vertically and in horizontally.

The available sites geomorphological map covers a zone of the plateau extending to the Danube on the North and two kilometers on the East and on the West therefrom. Three of the profiles on that map are drawn through or close to the sites. The profiles show that three of the river terraces (T_3, T_4 and T_5) were washed out in the geological past by erosion of the Danube and therefore the T_2 terrace is reduced in width. The report of EIA shall describe the time when the erosion processes developed and present evidence that now these processes are not endangering the potential sites.

[64] Minkov, M., D. Evstatiev, Foundations, facings and screens of consolidated loess soils. Tehnika, 1975.

Description of sites is made using data of the Research Department of Geotechnics (2012) and Energoproekt AD (1967-1968; 1999)[65, 66], Minkov, Evstatiev (1975). Analysis and findings conform with the IAEA Safety Guide Series, NS – G – 3.6, 2004, Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants and IAEA Safety Guide Series, SSG – 9, Seismic Hazards in Site Evaluation for Nuclear Installations, 2010.

Texture of the ground at the site 2

Site 2 is located on the first non-flooded terrace T_1 of the Danube to the East of units 1 and 2 of Kozloduy NPP in the direction towards the village of Harlets on the South of the Plant intake and outlet canals. The T_1 terrace is narrowed there by the Danube erosion in the distant geological past. The site is bordering on the South with T_2 and with T_0 on the North. The ground is low-hilly with surface on elevations between 34 m and 37 m. Single-storey warehouses and other service premises are built up on the Site. If the new nuclear unit is built on that Site, the facilities thereof shall be founded in an excavation pit.

The engineering-geological environment on Site 2 is similar to those on the sites of units 1-2 of the Kozloduy NPP.

The sub-grade is formed of the following soil types: silty subsiding loess with thickness from 7.0 m to 11.0 m forming subsiding sub-grade of type I. In depth there follows clayey non-subsiding loess layer with thickness 3 m - 4 m underbedded by alluvium sand and gravel layer with thickness 5.0 m to 8.0 m. The alluvium sand and gravel layer is deposited on Pliocene clays (Brusarska suite) with thickness 5.0 m - 7.0 m. Clays are bedded on sand layer with thickness 4 m - 5 m referred also to the Brusarska suite.

The ground water table is established at a depth of 8.0 m to 10 m from the ground surface.

The report of EIA will present earth-mechanical indices of soil types.

Texture of the ground at the site 4

The site is located on the first non-flooded terrace T_1 of the Danube to the West of Units 3 and 4 of Kozloduy NPP and SNFSF on the South of the intake and outlet canals. The site is found on elevation of about 36 m on built up area between existing service buildings. If the new nuclear unit is built on that Site, the facilities thereof shall be founded in an excavation pit.

The engineering-geological environment on Site 4 are similar to those on the first four nuclear reactors of Kozloduy NPP. The sub-grade is built of the following soil types: silty

[65] Reports from engineering-geological and hydrogeological prospecting works on the sites of 1st and 2nd reactors of Kozloduy NPP, Energoproekt, 1967-1968.

[66] Feasibility studies for erection of a new nuclear unit with equipment supplied for Belene NPP, Energoproekt, 1999.

subsiding loess with thickness form 6.0 m to 9.0 m forming subsiding sub-grade of type I. Loess in depth to 12.0 m - 15.0 m becomes more clayey, less subsiding to non-subsiding but very settling. Loess is underlain by thick (4.0 m - 7.0 m) alluvium sand and gravels. The latter are deposited on Pliocene clays (Brusarska suite) with thickness 6.0 m - 8.0 m.

The ground water table is established at a depth of 8.0 m to 10 m from the ground surface.

The report of EIA will present earth-mechanical indices of soil types.

Texture of the ground at the site 1

The site is located on the flooded terrace T_0 of the Danube, to Northeast of Units 1 and 2 of the Kozloduy NPP between the Open Switchyard and the Valyata, to the North of the intake and outlet canals. Open drain collectors are running through the Site. The ground is plain with slight gradient from southwest to northeast. The ground elevation is 25.0 m - 26.0 m. If the new unit is built on that Site, the facilities thereof shall be founded on embankment.

The sub-grade is built of the following soil types: sandy alluvium clay with thickness from 4.0 m to 6.5 m. The lower half of the layer in the northern part of the site is built up of alluvium sand. Clay and sand are underlain by alluvium gravel with thickness 7 m – 8 m bedded on Pliocene sand layer with thickness from 10 m to 15 m. The latter is deposited on Miocene sands of the Archarska suite starting approximately on elevation 0.00 m.

The ground water table is varying due to water levels in the Danube and is emerging on the ground surface or close thereto.

The report of EIA will present the earth-mechanical indices of the soil varieties.

Should decision will be made to erect the new power unit on that Site, the experience gained at the sub-grade preparation for Belene NPP may be applied.

Texture of the ground at the site 3

The site is located on flooded terrace T_0 of the Danube, Northwest of Units 5 and 6 of Kozloduy NPP. Open drain collectors are running through the Site. The ground is plain with slight gradient to the North. The ground elevation is 25.0 m - 26.0 m. If the new unit is built on that Site, the facilities thereof shall be founded on embankment.

The sub-grade is built of the following soil varieties: sandy alluvium clay layer with thickness 3.0 – 5.0 m. The lower half of the layer in the northern part of the site is built up of alluvium sand below thickness 2.5 - 3.0 m. Alluvium gravel layer with thickness 5 m - 8 m is bedded under clay and sand and is underlain by Pliocene clay layer with thickness of about 15 m. The last layer is deposited on Miocene sands of the Archarska suite starting on elevation 0.00 m.

The ground water table is varying due to water levels in the Danube and is emerging on the ground surface or close thereto.

The report of EIA will present earth-mechanical indices of soil types.

3.4.1.2 Hydrogeological Environmments on Sites

3.4.1.2.1 Deep aquifers

There are several aquifers in the region of Kozloduy NPP, including potential sites, in depth to hundreds of meters from the surface: Upper Cretaceous and Cretaceous-Jurassic-Cretaceous (Malm-Valaginian), Upper Cretaceous–Paleocene, Meotian-Pontian. These aquifers are well studied with oil and gas prospecting and were analyzed in former investigations for nuclear facilities in relation to pollution hazard[67].

The report of EIA will submit evidence that hazard from radioactive pollution of deep aquifers is excluded not only because of the great depth whereat the aquifers are established but also due to the presence of very thick layers of water-impervious sediments separating them one from the other and from shallow aquifers.

3.4.1.2.2 Shallow aquifers

These aquifers are investigated and analyzed in former investigations for nuclear facilities with regards to radioactive pollution [68, 69], etc.

Conclusion may be drawn from the above listed investigations that the hydrogeological environment on Sites 2 and 4, as well as 1 and 3, are identical and therefore they shall be examined in pairs. Analysis and evaluation of the environment have considered requirements of the following regulatory documents: BNRA, Ordinance for safety provision for nuclear plants (2004); IAEA Site Evaluation for Nuclear Installation, No. NS-R-3, 2003 и IAEA Safety Guides, No. NS-G-3.2, 2002.

3.4.1.2.3 Hydrogeological environment on Sites 2 and 4

The main hydrogeological units at the Danube terrace T_1, whereon the Sites are located, are:

- → Unsaturated (aeration) zone with thickness from 7 m to 10 m. Developed in silty-sandy loess (permeability coefficient = 0.7 m/d).

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[67] Evaluation of geological environment for long-term storage of radioactive wastes on the site of and round the Kozloduy NPP and complex analysis with feasibility assessment of the possibility for long-term storage of conditioned radioactive wastes on and in proximity to the Kozloduy NPP site, Geological Institute. 2003.

[68] Clarification of dispersion specifics of soil and water media in the region of the Kozloduy NPP sites with the purpose to analyze possible paths for migration of radio nuclides from the NPP into soil and hydrosphere, Akvater, Sofia. 1992.

[69] Report on EIA at Kozloduy NPP, Technical University, Sofia, 1999.

- → Water-saturated zone consisting of aquifer with two layers: upper and lower. Both aquifer parts are separated by "imperfect" backwater.

The upper layer covers the clayey lower loess section (k = 0.2 m/d) and mainly gravel-sandy deposits on the terrace with k = 50 - 80 m/d for gravel deposits and k = 11 m/d for sandy deposits. The shallowest bedded aquifer is formed in this layer. Water thereof flows southwest-northeast. Insignificant part of the recharge is formed by infiltrating precipitation. The main inflow comes in from the adjacent slope and through recharge arriving from Pliocene sands when in direct contact with alluvium of T_1 and T_0. This phenomenon is observed at Site 2. The ground water table varies between elevations 25.0 m - 27.5 m.

Imperfect backwater are Pliocene clays of the Brusarska suite with permeability coefficient k = 0.1 m/d. The layer thickness is from 11 m up to 16 m.

The lower strongly permeable layer is formed in sandy sediments of the Brusarska and Archarska suites.

Ground water recharge in T_1 comesized mainly from the slope adjacent to the terrace. Recharge sources are under-the-loess gravels and outflowing waters from the Pliocene aquifer in the contact areas thereof with alluvium sand and gravel. Recharge us formed also from precipitation infiltration.

3.4.1.2.4 Hydrogeological environment on Sites 1 and 3

The main hydrogeological units at terrace T_1, whereon Sites 1 and 3 are located, are:

- → Unsaturated (aeration) zone with thickness from 0 m to 5 m. Includes sandy alluvium clay with k = 0.5 m/d.
- → Water saturated zone. Similar to terrace T_1 this one consists of aquifer with two layers: upper and lower, separated by "imperfect" backwater.

The upper layer contains two sub-layers: clayey-sandy with thickness 4 m - 9 m (k = 0.5 m/d) and gravel-sandy with thickness up to 13 m (k = 50 m/d - 80 m/d). The aquifer is recharged by infiltrating surface waters from older terraces, from the Danube and from the lower aquifer in the eastern section of the region under investigation (Site 1) where alluvium gravel is bedded on sand of Brusarska and Archarska suites. The aquifer is drained by drainage systems and into the Danube in periods of low water.

Imperfect backwater: this part is played by clays of the Brusarska suite with permeability coefficient k = 0.1 m/d. The thickness of the layer at Site 3 varies from 5 m up to 16 m. The imperfect backwater in the region of Site 1 is interrupted and the upper and lower permeable layers are in direct contact.

The lower layer at terrace T_1 is formed in sandy sediments of Brusarska and Archarska suites.

Shallow ground water is drained by the Danube, and at high water levels the river is feeding and turning back the natural flow in southern direction creating backwater in the recent terrace.

The report of EIA shall submit in details all seepage specifics of the described hydrogeological units.

3.4.1.3 SEISMIC HAZARD IN THE REGION OF KOZLODUY NPP SITES

Earthquakes as potential external factors for the NPP safety are subject to great care worldwide. At the beginning of 1990 the Council of Ministers[70] gave the consent thereof for organization and carrying out of international expertises for the operating Kozloduy NPP and the designed Belene NPP. On the grounds of that decision, in June 1990 in Sofia, expert mission of the International Atomic Energy Agency (IAEA) was organized. The IAEA experts recommended analyses and expertises to be carried out in conformity with recent international standards for seismic security at NPP sites.

The Program "Investigation and activities to improve security on the sites of Kozloduy NPP and designed Belene NPP", 1991-1992, was drawn up in conformity with recommended activities. Several Annexes were attached to the Program and the activities for fulfillment thereof continued till the end of 1995.

Fulfillment of that Program involved ground and data processing geological and geomorpohological prospects in the region and sub-region of Kozloduy NPP with a view to define the main geological structures and assess Neogene-Quaternary activity therein. The capacity was clarified of established faults (like Ogostenska, South-Moesian, etc.) during Quaternary, the seismogenic potential thereof was evaluated and stability thereof during the present geologic age was proved. Maps were drawn up of particular tectonic regions, neotectonic and seismotectonic map of the regional district based on the latest studies and results and summarizing the former regional investigations for Kozloduy NPP. The NPP Site is located in relatively the most stable region of the southwestern part of the Moesian Platform: in the 30 km zone round the Site there are not any fault structures with significant energy potential (there is no data for presence of active "capable" faults).

One fundamental recommendation of IAEA involves establishment of Local Seismic Network (LSN) around the Kozloduy NPP Site. It is the basic requirement of IAEA to nuclear power plants sites[71]. LSN round the Kozloduy NPP Site, designed and erected in conformity with standards of IAEA[72] became operative in 1997 and is located in subregional district round the plant site. The LSN is intended for monitoring of weak

[70] Letter No. 198+0514-6189/04.01.1990 by MC regarding organization and holding international exeprtises for the operating KJozloduy NPP and designed Belene NPP, 1990.

[71] IAEA Safety Guides, No. 50 – SG – S1, Earthquakes and associated topics in relation to nuclear power plant siting. Vienna,1991

[72] IAEA-TECDOC-343, Vienna, 1991

seismicity and precise calculation of main dynamic and kinematic parameters of seismic events realized in the sub-region of Kozloduy NPP. The conclusion regarding seismotectonic stability of the local zone around KNPP is verified also by the accumulated data base supplied by acting the high-sensitive local seismologic network, in operation for 15 years now: **not a single micro-earthquake has been localized within the 30 km area round the site**.

3.4.1.4 METHODS FOR SEISMIC HAZARD ASSESSMENT

Assessment of seismic hazard on the territory of Bulgaria is of special importance considering the fact that the Country is located within the strongly active Aegean seismic zone that is part of the Alpine-Himalayan earthquake belt. The seismic hazard may be defined through methods of seismic division in regions, seismic hazard and seismic risk. Prognostic **seismic zoning** has been made on the whole territory of the country on the basis of complex analysis of geological, geophysical, seismologic and other data from a team of Bulgarian and foreign experts. Results are submitted in the publications of Bonchev, etc., in the form of maps including a complex map of possible center zones (PCZ) and maps of concussiveness. Zones are outlined with different magnitude intervals. That map allows to immediately evaluate intensity according to macro-seismic scale.

Various maps are drawn up including maps of concussiveness for periods of 1 000 years and 10 000 years. Since 1987 till now the first of them has been regulative for anti-seismic construction[73]. It is considered when planning buildings, dams, nuclear plants and other engineering projects. With the aim to reconcile Bulgarian standards to European standards, in particular Eurocode 8 (EC8) was necessary instead of intensities according macro-seismic scale, accelerations (displacements, velocities) of oscillations of particles at seismic waves propagation to be applied. Since 2012 the **seismic hazard** maps with new seismic zoning (2009) have been in use as a basis for new earthquake rating of construction in Bulgaria.

The seismic hazard presents evaluation of probability for the force of earth movements at specified point on the Earth's surface to surpass a set value during fixed period of time. Earth movements may be expressed through maximum acceleration, maximum velocity and maximum displacement at oscillation of particles caused by seismic waves. Lately, the main maximum earth acceleration is adopted as a parameter for evaluation of earth movements.

There are various methods for evaluation of seismic hazard, each of them with advantages and disadvantages thereof. The earliest method is the observation one and later on new methods have developed such as the **deterministic,** static, probabilistic, time dependent seismic hazard, spectral hazard. Each of these methods has undergone

[73] Standards for buildings and structures designing in earthquake regions. CTUP-BAS, Sofia, 1987.

various modifications in pursuit of elimination the disadvantages thereof. The **probabilistic** methods take special place. They, in turn, may be divided in historical and deductive methods. Venetziano, etc., in 1984 offered historic method requiring only a catalogue of historical earthquakes, appropriate functions of earth movements fading out in the analyzed region and backward function on the site. This historical method is further developed consequently and in 1995 Frankel presented probabilistic method for evaluation of seismic hazard based on spatial diffusion seismicity. The peak ground acceleration (PGA) is selected for parameter characterizing earth movements. On the other hand, deductive methods, further to catalogue of historical earthquakes and appropriate functions of earth movements fading, are requiring description of possible fractures and earthquake sources and their characteristics (seismicity parameters). The fundamentals of deductive methods are laid by Cornell in 1968. There are various modifications and applications of this method but evaluation of seismic hazard on the basis of outlined seismic sources continues to be related to numerous errors caused by lack of high-quality geologic and seismologic data.

The methodology for re-evaluation of seismic hazard on the site of Kozloduy NPP in 1991-1992 passed through several stages. The first stage is establishment of **seismo-tectonic model** of the Bulgarian territory and neighbouring seismic zones affecting the Bulgarian territory. As a basis for construction of such a model information was used from seismic zoning according to norms in 1987. The seismo-tectonic model identifies type, geometry and physical parameters of seismic centers affecting the seismic hazard on the Kozloduy NPP Site. By their type seismic sources in the model are: point, linear, spatial and disperse. Geometry of source covers position (coordinates), shape, depth, etc. the physical parameters are defined by the maximum magnitude above specified level (law of frequency). All parameters of the model are defined with distributions thereof. Establishment of **laws for fading** of impact (accelerations) is the second stage of activities on hazard evaluation. Due to lack of statistics by Bulgarian registers, adequate dependences from other seismic regions have been applied. Regarding Vrancha center particular laws of fading were used because of the quite specific character of impact. Application was adopted of two type of laws of fading: one for interfocus earthquakes and one for all the rest and each type is represented by at least two laws with relevant ratings. Calculation rating of seismic hazard (acceleration) is evaluated after the method of Cornell, respectively the realization thereof in the EQRISK Program of McGuire. Seismic hazard is probability for the force of earth movements at certain spot on the earth surface to exceed set values during a fixed period of time. Distribution of hazard is described generally either through the probability function of distribution P(x) thereof or through probability function for surpassing v(X).

Seismic hazard on the Kozloduy NPP Site is related to seismic hazard curves presenting annual probability of surpass as a function of the size of maximum acceleration. Surpass frequency v(X) is function of errors in time, power and localization of possible future earthquakes as well as of level of ground movements that may be exceeded for the site under consideration. As noted above the seismo-tectonic model and laws of fading are loaded with errors. Errors may be regitered in two ways: application of a logic tree or using the method of Monte Carlo. Evaluation for the Kozloduy NPP is performed through logic tree for multitude of combinations of various errors and the same bundle of seismic hazard curves is obtained respectively for maximum acceleration. All calculations are made by law for fading in rock. Calculation procedures register also statistics of results obtaining average (most probable) ratings and ratings with various confidential intervals. The methods of probabilistic analysis of seismisic hazard is based on standardized mathematical model of Cornell and software of McGuire 1976 and Toro and McGuire 1988, and improved later by Solakov, etc., 2001.

Seismic risk is defined by seismic hazard and by vulnerability of facilities and administrative structure for management of the construction project and Plant operation as well as by vulnerability of structures for shuttind down the reactor before loss of structural and functional integrity occurs due to earthquake impact. From engineering-structural and administrative point of view such risk may be minimized even with presence of close active fault. Eventual contamination by radioactive nuclides conditioned by partial vulnerability of weak elements of the engineering-structural and administrative systems must not be allowed regardless of the cost. There are a series of real negative examples to this effect from nuclear capacities operation round the world. Seismic risk is controllable by man and must be minimized. According to evaluation of seismic risk, measures are recommended for provision of engineering-structural integrity of facilities and infrastructure as well as for integrity of the administrative structure for Plant management allowing to bear maximum possible impact by design seismic event without disturbing the structural integrity thereof and without any long-term loss of operability.

3.4.1.5 PRESENT DESIGN SEISMIC CHARACTERISTICS OF THE KOZLODUY NPP SITE

3.4.1.5.1 Seismic analysis

As above noted the first stage of seismic hazard evaluation is establishment of a seismo-tectonic model in regional and local zones round the Kozloduy NPP Site. Basis for establishment of such a model is the analysis of seismicity in the region under consideration. At the next stage the results from tectonic and geo-morphological investigations must be used for justification of potential capacities of the model.

Seismicity of the region is studied in detail by the Geophysical Institute of BAS in 1990–1992. A catalogue of earthquakes is used covering the period since 375 B.C. till 1990. Catalogue data are unified and standardized in compliance with current requirements.

The greater part of observed seismic events are related to eight well known seismogenic regions: Sofia, Maritsa, Gorna Oryahovitsa, Kresna, Negorinska-Kraina and Kampuling-

Vrancha (shallow and medium deep) and local. Spatial, time and energy characteristics of these regions have been studied in detail. The Sofia seismic zone is located at the shortest distance of 80 km from the Kozloduy NPP Site. Maximum epicenter intensity (I_0) of the 9th degree (MSK) of earthquakes in 1641 and 1958 is registered in this zone. The observed maximum effect on the Kozloduy NPP Site from earthquakes in the Sofia Zone is I_{koz} = 3 (MSK).

Earthquakes within the 150-km region are generated in the earth's crust at a depth of up to 50 km. The maximum density of earthquake hypocenters is observed in deep layers between 5 km and 25 km. Strong inter-focus earthquakes with expressed macro-seismic effects (effects at great distances) are generated at depths from 90 km to 230 km in the Vrancha seismic zone that is more than 240 km away.

The main sources of seismic hazard are earthquake zones beyond the region of the Kozloduy NPP Site. The most important among them is the Vrancha zone in neighbouring Romania that has generated events with magnitudes M > 7. Maximum macro-seismic effects on the site I_{koz} = 6 - 7 were observed from the earthquake in 1977 with M = 7.2 and I_0 = 8.0 (MSK). The effect is due to specifics in center processes (strong extension in direction South-West of the isoseismic field).

Earthquakes generated beyond the above specified zones are related to known fault structures that cannot be defined as differentiated due to insufficient data required to receive the basic characteristics thereof. The strongest earthquakes beyond the defined zones are: event in North Greece in 1828 with M = 7.5 and I_0 = 10.0 (MSK) and earthquake in the region of Dulovo in 1882 with M = 7.3 and I_0 = 7.8 (MSK) with observed macro-seismic effects on the Kozloduy NPP Site – I_{koz} = 5 - 6 (MSK).

According to maps of concussiveness with period of 1 000 (valid until 2014) (*FIGURE 3.4-1: SEISMIC REGIONING MAP OF THE REPUBLIC OF BULGARIA FOR A 1000 YEARS PERIOD*) and 10 000 years the area of the Plant may be subjected to earthquake effects of VII degree according to the MSK-64 scale wherefore buildings and facilities must be secured with a seismic factor K_c = 0.10[74].

[74] Ordinance РД-02-20-2/2012 about design of buildings and facilities in earthquake regions

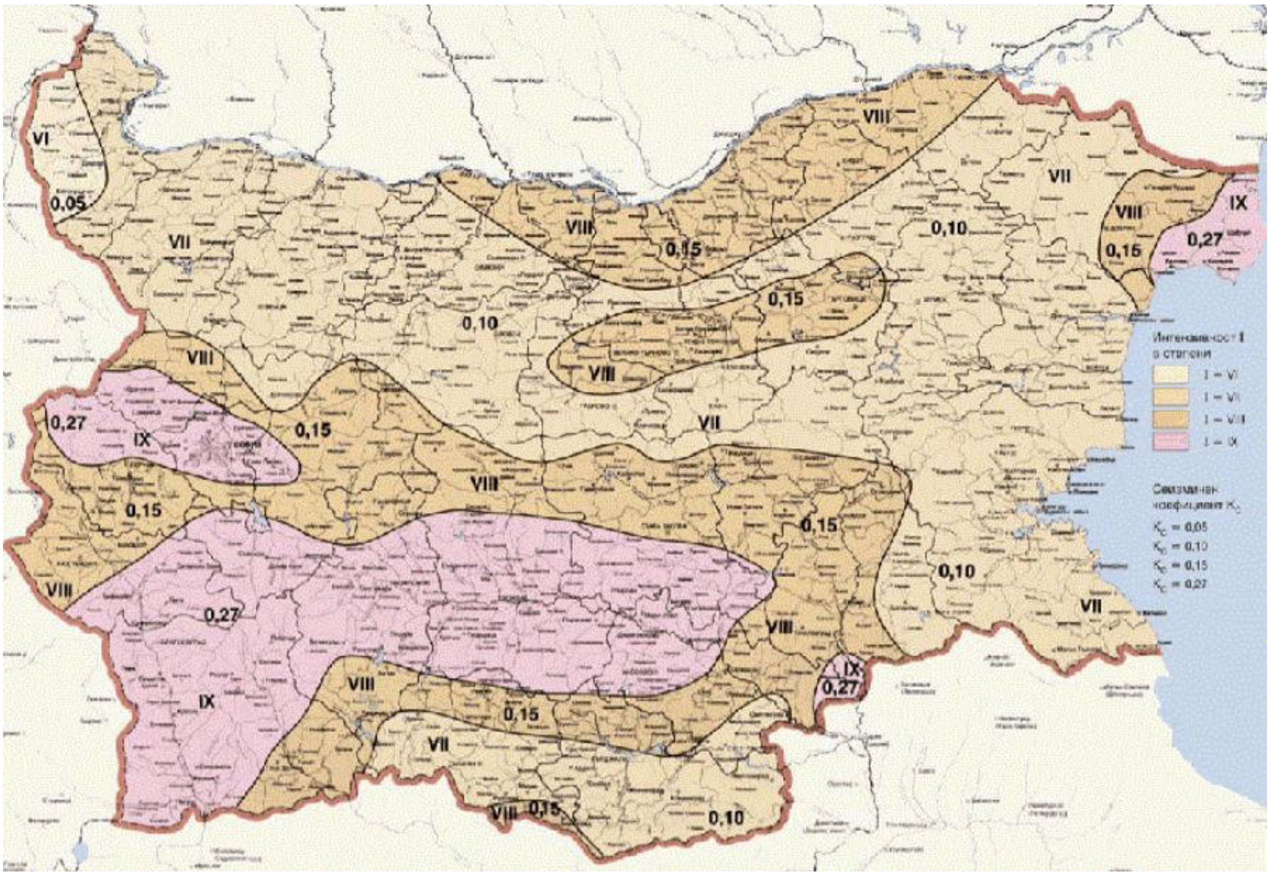

FIGURE 3.4-1: SEISMIC REGIONING MAP OF THE REPUBLIC OF BULGARIA FOR A 1000 YEARS PERIOD

The impact of local earthquake was analyzed additionally under recommendation by IAEA. Local centers have registered earthquakes with M < 4 and enter the category of background seismicity.

The Kozloduy NPP Site is located in the middle of stable regions in the southwestern part of the Moesia Platform characterized by extremely low seismic activity. During the period of regional instrument registration of earthquakes (1976 - 1997) on the whole territory of the local 30 km zone only three earthquakes occurred on Bulgarian territory with magnitude M < 2.0 and one earthquake on the territory of Romania with magnitude M = 3.6. Following the installation of high-sensitivity local seismic grid it was established that not a single seismic event of the lowest possible magnitude has occurred within the local zone. There are no historical earthquakes registered for the region. Lack of registered seismic activity and extremely weak sporadic seismic events characterize the region as the seismically "**most calm**" zone within the 320 km region.

Seismo-tectonic characteristics of the regional and local district of the Kozloduy NPP are defined on the basis of complex geological, geophysical, geodetic, geomorphology, seismic, seismologic and other investigations[75].

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[75] Investigation and activities for improvement of safety on the sites of Kozloduy NPP, 1991-92, Geomorphology and neotectonics, Sofia, 1992.

The analysis of tectonic processes in the Moesia Platform are conform to the basic objective laws of the last tectonic cycles. Tectonic displacements are observed only along borderlines of the Platform. The tectonic processes ended at the end of Triassic and beginning of Jurassic. Additional information about tectonics in the regional zone is obtained from geology-geophysical sections drawn by data from investigations along three regional profiles: Mokresh-|Shabla, Petrich-Nikopol and Madan-Strajitsa-Rousse while for the deep structure and fault tectonics in depth – through results from magnet-teluric drilling, gravimetric, geomagnetic and other measurements as well as through analyses of specifics of macro-seismic fields and seismic conductivity of seismic energy in particular zones. Best outlined fault system: North-Pre-Balkan (Belogradchik Flexure) cannot be reasonably accepted for seismic lineament. Characteristics of seismic activity are available in disjunctive knots at Chiren with Chiren Northeastern Fault and at Gabare-Drashan with Dolnolukovit one – all of them are beyond the 30 km local zone surrounding the Kozloduy NPP Site. By data from gravimetric and geomagnetic investigations anomalous sites have not been established within the 30 km local zone surrounding the Kozloduy NPP Site. A gravity transition with direction Northwest/Southeast is registered beyond that zone – South Moesia fault reflecting generally the Belogradchik Flexure within the area under consideration.

Established direct dynamic relation between general structural development of the territory and formation of relief thereof is applied for geomorphological evaluation of the neo-tectonic activity on the territory. Calm tectonic regime that has had effect on sub-horizontal distribution of geomorphological levels is observed in the local territory. Hereat are established already mentioned fracture lines only with subequatorial direction. These are rated as active during the Late Ceimmerian phase and since then have become passive, fossilized under the effect of thick Cretaceous-Paleocene and Neocene-Quaternary cover. The same conclusion was reached following analysis of the plan of the river-valley grid and the number of hypsometry of Quaternary terrace complex in transversely developed valleys of Ogosta and Skat rivers.

This characteristics of the 30 km zone is illustrated best by neo-tectonic and Geomorphologic investigations on Upper Plio-Pleistocene structural level and by location and development of the Danube terraces and Danube left-hand and right-hand tributaries with the same elevation on both sides of the river.

There are not any sorts of geology-geomorphological data for the local territory of Kozloduy NPP showing presence of active fault structures of Quaternary age but lineamentation is weakly expressed or is almost lacking.

Seismic investigations established that within the 30 km zone **there not any faults** of Jurassic-Paleocene age. Neocene and Quaternary deposits are bedded almost horizontally with lacking surface appearance of tectonic disturbances. Available data reject existence of a “capable“ fault, i.e. surface expressed structure with seismic potential as well as structures also in the sense of definition stated in Safety Guide 50-SG-S1 (rev.1) of IAEA.

Seismotectonic model of the local region (30 km zone) is built up through application of standard formalized procedure for integration of all available seismologic and geology-geophysical data. The map of complex lineament zones is marked according to data for Triassic-Jurassic fracture system. Lineament zones express the highest rate of heterogeneity of physical parameters in the Earth's crust and therefore are treated as zones of potential instability. Lack of evidence for Quaternary activity and movement in the local region as well as the fact that only three micro-earthquakes with magnitude M < 2.0 have been registered on Bulgarian territory (on Romanian territory – one only earthquake with magnitude M = 3.6) give grounds to draw the conclusion that earthquakes with M_{max} > 4.0 should not be expected in the whole local region. The result obtained is consistent with the seismic zoning of the Republic of Bulgaria.

Summary of results allows to draw the following fundamental conclusions:

→ Large fault structures with high energy potential are lacking within the prospected territories (there is not any data for presence of active „capable" fault);

→ The Kozloduy NPP Site is located in the comparatively most stable part of the Moesia Platform. This conclusion is verified also by accumulated data base from local seismologic grid round the Site operating for 15 years already.

3.4.1.5.2 Design seismic characteristics of the Kozloduy NPP Site

Effects of seismic phenomena are established through evaluation of seismic hazard at two design levels assumed in various combinations of accelerations in conformity with the recommendations of IAEA. These are the so-called design and extreme calculated accelerations for particular buildings, systems and components. Loadings by seismic impacts on the remaining parts of the Plant with no relation to nuclear safety are discussed in conformity with the general engineering standards. The power plant must withstand extreme calculated acceleration as to ensure fulfillment of basic safety functions.

The results of the calculation procedure for the seismic hazard evaluation for Kozloduy NPP site allow to determine the seismic characteristics of the input ground motion in earthquakes of intensity of design basis earthquake (of Seismic Level 1 according to IAEA rules) with frequency 10-2 events per year and Safe Shutdown Earthquake (of Seismic Level 2 according to IAEA rules) with frequency 10-4 events per year at the zero level of the site. The value of the peak acceleration for design basis earthquake (SL-1) is acceleration 0.1g with occurrnce period 100 yeras. The value of the peak acceleration for SSE is accelleration 0.2g with occurrnce period 10 000 years. The other seismic hcaracteristics of the deisgn seismic levels are also determined – design floor response spctra and respoective 3D accelograms (with duration of 61s), taking into account the geological conditions on the site.

Spectrum of response is identified for free surface to local earthquakes and relevant three-component accelerograms (with duration of 20 s). Effects of local earthquakes M = 4.5 below the Site at depth 5 km and M = 5.0 at 5.0 km distance and 5.0 km depth on structures and equipment are separately analyzed. Seismic characteristics: seismic levels of impact (acceleration), peak acceleration, design floor response spectra and respective 3D accelerograms have been discussed and confirmed by experts of IAEA in the period 1992 -2011 r.

Deterministic evaluation of seismic hazard for the Kozloduy NPP Site is identified with highest levels of seismic earth movements caused by heaviest earthquakes realized in nearest to the Site points of relevant seismogenic structures. Probability to surpass that level cannot be calculated directly and is evaluated following probability analysis of seismic hazard for the Site. Deterministic approach for evaluation of maximum acceleration is applied for seismic sources: Vrancha inter-focus, shallow earthquakes (all shallow sources) and local zone. Results are submitted in the report by the Institute of Geophysis /BAS/ in 1992. The maximum expected magnitude of each seismic source is linked to point closest to the Site rendering account also to the source size. The maximum acceleration is calculated through application of adequate laws of fading rendering account also to the local environment. The maximum accelerations calculated after the deterministic method are much lower than the ones calculated through probabilistic rating of seismic hazard (1.35 – 1.7 times).

Experimental investigations of dynamic characteristics of earth layers on the construction site of Kozloduy NPP are also of interest since the geotechnical model of “free surface” profile is drawn up in conformity therewith. Ground measurements are carried out for calculation of the velocity of propagation of seismic waves through straight and reverse seismic-logging and by transverse and surface seismic profiling. It is established that transverse waves spread in clays with lower velocity of 170 m/s and with higher velocity (680 m/s) in marls while the velocity of longitudinal waves is 470 m/s in clays and 2 700 m/s in marls. The interval of changes of shearing strain is from 10^{-6} to 10^{-1} cm/cm and each lithological variety is submitted with graphical relation of such strain with the shearing modulus coefficient G/G_{max} (0.0 to 1.2) and fading coefficient D (0÷40 %). The elaborations of BAS are summarizing data for geotechnical seismic model of the “free surface” profile valid for the construction site and, regardless of the heterogeneous geological environments, allow identification of the “soil-structure” interaction. This is verified by analyses for project “Benchmark study for the seismic analysis and testing of WWER-Type NPP” of IAEA, the Program for Modernization of Units 5 and 6 and other documents, in the preparation whereof have assisted European and American companies with rich experience in seismic deisgn and seismic re-valuation of nuclear plants.

3.4.1.5.3 Complex criteria for selection of one out of the four potential sites

Selection by seismotectonic, geologic and hydrogeologic indications of one of the four potential sites for erection of the new nuclear unit shall be made on the basis of Ordinanace by NRA of 2004 about provision of nuclear plants safety and the following documents of IAEA: Safety Guide Series NS-R-3, 2003 и NS-G-3.6, 2004; Specific Safety Guide Series SSG-9, 2010 and SSG-18.

The following site conditions have been considered for the criteria selection:

→ Tectonic and seismic environments on the four sites are the same: existence of active tectonic faults in the 30 km Bulgarian zone is not proved and the seismic characteristics on the four sites for the respective seismic levels should not differ substantially from the current seismic charactersitics of Kozloduy NPP site (with relatively similar geological characteristics);

→ Prior to the construction works on each site exist possibilities for applying of sub-grade improvement methods so that the bearing capacity thereof will comply with loading while settlings shall enter admissible range limits..

The following criteria are applicable for selection of one out of the four sites with the above described environments:

→ Depth of ground water table.

→ Hazard of ground water table uplift on the site at rising level in the Danube, resulting from extreme combination of hydrologic and weather circumstances (demolition of Zhelezni Vrata facility in combination with excessive precipitation on the catchment basin of the river);

→ Hazard of secondary strain occurrence in the earth base upon seismic impacts on structures (the greater the elastic module of the base, the lower the ground water table, the smaller the strain);

→ Retaining capacity of earth base toward migration of radio nuclides (the lower the permeability coefficient and the greater the soil sorption capacity, the greater the retaining capacity thereof).

3.4.1.6 PREDICTION OF THE IMPACT

3.4.1.6.1 Exogenic (surface and pre-surface) geologic processes

Impacts of the following processes shall be analyzed in the REIA:

→ River erosion: effects thereof are always evaluated for erection of nuclear facilities near a large river (IAEA Specific safety guide No SSG-18, 2011). On the grounds of river terraces dating, made in Item 3.4.1.1.3, is proven that the erosion activity of the river at the first non-flooded terrace (Sites 2 and 4) faded 71 000 years ago and terminated 6 000 years ago at the flooded terrace and activation thereof is not expected during the coming millennia.

→ High natural ground water table and presence of water-rich aquifers close to the elevation of nuclear facilities foundations. Proof shall be given that ground water table at the first non-flooded terrace (Sites 2 and 4) is sufficiently deep below the minimum admissible one while a thick structural embankment shall be needed on Sites 1 and 3 on the flooded terrace to move the facilities away from the ground water table.

→ It is proven that long-term uplift of ground water and flooding of the facilities sites is impossible. Short-term uplift shall be analyzed for most unfavourable combination of hydrologic and weather factors and shall be verified that facilities located on the non-flooded terraces of the Danube are not endangered by such phenomenon (IAEA Safety Guide Series, SSG – 18, 2011).

→ Loess subsidence and settling hazard on Sites 2 and 4 shall be analyzed. Methods shall be described whereby such hazard will be eliminated. Experience from already built up facilities of the Kozloduy NPP will be applied.

→ Occurrence of other processes of geologic hazard like Karsts and landslides is impossible since there are not any preconditions therefor.

The Plant is located on the non-flooded terrace of the Danube and is not endangered by flooding or erosion activities. The ground water table is at 10 m – 12 m from the ground surface.

Sub-grade is scraped up to depth 12 m – 14 m in loess followed in depth by alluvium deposits of the terrace and Pliocene clays. Foundation works for all nuclear facilities in the loess at Units 1÷4 were carried out through deepening of foundations and erection of silt-concrete pad, and a combination of silt-concrete and gravel mat for Units 5 and 6. These heading works eliminated the hazard of loess subsidence, and reduced sub-grade settling to 5 cm – 10 cm. Furthermore, the silt-concrete pad stands successfully for additional engineering barrier with regards to radio nuclides spread.

Sites 1 and 3 are located in the flooded terrace T_0 of the Danube on elevation 26 m - 28 m. The terrace footing on elevations from 13 m to 15 m at Site 3 is formed in Pliocene clays (Brusarska suite) and at Site 1 is formed in Miocene sands (Archarska suite). Alluvium with average thickness of about 13 m – 14 m has a two-layer structure: gravel-sandy in the bottom section and clayey-sandy in the top section and is characterized by high heterogeneity in both vertical and horizontal directions. Ground water is springing on the surface or close thereto.

Should any of these sites will be selected for erection of the new nuclear unit, foundations shall have to be constructed on thick structural embankment including removal of weak alluvium materials. The experience gained at Belene NPP where the earth sub-base is similar to that at Sites 1 and 3 may be applied.

Sites 2 and 4 are located on the first non-flooded terrace T_1 of the Danube with surface on elevations 35 m - 38 m. Three sediment complexes are distinguished in the geological profile of the terrace: loess, alluvium and lake (Brusarska suite). Loess complex is 12 m – 14 m thick. Loess is underlaid by alluvium in the terrace formed of sands in the top section and gravel in the bottom part. The alluvium top is on average elevation of 22 m – 24 m. the terrace footing on elevation from 15 to 18 m is cut in Pliocene clays of the so called Brusarska suite.

Ground water table at the sites is at average depth of 8 m to 10 m from the ground surface.

Should the new nuclear unit be built on these sites the foundation thereof shall be erected in excavation. Foundation works shall be carried out in subsiding loess and schemes applied at the existing Units may be used.

Forecast of impacts on the geological environment at Sites 1 and 3

Sites 1 and 3 have similar engineering-geological and hydrogeological environments since located on the recent, flood terrace of the Danube. Should the new unit be erected on these sites the design will have to provide for sub-grade preparation as at the Belene NPP site and include stripping weak layers off to gravels and erection of a thick structural embankment up to elevation of 34 m - 35 m

The main problem in engineering-geological and hydrogeological environments on Sites 1 and 3 is the high ground water table. Short-time rise of the table may occur in emergencies caused by demolition of the Zhelezni Vrati facility.

According to references, Research Department in Geotechnics (2012), compared to the other sites, there is no clayey layer at Site 1 below the alluvium gravel and the latter together with sand of the Brusarska suite is forming hydraulic connection with sands of Archarska suite. This fact is facilitating spread of radio nuclides along streams of ground water.

Forecast of impacts on the geological environment at Sites 2 and 4

Sites 2 and 4 possess similar engineering-geological and hydrogeological environments since located on the first non-flooded terrace of the Danube. Unfavourable effects on the geological environment are not to be expected with sub-grade previously prepared as at the existing Units of Kozloduy NPP and under normal operation circumstances. Presence of a thick layer of Pliocene clay under alluvium sand and gravel in the non-flood terrace will impede to maximum the migration of radio nuclides toward the Archarska suite aquifer below the clays. Eventual failures of dams upstream the Danube would cause minimum uplift of ground water table.

3.4.1.6.2 Endogenic (seismotectonic) geological processes

The Kozloduy NPP is located in calm tectonic zone of the Earth's crust – on the Moesia Platform. Active faults have not been established within the 30 km range of the Plant. The sites with regards to seismotectonic environment possess the same parameters as those at the sites of existing Units.

In the process of the investment intention realization and operation of new unit no significant modification is expected of the geologic environment endogenic parameters. The selection of the site is subject to a related project, which is being implemented in parallel with the current EIA, and the assessment will be made according to art. 25, item 1 of the Regulation for safety assurance of nuclear power plants (2004). The impact in the process of construction is related to removal of the soil layer and other exogenic parameters of the geological environment. As explained above, the Report on EIA shall analyze and evaluate inpact on soils within the region during the civil works, operation and decommissioning of the NPP.

Conversely, the effect of endogenic processes on safe and long-term functioning of the New Nuclear Unit that may generate harmful consequences for the environment was described in the section treating seismicity. This effect shall be discussed in more details in the REIA, the section on seismic hazard and evaluation of design seismic characteristics of sites and facilities of the Kozloduy NPP Units. There is no doubt, on that basis, that the design scheme shall be extension of principles for the existing Plant Sites and shall develop them in a state-of-art way. The spatial scheme of the new building within the framework of related procedures shall be developed with a view to existing build-up and general final appearance of the power site. Building structures shall conform to technological demands and, according to specifications, shall stand to external seismic effects continuing the principles of design and construction of existing sites of the Kozloduy NPP.

In the investigations prepared by the Geophysical Institute at BAS for seismic assurance of the Kozloduy NPP Site, approved by missions of IAEA 1992, allow to draw the main conclusion that can be expected once in 100 years the earthquake with acceleration 0.1 g and the maximum design with 0.2g – once in 10 000 years. Data is summarized about engineering-geological environment on the site, physic-mechanical parameters of soils and response spectrum of the Site, required to solve the task of soil-construction interaction.

The behavior of facilities and systems in the Units in time of earthquake during the last years is analyzed in detail by Risk Engineering OOD in relation to SAR and PSA. The analyses are submitted in the report *"Assessment of response to capacity of building structures of Kozloduy NPP Units 5-6 and identification of probability parameters of elements fragility for the purposes of PSA, level 1, with account to seismic initiators"* and are discusses afterwards in the EIA report for Units 5-6 in 1994. Building structures response is rated, probability parameters of the elements fragility are identified, probability analysis is made for failure of critical structure elements in earthquakes and the behavior of Units is modeled after the method "tree of events".

Protective functions to be undertaken at occurrence of various initial events have been defined to prevent failure of the core and limit consequences from eventual failure. These protective functions are the same as those counted for at internal initial events since separate emergency systems in case of earthquake are not designed for Units 1÷4. Conservative assumptions were made when building trees of failure, while operator activities in case of earthquake as well as the so called passive failure of equipment due to demolished building structure are not included. Simultaneously, the elements are grouped by design criteria, method of seismic qualification and parameters of response.

Summarized assessment of forces and displacements in the structure of the reactor compartment in unit 5 at earthquake demonstrates good behavior of the reactor and reliability of structure thereof under maximum design seismic impact.

Investigations under the project "Benchmark study for the seismic analysis and testing of WWER-Type NPP" whereat inspection is made of building structures and equipment under seismic impact initiated by explosions at about 2 km to Southwest of the site of EP-2 is of exceptional importance. Dynamic parameters of housing and equipment in the ractor compartment and turbine hall of Unit 5, acceleration and amplitude-frequency parameters of particular equipment types are identified. Suggestions for engineering schemes are made.

On each of the Kozloduy NPP units a Anti-Seismic Emergency Protection System (ASEP) is installed that will trip reactors in case of earthquakes with accelerations higher than the set threshold. A system of accelerographs SASCES (System for Accelerographic Seismic Control of Equipment and Structures) was commissioned in 1993. The system includes accelerographs of the SMA – 1 type (4 pcs.), SMA - 2 (3 pcs.) and SSA (4 pcs.) located on the free field and on various elevations on Units 3 and 5. The system ensures seismic control of equipment and structures, registration and filing of data. The layout of accelerographs locations is approved by IAEA. Schedules for monthly, six-monthly and annual inspections are developed. Written procedures are drawn for each activity in conformity with the quality assurance system. Reports are issued for each inspection. Activities are carried out by qualified staff. Reports are filed to the dossier of the relevant equipment. Seismic monitoring of the Kozloduy NPP facilities and site and cadastre servicing are performed on the territory of the Company. Resource management includes conditioning, control of state and development of engineering-construction projects through specialized inspections and measurements, programs for complex and 72-hours tests on new build facilities and equipment, post-maintenance and reconstruction tests, development and/or provision of measures for corrective action on equipment, control of changes. In connection with the project BG-9512-02-01 under PHARE Program, and the Program for Modernization of units 5-6, measures were outlined for seismic qualification of the Kozloduy NPP including in respect of assurance with regard to eventual increased seismic impact: from 0.1g (VII degree by MSK) to 0.2g (VIII degree by MSK) the main source being Vrancha.

Regarding the seismic risk rating, measures are recommended for provision of engineering-structural integrity of facilities and infrastructure as well as integrity of administrative structure for Plant management in conformity with the provisions of Ordinance No. РД-02-20-2 (2012) on the design of buildings and facilities in seismic areas allowing to endure maximum possible impact from higher than the design basis seismic event without disturbing the structural integrity thereof and/or without long-term loss of efficiency.

3.4.2 NATURAL RESOURCES

3.4.2.1 UNDERGROUND NATURAL RESOURCES

3.4.2.1.1 Current status

At the moment of ToR preparation, there are not any data for availability of underground natural resources on the four sites territories. Further investigations, extracts from data bases and specialized maps and registers of the MIET shall be carried out by the National Geologic Fund for preparation of the REIA.

3.4.2.1.2 Prediction of the impact

If, during the report of EIA preparation information availability of underground natural resources should be established, an estimate of the IP impact thereon shall be prepared .

3.4.2.2 CONSTRUCTION MATERIALS (GRAVEL, SAND, ETC.)

Gravel and sand shall be among the materials to be applied in the main stages of the new nuclear unit construction from site base works trough construction of underground and ground communications, to the main above-ground erection of buildings and facilities on the Site. Building qualities of materials in relation to the project specifics and relevant civil works shall be specified as per the engineering design related to realization of the IP. Requisite quantities of river gravel and sand shall be supplied on the project from authorized under the WL gravel pits within or outside the region. Authorization is legalized by the Waters Law. Authorizing regime is conducted by the Executive Agency for Exploration and Maintenance of the Danube River – Rousse for extraction from the Danube, by the Ministry of Environment and Waters (MoEW) for extraction from dams according to Annex 1 to the WL and by the Basin Directorate for Water Management in Danube Region (BDWMDR) for ballast pits on interior rivers.

3.4.2.2.1 Current status

Gravel and sand are extracted at 24 locations on the Danube according to permits issued by the competent authority EAEMDR, Rousse. Extraction from the Ogosta Dam is permitted also and the permit is within the MoEW licensing regime authority. There are also small ballast pits on Ogosta and Iskar rivers wherefore the licensing regime is managed by BDMDRW. These quantities shall probably be insufficient regardless of the selected site. The materials shall be considered during the next design stages including locations of extraction and application during the preparation of building mortars. Site selection for implementing the IP shall be of significance with regard to access via construction roads, existing batching plants and location of new ones.

3.4.2.2.2 Prediction of the impact

Extraction of aggregates from dynamic supplies in water sites, rivers, exerts significant effect on ecologic state of the water site and therefore permission thereof includes restrictive measures with certain prohibitions in WL, Art. 118з, or as by prohibitions for extraction from riverbeds introduced by the River Basin Management Plan (RBMP) and included in the Programs of Measures. The report of EIA shall assess in detail this point in terms of its impact.

3.5 LANDSCAPE

3.5.1 CURRENT STATUS

The Sites, subject to Investment Proposal, are part of the territory owned by Kozloduy NPP EAD and the 30-km zone thereto entering the Western sub-region of the Danubian Plain as part of the Mizia Region.

According to the map with **regional landscape zoning** of Bulgaria[76], the territory of Kozloduy NPP EAD is located in the:

A. North Bulgarian landscape zonal *district;*

→ I. North Danubian-plain landscape sub-district;

4. Zlatiiski landscape *region;*

5. Dolnoiskarski landscape *region;*

→ II. South Danubian plain landscape sub-district;

13. Lyutensko-Borovanski landscape *region.*

Specified structures within the 30-km zone round the Kozloduy NPP EAD are presented within the range of:

[76] Petrov, P. 1997. Landscape structure, B: “Geography of Bulgaria”. Acad. publ. “Prof. Marin Drinov”. Sofia.

- → Kozloduy Municipality and the eastern part of Lom Municipality: covering part of the Zlatiiski landscape region (4)l
- → Valchedram, Hayredin, Krivodol and Mizia municipalities: in the Zlatiiski (4) and Lyutensko-Borovanski (13) landscape regions;
- → Oryahovo Municipality: in the Dolnoiskarski landscape region (5);
- → Parts entering the 30-km zone of the KNPP in Byala Slatina, Borovan and Boychinovtsi municipalities: in Lyutensko-Borovanski landscape region (13).

According to the **typologic classification system of landscapes in Bulgaria** the Project enters the landscape structure characterized by 8 groups, 5 sub-groups and 2 landscape types of the Plain Landscapes class:

1. Class	Plain landscapes;
1.1 Type	Landscapes with moderate continental meadow-steppe and forest lowlands;
1.1.1. Sub-type	Landscapes of meadow-steppe lowlands;
1.1.1.1. Group	Landscapes of meadow-steppe alluvial lowlands with medium degree of agricultural reclamation;
1.1.2. Sub-type	Landscapes of meadow-marsh lowlands;
1.1.2.2. Group	Landscapes of meadow-marsh alluvium lowlands with comparatively low degree of agricultural reclamation;
1.1.3. Sub-type	Landscapes of forest lowlands;
1.1.3.3. Group	Landscapes of forest lowlands on river islands;
1.1.3.4. Group	Landscapes of forest lowlands over the flood terrace hills with comparatively low degree of agricultural reclamation;
1.2. Type	Landscapes of moderate-continental steppe, meadow-steppe and forest-steppe plains;
1.2.5. Sub-type	Landscapes of chernozem meadow-steppe plains;
1.2.5.7. Group	Landscapes of chernozem meadow-steppe plains on loess rocks with high degree of agricultural reclamation;
1.2.5.8. Group	Landscapes of chernozem meadow-steppe plains on calcareous rocks with medium degree of agricultural reclamation;
1.2.6. Sub-type	Landscapes of forest-steppe plains;
1.2.6.9. Group	Landscapes of forest-steppe plains on loess rocks with high degree of agricultural reclamation;

1.2.6.10. Group Landscapes of forest-steppe plains on calcareous rocks with medium degree of agricultural reclamation.

Numerical indices of landscape taxonometric ranks are part of the Landscape Map of the country and identify hierarchic landscape classification whereto the territory of the investment proposal belongs.

The accuracy for identification of belonging of a specified landscape of the charts above does not comply entirely with the objectives on territory of the investment proposal. The scale of such maps (M 1:400000) does not allow detailed characterization of considered territory and therefore a more detailed system for landscape classification according to leading/physiognomic component[77] is applied.

3.5.1.1 LANDSCAPES ON THE KOZLODUY NPP TERRITORY

Landscap, anthropogenic. The Kozloduy NPP Site is part of anthropogenic landscape. The following subtypes thereof occur on the Site:

→ Landscape “anthropogenic industrial”: formed by the buildings of Units 1, 2, 3, 4, 5 and 6 of the Kozloduy NPP, administration buildings, electric and other equipment and parking lots;

→ Landscape “anthropogenic communication” in the structure whereof enter road communications on the territory of the Kozloduy NPP and existing routes of overhead transmission line HV.

Furthermore, on the territory of Kozloduy NPP occur:

Landscape forest. Physiognomic component of this landscape is tree vegetation. The territory of the landscape is broken by communication lines, buildings, open spaces, etc. Landscape forest is created to arrange green spaces and development of environment. The component structure includes various tree and shrub specieis. Landscape forest possesses stability and capacity for self-organization and self-regulation.

Landscape aquatic. Leading and physiognomic component is surface water. The component is represented by the intake and outlet canals to the Plant and covers comparatively large area providing grounds to be distinguished as an independent landscape. The latter is unstable in time, the existence thereof depends entirely on the anthropogenic activities.

3.5.1.2 LANDSCAPES ON THE TERRITORY OF SITE 1

According to the leading landscape-forming component on the territory of that Site, the following landscape structures can be distinguished:

[77] Petrov, P. 1990. Landscape Science. University publisher, SU Kliment Ohridski.

Landscape agrarian. The structure of agrarian landscapes includes pastures and arable areas in the lands of Harlets village.

Landscape anthropogenic. On the territory of Site 1 is distinguished the variety *anthropogenic communication landscape* wherein the anthropogenic effect is expressed in construction of various drain collectors and field roads.

3.5.1.3 LANDSCAPES ON THE TERRITORY OF SITE 2

The following landscape structures can be distinguished on the territory of that Site:

Landscape agrarian. The appearance thereof is formed by arable areas as part of the Harlets village lands. Arable lands are formed under the effect of purposeful anthropogenic activity resulting in landscape changes aimed to meet specific demands. Existence of such landscapes depends on anthropogenic activities – man may continuously maintain them in a particular state.

Landscape anthropogenic. The structure includes abandoned buildings and facilities of a former farm yard on the territory of KNPP.

Landscape forest. The structure includes tree-shrub massifs on the KNPP territory established with the purpose of greening and isolation of the Plant territory.

3.5.1.4 LANDSCAPES ON THE TERRITORY OF SITE 3

Landscape agrarian. The greater part of this Site territory is occupied by arable areas within the Harlets village lands. Landscape agrarian, crop rotation and agrarian of the perennial plants

Landscape anthropogenic. The anthropogenic landscape structure includes open irrigation channels and field roads.

3.5.1.5 LANDSCAPES ON THE TERRITORY OF SITE 4

The Site territory is part of landscape anthropogenic on the NPP territory. The following varieties thereof occur:

- → Landscape anthropogenic industrial: established by built up service departments – Equipment Office, Car-Repair Shop and Assembly Shop;.
- → Anthropogenic communication: the structure thereof includes all road communications and existing routes of high-voltage overhead transmission lines.

3.5.1.6 LANDSCAPES WITHIN THE REGION OF THE INVESTMENT PROPOSAL

Depending on leading and/or physiognomic landscape-forming components, the landscapes on the territory of the 30-km zone round the NPP are classified as follows:

Landscape forest. Leading and physiognomic component in this landscape is tree vegetation. These are natural territorial complexes of the Kozloduy Municipality forest fund, the eastern part of Lom Municipality, Valchedram, Hayredin, Mizia, Oryahovo municipalities and parts entering the 30-km zone of KNPP in the Byala Slatina, Borovan, Krivodol and Boychinovtsi municipalities.

The landscape horizontal structure is characterized by broken grounds and covers river bank territories and hilly slopes. The structure thereof includes tree species forming also the visual appearance of the landscape. Various species of willows (*Salix sp.*) and poplars (*Populus sp.*), Downy oak (*Quercus pubescens*), Turkish oak (*Quercus cerrsi*) and Hungarian oak (*Quercus frainetto*), Field elm (*Ulmus campestre*), Lime-trees (*Tilia sp.*) etc. Furthermore, common Acacia cultures (*Acacia pseudoacacia*) occur as well as pure and mixed cultures of Black pine (*Pinus nigra*). Belts of poplar cultures (*Populus sp.*) are grown alongside the Danube and cover the main part of islands. Most common among shrub species are the amorpha speciesn (*Amorpha sp.*). Landscape forest is characterized by high resistivity because of available capacities for self-regulation and self-renewal.

Landscape grassland. That landscape occupies considerable areas in the valleys round the investment proposal territory. Out of the varieties thereof there occurs the “meadow marshy” landscape in micro-depressions of flooded river terraces and in isolated plots round marshes within the region.

Landscape agrarian. Agrarian landscapes present natural-territorial complexes of lands in the municipalities surrounding the NPP territory. The landscape appearance is characterized by arable lands and pastures formed under the effect of purposeful anthropogenic activities aimed to meet specific demands. Existence of such landscapes depends entirely on the anthropogenic activities – man may maintain them permanently in a particular state.

Landscape aquatic. Leading and physiognomic component in this landscape is surface water represented by landscape “aquatic river”. The structure of river landscapes includes the Danube, Skat, Ogosta and Tsibritsa rivers and tributaries in the catchment areas thereof.

Landscape anthropogenic. Anthropogenic landscapes on the territory of the 30-km zone round the NPP are represented generally by the following varieties: “anthropogenic settlement”, “anthropogenic communication” and “anthropogenic industrial”.

3.5.2 Prediction of the impact

The Sites, subject to REIA, are part of agrarian and anthropogenic landscape.

The landscape structure on one of the surveyed sites shall change as a result of the investment proposal implementation and the landscape components (geologic base, soils and vegetation) shall be affected. Excavation works shall directly affect the geological base component. The impact is assessed as direct, irreversible, negative, local and small by range. Soils are subject to mechanical impact by excavation-embankment works and the humus layer shall be stockpiled in temporary depots. Vegetation on such plots shall be exterminated. The impact on the soil and vegetation landscape components is assessed as direct, negative, reversible, and local.

The following shall be studied and analyzed in the REIA:

- Landscape structure and functions;
- Analysis and evaluation of pollutants migration;
- Potential of self-cleaning and self-restoration;
- Capacities for realization of the investment proposal;
- Formulation of criteria for site selection;
- Assessment of expected landscape disturbances and changes;
- Measures for reduction, prevention and obstruction of negative consequences from the investment proposal realization.

3.6 BIOLOGICAL DIVERSITY

The subject of assessment in the report of EIA is the impact of the new unit on one of the four alternative sites designed for erection thereof. Impacts on the biological diversity (protected vegetation and animal species) in the range of the 30-km zone around the Kozloduy NPP shall be analyzed and assessed.

3.6.1 CURRENT STATUS

3.6.1.1 FLORA

According to the geo-botanical zoning of Bulgaria, the territory within the 30-km range of IP is referred to as the Euro-Asian steppe and forest-steppe area, Lower Danube Province, Danube River District, Zlatiiski Region. The territory is forestless and occupied mainly by agricultural cereals and vineyards. There are sparse remains of forests including Turkish oak (*Quercus cerris* L.), *Quercus virgilliana* Ten., and Downy Oak (*Quercus pubescens* Willd). In some places secondary forest associations grow with prevalence of Oriental Hornbeam (*Carpinus orientalis* Mill.), South European Flowering Ash (*Fraxinus ornus* L.), etc. Man-made plantations of Acacia (*Robinia pseudoacacia* L.) are established also. In many places, degraded forests are replaced by bushy associations including the Smoke Tree (*Cotinus coggygria*). In forestless plots secondary grass formations are formed with the prevalence of *Chrysopogon gryllus* (L.) Trin.), Yellow Bluestem (*Dichanthium ischaemum* (L.) Roberty), Bulbous Bluegrass (*Poa* *bulbosa* (L.), etc. A series of steppe elements play a part along with the Montpellierian Camphor-fume (*Camphorosma monspeliaca* L.), Danubian Clustered Broom (*Chamaecytisus danubialis* (Vel.) Rothm.), *Potentilla pirotensis* (Borbas) Markova, etc. In places of excessive moisture along the Danube, forest associations occur with prevailing White Willow (*Salix alba* L.), White Poplar (*Populus alba* L.) and Black Poplar (*Populus nigra* L.). On isolated plots there are cultures of hybrid poplars (*Populus X euroamericana*). Associations are also formed also of marshy and boggy grass vegetation with prevailing Reed (*Phragmites australis* (Cav.) Trin ex Stend.), Narrowleaf Cattail (*Typha angustifolia* L.), Lakeshore Bulrush (*Schoenoplectus lacustris* L.), etc.

Data from the last publication of the Red Book for the Republic of Bulgaria, Volume 1, Plants and mushrooms (Peev, D., etc. on-line)[78] show that within the 30-km range of the territory, the following plant species occur: Water Soldiers (*Stratiotes aloides*), Chinese licorice (*Glycyrrhiza glabra*), Rumelian Corn-flower (*Centaurea rumelica*), Yellow Water-lily (*Nuphar lutea*), (*Astragalus dasyanthus*), Military Orchid (*Orchis militaris*), Fringed Water-lily (*Nymphoides peltata*).

Assessment of flora and vegetation shall cover expected impact during the civil works and operation of the IP on the protected vegetation species, as per the Biological Diversity Act, growing in the area of the investment proposal (IP) – the four alternative sites and those included in the range of impact within the 30-km perimeter.

3.6.1.2 FAUNA

According to the zoo-geographic zoning of Bulgaria, the 30 km area around the Kozloduy NPP is located in the Danube zoo-geographic region, in the belt of plain-hilly and hilly-foothill belt of oak forests. Euro-Siberian and European species prevail with the addition of a significant number of Mediterranean species. The ornitho-fauna also features Euro-Siberian, European and Mediterranean elements. On the one hand, strong anthropogenization of lands in the region (drying up of the Kozloduy swamp, bunding of the Danube River and Ogosta River, Ogosta riverbed regulation, cutting off natural vegetation on the Danube islands, excessive application of chemicals in the Zlatiyata, etc.) has drastically affected fauna and recent complex formation. The fauna may be subdivided in three categories in terms of stability thereof to the degree of anthropogenic loading: synanthropic, eusynanthropic and ecologically plastic species. The species composition of animal associations has markedly changed due to significant anthropogenic impact.

TABLE 3.6-1 PROTECTED AREAS OF THE NATURA 2000 NETWORK AND AFTER THE RAMSAR CONVENTION IN R. OF BULGARIA AND R. OF ROMANIA ON THE AREA OF 30KM RANGE

[78] Peev, D. (ed.).Red Book of Republic of Bulgaria, Cl. 1. Plants and mushrooms (in press).

Directive / Country	Birds Directive (SPA)	Habitats Directive (SCI)	Total	Ramsar Convention
Bulgaria	BG0002007 BG0002008 BG0002009 BG0002104	BG0000199 BG0000508 BG0000527 BG0000533 BG0000614	9	Maintained Ibisha reserve
Romania	ROSPA0010 ROSPA0023	ROSCI0045 ROSPA0135	4	
Total	**6**	**7**	**13**	**1**

On the other hand, among factors justifying the species richness in the region is the availability of a large ecological corridor (the Danube River), relative proximity of the Danube Delta, migration stream of birds over the territory and low altitude. The Kozloduy NPP is located in the middle of an ecological complex of large swamps with part of them already dried up or transformed into fish-breeding ponds (Bistretsko, Tsibarsko and Kozloduysko Ostrovsko[79], inter-continental dunes (at Bistrets and Duboleni), the Danube islands (Tsibar, Tsibritsa, Svraka, Kozloduy, Kopanitsa), river mouths (Ziu, Ogosta, Skat), flooded island forests, large sand strips (between Lower and Upper Tsibar). A large part thereof is included in the protected areas of the Natura 2000 network and the Ramsar Convention: ***Table 3.6-1*** *Protected areas of the NATURA 2000 network and after the Ramsar Convention in R. of Bulgaria and R. of Romania on the area of 30*).

Seven species of worldwide endangered birds occur in that ecological complex during the various seasons of the year: Dalmatian Pelican *(Pelecanus crispus),* Lesser White-fronted Goose (*Anser erythropus),* Red-breasted Goose *(Branta ruficollis),* Ferruginous Duck (*Aythya nyroca)*, White-tailed Eagle *(Haliaetus albicilla),* Red-footed Falcon (*Falco vespertinus),* Corn Crake *(Crex crex).*

The greater, larger-scale range of the studied territory (with radius of 30 km) and the greater time interval of tens of years are of significant importance to the studies related to biological diversity and conservation.. References since the end of the 19th century to date shall be used for description of some elements of ecosystems in the region. The UTM coordinate network is applied with the help of modern atlases tht have been compiled for occurrence of plants and animals in Europe, on the Balkan Peninsula and in Bulgaria.

[79] MICHEV, T., M. STOYNEVA (eds). 2007. Inventory of Bulgarian Wetlands and their Biodiversity. Publ. House Elsi-M, Sofia, 364 pp

Invertebrates

Populations of terrestrial invertebrates with conservation status are not expected to be found on the territory of the four sites under assessment. The region of the 30-km area round the investment proposal location is very poorly studied in respect of biodiversity of terrestrial invertebrates. One species of mayfly – *Brachycercus harrisella* (Harris' mayfly), included in the Red Book of Republic of Bulgaria of the category "Critically endangered" (Golemanski, (edit.) 2011)[80] was reported at the Danube at Kozloduy in the period 1955-1964. The species may be treated as both terrestrial and aquatic fauna because of the fact that larvae are developing on bottoms of large rivers and the imago is flying toward the land. The imago (adult specimens) lives shortly and keeps close to the water basins wherefore direct impact is not expected on flying insects since indirect impacts on insects with that short life of imago are very difficult to define. Other data for protected and vulnerable terrestrial invertebrates are unavailable.

Aquatic invertebrates

Water supply from the Danube is foreseen for the circulating water system of the Kozloduy NPP new nuclear unit. Service water supply will also be related to activities in the Danube riverbed. Such activities will affect aquatic invertebrates like zooplankton and zoobentos including mussels, snails and crayfish. Impact on 4 species of water invertebrates is expected in the affected section of the Danube and appurtenant water basins (e.g. lower reaches and mouth of the Ogosta River) as follows: Striped Nerite (Theodoxus transversalis), Thick Shelled River Mussel (Unio crassus) (Endangered species according to IUCN Red List, App. 2 and 3, BDA), Depressed River Mussel (Pseudanodonta complanata) (Vulnerable species according to IUCN Red List), Narrow-Clawed Crayfish (Astacus leptodactylus) (App. 4, BDA).

Invasive alien species

The activities foreseen during the civil works and operations of the new nuclear unit shall affect not only the native species but invasive alien species as well. The effect may be both negative and positive and will in turn reflect indirectly on native species and ecosystems. Not all of the alien species have expressed a negative impact on native species but such an effect may be obtained with changes in the environment (Panov *et al.,* 2009)[81].

The following alien species of aquatic invertebrates and fish with potentially negative impact on native species and ecosystems, have been established or are expected to invade the Bulgarian section of the Danube: Chinese Pond Mussel (*Anodonta woodiana*), Quagga Mussel (*Dreissena bugensis*), Asian clam (*Corbicula fluminea*), Chinese Mitten

[80] Golemanski (ed.) 2011. Red Book of Bulgaria,

[81] Panov, V. E., B. Alexandrov, K. Arbačiauskas, R. Binimelis, G. H. Copp, M. Grabowski, F. Lucy, R. SEW Leuven, S. Nehring, M. Paunović, V. Semenchenko and M. O. Son, 2009. Assessing the risks of aquatic species invasions via European inland waterways: From concepts to environmental indicators. Integrated Environmental Assessment and Management, 5 (1), pp. 110–126

Crab (*Eriocheir sinensis*), Spiny-cheek Crayfish (*Orconectes limosus*) and fish: Paddlefish (*Polyodon spathula),* Bighead Carp *(Aristichthys nobilis*), Gibel Carp *(Carassius gibelio*), Grass Carp (*Ctenopharyngodon idella*), Silver Carp (*Hypophthalmichthys molitrix)*, Topmouth gudgeon (*Pseudorasbora parva*), North Amerikan Catfishes (*Ameiurus melas/ Ameiurus nebulosus / Ictalurus punctatus)*, Eastern Mosquitofish (*Gambusia holbrooki)*, Black-striped Pipefish (*Syngnathus abaster*), Pumpkinseed (*Lepomis gibbosus*), Amur Sleeper (*Perccottus glenii)* (Schiemer *et al*.2004[82]; Liška *et al*.2008[83], Polačik *et al*. 2008[84]).

The planned activities are expected to create a favorable environment for the introduction of new alien species or increased impact of already existing ones resulting, due to temporary or lasting changes in habitat qualities (increased water temperature, changes in flow velocity, food supply, substrate type, etc.).

Water supply from the Danube is foreseen for the circulating water system of the Kozloduy NPP new nuclear unit. Service water supply will also be related to activities in the Danube riverbed. Such activities will affect aquatic invertebrates like zooplankton)

Ichthyofauna

Circulation water from the Danube River shall be supplied to the new power unit whereat part of the civil works shall be carried out in the Danube riverbed: erection of cooling system (drain collectors), renewal of existing and building up new pump stations, increased water traffic, handling works, etc.

Warm water volumes used for cooling shall outfall into the Danube and pump units shall deliver water (from the Danube and other sources) to maintain circulation and technical functions of the new nuclear unit. These activities are expected to inevitably affect to a high extent 15 fish species included in Annex 2 to BDA and occurring in the 30-km range of IP impact (Drenski, 1951[85]; Karapetkova, 1994[86], Stefanov, 2007[87]) Pontic Shad (*Alosa pontica*), Asp (*Aspius aspius*), Mediterranean Barbel (*Barbus meridionalis*), Balkan Loach (*Cobitis elongata*), Spined Loach (*Cobitis taenia*), Golden spined loach (*Sabanejewia aurata*), Ukrainian Brook Lamprey (*Eudontomyzon mariae*), White-finned Gudgeon

[82] Schiemer F., G. Guti, H. Keckeis and M. Staras 2004. Ecological status and problems of the Danube River and its fish fauna: a review. In: Welcomme R.L., T. Petr (Eds.), Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries “Sustaining Livelihoods and Biodiversity in the New Millennium”, 11-14 February 2003, Phnom Penh, Kingdom of Cambodia. Vol. 1: 273-299.

[83] Liška I., F. Wagner, J. Slobodník 2008. Joint Danube Survey 2. Final Scientific Report. ICPDR, 242 pp.

[84] Polačik, M., T. Trichkova, M. Janáč, M. Vassilev, P. Jurajda, 2008. The ichthyofauna of the shoreline zone in the longitudinal profile of the Danube River, Bulgaria. Acta zoologica bulgarica, 60 (1): 77-88.

[85] Drenski P. 1951. Fish in Bulgaria. Bulgarian Fauna II. C., BAS, 270 p.

[86] Karapetkova M. 1994. Vertebrates. – B: Rusev B., Limnology of Bulgarian Danube tributaries, MEW, C., BAS, 175–186

[87] Stefanov T. 2007. Fauna and distribution of fishes in Bulgaria. – In: Fet V., A. Popov (eds): Biogeography and ecology of Bulgaria. Dordrecht (Springer), 109–139.

(*Gobio albipinnatus*), Danube Ruffe (*Gymnocephalus baloni*), Striped Ruffe (*Gymnocephalus schraetser*), Weatherfish (*Misgurnus fossilis*), Sabrefish (*Pelecus cultratus*), European Bitterling (*Rhodeus amarus*), Zingel (*Zingel zingel)*, Streber (*Zingel streber).*

Herpetofauna

Ten amphibian species and 9 reptile species that are on the list in appendices of the BDA occur in the 30-km zone around the Kozloduy NPP (Biserkov et.al., 2007[88]; Naumov and Stanchev, 2010[89]; Stojanov et al., 2011[90]):

Danube Crested Newt (*Triturus dobrogicus*), Smooth Newt (*Lissotriton vulgaris*), European Fire-bellied Toad (*Bombina bombina*), European Spadefoot Toad (*Pelobates fuscus*), Caucasian Toad (*Bufo bufo*), Green Toad (*Pseudepidalea viridis*), European Tree Frog (*Hyla arborea*), Agile Frog (*Rana dalmatina*), Marsh Frog (*Pelophylax ridibundus*), Edible Frog (*Pelophylax kl. eculentus*), European pond turtle (*Emys orbicularis*), Hermann's Tortoise (*Testudo hermanni*), European Green Lizard (*Lacerta viridis*), Balkan Wall Lizard (*Podarcis tauricus*), Caspian Whipsnake (*Dolichophis capius*), Aesculapian Snake (*Zamenis longissimus*), Eastern Four-lined Snake (*Elaphe sauromates*), Dice Snake (*Natrix tessellata*), Nose-horned Viper (*Vipera ammodytes*).

Mammals

The following species listed in BDA occur in the area of the 30-km zone: European Hedgehog (*Erinaceus europaeus*), Mole (*Talpa europaea)*, Mound-building Mouse (*Mus spicilegus*), Lesser Mole Rat (*Spalax leucodon*), Eurasian Red Squirrel (*Sciurus vulgaris*), Edible Dormouse (*Glis glis*), European Ground Squirrel (*Spermophilus citellus*), Hamster Dobrogean (*Mesocricetus newtoni*) *and* European Hamster (*Cricetus cricetus*), Least Weasel (*Mustela nivalis*), European Otter (*Lutra lutra*), European Roe Deer (*Capreolus capreolus*), European Badger (*Meles meles*), European Polecat (*Mustela putorius*).

Chiropterofauna

The following species under the BDA occur within the 30-km area. Common Pipistrelle (*Pipistrellus pipistrellus*), Nathusius' Pipistrelle (*Pipistrellus nathusii*), Long-fingered Bat (*Myotis capaccinii*), Serotine Bat (*Eptesicus serotinus*), Common Noctule (*Nyctalus noctula*), Leisler's Bat (*Nyctalus leisleri*), Savi's Pipistrelle (*Hypsugo savii*), Parti-coloured Bat (*Vespertilio murinus*), Greater Horseshoe Bat (*Rhinolophus ferrumequinum*), Lesser Horseshoe Bat (*Rhinolophus hipposideros*), Mehely's Horseshoe Bat (*Rhinolophus mehelyi*), Mediterranean Horseshoe Bat (*Rhinolophus euryale*), Grey Long-eared Bat

[88] Biserkov V., B. Naumov, N. Tsankov, A. Stoyanov, B. Petrov, D. Dobrev, P. Stoev. 2007. Guide to amphibians and reptiles in Bulgaria. Sofia, Green Balkans, 196 pp.

[89] Naumov, B., M. Stanchev, 2010. Amphibians and reptiles in Bulgaria and the Balkan Pennisula. http://www.herpetology.hit.bg

[90] Stojanov, A., N. Tzankov, B. Naumov. 2011. Die Amphibien und Reptilien Bulgariens. Frankfurt am Main, Chimaira, 588 pp

(*Plecotus austriacus*), Common Bent-wing Bat (*Miniopterus schreibersii*), Greater Mouse-eared Bat (*Myotis myotis*), Mouse-eared Bat (*Myotis blythii*), Whiskered Bat (*Myotis mystacinus*) and Alcathoe's Bat (*Myotis alcathoe*).

Ornitofauna

According to Iankov (2007)[91] the nest ornithofauna in the UTM square GP24, wherein the site of Kozloduy NPP is located, amounts to 55 bird species. The number of breeding bird species in the neighbouring square (GP25), covering both banks of the Danube with appurtenant Kozloduy and Kopanitsa islands, is 58. Square GP13 with 101 nidifying species is distinguished by the greatest species variety among up to now studied UTM squares within the 30-km range. Nidificating stocks of Black-crowned Night Heron *(Nycticorax nycticorax)* and Black-headed Gull *(Larus ridibundus)* are also established in this square.

Within the 30-km range of the IP impact also occur about 80 bird species (according to Letter BSPB, Ref. No. 26/14.01.2013) with 28 out of them listed in the Red Book of Bulgaria, 53 species of concervation concern in Europe and 7 worldwide. The species of highest concervation concern are: Dalmatian Pelican *(Pelecanus crispus),* Black Stork *(Ciconia nigra),* White Stork *(Ciconia ciconia),* Lesser White-fronted Goose *(Anser erythropus),* Montagu's Harrier *(Circus pygargus),* Red-footed Falcon *(Falco vespertinus),* Goosander *(Mergus merganser),* Black-headed Gull *(Larus ridibundus*), Common Goldeneye *(Bucephala clangula),* Common Shelduck (*Tadorna tadorna),* Eurasian Sparrowhawk *(Accipiter nisus),* White-tailed Eagle *(Haliaeetus albicilla*), Crested Goshawk *(Accipiter gentilis),* Smew *(Mergus albellus)* Common Kingfisher *(Alcedo atthis),* European Roller *(Coracias garrulus),* Grey-headed Woodpecker *(Picus canus),* Syrian Woodpecker (*Dendrocopos syriacus),* Red-backed Shrike *(Lanius collurio),* Lesser Grey Shrike *(Lanius minor),* Ortolan Bunting *(Emberiza hortulana),* etc. (Michev & Profirov, 2003[92]).

The following species are **breeding or feeding** in the area under consideration: White-tailed Eagle *(Haliaeetus albicilla*), Mallard *(Anas platyrhynchos*), Great Cormorant (*Phalacrocorax carbo),* Pygmy Cormorant (*Phalacrocorax pygmeus),* Black-crowned Night Heron *(Nycticorax nycticorax)*, Little Egret *(Egretta garzetta)*, Black Stork *(Ciconia nigra),* White Stork *(Ciconia ciconia),* Long-legged Buzzard *(Buteo rufinus),* Montagu's Harrier *(Circus pygargus).*

During migration the following species are observed: Common Buzzard (*Buteo buteo)*, Lesser Spotted Eagle (*Aquila pomarina*), Montagu's Harrier (*Circus pygargus*), Western Marsh-harrier (*Circus aeruginosus*) and Hen Harrier (*Circus cyaneus*), White Stork (*Ciconia ciconia*) and Black Stork (*Ciconia nigra*), Dalmatian Pelican *(Pelecanus crispus)*

[91] Yankov P. 2007. Atlas of nidifyingbirds in Bulgaria.

[92] Michev, T., L. Profirov. 2003. Midwinter Numbers of Waterbirds in Bulgaria (1977-2001). Results from 25 years of mid-winter count carried out at the most important Bulgarian Wetlands. Publ. House Pensoft, Sofia, 160 pp.

(Data from a project of MoEW for birds migration – LOT 7, Biserkov et.al., 2011[93], RIEA for Valchedrum WPP, RIEA Oryahovo WPP, Michev et al., 2011[94], 2012[95]).

A number of wintering waterbirds such as Mallard (*Anas platyrhynchos)*, Common Teal (*Anas crecca*), Greater White-fronted Goose (*Anser albifrons*), Common Goldeneye (*Bucephala clangula*), Common Shelduck (*Tadorna tadorna*), Goosander (*Mergus merganser*) also are observed. Due to the security regime established on the area of the NPP and appurtenant grounds, as well as to the favourable effect of the hot channel, there is a positive effect on these species: Great Cormorant (*Phalacrocorax carbo)*, Dalmatian Pelican *(Pelecanus crispus),* Mallard (*Anas platyrhynchos)* etc. (Data from Mediterranean count of waterbirds in Bulgaria (by EEA at MEW) for the section Tsibar-Somovit, own field investigations).

The assessment on the fauna shall cover expected impact in the time of civil works and operation of IP on protected animal species under BDA occurring in the area of the investment proposal (IP): the four alternative sites, and those in the range of impact within the 30-km perimeter.

Site 1

There are open drain collectors on the Site (***Figure 3.6-1:*** *Site 1. Reedy drain canal*), and part of the latter is used for agricultural crop growing. The Site is located on the grounds of a former Kozloduy swamp. Comparatively large plots are covered by weed or grass associations dominated by Bermuda Grass (*Cynodon dactylon*), Orchard Grass (*Dactylis glomerata*) or by shrubs of Blackthorn (*Prunus spinosa*), Wild Briar (*Rosa* sp.), etc. The drain collectors are thickly overgrown by Bulrush (*Typha sp.)* and open water surface is almost lacking. One species has been found as per the BDA: Liquorice (*Glycyrrhiza glabra*). There are suitable habitats and a nutritive base for specific groups of invertebrates. Drain collectors are a suitable habitat for tailless amphibians and tritons. Scattered shrubby vegetation and applied agricultural practices are the basis for the dwellings of small mammals. The ground provides very limited conditions for presence of daytime and winter shelter of bats. Probable bird species that may occur on the Site are: Mallard (*Anas platyrhynchos),* Common Buzzard (*Buteo buteo)*, Common Moorhen (*Gallinula chloropus),* Eurasian Coot *(Fulica atra),* Common Wood Pigeon (*Columba palumbus)*, Little Owl (*Athene noctua),* European Scops Owl (*Otus scops),* Syrian Woodpecker (*Dendrocopus syriacus),* Common Kingfisher (*Alcedo atthis),* Great Reed Warbler (*Acrocehalus arundinaceus),* Eurasian Reed Warbler (*Acrocephalus scirpaceus),* Western Jackdaw (*Coleus monedula)*, Rook (*Corvus frugilegus)*, Magpie (*Pica pica)*,

[93] Biserkov et.al. 2011. Red Book of Bulgaria, V. 2, animals On-line.

[94] Michev, T., L. Profirov, J. Nyagolov, M. Dimitrov. 2011. The autumn migration of soaring birds at Burgas Bay, Bulgaria". – British Birds, London.

[95] Michev, T., L. Profirov, N. Karaivanov, B. Michev. 2012. Autumn Migration of Soaring Birds over Bulgaria. – *Acta zoologica bulgarica,* 64, 33-41

Eurasian Jay (*Garrulus glandarius),* Hooded Crow (*Corvus cornix),* Eurasian Tree Sparrow (*Passer montanus)*, Common Blackbird (*Turdus merula)*.

FIGURE 3.6-1: *SITE 1. REEDY DRAIN CANAL*

Site 2.

The Site covers part of the former farmyard and agricultural lands (***Figure 3.6-2:*** *Site 2. Agro-areas*). One plant species is established in terms of BDA: Licorice (*Glycyrrhiza glabra*). The Site provides extremely limited possibilities for the existence and development of a great part of vertebral animals. There are practically no shelters for bats. The Site has low potential as a hunting and feeding territory. Probable bird species that may occur on the Site: Mallard (*Anas platyrhynchos)* (uses agricultural lands for feeding and resting in winter), Rook (*Corvus frugilegus)*, Great Cormorant (*Phalacrocorax carbo)*, Eurasian Sparrowhawk (*Accipiter nisus)*.

Site 3.

The Site includes open drain collectors, abandoned, and arable agricultural lands, pastures with shrubs and ground depressions (probably parts of the former Kozloduy Swamp with swampy vegetation and prevailing weed associations (*Phragmites australis*) as well as grass associations dominated by Bermuda Grass (*Cynodon dactylon*), Orchard Grass (*Dactylis glomerata*) etc. (***Figure 3.6-3***). One plant species listed in the BDA is recorded: Licorice (*Glycyrrhiza glabra*).

Drain collectors are suitable habitat for tailless amphibians and tritons, Commons Moorhen, Eurasian Coots, Eurasian Reed Warbler. Scattered shrubby vegetation and applied agricultural practices are the basis for dwellings of small mammals.

FIGURE 3.6-2*: SITE 2. AGRO-AREAS*

The ground provides favourable conditions as a hunting territory for migrating bat species and limited possibilities for shelter in isolated old trees. Probable bird species that may occur on the Site: Great Tit *(Parus major),* Blue Tit *(Parus coeruleus)*, Yellowhammer (*Emberiza cirtinella),* Common Blackbird (*Turdus merula)*, Eurasian Collared Dove (*Streptopelia decaocto)*, Fieldfare (*Turdus pilaris)*, Red-backed Shrike (*Lanius collurio)* etc.

Site 4.

There are buildings and a parking lot on the Site. The fully technogenic character of the Site does not afford habitats (but there are habitats of low significance) and is not feeding territory for a greater part of vertebrals. The Site provides limited possibilities for daytime summer shelters of synanthropic bird species like: Great Tit (*Parus major),* Willow Sparrow (*Passer hispaniolensis*), Brambling (*Fringuilla montifringuilla)*, Blue Tit (P*arus coeruleus*), Domestic Pigeon (*Columba domestica*) и др.

FIGURE 3.6-3*: SITE 3. TYPICAL LANDSCAPE*

3.6.2 PREDICTION OF THE IMPACT

3.6.2.1 CONSTRUCTION STAGE OF THE NEW NUCLEAR UNIT

Site 1:

Direct impacts:

→ Possible extermination of specimens of the rare vegetation species Chinese licorice and small-size mammals, invertebrates and larvae thereof by heavy-weight transport and construction machines;

→ Possible destruction habitats of animal species, shelters of vertebrate fauna and forest species of bats;

→ Possible mortality of specimens in shelters;

→ Possible changes in natural characteristics of hunting habitats, rest places and nutritive basis with partial or complete extermination of vegetation on sites.

Indirect impacts:

→ Possible deterioration of the vegetation communities and habitats of species

→ Possible introduction and spread of weed, ruderal and invasive plant species.

Site 2:

Direct impacts:

→ Possible extermination of specimens of rare vegetation species Chinese licorice and small-size mammals, invertebrates and larvae thereof by heavy-weight transport and construction machines;

Indirect impacts:

→ Disturbance of some bird species and deterioration of their feeding habitats;

→ Possible introduction and spread of weed, ruderal and invasive plant species.

Site 3:

Direct impacts:

→ Possible extermination of specimens of the rare vegetation species Chinese licorice and small-size mammals, invertebrates and larvae thereof by heavy-weight transport and construction machines;

→ Possible destruction of habitats of animal species, shelters of vertebrate fauna and forest species of bats;

→ Possible mortality of specimens in shelters;

→ Possible changes in natural characteristics of hunting habitats, rest places and nutritive basis with partial or complete extermination of vegetation on sites.

Indirect impacts:

→ Possible deterioration of the vegetation communities and habitats of species;

→ Possible introduction and spread of weed, ruderal and invasive plant species.

Site 4:

Direct impacts:

→ Not to be expected.

Indirect impacts:

→ Not to be expected.

3.6.2.2 OPERATION STAGE OF THE NEW NUCLEAR UNIT

3.6.2.2.1 On sites

Site 1:

Direct impacts:

→ Not to be expected.

Indirect impacts:

→ Possible negative cumulative impacts on habitats of species in terms of BDA.

Site 2:

Direct impacts:

→ Not to be expected.

Indirect impacts;

→ Possible negative cumulative impacts on habitats of species as per the BDA.

Site 3:

Direct impacts:

Indirect impacts:

→ Possible negative cumulative impacts on habitats of species as per the BDA.

Site 4:

Direct impacts:

Indirect impacts:

→ Additional impacts are not to be expected.

3.6.2.2.2 Impacts due to the implementation of the new nuclear unit beyond the sites

Construction stage of the new nuclear unit

Direct impacts:

→ Expected disturbance of species due to noise, vibrations, strong waves resulting from intensified water traffic and earth excavation works.

→ Expected changes in number of species and population structure.

Indirect impacts:

→ Possible changes in habitats quality and habitats of species;

→ Possible changes in quality or reduction of nutritive base;

→ Possible contamination by toxic elements, etc.;

→ Possible introduction of new invasive alien species.

Operation stage of the new nuclear unit

Direct impacts:

→ Possible changes in the biological species population structure;

→ Possible mortality of hydrobionts due to suction of larvae or juvenile specimens at maintenance of circulation, engineering and household water supply system;

→ Possible risk of radioactive contamination.

Indirect impacts:

- → Possible changes in composition and structure of hydrobionts;
- → Possible changes in quality of habitats;
- → Possible changes in the physical-chemical parameters of water (permanent increase of water temperature, changes in water velocity in some sections);
- → Possible changes in the nutritive base quality;
- → Possible formation of favorable conditions for introduction of invasive species;
- → Possible negative cumulative impacts.

On the grounds of forecasts for impacts resulting from the implementation of new nuclear unit, the Biodiversity component shall be discussed in detail in the Environmental Impact Assessment Report.

3.6.2.3 RESEARCH METHODS

Potential associations of species in the region of Kozloduy NPP and in the region of eventual impact of the new nuclear capacities shall be defined on the grounds of data from main publications on selected model groups to be studied (Hubenov 2007[96]; Chobanov 2009[97]). Field investigations shall be aimed at expert assessment of habitats in terms of what animal species may occur on the four sites territories and in the region of immediate impact of the new nuclear unit.

Two field investigations are planned for the period January-March 2013 on the foreseen four construction sites and surroundings thereof, specific spots with expected impact and in the aquatory of the Danube River and Ogosta River (Bibby et al., 1992[98]).

3.6.2.3.1 Flora, vegetation and habitats assessment

Routing and semi-stationalry investigation methods shall be applied. Results shall be used from field investigations in the nearest located protected zones of the Natura 2000 ecologic network in the results of maps drawn of habitats and species habitats in the season 2011 and 2012 seasons as well as consultations with experts, NGO and available data base.

Available references shall be analyzed (Peev et.al On-line[99]; Biserkov et.al., On-line[100]; Bondev, 1999[101], 1997[102], 2002[103], Velchev 1982-1989[104]; 1997[105], 2002[106], Delipavlov

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[96] Hubenov, Z. (2007). Fauna and Zoogeography of Marine, Freshwater, and Terrestrial Mollusks (Mollusca) in Bulgaria. In: V. Fet & A. Popov (Eds.). Biogeography and Ecology of Bulgaria. Springer, 141-198 pp.

[97] Chobanov, D.P. (2009). Analysis and assessment of faunistic diversity of Orthoptera in Bulgaria. Dissertation. Inbstitute in zoology, BAS, pp. 565.

[98] Bibby, C. J., N. D. Burgess, D. A. Hill. 1992. Bird Census Techniques. The University Pres, Cambridge: 257 pp.

2003[107]; Jordanov, 1963-1979[108]; Kojuharov, 1995[109]; Petrova & Vladimirov 2009[110]; 2010[111]; Walter & Gillett 1998[112]) as well as available data base of the state of flora and habitats on the territory subject to impact of the IP and field investigations for assessment of critical areas state.

3.6.2.3.2 Assessment of faunistic diversity

Three field investigations have also been scheduled also for the period January-March, 2013, on the four potential sites and the surroundings thereof, specific locations with expected impact.

Approaches for direct field investigations shall be used: routing or line transects and point counts (Bibby et al., 1992[113]). Results shall be used from field investigations of the nearest located protected zones on the Natura 2000 ecologic grid as a result of mapped habitats and species habitats during the season 2011 and 2012 seasons. Review shall be made of published scientific results as well as consultations with experts, NGOs and available data bases.

Fish shall be caught by electrofishing according to the European Standard EN 14011.

Bottom macroinvertebrate species (including invasive species) and assessment of the ecological status of water bodies shall be made after the methods instructed in Ordinance No. 1 for water monitoring (Cheshmedjiev et.al. 2010[114]). According to the

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[99] Peev, D. (ed).Red Book of Bulgaria, V.1. Plants and mushrooms (in press)

[100] Biserkov V. et.al. 2011. Red Book of Bulgaria, V. 2, Animals (in press)

[101] Bondev, I. 1991. Vegetation of Bulgaria. Map at M 1:600 000 with explanatory text.

[102] Bondev, Iv. 1997. Geobotanic mapping. B: Jordanova, M.,D. Donchev. Geography of Bulgaria Acad. Publ. 283-304

[103] Bondev, Iv. 2002. Geobotanic mapping. – B: Kopralev, I. (ed.), Geography of Bulgaria. Physical and Social-Economic Geography, Publ. ForKom, Sofia, 336-352.

[104] Velchev, V. (ed.). 1982-1989. Flora PR Bulgaria. Volumes 8-9. Publishers of BAS, Sofia

[105] Velchev, V. 1997. Vegeration types. B: Jordanova M., D. Donchev. (eds). Geography of Bulgaria, Acad. Publ., 269-283.

[106] Velchev, V. 2002. Vegeration types. B: Kopralev, I. (ed.), Geography of Bulgaria. Physical and Social-Economic Geography, Publ. ForKom, Sofia, 324-336

[107] Delipavlov,D. & Cheshmedjiev, I. (ed.) 2003. Guide to plants in Bulgaria. Academic publishers of the Agrarian University, Plovdivв.

[108] Jordanov, D., (ed.) 1963-1979. Flora of Republic of Bulgariea, Volumes 1-7. – Sofia.

[109] Kojuharov, S., (ed.). 1995. Flora of Republic of Bulgariea, Volume10. – Sofia.

[110] Petrova, A. & Vladimirov, V. (eds) 2009. Red list of Bulgarian vascular plants. - Phytologia Balcanica, 15(1): 63-94.

[111] Petrova, A. & Vladimirov, V. 2010. Balkan endemics in the Bulgarian flora. – Phytologia Balcanica, 16(2): 293-311.

[112] Walter & Gillett 1998

[113] Bibby, C. J., N. D. Burgess, D. A. Hill. 1992. Bird Census Techniques. The University Pres, Cambridge: 257 pp.

[114] Cheshmedjiev S., R. Mladenov, D. Belkinova, G. Gecheva, I. Dimitrova-Dyulgerova, P. Ivanov and S. Mihov 2010. Development of classification system and biological reference conditions for Bulgarian

Ordinance, specimens are collected according to ISO 7828 Standard (Water quality - Methods of biological sampling - Guidance on handnet sampling of aquatic benthic macro-invertebrates, 6, 1985) while metrics are conformable with the European Framework Directive (Directive 60/2000 EC). The following indices are applied for the assessment of the ecological status: the so called „Biotic index" (Gerasimov & Peev, 1999[115]; %EPT (% taxa of the Ephemeroptera, Plecoptera and Trichoptera groups – according to the Biotic index), index KN (Janeva, Russev, 1987[116]); Saprobic index – if the species composition allows, structural parameters – if the species composition allows (Shannon & Weaver, 1963[117] . Gerasimov & Peev, 1999[118]).

3.6.3 PROTECTED AREAS

3.6.3.1 CURRENT STATUS

The four alternative sites for the IP do not fall in protected zones. According to the Register of protected areas and protected zones in Bulgaria (Letter by EEA, Ref. No. 301/20.12.2012, RIEW-Vratsa, Ref. No. B2975/10.01.2013) the territory of the 30-km range of IP impact covers the following protected areas:

Ibisha Reserve Maintained on area of 34.47 ha on the land of Dolni Tsibar village, Valchedrum Municipality; declared by Order No. РД-794/08/10/1984 with the purpose of preserving typical Danube island associations: flood forests and swamps inhabited by protected plant and animal species.

Kozloduy Protected Area covering 10 ha on the land of Kozloduy town, re-classified from hystorical place with Order by MoEW No. РД-639/26.05.2003 for preservation of typical landscape.

Kochumina Protected Area on area of 2.5 ha on the land of Selanovtsi village, Oryahovo Municipality, declared by Order No. РД-2109/20.12.1984 and re-classified by Order No. РД-642/ 26.05.2003; with the purpose of preserving water-lily habitats.

Gola Bara Protected Area on area of 2 ha on the land of Selanovtsi village, Oryahovo Municipality, declared by Order No. РД-2109/20.12.1984 and re-classified by Order No. РД-643/ 26.05.2003; with the purpose of preserving water-lily habitats.

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rivers and lakes according to the Water Framework Directive. - Biotechnology & Biotechnological Equipment 24/2010/SE (special edition/on-line), 155-163.

[115] Gerasimov S., D. Peev, 1999. National program for biomonitoring. Publ. Gealibris, Sofia. 240p.

[116] Janeva I., B. Russev 1987. Comparative analysis about biological methods for quality estimations for running waters. Ist National conference of problems of Biological Monitoring. Plovdiv. 22-24 Oct. 1987, 97-102

[117] Shannon S., W. Weaver 1963. The mathematical theory of communication. Urbana University Illinois Press, 117.Pielou E. 1966. Species diversity and pattern diversity in the study of ecological successions. – Journal of Theorethical Biology, London, 10: 370-383

[118] Gerasimov & Peev, 1999. Biotic index (modified Ireland biotic index).

Kalugerski grad – Topolite Protected Area on area of 0.2 xa, on the land of Selanovtsi village, Oryahovo Municipality, declared by Order No. РД-2109/20.12.1984 re-classified by Order No.РД-644/ 26.05.2003; with the purpose of preserving water soldier (*Stratiotes Aloides*).

Koritata Protected Area on area of 2 ha on the land of Sofronievo village, Mizia Municipality, declared by Order No. РД-407/07.05.1982 and re-classified by Order No. РД-641/ 26.05.2003; with the purpose of preserving the natural habitat of peony (*Paeonia Peregrina)* and remarkable landscape.

3.6.3.2 PREDICTION OF THE IMPACT

The existing site of Kozloduy NPP is located at sufficiently great distance from any protected natural territories. Nevertheless the REIA shall include assessment to what extent civil works, operation and decommissioning of new nuclear capacities will not endanger the cenoses therein.

3.6.4 NATURA 2000 ZONES

The nearest Protected zones of the European Ecological Network NATURA 2000 to the Kozloduy NPP and sites foreseen for the construction of a new nuclear unit are:

- → Protected zone BG0000533 Kozloduy islands – type "B" according to Directive for habitats and Directive 92/43/EEC for preservation of natural habitats of wild flora and fauna;
- → Protected zone BG0002009 Zlatiyata – according to Directive for wild birds;
- → Protected zone BG0000614 Ogosta River - type "K" according to Directive 92/43/EEC for preservation of natural habitats of wild flora and fauna.

Impact assessment on the subject and objectives of Protected Areas shall be the theme of a particular report on assessment of the investment proposal conformity (CAR) with objectives for protected zones preservation[119].

3.7 WASTE

3.7.1 CURRENT STATUS

3.7.1.1 NON-RADIOACTIVE WASTE

Assessment of current status shall be made in thereport of EIA in compliance with the Waste Management Act (WMA), SG 53/2012, and subregulatory acts thereto. Non-

[119] Ordinance for terms and order to make assessement of plans, programs, designs and investment proposals compatibility with subject and objectives for protected zones preservation (Approved by DCM No. 201/31.08.2007, Published in SG 73/11.09.2007)

radioactive waste in the Kozloduy NPP are managed at present according to Program for Non-radioactive Waste Management in Kozloduy NPP and regulations for safety assurance in non-radioactive waste management.

Table 3.7-1: Non-radioactive waste generated in Kozloduy NPP EAD for the period 2000 – 2011. shows classification and quantitative characteristics of waste generated on the area of Kozloduy NPP for the period 2007-2011.

TABLE 3.7-1: NON-RADIOACTIVE WASTE *GENERATED IN* KOZLODUY *NPP EAD FOR THE PERIOD 2000 – 2011.*

№	Name	Code acc. to Ordinance No. 3	Quantity, tons				
			2007	2008	2009	2010	2011
Hazardous waste							
1	Non-chlorinated hydraulic oils, mineral-based	13 01 10*	-	-	-	-	-
2	Non-chlorinated motor, lubrication and gear transmission oils, mineral-based	13 02 05*	13.10	-	26.60	-	7.8
3	Non-chlorinated insulation and heat-transfer oils, mineral-based	13 03 07*	-	-	4.60	23.14	24.8
4	Deposits from oil-trap shafts (collectors)	13 05 03*	7.60	13.3	-	6	-
5	Oil from oil-water separators	13 05 06*	-	-	2.50	11.5	7.86
6	Diesel oil, boiler and diesel fuel	13 07 01*	-	-	-	-	-
7	Other emulsions	13 08 02*	-	-	-	-	-
8	Waste, mentioned nowhere else (scavenged grease and lubricants)	13 08 99*	-	-	-	-	-
9	Packing containing residues from hazardous substances or polluted by hazardous substances	15 01 10*	-	-	0.20	2.4	3.264
10	Absorbents, filter materials, towels and protective clothes contaminated by hazardous substances	15 02 02*	-	-	-	-	-
11	Obsolete vehicles	16 01 04*	-	-	-	-	234.58
12	Oil filters from vehicles	16 01 07*	-	-	-	-	-
13	Antifreeze liquids containing hazardous substances	16 01 14*	-	-	-	-	-
14	Transformers and capacitors containing PCBs	16 02 09*	-	12.50	-	0.676	-
15	Obsolete equipment containing hazardous components (3), other than mentioned in codes from 16 02 09 till 16 02 12	16 02 13*	-	-	2.10	3.2	4.302
16	Inorganic waste containing hazardous substances	16 03 03*	-	0.50	0.032	-	-
17	Organic waste containing hazardous substances	16 03 05*	-	0.40	-	-	-
18	Gases in pressure vessels (including halons) containing hazardous substances	16 05 04*	-	-	-	-	-

№	Name	Code acc. to Ordinance No. 3	Quantity, tons				
			2007	2008	2009	2010	2011
19	Lead rechargeable batteries	16 06 01*	-	-	104.7	20.650	47.469
20	Ni – Cd batteries	16 06 02*	-	-	0.30	1.46	1.9
21	Insulation materials containing asbestos	17 06 01*	0.50	-	13.60	0.06	22.280
22	Building materials containing asbestos	17 06 05*	-	-	-	-	-
23	Deposits from physical-chemical treatment containg hazardous substances	19 02 05*	-	-	-	-	-
24	Solvents	20 01 13*	-	-	-	-	-
25	Photographic chemical substances and compounds	20 01 17*	-	-	-	-	-
26	Fluorescent pipes and other waste containing mercury	20 01 21*	1.40	1.40	0.40	3.5	4.29
Industrial waste							
27	Bran, wood shavings, cuts, pieces, timber materials, chip board panels and veneer, miscellaneous as mentioned in 03 01 04	03 01 05	5.40	0.90	6.40	5.2	7.8
28	Photographic films and paper containing silver or silver compounds	09 01 07	-	-	-	-	-
29	Photographic films and paper, free of silver or silver compounds	09 01 08	-	-	-	-	-
30	Shavings, cuttings and scrap of ferrous metal	12 01 01	-	-	6.90	6.2	8.08
31	Shavings, cuttings and scrap of non-ferrous metals	12 01 03	-	-	-	0.22	0.420
32	Paper and cardboard packings	15 01 01	-	0.10	-	-	-
33	Plastic packs	15 01 02	-	-	-	-	-
34	Metal packs	15 01 04	-	-	-	-	-
35	Glass packs	15 01 07	-	-	-	-	-
36	Absorbents, filter materials, towels and protective clothes other than those mentioned in 15 02 02	15 02 03	3.30	3.50	1.50	-	-
37	Obsolete tires	16 01 03	-	15.0	-	2.2	8.212
38	Obsolete vehicles free of liquids or other hazardous components	16 01 06	-	-	-	-	-

№	Name	Code acc. to Ordinance No. 3	Quantity, tons				
			2007	2008	2009	2010	2011
39	Antifreeze liquids other than those mentioned in 16 01 14	16 01 15	-	-	-	-	-
40	Obsolete equipment other than that mentioned in codes from 16 02 09 to 16 02 13	16 02 14	-	7.80	18.2	64.2	54.739
41	Components removed from obsolete equipment other than that mentioned in code16 02 15	16 02 16	-	-	8.78	71	41.322
42	Inorganic wastes other than that mentioned in 16 03 03	16 03 04	-	2.40	1.80	6.26	4.392
43	Organic wastes other than that mentioned in 16 03 05	16 03 06	-	0.60	5.20	-	-
44	Alkaline batteries (except for 16 06 03)	16 06 04	-	-	-	-	0.099
45	Other batteries and rechargeable batteries	16 06 05	-	-	-	-	-
46	Sediments from physical-chemical treatment other than that mentioned in 19 02 05	19 02 06	5.0	-	-	-	-
47	Infiltrate from waste landfills other than that mentioned in 19 07 02	19 07 03	1234	1139	839	1365.5	1365.5
48	Residues from screens and seives	19 08 01	8.0	-	-	-	-
49	Sediments from urban wastewater treatment	19 08 05	-	-	-	-	-
50	Wastes mentioned nowhere else	19 09 99	-	-	16.0	-	-
51	Ferrous metals	19 12 02	-	1186	1052.9	1314.2	1508.324
52	Non-ferrous metals	19 12 03	-	16.70	143.28	66.955	81.155
53	Sharp tools	18 01 01	-	-	-	-	-
54	Wastes collection and making harmless whereof is not subject to special provisions aimed to prevent infections	18 01 04	-	-	-	-	-
Building waste (debris)							
55	Concrete	17 01 01	15.0	4.3	4.0	3.0	4.0
56	Excavated earth masses other than those mentioned in 17 05 05	17 05 06	-	-	-	-	-
57	Insulation materials other than those mentioned in 17 06 01 and 17 06 03	17 06 04	73.0	131.0	79.0	99.9	265.16
58	Combined waste from civil works and demolition other than	17 09 04	67.50	16.60	111.5	156.5	49.75

№	Name	Code acc. to Ordinance No. 3	Quantity, tons				
			2007	2008	2009	2010	2011
	those mentioned in 17 09 01, 17 09 02 and 17 09 03						
	Household wastes						
59	Paper and cardboard	20 01 01	74.2	31.30	19.1	6.855	65.03
60	Glass	20 01 02	-	-	-	-	-
61	Medical products other than those mentioned in 20 01 31	20 01 32	0.20	0.20	0.20	-	-
62	Wood materials other than those mentioned in 20 01 37	20 01 38	-	90.39	56.91	131.2	168.1
63	Plastics	20 01 39	-	6.80	0.30	-	-
64	Other fractions nowhere else mentioned (sediments from Cold Channel cleaning)	20 01 99	-	-	-	-	-
65	Bio-degradable waste	20 02 01	28.6	40.0	43.50	44.,3	36.9
66	Soil and stones	20 02 02	2.0	13.0	2,0	-	-
67	Mixed household waste	20 03 01	1114.0	1238.9	881	899	957.35
68	Waste from sewerage systems cleaning	20 03 06	16.0	-	-	-	-

Hazardous waste[120] – this includes disused luminescent and mercury lamps, rechargeable batteries; packing of chemical compounds and mixes – a great part of chemical compounds and mixes used at Kozloduy NPP EAD are delivered in tankers. When the chemical compounds quantity is smaller the same are supplied in drums, cans, etc.; waste oil products generated at treatment of oil-containing waste water in local treatment facilities on the territory of Kozloduy NPP EAD. Such waste is collected in 5t tankers and removed by an outside company, holder of relevant permit. The total quantity of settled oil products in the treatment facility amounts to about 60t. Sediments from sludge thickeners: annual quantity of about 10 m^3.

Industrial waste – The greater part of industrial waste at Kozloduy NPP consists of metal scrap (old worn-out machine components, worn-out steel ropes, etc.). These are not directly related to the production activity but result from repair of equipment on the work sites. Brass waste is generated further to metal waste during maintenance of brass components.

Building waste (debris) is generated depending on the scope of repair activities performed. Quantities thereof range at about 200 m^2 per annum. Currently excavated earth masses and concrete debris are disposed at the Depot for Non-radioactive Household and Industrial Waste (DNHIW). Building debris management shall conform with provisions of the Ordinace for building debris management and application of recycled building materials (published in SG 89/134.11.2012).

Household waste: it is generated at all work premises of the administration and business buildings, cafes, canteens and during the Plant Site cleaning from branches, leaves, etc.

The strong points of non-radioactive waste management on the Kozloduy NPP EAD[121] are:

- Available own repository for household and industrial wastes;
- Fulfilled programs for radiation and non-radiation monitoring of environment within the repository region;
- Separate collection and treatment of generated waste;
- Introduced accounting for categorisation of waste, keeping of logbooks and issuing periodic and annual reports.

Waste generated on the territory of the Kozloduy NPP shall be classified in the REIA. Waste management is implemented in compliance with WMA (SG, 53/2012) and sub-regulatory acts thereto.

[120] Ordinance 3/2004 for wastes classification, designated by symbol (*)

[121] Program for management of activities related to non-radioactive waste, Kozloduy NPP EAD, 2010.

Kozloduy NPP EAD has permission to collect waste, transport, utilize and safely dispose it. The Permit is issued by RIEW-Vratsa, that also exercises control on the activities performance.

At present, part of the waste is collected separately but such collection has still not been organized for the remaining waste. The latter includes used grease and lubricants, small batteries, sodium and other lamps with metal halogenides, packing of chemical substances and compounds.

Subject to separate collection and treatment is:

- → Waste defined as hazardous due to specific features thereof and/or provisions of regulatory acts;
- → Industrial waste, hazardous and utilizable industrial waste are stockpiled temporary in specified locations on the Plant Site, and further on they are sold or transferred to persons with license, complex license or registering document as per the WMA or to organization for utilization. A site of NHIWD is set with *Decision 05-ДО-72-01/12.06.2008 of RIEW-Vratsa* for temporary storage of waste before disposal, regulating the composition and quantities of waste whereof such storage is allowed. Activities for safe waste disposal in specially designed repository, code D5[122], are allowed on that site. The permit complements the provisions of *Decision 05-ДО-72-01/24.01.2006 and has been in force since 31.12.2010* with last amendment in force till 31.12. 2015 г.[123]

Transportation of waste is carried out by plant-own specialized or all-purpose vehicles or by machines of outside companies operating under contract on the Site.

Radiation control is performed in the protected zone of Kozloduy NPP at locations with waste generation and collection in compliance with standard requirements and on the basis of company documents. Containers for household and non-utilizable small-size industrial waste are subject to daily dosimetric control.

Since the beginning of 2001, Kozloduy NPP EAD has used its own Depot for non-radioactive household and industrial waste (DNHIW) compliant with the current applicable standards. Non-radioactive solid household waste and non-utilizable industrial small-size building debris are stockpiled in the DNHIW. Construction and operation of the Depot cover two stages on total stockpiling area of a little more than 1.1 ha. The design capacity of the facility is 45 000 m^3 with operation lifetime of 9 years for the first stage and 15 years for the second stage.

The Depot is located at about 3.7 km to South of the Danube River midstream opposite to the 693rd kilometer of the river. The Site borders on the East with canals for service

[122] Wastes management Act, SG 53/2012.

[123] Letter by Kozloduy NPP EAD, Safety and Quality Directorate, Ref. No. Д „Б и К“ 190/8.02.13.

water supply system of Kozloduy NPP, HV overhead lines are located to West therefrom and to South lie a 'lime yard', radioactive waste storage and the open switchyard.

Figure 3.7-1: ***Annual volumes of non-radioactive waste stockpiled in the depot during the period 2001 - 2011Error! Reference source not found.*** is showing annual quantities of non-radioactive waste stockpiled in the depot during the period 2001 - 2010.

FIGURE 3.7-1: ANNUAL VOLUMES OF NON-RADIOACTIVE WASTE STOCKPILED IN THE DEPOT DURING THE PERIOD 2001 - 2011

Error! Reference source not found. is showing the volume of stockpiled waste and time for filling up the DNHIW of Kozloduy NPP EAD with waste generated in the period 2007-2011 [124]

ERROR! REFERENCE SOURCE NOT FOUND. **VOLUME OF RECEIVED WASTE AND TIME FOR FILLING UP THE DNHIW OF KOZLODUY NPP EAD**

Years	Volume of received waste m³	Volume of received waste with piling , m³	Time for filling up, years
by 31.XII 2001	7 298	-	1
by 31.XII 2002	5 397	12 695	2
by 31.XII 2003	4 690	17 385	3
by 31.XII 2004	4 267	21 652	4
by 31.XII 2005	4 690	26 342	5
by 31.XII 2006	5 153	31 495	6
by 31.XII 2007	4 421	35 916	7
by 31.XII 2008	4 836	40 752	8

[124] Annual reports by Kzoloduy NPP EAD about plant non-radiation monitoring

Years	Volume of received waste m³	Volume of received waste with piling , m³	Time for filling up, years
by 31.XII 2009	5 519	46 271	9
by 31.XII 2010	4 747	51 018	10
by 31.XII 2011	4 949	55 967	11

Source: *Annual reports by Kzoloduy NPP EAD about own non-radiation monitoring*

Since the last *Annual report by Kozloduy NPP EAD about plant non-radiation monitoring* of the NHIWD specifies that only 85% of the first stage capacity of the depot are filled up (from 2001 till 2011) then with a 9% increase of waste disposal per annum the first stage will be used till 2016.

Waste disposal whereof Kozloduy NPP EAD is in possession of a permit valid till 31.12.2015 is foreseen also upon realization of the IP. Should new waste subject to categorisation be generated at the realization of new nuclear unit, such waste shall be characterized as well[125]. When necessary, should the waste not comply with the depot class, such waste shall have to be treated before disposal[126]. Kozloduy NPP EAD has a *Program for own monitoring of the non-radioactive household and industrial waste depot* aimed to identify and ensure organization of efficient own monitoring of the depot for non-radioactive household and industrial waste at Kozloduy NPP. The Program covers:

- → Monitoring of gas emissions from a waste body;
- → Water monitoring;
- → Monitoring the condition of the depot body;
- → Meteorological monitoring.

Figure 3.7-1: *Plan with disposition of boreholes round the depot for household, building and industrial waste of Kozloduy NPP* presents a plan with location of boreholes for ground water control in four monitoring stations to North of the Depository for household, building and industrial waste of Kozloduy NPP EAD.

The report of EIA shall submit quantitative characteristic and classification of waste generated on the territory of Kozloduy NPP EAD in conformity with WMA and *Ordinance 3/2004 for waste classification* during the period 2007-2011.

[125] Manual for fundamental characterization of waste and application of criteria for acceptance of waste on various class repositories, MEW, Sofia, 2011.

[126] Manual for preliminary treatment of waste before being disposal, MEW, Sofia, 2005.

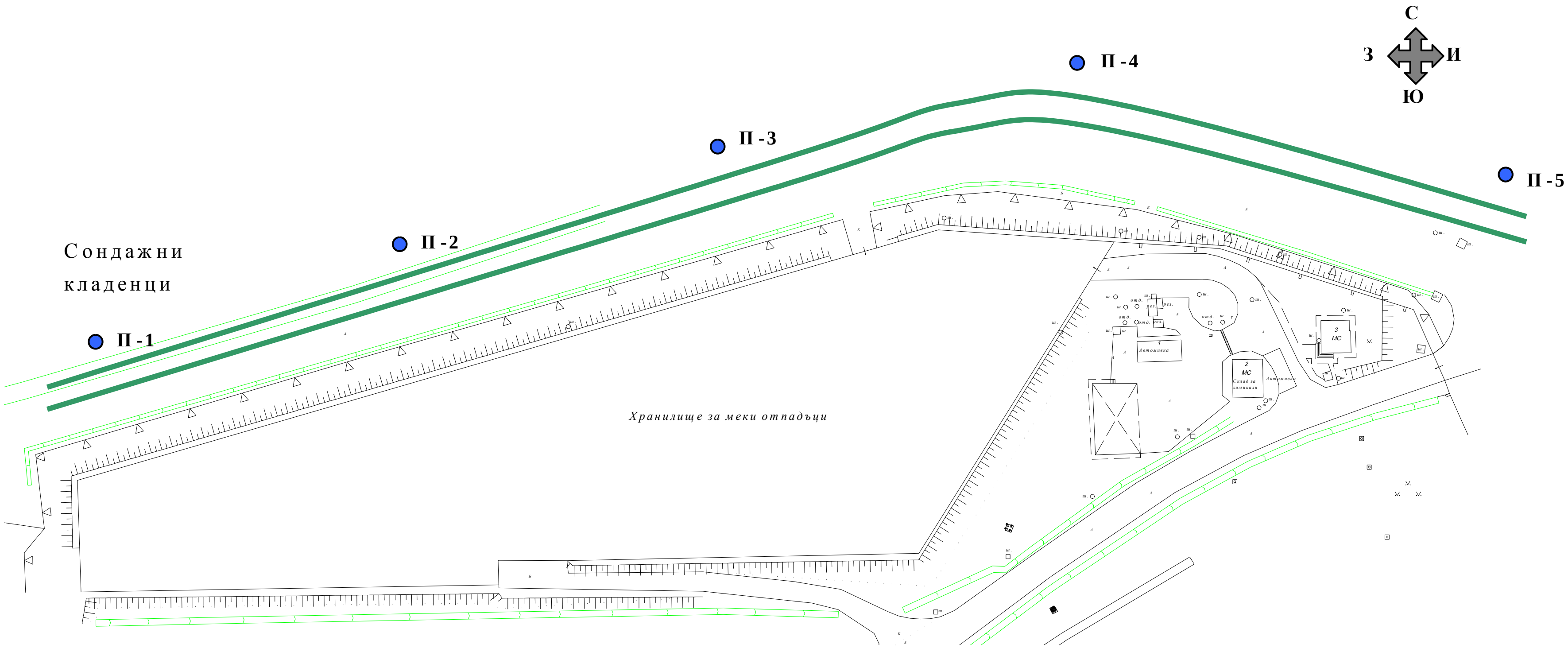


FIGURE 3.7-1: PLAN WITH DISPOSITION OF BOREHOLES ROUND THE DEPOT FOR HOUSEHOLD, BUILDING AND INDUSTRIAL WASTE OF KOZLODUY NPP EAD

3.7.1.2 RADIOACTIVE WASTE

The Kozloduy NPP radioactive wastes (RAW) management activities cover preliminary treatment, treatment and storage of primary liquid and solid RAW. The said activities are carried out on the Plant Site.

Operation RAW on the Site of Kozloduy NPP are stored in the various premises as untreated, treated or conditioned RAW and possible alternatives for consequent treatment, release and/or burying thereof are not limited.

The approach accepted since 2005 to date for management of RAW from Kozloduy NPP consists in transferring currently generated solid RAW and liquid concentrate for treatment by the RAW State Enterprise, and stage-by-stage release of historical solid RAW.

Solid RAW that are intermediate level volume-activated materials are stored in special protective facilities (mortuary tubes) located in the central reactor halls of Units 1 - 4 and the auxiliary building (AB – 3) at Units 5 and 6.

Liquid RAW generated at Kozloduy NPP is water-soluble waste mainly, and comparatively small by volume organic substances. The technological radioactive contaminated wastewater is collected through special systems and is treated, whereat distillate and concentrate is obtained. The distillate is released to the environment upon established compliance with requirements of technological regulations for specific and general activity.

The concentrate is stored in tanks of stainless steel located in the auxiliary buildings of the Kozloduy NPP Units. Technologies are being implemented at present for extraction and treatment of concentrates from Units 1÷4.

Organic liquid RAW (waste sorbents) are collected and stored in separate tanks in the auxiliary buildings of the Kozloduy NPP Units. A technology is under implementation at present for treatment thereof at Units 1÷4.

Sewage sludges and sediments form a comparatively quantity but are referred to as the so called specific waste since their generation is irregular and they require special methods for treatment and storage. A technology is under implementation at present for treatment thereof at Units 1÷4.

Annually, Kozloduy NPP generates comparatively small quantities of radioactive contaminated waste oils that are treated and managed as non-radioactive liquid waste.

In 2005, a Specialized Division (SD) for radioactive waste treatment (Kozloduy RAW SD) was established on the Kozloduy NPP Site as a part of State Enterprise RAW. Technologically, the Division comprises:

→ Line for solid RAW treatment;

- Line for treatment of secondary liquid RAW and RAW conditioning;
- Shop for metal RAW decontamination.

The volume of solid compactable RAW is reduced through compaction with volume reduction coefficient of about 7. Solid uncompactable waste is comparatively small part of the total quantity and is collected in 200-liters drums without any further treatment. Great part of metal RAW are decontaminated in the decontamination workshop and released from regulatory control for recycling or reuse.

The volume of liquid RAW is reduced through evaporation while observing the restriction stipulated in the technological regulations.

Solid and liquid RAW are conditioned through cementation. Conditioned RAW for final disposal is stored in reinforced-concrete containers (RCC). Conditioned RAW from Kozloduy NPP is transported to the temporary storage (until final disposal). The storage is an over-ground reinforced-concrete facility ensuring requisite engineering barriers between stored RAW and environment and staff. The capacity of the CRAWS (Conditioned Radioactive Wastes Storage) is 1 920 reinforced-concrete containers with conditioned RAW (960 containers in each of the two fields: “A” and “B”, arranged four-high). RAW is stored also on the ‘Lime Yard’ site.

Subsites for RAW storage have been differentiated at the ‘Lime Yard; site and used by the State Enterprise RAW, as presented in ***Table 3.7-2:*** *Subsites on the Lime Yard site.*

TABLE 3.7-2: *SUBSITES ON THE LIME YARD SITE*

Type of facility	Function	Features
Trench-type storage	Temporary storage of solid RAW categories 1 and 2	Reinforced-concrete design, hopper-type. Separated in forty cells with top manhole, each cell with dimensions 2.7x5.9x6.0 m and capacity 96.5 m^3. Instruction by Kozloduy RAW SD for grouping of drums will reach free-release levels in 60 years
Storage for treated solid RAW	Temporary storage of treated solid RAW categories 1 and 2.	Building type, reinforced-concrete panel design with receiving transport corridor. The storage useful capacity is 1130 RCCs.
Site No. 1 for solid RAW storage in RCC	Temporary storage of treated solid RAW, category 2a, packed in reinforced-concrete containers.	Capacity to hold 130 RCC with external dimensions 1.95x1.95x1.95 m and useful capacity of 5 m^3. The site is empty at present.
Site No. 2 for solid RAW storage in RCC	Temporary storage of RCC with solid RAW category 2a.	Capacity to receive 2000 RCC (of the RCC-2 type).
Site for solid RAW storage in multiton containers (MTC)	Temporary storage of low-level solid RAW.	Capacity to receive 14 MTC (large freight container) with external dimensions 5.8x2.2x2.4 m and useful capacity 30m^3.
Contaminated soil repository (CSR)	Storage of low level contaminated soil.	Closed reinforced-concrete design with cast-in-situ walls and bottom slab and assembled roof structure: width – 15.80

Type of facility	Function	Features
		m; length – 107 m; height – 6.75 m. The whole available capacity is unoccupied at present.

As a part of preparation for Units 1÷4 decommissioning, the following Works are in various stages of implementation at present:

- Facility for retrieval and conditioning of spent ion-exchange resins;
- Facility for retrieval and treatment of radioactive concentrate;
- Size reduction and decontamination workshop;
- Facility for high volume reduction and RAW treatment (plasma melting facility);
- Other facilities covering treatment of all types of RAW generated in the course of Units operation and as a result of the decommissioning process.

The state of RAW storage facilities at Kozloduy NPP as at 31.12.2009 according to data presented in the Strategy for management of spent nuclear fuel and radioactive waste till 2030 (approved with Decision of the Council of Ministers on 5 January 2011):

→ **Electricity Production - 1 Site (EP-1) – Units 1÷4 at Kozloduy NPP;**

✓ **State of solid RAW storage facilities:**

- KNPP Units 1-2 RAW repositories (AB-1): 393 m^3 untreated solid RAW, fillup – 39%;
- KNPP Units 3-4 RAW repositories (AB-2): 100 m^3 untreated solid RAW, 120 m^3 compacted, fillup – 22%;
- Mortuary tube (facility for storage of category 2-II) for RAW from Kozloduy NPP units 1-2 (Central Hall - 1): 52 m3, fillup – 64% ;
- Mortuary tube for RAW from Kozloduy NPP units 3-4 (Central Hall-2): 32 m^3, fillup – 39%.

It is expected that Units 1÷4 shall generate annually some 160 m^3 compactable RAW in the form of special clothing, personal protective equipment, plastics, etc. 160 m^3 solid RAW are planned for retrieval from each of Units 1 and 2 annually and 40 m^3 from each of Units 3 and 4.

✓ **State of liquid RAW storage facilities:**

Evaporate Concentrate Tanks (ECTs) of Units 1 and 2 of Kozloduy NPP (AB-1) are storing a total of 1890 m^3 solidified concentrate. A project for concentrate retrieval and treatment is under way. At present some 1140 m^3 of boron solution are stored in AB-1 containing approximately 14 440 kg of boron acid. The expected evaporate concentrate to be obtained after treatment shall amount to about 75 m^3 – 90 m^3. The tanks for spent sorbents shall store about 360 m^3 of spent sorbents (ion-exchange resins, activated carbon).

The technological systems contain about 360 m^3 sewage sludge and sediments. The expected quantites of liquid RAW upon decommissioning of Units 1 and 2 are as follows: from decontamination of technological facilities – about 570 m^3 conditioned RAW and secondary RAW generated in the form of water from special washing machines, special sewage systems, etc. – about 18 m^3 of conditioned RAW.

The ECTs of Kozloduy NPP Units 3-4 (AB-2) store a total of 1910 m^3 solidified concentrate. A project for concentrate retrieval and treatment is under way. At present some 2700 m^3 boron solutions are stored in AB-2. The expected evaporate concentrate to be obtained after treatment shall be about 180 m^3 - 220 m^3. The tanks for sorbents store 240 m^3 of spent sorbents (ion-exchange resins, activated carbon).

The technological systems contain about 410 m^3 of sewage sludge and sediments. Some 2000 m^3 conditioned product is expected from activities related to equipment decontamination upon decommissioning .

→ **Electricity Production - 2 (EP-2) – Kozloduy NPP Units 5&6;**

✓ **State of solid RAW repositories:**

- RAW repository (AB-3), category 2-I, 2-II: 871 m^3 compacted RAW and 15.7 m^3 activated materials. Fillup - to about 35 %.
- Storage out of AB-3: 700 m^3 compactable low-level waste (dose rate < 1μSv/h and specific activity less than 104 Bq/kg).

✓ **State liquid RAW repository:**

The ECTs store a total of 2100 m^3 solidified concentrate with 1310 m^3 of them being solidified phase and 790 m^3 liquid phase. The free capacity (ullage) is 1491 m^3.

Tanks for spent sorbents hold 146 m^3 of spent sorbents (ion-exchange resins, activated carbon). The free capacity is 54 m^3.

AB-3 stores about 130 m^3 of sludge. As at present, no project for sludge retrieval and treatment has been elaborated. Some 180 m^3 of evaporate concentrate is expected to be generated annually during the period 2010-2030. About 250 m^3 shall be transferred annually for treatment to the Kozloduy RAW SD. With the designed rates of generation and transfer, in ten years time, just the solid phase of historically generated liquid concentrate will remain.

At present there are not any implemented facilities for retrieval and conditioning of evaporate concentrate, sludge, sewage sludge and resins.

Summarized data of radioactive stored in Kozloduy RAW SD is submitted in Error! Reference source not found. [127]

TABLE 3.7-4: SUMMARY DATA OF RADIOACTIVE WASTE STORED AT KOZLODUY RAW SD ACCORDING TO TYPE AND NUMBER OF PACKAGES, AS AT 31.12.2009.

PROJECT	Quantity of stored RAW
Storage for conditioned RAW (SCAWSW), number	**1130 pcs. RCC (capacity)**
RCC-1	296
RCC -3	647
TOTAL	**943**
Trench repository for temporary storage of solid RAW, m^3	**386 m^3 (capacity)**
Untreated	1917
Packed in 210 l drums	4
Compacted with a force of 910 t	983
TOTAL	**2904**
Ftemporary storage facility of solid RAW, m^3	**-**
Untreated	0
Packed in 210 l drums	0
Pressed with a force of 910 t	386
TOTAL	**386**
Site for temporary storage of solid RAW in RCC-1	**-**
RCC -1 (pcs.)	0
Site for storage of solid RAW in RCC -2	**0**
RCC – 2 (pcs.)	233
Site for temporary storage of solid RAW in MTC (large freight containers) [m^3]	**420 m^3 (capacity)**
Untreated	78
Packed in 210 l drums	125
Pressed with a force of 910 t.	0
TOTAL	**203**

Part of RAW is conditioned at the Kozloduy RAW SD and is intended for final disposal in National Disposal Facility for Low and Intermediate Level RAW after the erection thereof in 2015.

[127] Strategy for management of spent nuclear fuel and radioactive waste till 2030 approved by Decision of the Council of Ministers acc. to Item 5 of the agenda of Record No. 1/05.01.2011, pp. 46/47.

The National Disposal Facility for Low and Intermediate Level RAW (NDRAW) is intended for final disposal of conditioned low and intermediate level RAW generated during the Kozloduy NPP operation, decommissioning of Kozloduy NPP and Belene NPP operation.

NDRAW must as well ensure:

- ✓ Capacity for final disposal of the backlog of low and intermediate level RAW generated in the country and stored in places where denerated and in facilities of RAW management of SE RAW;
- ✓ Capacity for final disposal of all RAW expected to be generated till 2075;

According to preliminary calculations, the RAW quantities expected to be disposed in the NDRAW will amount to 138 200 m^3 (345 500 t), which determines also the maximum capacity of the disposal facility.

3.7.2 PREDICTION OF THE IMPACT

3.7.2.1 NON-RADIOACTIVE WASTE

The IP Estimate of the impact shall reflect expected changes in the quantitative and qualitative parameters of waste as a factor of impact on environmental components evaluating the necessity of new sites for temporary storage and new facility for wastes treatment. The evaluation shall be single for all sites and justified on the grounds of capacities of existing sites for temporary storage and available facilities for treatment of waste.

3.7.2.1.1 Construction

Solid non-radioactive waste is expected to be generated in the process of activities related to erection of a new nuclear unit as follows:

- → **Building waste** – expected types of waste in the process of civil works: soil, building debris, etc., are generated at installation of technological equipment, erection of auxiliary concrete structures, etc. Such waste has period for generation limited in duration, the time of civil works on the Project. Impact evaluation and forecast shall be made on the grounds of comparative analysis with standard requirements including Ordinance for building waste management and application of recycled building waste (published SG 89/13.11.2012);
- → **Household waste** – generated by life activities of builders. As early as that stage, separate collection of wastes should be introduced in packages conforing with the provsionsi of Art. 33, Para. 4 of the Waste Management Act (WMA). During civil works on the project, 3000-4000 persons are expected to operate on average annually in the course of five years. Methodologically,

accumulation rate[128], work day duration and number of work days in a month shall be considered. The quantity of generated household waste is evaluated to about 1500 m^3 - 2000 m^3 per annum. The existing good practices for household waste management shall probably continue, i.e. such wastes shall not have significant impact on the environment components with environment friendly management thereof. Separate collection should be introduced for household waste in packages meeting the provisions of Art. 33, Para. 4 of WMA. The bio-degradable "green" waste generated through site cleaning for erection of the new nuclear unit should be managed in compliance with the new WMA and sublegislative acts thereto.

→ **Hazardous waste** – temporary storage is foreseen on the construction site in places isolated for the purpose, wherefrom the accumulated specified quantities shall be transferred for subsequent treatment to persons in possession of permit, complex permit or registration document as per the WMA or to organizations for utilization.

The report of EIA shall include the quantities of generated waste in the process of new nuclear unit implementation at that stage. Also, the report of EIA shall submit classification of non-radioactive solid waste according to *WMA and Ordinance 3/2004 for waste classification* and measures to be undertaken for environment friendly management of waste.

3.7.2.1.2 In the process of operation

Generation of household, industrial, building and hazardous waste is expected in the process of new nuclear unit operation, since in work premises and on sites of various operation activities, repairs, reconstruction of buildings, premises, etc., conditions are created annually for generation of varying types and quantities non-radioactive waste with impact thereof on environmental components that shall be subject to estimates in the REIA.

Household waste – in the process of operation insignificant increase is expected of the household waste quantity to be calculated on the basis of a methodology as specified in the *Guidelines for calculation of the number and types of containers and equipment required for waste collection and transportation, MEW, Sofia, 2004.*

Building wastes – generation of building waste is expected also at the stage of operation and repair activities. Bearing in mind practices of the Client for building waste management, forecast shall be made of impact thereof on the environment with observation of standard requirements and *Ordinance for building waste management and application of recycled building waste (published SG 89/13.11.2012).* Generated waste shall be evaluated by types and quantities on the grounds of methodical instruction of

[128] Guidelines for calculation of the number and types of required containers and equipment for waste collection and transportation, MEW, Sofia, 2004.

the *National strategic plan for management of waste from construction works and demolition activities on the territory of the Republic of Bulgaria for the period 2011-2020, MEW, Sofia.*

Industrial non-hazardous waste – various by volume and origin waste shall be generated during operation. Such waste shall be classified in conformity with *Ordinance No. 3/2004 for waste classification* including quantitative and qualitative parameters of waste. The latter shall be managed in compliance with valid laws including the *Ordinance for requirements to treatment and transportation of industrial and hazardous waste.* Other waste generation also expected: Sludge from sewage water treatment plant wherefore measures must be offered in the report of EIA for environment friendly management thereof. Industrial waste shall continue be disposed of at the Depot for Non-radioactive Household and Industrial Waste (DNHIW) of Kozloduy NPP.

A high percent of conventional waste is expected to be formed by waste for re-utilization. Such waste shall be stored temporary on locations isolated for the purpose – temporary sites. After accumulation of specified quantities of waste, they shall be transferred under contract for furhter treatment. Final delivery and safe disposalshall be realized on the basis of contracts with persons in possession of permit, complex permit or registration document as per the WMA or organizations involved in waste re-use.

Hazardous waste – in the process of operation machine oils, greases and lubricants are expected to be used that will in time turn into hazardous waste. Various chemical substances and compounds shall be used as chemical reagent. Packing of such chemical substances and compounds are hazardous waste also. During operation release of sludge with hazardous properties is also expected, containing oil products from sludge/oil separators. Such waste shall be managed in compliance with valid laws including *Ordinance for requirements to treatment and transportation of industrial and hazardous waste.*

All types of non-radioactive waste shall be addressed and classified in the REIA. Analysis and evaluation of that environmental impact factor shall be performed in compliance with the new WMA (SG 53/2012) and sub-regulatory acts thereto. Qualitative and quantitative parameters of non-radioactive waste generated during operation of the new nuclear unit of Kozloduy NPP EAD shall be specified in detail in the EIA[129]. Estimate of this environmental impact factor, the cumulative effect included, shall be made on the grounds of a comparative analysis of expected waste from the IP realization and the currently existing waste streams. The estimate shall cover also impact of waste treatment methods applied on the territory of Kozloduy NPP EAD, and available treatment facilities and necessity of new ones, e.g. NHIWD. The EIA report will address in detail the management of non-radioactive waste, treatment thereof and expected impact of that factor on the environment components. Measures for restriction and minimization of such impacts shall be offered in the EIA - R.

[129] After recommendation by RIEW – Vratsa, Letter with Ref. No. B2975/10.01.2013.

3.7.2.2 RADIOACTIVE WASTE

The estimate of the impact within the framework of the report of EIA shall reflect the expected changes in qualitative and quantitative parameters of RAW as a result of the IP realization and as an environmental impact factor on components including evaluation of the necessity of new storage facilities and treatment. The evaluation shall be single for all considered sites and justified on the grounds of capacity of existing repositores and facilities for waste treatment.

According to provisions in the Client's ToR, for IP implementation for a new nuclear unit on the site of Kozloduy NPP, one of the two feasible alternatives is related to application of equipment from the nuclear island, ordered for the Belene NPP, and in this sense the forecast of impact within the EIA framework will logically be prepared on the grounds of expected design volumes of RAW and methods for their treatment defined as estimated values according to the Technical Design for Belene NPP (***Table 3.7-3:** C).*

TABLE 3.7-3*: TABLE 3.7-3: C*

Waste types	Generated waste per one Unit, m³/y	Type of treatment	Waste after treatment, m³/y
Solid radioactive waste			
Category 2-I			
1.1 Combustible	175	Fragmentation (when necessary)	8.8
		Sorting	
		Packing	
		Plasma melting	
1.2 Metals	20	Fragmentation (when necessary)	6.5
		Sorting	
		Packing for transportation to the plasma melting facility(if fit)	
		Plasma melting, or	
		ompaction, or	
		No further treatment	
1.3 Tube electric heaters	1	Fragmentation	0.5
		Sorting	
Category 2-II			
2.1 Combustible	38	Fragmentation (when necessary)	1.9
		Sorting	

Waste types	Generated waste per one Unit, m^3/y	Type of treatment	Waste after treatment, m^3/y
		Packing	
		Plasma melting	
2.2 Metals	5	Fragmentation (when necessary)	2
		Sorting	
		Packing for transportation to the plasma melting facility(if fit)	
		Plasma melting, or	
		Compaction, or	
		No further treatment	
2.3 Ion-exchange resins	17	Pyrolysis	6
2.4 Vent filters	1	Sorting	0.6
		Compacting	
		Category 2-III	
3.1 Detection assemblies and waste from radiation surveillance specimens	0.2	Sorting	10 capsules
3.2 Assemblies of reactor internal detectors	0.078	Sorting	4 capsules
3.3 Control rods absorber	0.049	Sorting	7 cartridges
		Liquid radioactive media	
4.1 Run-offs from sanitary barriers of buildings	972	Concentration	31
4.2 Water from special washing machines	475	System for treatment of water from special washing machines	3
		Plasma melting	
		Category 2-I	
4.3 Solidified (ion-exchange resins)	7	cementation	20.16
		Category 2-II	

Waste types	Generated waste per one Unit, m^3/y	Type of treatment	Waste after treatment, m^3/y
4.4 Ion-exchange resins	7	Joint cementation	57.96
4.5 Evaporate concentrate	13.4		
4.6 Titan shots	0.07	cementation	1.8
4.7 Sludge	3	cementation	1.08

All types of RAW as specified shall be treated and classified in detail in the report of EIA including quantitative and qualitative evaluation of liquid and solid waste generated in the process of new nuclear unit operation on the Kozloduy NPP Site. Estimates of the expected impact on environment shall be made in the IEA-R on the grounds of comparative analysis of expected RAW generated as a result of the IP realization and the currently existing streams of generated waste.

3.8 HAZARDOUS SUBSTANCES

3.8.1 EXISTING STATUS

For the purposes of the main and the auxiliary production activities on-site of Kozloduy NPP (KNPP), different raw and processed materials are kept and used, among them chemical substances and mixtures. The biggest quantities of industrial chemicals are used for the production of demineralized water and for the maintenance of the water-chemistry regime on the primary and secondary circuits.

The main non-radioactive substances used at KNPP EAD are:

- Industrial and laboratory chemicals: nitric acid, hydrochloric acid, sulfuric acid, oxalic acid, sodium hydroxide, potassium hydroxide, ammonia, sodium hypochlorite, potassium permanganate, ferric chloride, hydrazine hydrate, hydrated lime, etc.;
- Fuel and lubricants: oils (transformer, compressor, turbine, engine, etc.), grease and lubricants, diesel fuel, gasoline;
- Primers, paints, varnishes, adhesives and solvents;
- Ion exchange resins;
- Others.

Conditions are provided at the site for storage of the required quantities of petroleum products - gasoline, diesel and oil, as well as for storage of cooling hydrogen for the power generators, produced by the auxiliary electrolysis facilities. The operation of the service machines shall use diesel fuel and lubricating oils. The diesel fuel must have minimal sulfur content[130].

The good practice must be continued and in the future the deliveries of packed lubricants and engine oils have to be accompanied with material safety data sheets[131].

The hydrogen for cooling of the electric generators is produced by in-house electrolysis facilities.

The environmental impact assessment report shall present information about the chemical substances and mixtures used KNPP, and shall assess the cumulative impact of the additional quantities needed for new unit.

3.8.2 PREDICTION OF THE IMPACT

The estimate of the impact of the investment proposal (IP) will assess the need for new quantities of hazardous substances and mixtures at the implementation stages. The assessment will be well defined for all sites and will be justified because the methodology for impact assessment is based on an analysis of the IP planned values for the quantities of hazardous chemical substances and mixtures compared with the quantitative values in the normative documents[132],[133]. The impact estimate shall take into account the chemical substances and mixtures present at the Kozloduy NPP EAD site and the cumulative impact of the additional quantities needed for new unit[134].

3.8.2.1 DURING THE CONSTRUCTION PERIOD

During the construction process, the following shall be used:

→ ***Fuels*** - needed for the operation of the construction machines. The proposed method shall be evaluated for filling of the machines with diesel and other fuels, as well as the provided measures for limitation of the impacts of accidental spills and others.

→ ***Lubricants*** - it is expected that during the construction period a variety of types and amounts of oils and lubricants shall be used – machine and compressor oil, turbine oil, engine oil, various kinds of lubricants. As a rule, they are delivered with relevant certificates and other documents such as

130 Ordinance on the quality of the liquid fuels, the conditions, the order and the way of their control.

131 Law on Protection from the Harmful Impact of Chemical Substances and Mixtures / or the Regulation on classification, labeling and packaging (CLP).

132 Law on the limitation of the harmful effects of chemical substances and mixtures, Regulation on the order and conditions of storage of hazardous substances and mixtures

133 Ordinance on the manner of storage of hazardous substances and mixtures

134 Recommendation of the Ministry of Environment and Forests (R Romania), letter with outdoung No. 3672 RP 18.10.2012

Material Safety Data Sheets specifying the proper way of storage, handling and treatment.

→ Others.

3.8.2.2 DURING THE OPERATION STAGE

→ ***Liquid fuels*** **–** for the operation of the diesel generators providing backup power supply for power generation units, for the consumption of the vehicles and the different plants and units KNPP. Specified quantities of diesel fuel, gasoline, etc. shall be needed The EIA report shall identify exemplary quantitative and qualitative specifications of the fuels and shall analyze the possibilities for their safe storage.

→ ***Oil and lubricants*** **–** during the operation of the new nuclear unit, it is expected that a variety of types and amounts of oils and lubricants shall be used – machine and compressor oil, turbine oil, engine oil, various kinds of lubricants. As a rule, they are accompanied by relevant certificates and other documents such as Material Safety Data Sheets specifying the proper way of storage, handling and treatment.

→ ***Chemical substances and mixtures*** **–** various types of chemical reagents certified for operation in the nuclear industry shall be delivered and used for the main technology process. The main and more important substances and mixes are: ammonia, sulfuric acid, hydrochloric acid, nitric acid, sodium hydroxide, etc. During the storage and use of hydrazine hydrate, ammonia and other substances, there is a potential risk that in case of emergency surge emissions of hazardous toxic substances may occur in the operation and ambient environment.

To ensure the water-chemistry regime ot he KNPP units, and the other production and auxiliary activities, delivery and use is required of large quantities of chemical reagents, some of which are: boric acid, nitric acid, sulfuric acid, hydrochloric acid, sodium hydroxide, technical potassium hydroxide, ferric chloride, ammonia, hydrazine, hydrated lime, etc.

The EIA report shall review the proposed possibilities for air separation and the capacity of the existing nitrogen-oxygen stations to accommodate the requirements of the new power unit.

The delivery of chemical substances and mixtures will continue the good practice and these will be accompanied by Material Safety Data Sheets, which is a prerequisite for their environmentally safe storage and use.

During the construction and the operation of the new power unit, hazardous chemicals and mixtures will be used, with different compositions, properties, hazard category, packaging, etc. and therefore their legally assured use is mandatory. The requirements to the Supplier are activity specific, as well as the proper storage of the chemical substances and mixtures, the preventive measures to minimize accidents and emergencies and the environmental management of their waste.

During the assessment of the suitable site in terms of the location for the implementation of the investment proposal the recommendations shall be taken into account for discharge of dangerous liquids, specified by the Guidelines for evaluation of sites for nuclear power plants, using the following methodological recommendations:

- ✓ During the assessment of the possibility of uncontrolled discharge of dangerous liquids, special attention must be paid to:
  - Flammable gases and vapors forming explosive clouds that can enter the inlets of the ventilation systems and may burn or explode;
  - Suffocating or poisonous gases that may endanger human health and threaten vital safety functions;
  - Corrosive gases and liquids that may endanger human health and threaten the functionality of the equipment;

  The preliminary assessment will include identification of all activities and facilities involved in the processing, manipulation, storage or transportation of flammable, toxic or corrosive liquids.

  Additionally, the EIA report shall develop a detailed assessment including the following:
  - Potential hazards from hazardous liquids, which have not been eliminated in the preliminary assessment;
  - Location of the source of the liquid and maximum stock quantity stored and/or otherwise available quantities;
  - Determination of the maximum quantity of hazardous liquids that could be released, their flow rate and the respective probability of leakage;
  - Potential for breaking of a container or any other leakages from the facility storage;
  - Probability of leakage of hazardous liquids from a mobile source on the assumption that the maximum transported quantity is released;

- Interaction of the dangerous liquid with the nearby water sources.

The important parameters and properties to be established for incorporation into the design basis for protection of NPP from hazardous liquids, are as follows:

- quantity of liquid or gas;
- surface area of the spillage;
- chemical composition
- concentration (corrosion potential);
- vapor partial pressure;
- boiling point;
- ignition temperature;
- toxicity.

The EIA report shall describe and analyze the planned use of hazardous chemical substances and mixtures in terms of possible environmental impact. The estimate will be based on the data about the quantities from the feasibility studies and the data about the properties and the composition from the Safety Data Sheets and the existing practices for management of such substances, including instructions, procedures and implemented good practices.

3.9 HARMFUL PHYSICAL FACTORS

3.9.1 NOISE

3.9.1.1 CURRENT STATUS

The construction site of the new nuclear unit shall be situated near/on the site of KNPP. Four options have been proposed for its location, During the site inspection, it was found that currently there are no noise sources at the sites 1, 2 and 3. Site 4 is an area with production and storage facilities with various limited activities. There are six units on-site KNPP - currently units 5-6 are in operation and the other four have been shutdown.

The noise regime at the plant's site was established through noise measurements of real conditions during the preparation of the KNPP's EIA report in 1999. The equivalent noise level was measured at selected locations of the site near the major environmental noise sources- open switchyard, WWTP, ventilation systems, vehicles, etc. The noise level varies in the range of 52 dBA – 97 dBA. At some locations, between the buildings and the outdoor facilities, the noise levels exceed the hygiene norms for industrial areas - 70 dBA. The results of the noise measurements are recorded in Protocol 12/08.1999 enclosed to the EIA report. It was concluded that the production activity at Kozloduy

NPP site is not a source of noise for the territory of the town of Kozloduy due to the large distance from the site (over 2 km). The study of the noise regime was conducted in compliance with the applicable legislation at the time.

New measurements for determination of the noise regime on-site KNPP were conducted in 2010 by the Regional Laboratory of RIEW-Pleven in accordance with the methodology for determination of the total sound power emitted in the environment by the industrial plant and determination of the noise level at the location of impact, MoEW, 2007. (Protocols 618 and 621/13.09.2010). The measurements were conducted along two measurement contours. The first contour includes Electricity production–1, including reactors 1 ÷ 4, while the second contour is around Electricity production-2 which encompasses reactors 5 and 6. The contours included the auxiliary facilities of the reactors - major sources of noise. The equivalent noise levels measured along the first contour are within 47.4 dBA - 62.5 dBA, and the one along the second contour - within the range of 47.3 dBA - 66.6 dBA, none of these exceeds the limit of 70 dBA, set for production and storage areas.

The EIA report shall specify the measuring contours and the sound levels measured at different locations. The calculated total sound power levels for the two contours are: first contour – 113.7 dBA, second contour – 119.1 dBA.

The assessment of the existing noise regime at the site of Kozloduy NPP shall be amended with more information, obtained additionally.

The settlements near the site of Kozloduy NPP are:

→ town of Kozloduy – 2.6 km;

→ village of Harlets – 3.5 km;

→ village of Glozhene – 4 km;

→ town of Mizia – 6 km;

→ village of Butan and town of Oryahovo – 8.4 km.

Due to the big distances to the settlements, the production activity at KNPP site is not a source of noise for their territories.

The KNPP site and, respectively, the sites subject to EIA, are connected to the national road network by roads II-11 and II-15. The site is not connected to the national railway network.

3.9.1.2 PREDICTION OF THE IMPACT

The noise emission into the environment is connected to the three main stages of the IP's implementation– construction, operation and decommissioning.

3.9.1.2.1 Construction

The main environmental noise source will be the construction machines and the vehicles servicing the construction used for delivery of the necessary materials and equipment, as well as for waste disposal. The noise levels of the traditionally used machines and equipment are within the range 80 ÷ 105 dBA, according to data from measurements by NCPHP - Sofia and literature sources. The construction machinery will be located at the selected site. The EIA report will give the noise characteristics of the individual machines and facilities and the expected equivalent noise level shall be determined at the site, in the vicinity of the operating machines equipment. Additionally shall be determined also the anticipated equivalent noise level of the construction traffic, using data on the expected trips of the trucks and their speed, in accordance with the methodology stipulated in Ordinance 6 on the parameters for noise in the environment, considering the degree of discomfort during the different hours of the day, the limit values of the parameters for noise in the environment, the methods for evaluation of the noise parameters and the adverse effects from noise on the public health (Ministry of Health, Ministry of Environment and Water StG 58/2006), compliant with European Directive 2002/49/EC.

The construction works carried out at the site will not be a source of noise for the residential areas in the region, due to the big distances. The impact of the noise emitted by the construction machinery is expected to be in the industrial zone of KNPP. The noise from the construction traffic will affect the settlements in the region through which it will pass, as well as the site of KNPP when crossing it. The EIA report will comprise a hygienic assessment of the expected impacts due to noise from the construction and transport machines used during the site construction, on areas with regulated noise regime (residential areas of nearby settlements, the industrial site of KNPP and the site of the new unit). The assessment will be made in accordance with the norms on noise regulated in Ordinance 6 on the parameters for environmental noise, 2006.

3.9.1.2.2 Operation

The environmental noise sources are the primary and the auxiliary technological equipment and the vehicles servicing the operation activities. The environmental noise emission will be determined on the basis of the passport data about the noise characteristics of the planned facilities. In the absence of such data, the Bulgarian legislation (Ordinance 6 on the parameters of environmental noise, 2006) allows the use of data from similar site (with technology and equipment similar to those of the studied investment proposal). The EIA report will give the environmental noise levels around the site by means of modeling in accordance with EN ISO 9613-1,2: Acoustics. Attenuation of sound during propagation outdoors. The modeling will be carried out after provision of specific inputs (sound power of the noise sources, coordinates X, Y, Z, incl. heights of the buildings, general plan of each of the alternative sites, type, intensity and routes of the internal transport, etc.). In case the full range of data is unavailable during the preparation of the EIA report, data will be used about the environmental noise propagation of a similar site. The EIA report will assess the expected changes in the existing noise levels along the borders of KNPP after the construction of the new nuclear unit.

The expected equivalent noise level emitted by the operation traffic shall be determined in accordance with the provided data on the traffic intensity.

It is not expected the operation of the new nuclear unit at the site to be a noise source of for the residential areas in the region, due to the big distances. The noise impacts are expected at the industrial area of Kozloduy NPP. The noise from the operation traffic of the site will affect the settlements in the region through which it will pass and the site of KNPP when crossing it. The EIA report will comprise a hygiene assessment of the expected noise impacts from the operation and transport machines used during the site's operation of on areas with regulated noise regime (residential areas of nearby settlements, the industrial site of KNPP and the site of the new unit). The assessment will be made in accordance with the norms on noise regulated by Ordinance 6 on the parameters for environmental noise, 2006.

On the basis of the analyses and the estimate of the impact due to the environmental noise, the EIA report will propose the best site for the implementation of the investment proposal with regards to the factor 'Noise'. Different noise impacts on the territories with regulated noise regime are expected, mainly for the alternative sites. At the construction phase, the impacts depend on the different activities for preparation of the site and the respective different intensity of the construction traffic. At the operation different cumulative effects are expected due to the activities carried out at the sites of Kozloduy NPP and of the new nuclear unit, related to the noise levels at their borders.

If necessary, the EIA report will propose measures to minimize the noise impact during the construction and the operation of the site.

3.9.2 VIBRATIONS

3.9.2.1 CURRENT STATUS

There is no data about existing technology vibrations in the environment of Kozloduy NPP site. The 1999 EIA report of Kozloduy NPP concluded that technology vibrations do not occur in the space between the installations and the environment outside the plant site, and that they exist only in the operation environment. The existing technology process equipment is not source of vibrations into the environment. For machines and equipment, the limitation of the vibration propagation outside their source is achieved by implementation of specific technical requirements to the installation: anti-vibration processing of the bases and their foundations by means of rubber pads, insulation joints from vibration-absorbing materials, elimination of the fixed connection between the vibrating platforms and the structural components of the buildings, etc. The vibrations at industrial sites are a factor only of the working environment.

The vehicles servicing the operation of Kozloduy NPP are not sources of vibrations into the environment. They use class II roads of the national road network, which is consistent with the category of the traffic, during which the vibrations from heavy vehicles subside over short distances around the road route.

3.9.2.2 PREDICTION OF THE IMPACT

The construction machinery used during the construction of the site is not a source of vibrations into the environment. Vibrations are factor of the working environment during the operation of the machinery, facilities and vehicles.

The design of the project does not envisage the future equipment as a source of vibrations into the environment.

Therefore, the technological vibrations shall not be considered by the EIA report as an environmental factor.

The heavy vehicles used in the different phases of implementation of the investment proposal may be a source of vibrations propagating in the ground media only if the route is not consistent with the necessary road category for the respective traffic which must be considered during the preparation of the design transport schedule

3.9.3 NON IONIZING RADIATION

3.9.3.1 EXISTING STATUS

Non-ionizing radiation (NIR) is a general term for the radiation within the electromagnetic spectrum, whose single photon energies are smaller than the ones required to ionize the atom, i.e. for the detachment of an electron from its electronic shell. These include the ultraviolet (UV) radiation, the visible light, the infrared radiation, the radio and microwave (VHF) electromagnetic fields (EMF - 300 kHz to 300 MHz), extremely low frequency fields (ELF - 1 Hz to 300 Hz), static electric and magnetic fields. Given that the electromagnetic radiation is part of the NIR, this approach allows differentiated bandwidth evaluation of the different types of radiation and comprehensive assessment of the whole NIR range.

NIR, even with high and ultra high frequency, cannot cause ionization in a biological system. However, they produce other biological effects - by heating, changes in chemical reactions or inducing electrical currents in tissues and cells, and therefore it is necessary to examine them as a potential risk factor for human health. Currently, in Bulgaria there are no regulated thresholds of electrical and magnetic field for work environment, except in the frequency range from 0 to 60 kHz. This requires that the evaluation of the electromagnetic fields at work is carried out only in accordance with international documents, such as the ICNIRP Guidelines, IEEE and others. Regarding the settlements, only Ordinance 9/1991 is applicable on the limit emission levels of electromagnetic fields in populated areas and determination of safety zones around emitting sites (StG 35/3.05.1991, amended by StG 8/22.01.2002).

TABLE 3.9-1: *LIMIT LEVELS OF INTENSITY AND POWER DENSITY OF* **THE** *EMF* **FLOW IN** *POPULATED AREAS*

No.	Bandwidth of the emitter	Limit level
1.	from 30 to 300 kHz	25 V/m
2.	from 0.3 to 3 MHz	15 V/m
3.	from 3 to 30 MHz	10 V/m
4.	from 30 to 300 MHz	3 V/m
5.	from 0.3 to 30 GHz	10 µW/cm^2

The Ordinance determines the standards and the requirements for protection of the population against the harmful effects of electromagnetic fields (EMF) emitted only from communication sources in the frequency range from 30 kHz to 30 GHz - Table 3.9-1: Limit levels of intensity and power density of *the* EMF *flow* ***in populated areas***.

For the other bandwidths, the international regulations and recommendations of the European Union apply. Also, applicable are the provisions of the Health Act of 1 January 2005, as last amended by StG 9/28.01.2011.

Hygiene significant values of ELF **(1 Hz - 300 Hz)** are expected on the territories of the substations for high and ultra high voltage, around the overhead power lines HV, the electrical machines, the transformers, etc.

Additional sources of electromagnetic radiation in a wide frequency range (ELF and low frequencies up to 300 kHz) are the video monitors for surveillance are control.

The main sources of ELF electric and magnetic fields (power frequency 50 Hz) in the work environment are the open switchyards of the transformer systems, the bus systems, the circuit breakers, the power lines. Sources of ELF fields (mainly magnetic) can be turbine generators, rectifiers, LV power systems.

The sources of radio and microwave ultrahigh frequency electromagnetic radiation at Kozloduy NPP are in:

- → security systems;
- → mobile connection systems;
- → emergency public address systems.

3.9.3.2 PREDICTION OF THE IMPACT

It can be concluded that the exposure of the personnel to EMF with industrial and radio frequencies is expected to be constant, but low, subject to the standards in the country, if the design is prepared according to the legal requirements in Bulgaria and the recommended exposition by the European Commission, respectively.

No exposure is expected of the population to power frequency EMF emitted from sources in the NPP.

3.9.4 HEAT EFFECT OF THE DANUBE RIVER

3.9.4.1 CURRENT STATUS

Periodically, throughout the period of operation of Kozloduy NPP surveys have been were conducted to determine the impact of the plant on the temperature regime of the Danube river. During 1978-95, 12 research expeditions have been carried out by teams from the UASG. For the purposes of the 1999 EIA report of Kozloduy NPP, the team that prepared the document with the assistance of the KNPP management organized a research expedition along the Danube on 4 and 5 August 1999.

The report analyzed and summarized the main results of the research expeditions and the known publications on issues about the thermal characteristics and the Danube thus influenced.

The water temperature of the Danube River is a hydrologic element/indicator, for which the regime monitoring began relatively late - after 1941. There are few publications of studies on the temperature regime of the Danube.

The distribution of the water temperature across the width of the river depends on the amount of water in it, the season and the hydraulic characteristics of the river section. The maximum measured differences along the river width reach 0.2˚C - 0.4˚C and are highest in the early morning hours. During the warm season the river is virtually isothermal along its cross-section.

At the depth of the stream, the water temperature, especially in the central part of the river bed, is equal. Relatively rarely, in the area of the fairway differences occur within a 0.2˚C - 0.4˚C. Due to the intense turbulent mixing and the inertia of the thermal processes in the surface flows, at relatively rapid changes in air temperature, changes in water temperature at depth remain within a 0.2˚C - 0.4˚C.

The water temperatures along the Bulgarian section of the Danube decreases from Novo Selo to Silistra. Upon cooling, the maximum temperature difference in the section is observed in March and reaches 0.5˚C. Upon warming, the maximum temperature difference between the two points reaches 1.3˚C and is observed in August. A seasonal relation is observed with peaks during the summer months.

The changes in the average daily water temperatures for the period 1941-1985, as well as their extremes in the natural regime of the river, without taking into account the impact of Kozloduy NPP show that in some months the average monthly temperatures change by more than 3°C, i.e. the amplitude of the variations of the monthly average water temperatures of the Danube is compatible with the acceptable normative difference of 3°C. (Pursuant to Ordinance 7/1986 canceled during the preparation of this assignment)

Based on 10-year observations (1975 - 1985) at Lom and Oryahovo and the data from the operation of Kozloduy NPP a relation has been derived from 120 observation points, upon which the natural temperature of the water at Oryahovo has been determined, considering the impact of the outlet canal of Kozloduy NPP at $^{km}686,4$:

$$T_{Or.\,nat.} = T_{Or.} - 1.126 * dT_{NPP} * ((Q_{Lom} * T_{Lom}) / Q_{NPP} * (T_{Lom} + dT_{NPP}))^{-0.445}$$ (St. Modev),

where:

- $T_{Or.\,nat.}$ – temperature of the water at Oryahovo under natural conditions;
- $T_{Or.}$ – temperature of the water at Oryahovo after the commissioning of Kozloduy NPP;
- Q_{Lom} and T_{Lom} – the water quantity of the Danube in m^3/s and the temperature of the water in °C for Lom;
- Q_{NPP} – the water quantity for the intake canal of Kozloduy NPP in m^3/s;
- dT_{NPP} – the temperature difference between the water in the discharge and intake canals in the area of the river bank pump station (BPS) in °C.

This relationship has allowed easy and representative assessment of the impact of the water discharged by the plant into the Danube.

The observations on the variations of the water temperatures at different points of the Danube, although limited, cover different days and seasons and cover the annual cycle. The data analysis showed that the smallest daily amplitudes of the water temperatures are during the months April-May and October-November. Thus, the daily variations in the water temperature rarely exceed 0.5°C - 1.2°C. The biggest daily fluctuations in the water temperature occur during the coldest and the warmest months of the year (for the water) - January and August. In August the daily fluctuations in the water temperature reach 1.6°C - 2.2°C.

Of essential significance for the thermal field assessment as influenced by Kozloduy NPP is the heat balance of the section of $^{km}687$ (SPS) to $^{km}678$ (Oryahovo).

For assessment of the degree of the possible thermal impact of Kozloduy NPP upon the Danube, the elements of the heat balance of the section of $^{km}687$ (SPS) to $^{km}678$

(Oryahovo) have been compared to the heat from Kozloduy NPP discharged into the Danube.

The analysis of these results by the document development expert team showed that the hydrodynamic characteristics of the mixing zone of the two currents plays a significant role for the redistribution of the heated water in the Danube, discharged via the discharge water canal.

Earlier studies showed that the operating fluid amount of the pumps at BPS is variable from 6.0 m^3/ s to 5.5 m3/^{s}. Actually, at full capacity of the plant during the then existing operation mode with six power units, it could have been expected that Kozloduy NPP would discharge about 180 m^3/s hot water with temperature above 10˚C above the natural temperature into the Danube via the existing outlet channel.

The change of the temperature regime of the river as a result of the discharge of the water heated by Kozloduy NPP is a specific form of pollution. In accordance with the applicable norm[135] , the assessment of the thermal pollution of surface flows should be carried out for the minimum average monthly quantity of water (in a year with 95% provision) and natural temperature of the surface flow - average for the warmest or the coldest months of the year. The norm does not take into account the probability of combinations with water quantity with 95% provision and average water temperature for the last 10 years, and whether this temperature is representative of the natural temperature regime of the surface flow.

In order to determine the thermally polluted area downstream of Kozloduy NPP, in 1978-91 UASG conducted research expeditions -water flow of the Danube before BPS, water quantity taken in for the cooling system of the plant, temperature difference between the taken in and discharged river water and geometric characteristics of the section of the Danube - average width and average depth.

Along with model studies for the development of measures to minimise the entry of floating objects to the forechambers of the BPSs 1, -2 and -3, in 1991 the UASG conducted a study of the thermal pollution of the Danube by the NPP. Some of the more important results had shown that:

- The water temperature in the outlet canal before the discharge into the river follows the natural increase of the temperature of the water in the Danube before the BPS as per hours during the day, with temperature difference of 7.5˚C - 8.5˚C under normal operating conditions;
- The thermal stratification of the flow in the thermal loop is obtained only up to about 600 m after the discharge of the hot channel (HC). The maximum

[135] During the preparation of the present assignment, Ordinance 7/1986 has been cancelled by an Ordinance for cancellation of Ordinance 7/1986 prom. StG 22/05.03.2013

stratification along the vertical (about 4°C) is observed at about 200 m after the discharge and at about 80-100 m in the fairway profile of the river;

→ The stain of "thermal pollution" of the Danube River (with $\Delta T = 3°C$) then occurs at about 1700 m after the discharge of the HC with a maximum width of about 80 to 130 m.

For the determination of certain actual characteristics of the thermal effects of Kozloduy NPP on the Danube for the purposes of the 1999 EIA, the experts of the team and the NIMH – BAS, together with the management and using a cutter from the plant, carried out research expeditions on 4 and 5 August, 1999 on the Danube from the port of Kozloduy to the village of Ostrov.

The conclusion of the experts is that the results of the examination of the isotherm +3°C (temperature field with temperature 3°C higher than the natural temperature of the Danube) from the previous studies and from this experiment, are a reason to assume that there is a reconciliation of the results of different studies.

The impact of the plant was more pronounced during the dry years. Due to the fact, that before the conduct of the experiment for the purposes of the 1999 EIA no expedition measurements and observations at very low flow of the Danube River (close to the runoff with 95% provision) have been carried out, data had been taken for the observed water temperatures in the section Lom - Oryahovo in 1983 - one of the dry years, for which there is detailed data about the water temperature at Oryahovo and at the BPS, as well as about the plant operation. The results of the calculations have shown that in some periods too high water temperature difference has been observed for the Danube section "Oryahovo - Lom". The analysis also showed that the average monthly water temperatures at Oryahovo, after the commissioning of the NPP, were higher by 1.8°C and the annual temperature were 1.9°C higher than the natural.

3.9.4.2 PREDICTION OF THE IMPACT

With the derived relations, the team made calculations to determine the size of the heat-influenced area of the Danube after the discharge channel for hot water at average monthly water flows with 95% provision. Calculations have been made for two isotherms +3 and +5°C. The results showed that during operation of four reactors with a total volume of heated water 104 m^3/s with temperature of 10°C above the temperature of the water in the Danube, the thermally influenced area with probability of exceeding 5% and temperature +3°C above the natural in different months of the year varies within the section from ^{km}684.3 to ^{km}676.1, and is formed near the Bulgarian coast, and has a maximum width from 100 m to 185 m.

The largest size of the heat influenced area is typical for October with 4 operating reactors.

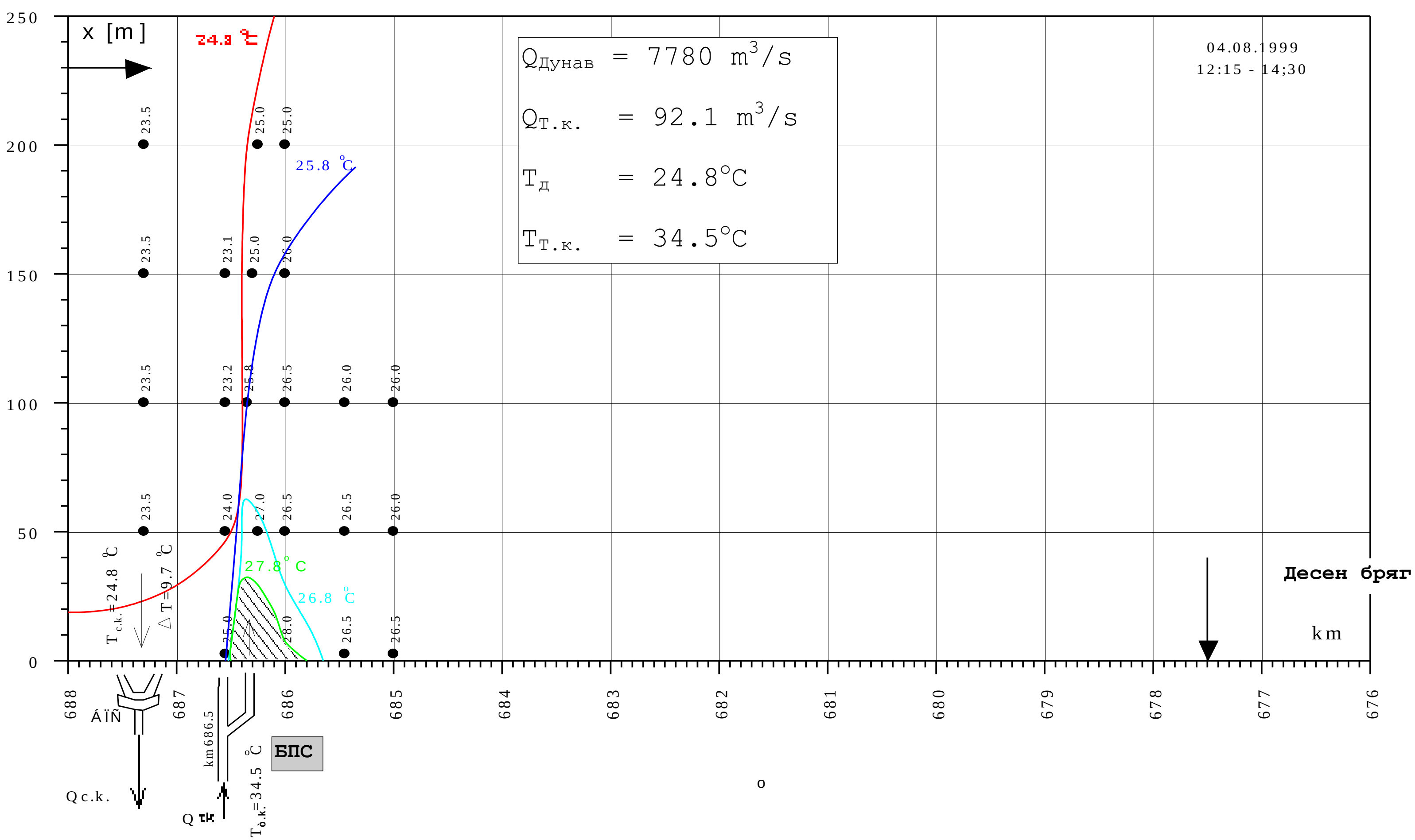


FIGURE 3.9-1: ISOTHERM DIAGRAM AND RESULTS FROM THE MEASUREMENT OF THE THERMALLY INFLUENCED AREA OF THE DANUBE RIVER ON 04 AUGUST 1999.

It is important to note that unlike most other countries, Bulgaria limits only the permissible excess (less than 3ºC) above the temperature of the water at natural conditions, without referring to an upper temperature limit, in accordance with Ordinance 7/86.

The EIA report will analyze and estimate the current and expected impact of the implementation of the new nuclear unit on the temperature regime of the Danube.

3.10 HEALTH-HYGIENE ASPECTS OF THE ENVIRONMENT

3.10.1 EXISTING STATUS

The EIA report will examine the conditions at four alternative sites and shall select the one with the most favorable indicators according to the defined criteria for construction and installation of new unit, including the health and hygiene aspects of the environment and the human health risk, according to a document from the Ministry of Environment and Water with Ref. No. OBOC 220/9.01.2013.

The purpose of this part of the ToR will be to identify the potential impacts in terms of the health and hygiene aspects of the environment and human health risk, given the current reactors at the site of Kozloduy NPP and the construction of the new nuclear unit.

The radiological impact of NPP on the environment and the population will be studied in two areas: Precautionary Protective Action Zone (PPAZ) - 2 km, Urgent Protective Action Zone (UPAZ) - 30 km around the NPP. The investment proposal (IP) determines the various existing nuclear and non-nuclear power capacities and facilities at the production site of the NPP, which will be reviewed and assessed as possible factors for adverse impact on the personnel and the population of the settlements in Bulgaria and Romania, within the defined impact zones when the IP is implemented.

The available data on the population of Vratsa region show that the diseases of the circulatory system, the increased malignancy, the diseases of the respiratory system are still dominant amid a population which is declining rapidly. It should be noted that the above-background radiation, although negligible in terms of health risks and health status of the population within the 30 km zone, is mainly due to the presence of gases and aerosols in the surface layer of the air, discharged by KNPP. The method for assessment of the condition of the environment at NPP site and impact areas (mainly 30 km) is based on the regulations approved by the Ministry of Health, developed by the NCPH and NCRRP in accordance with the EU directives and the developments of EPA - USA [136], [137]. The method consists of 4 individual steps:

136 United States Environmental Protection Agency: Integrated Risk Information System. Accessibile at: http://www.epa.gov/

137 Directive №307/2002 „On the radiation protection", EU

- → Determination of the hazard;
- → Determination of the exposure level – dose – response;
- → Assessment of the exposure in terms of impact on the population and the personnel of KNPP;
- → Estimates of the impact degree on the health of the population and the personnel.

For the implementation of the assessment method, data will be used from the scheduled medical examinations conducted of the Kozloduy NPP personnel. The results of medical check-ups allow identification of the "health situation" and the health of the workers from different professions. The reasons shall be analyzed for temporary disability of the personnel and also the cases of radiation doses for various production reasons, in accordance with letter of the MoH with Ref. number 26-00-2370/ 11.01.2013 and letter from Vratsa Regional Health Inspectorate with Ref. number КД-04-35-13/ 09.01.2013.

The EIA report section "Health-hygiene aspects" will analyze the **demographic and health status** of the personnel and the population during the construction, the operation and the decommissioning of the new nuclear unit. Current data will be used from the Medical Service of the plant about the regular examinations and the other medical examinations.

For the purposes of the EIA report, a comparative analysis will be conducted of the morbidity per disease class, estimated during a transition period of 5-10 years and currently. The prevalence of pediatric diseases and malignant neoplasms shall be presented and analyzed in detail. The annual health and demographic analyzes of RHI Vratsa will form the basis of the EIA report study.

The probability for occurrence of a harmful effect on human health and the assessment of its severity determine the term **"injury"**. The main components of the injury are the following stochastic variables:

- → Probability of lethal cancer;
- → Probability of non-lethal cancer;
- → Probability of severe hereditary effects and reduced life expectancy if the injury is manifested.

In the study, the values of the so called **nominal eco-coefficients**[138], [139] of variability of stochastic effects shall be determined for personnel in ionizing radiation environment.

138 New power source of the Temelin NPP: Effects on the public health, EIA, 2010

139 Глазунов И. С. и кол. Радиационна медицина. Ръководство за лекари и студенти. С., 1960 г.

The EIA report will consider the principles of radiation protection and its main goal - reducing the radiation induced cancer to a minimum.

The EIA report shall pay particular attention to the analysis of the radiation exposure of **the personnel,** reporting the persons who have received doses above the individual dosimeter (1 mSv) and the average annual effective dose.

In the EIA report the radiation exposure of **the population** in the region of Kozloduy NPP will be determined using a mathematical model for assessment of the spread of radioactive substances in the air for the purpose of the assessment of the incidence for children and adults.

Previous studies present data and analysis on the effects of harmful non-radiation factors on the environment. The EIA report shall update the studies in terms of the effects of harmful physical factors on the health of the personnel and the population. The thermal impact of Kozloduy NPP in its current capacity, with forecast of the impact of the future nuclear power, is considered the most dangerous non-radiation factor, followed by the electromagnetic fields around the substations and the high voltage transmission lines. As non-radiation factors, the importance will be added of noise, vibration and lighting on the work environment and to some extent on the population.

The analysis of the impact of various harmful physical factors at the territories of the new unit on the environment and people will be performed at the different stages of the Report - construction, operation and decommissioning.

For the purpose of the IP and its implementation, the climatic and landscape conditions in area of Kozloduy NPP and the territory of Municipality Kozloduy will be explored in terms of health prevention, taking into account the specifics of the 30 km and the 100 km areas of impact around the nuclear power plants.

For this specific estimate study, the best practices of the Czech Republic will be used for calculation of the total effective doses and partial effective "Sv" doses from separate sources for the next years, as well as the probability of health problems. The EIA report will determine the magnitudes risk values with leading start releases into the air and water.

As a result from the objective data presented in the IP, the extent of the possible cumulative effect on the population of the Republics of Bulgaria and Romania will be assessed.

3.10.2 PREDICTION OF THE IMPACT

There are five Bulgarian municipalities within a radius of 30 km from the UPAZ around the Kozloduy NPP site.. According to the 2011,[140] census, the municipality of Kozloduy, including the town of Kozloduy and 4 villages: Harlets, Butan, Glozhene and Kriva Bara has a totalof 21 180 residents; the Municipality of Oryahovo has 11 522 residents; Municipality of Mizia -7 570 residents; Municipality of Vaulchedrum – 9 900 residents; Municipality Hayredin – 5 001 residents. This region includes some settlements from the Lom Byala Slatina, Boychinovtsi, Krivodol and Borovan Municipalities.

During the construction and the future operation of the plant, the spread of the different quality and quantities of specific air pollutants will predominantly follow the characteristic directions of the wind rose in the region - north-west/west and north-east/east. These fixed factors will be addressed by the EIA report with assessment of the possible adverse effects on the health of the population in the 30 km area for urgent protective action zone (UPAZ).

In the EIA report, based on analysis of the recent data available, an estimate and a comprehensive assessment shall be carried out of:

- → The hygienic characteristics of the used physical, chemical, radiological or mechanical agents during the operation;
- → Health and hygiene analysis of the potential pathways of impact of the investment project on the health of the personnel, the public and the environment;
- → Determination of the potentially affected population and the sites with specific hygienic-protection status;
- → Identification of the risk factors for the health of employees at the site;
- → Possibilities for combined, complex, cumulative and remote impact of the determined factors;
- → Assessment of the risk for human health and adequate protection measures.

The EIA report will assess the **Radiation exposure of the population** with study of the paths of intake of manmade radio nuclides in the environmental sites on both Bulgarian and Romanian territory (MoEF, R. Romania ref. number 3672 RP 18.10.2012) by means of discharge of gases and aerosols in the low atmosphere and by means of discharge of radioactive liquids.

The EIS report will also **evaluate the degree of pollution of other major environments such as air, surface and ground water, soil, etc.** from the specific

140 Population by 01.02.2011 per districts, municipalities, settlements http://www.nsi.bg/census2011/PDOCS2/Census2011_Age.xls

activity of the NPP during the implementation and the operation of the investment proposal, connected directly to and having special importance for the determination of the potential impacts on the health and hygiene aspects of the environment and the risk for human health, respectively.

The EIA report shall assess the impact of the activity on the health and hygiene conditions of the nearby settlements and the other sites **subject to health protection** against air pollution by particulate matters, mainly $PM_{2.5}$ and PM_{10}, pollution from harmful exhaust emissions and noise, ionizing radiation and radioactive materials, while the estimates on health positions, based on studies of similar objects, are that the above hazards shall be practically absent or shall be within the specified limit admissible values (LAV).

The EIA report shall examine all health risk factors in the work environment per types. The health assessment will be consistent with the requirements of **Ordinance 13/2003** on the protection of the workers against risks related to exposure to chemical agents at work (SG 8/2004, am. SG 71/2006, am. SG 67/2007)

Considering the characteristics of the individual factors in terms of their impact on the health of the personnel and the public, these will be classified and treated under the health and hygiene requirements as follows:

- Chemical factors;
- Physical factors;
- Radiation factors;
- Non-ionizing radiation, etc.;
- Psycho-sensory factors;
- Social factors.

Based on the studied indicators, the health risk will be assessed, with **discussion of measures for health protection** and effective risk management.

Based on studies and analysis, the EIA report shall make an estimate of the possible effects on the health and hygiene aspects of the environment and human health risks resulting from the construction of the new unit, in accordance with the requirements of Annex I of the Commission Recommendation of 11 October 2010 on the application of Article 37 of the Euratom Treaty. The identification of the potential impacts shall be accompanied with proposal of adequate measures to prevent the occurrence of health risk to the personnel and the population.

3.11 RADIATION RISK FOR THE POPULATION FROM RADIOACTIVE DISCHARGES DURING NORMAL OPERATION

3.11.1 EXISTING STATUS

3.11.1.1 DOSES FROM GAS-AEROSOL EMISSIONS

In 2011, the estimated maximum individual effective dose for the population, totally from the gas-aerosol (with ^{14}C and ^{3}H) and liquid discharges from Kozloduy NPP in the environment is 6.98 μSv/a. This is only 0.3% of the exposure from the natural background radiation in the country (2.33 mSv) and 0.7% of the limit for the population (1 mSv) as per BNRP-2012.

Over the past 5 years, the maximum individual effective dose for the population varies within 4 ÷ 7 μSv/a, which is below the statutory effective dose for the population - 1 mSv/a, BNRP-2012.

For 2011, the maximum annual individual effective dose within the 30 km area from gas-aerosol discharges (RSF + LLA + ^{131}I+ ^{3}H + ^{14}C) of Kozloduy NPP was estimated at 2.72 μSv/a.

The collective effective annual dose is estimated at 3.49 x 10^{-2} manSv/a. The normalized collective effective annual dose for the population within the 30 km area from gas-aerosol emissions is 1.87 x 10^{-4} manSv/GW.a. The estimates per components RNG, LLA and ^{131}I for Kozloduy NPP are fully comparable with the data for a large number of PWR reactors in the world.

The distribution of the individual effective doses in the area around Kozloduy NPP shows that in 2011 the maximum values were obtained along the southeast direction, at distance of 1.5 km for the age group 7÷12. This is due to the wind rose for the region.

3.11.1.2 DOSES FROM LIQUID DISCHARGES

The low values of the discharges of treated water from Kozloduy NPP in 2011, and the previous years determine the low levels of exposure of the population in the region. The released tritium activity in 2011 was 22.9 TBq and represents 12% of the permissible level and 88% of the control level for the period. The total activity (excluding tritium) of the liquid releases is 420 MBq, which is only 0.28% of the control level limit allowed by the Bulgarian NRA for the period.

The collective dose for the population in the 30 km area of the liquid radioactive discharges in 2011 was estimated at 4.47x10^{-3} man.Sv/a. The normalized collective dose per unit produced electricity is 2.40x10^{-3} man.Sv/(GW.a). This exposure is only 12% of the average value for PWR reactors in the world: 2.10^{-2} man.Sv/GW.a. (UNSCEAR'2000).

The maximum individual effective dose for the 30 km area is set as $6.05x10^{-7}$ Sv/a, and for a representative from the critical group of the population along the Danube (Oryahovo, villages of Leskovets, Ostrov and Gorni Vadin) it is $4.26x10^{-6}$ Sv/a, respectively. This exposure is negligible and represents less than 0.5% of the annual effective dose limit of 1 mSv (BNRP-2012). Compared to the limit exposure 0.25 mSv/a from radioactive discharges from the NPP (Ordinance to ensure the safety of nuclear power plants, 2004), the maximum dose is only 1.7%, and compared to the quota for liquid discharges 0.05 mSv/a - 8.5%.

The obtained assessments for the dose effects of the discharges from Kozloduy NPP are fully comparable with the world practice, according to official data of the United Nations (UNSCEAR-2000). It should be noted that since then the international best practice shows continuous improvement in the control of the discharges, and lower emissions and actual reporting, respectively, resulting in lower dose estimates for the population in the areas of KNPP. Since the comparison is made on the collective dose, in the assessments of Kozloduy NPP the relatively small population density in the region, compared with many other NPPs worldwide also positively affects the assessment.

The low values of the radioactive discharges from Kozloduy NPP determine the values for the radiation exposure with negligible radiation risk to the population in the region of the plant. The additional radiation exposure of the population in the 30 km area averages about 500 times lower than the natural background radiation (2400 μSv).

The collective dose to the population in the UPAZ of 30 km around Kozloduy NPP is $3.49x10^{-2}$ man.Sv for the population in that area of 72 416 people.

3.11.2 PREDICTION OF THE IMPACT

3.11.2.1 DOSES FROM GAS-AEROSOL EMISSIONS

The main routes for radiation exposure o humans are: external exposure from radioactive cloud, external exposure from the ground surface, internal radiation by radio nuclides entering the body through inhalation (by breathing) and internal exposure due to radio nuclides entering the body through the food chain (oral route of exposure).

The assessment of the external and the internal exposure of the population in the area of NPP will consider the following ways of impact:

- ✓ External exposure from radioactive cloud;
- ✓ External exposure from deposits on the ground surface;
- ✓ Internal radiation due to inhalation;
- ✓ Internal radiation due to consuming of radioactively contaminated food.

The assessment of radiation exposure of the population will include:

- ✓ Assessment of the maximum individual effective dose for the population and estimated collective effective annual dose
- ✓ Analysis and conclusions about the radiobiological effects and the radiation risk for the population in 30 km area around Kozloduy NPP.

The estimates of the radiation risk will be in the following ranges:

1) Risk of radiation-induced cancer for the general population and the persons of working age;
2) Risk of hereditary diseases for the general population and the persons of working age;
3) Risks and damage to certain tissues for the general population;
4) Risk of hereditary diseases for the first generation and for two generations;
5) Risks of hereditary diseases for the reproductive population estimated for two generations when the first generation is exposed before the second;
6) Risks of hereditary diseases for the reproductive population estimated for the first generation after the exposure.

The assessment of the exposure to radiation will consider both the external and the internal impact of the radioactive discharges and the annual individual effective dose, the annual individual equivalent dose and the dose for the critical group, and also the collective dose for the population per age groups will be assessed.

The input data will be from the radiation monitoring at the source - radioactive releases into the atmosphere and the hydrosphere, actualmeteorological and hydrological data, statistical demographic data, data about the consumption of food produced in the region for the period of the assessment. The radioactive discharges may be released into the atmosphere or in the water, while the models should describe the transfer of radio nuclides through different parts of the biosphere to the humans.

A conservative approach will be used for comparison to the annual administrative boundaries of the discharges, per components at the whole site at 1200 MW operating power. The boundaries will be defined in such way, that when approached, the control level for individual effective dose for the population - 50 μSv/a is not exceeded.

3.11.2.2 DOSES FROM LIQUID DISCHARGES

The liquid radioactive discharges into the Danube are spread due to the basic water movement and the sedimentation processes. The main routes for radiation exposure for humans are: external exposure from contact with the aquatic environment and the bottom sediments, consumption of foods taken from the river, using the river water for drinking, consumption of food from crops and pastures irrigated with water from the river.

The EIA report will address each of these routes. It will take into account the physical movement and the dispersion of the water masses together with the radioactive decay of the radio nuclides. The resulting concentration of radioactive substances in the water and in the bottom sediments forms the input for calculation of the uptake by humans through contact with the environment and uptake and the subsequent individual and collective doses.

The input data will be radionuclide distribution and the activity of the discharges into the treated water discharges. In 2011, a total of 38 800 m^3 of treated water was discharged into the Danube.

The hydrological data needed to assess the radiation exposure are: average speed of the river, average depth, distance, average width of the river; location and capacity of the receptacle - the river.

Statistical data about the consumption habits of the population. Demographic data about the population per age groups.

3.11.3 MODELS AND SOFTWARE FOR ASSESSMENT OF THE RADIOBIOLOGICAL EFFECTS AND THE RADIATION RISK FOR THE REFERENCE INDIVIDUAL AND FOR ASSESSMENT OF THE DOSES FOR THE POPULATION FROM LIQUID AND GASEOUS RADIOACTIVE DISCHARGES INTO THE ENVIRONMENT

The assessment of the radiobiological effects and the radiation risk to a reference individual for radioactive releases from Kozloduy NPP shall be carried out with the program HeConEmpPop (Health consequences for employees and population). The modeling program formalizes the assessment methodology for radiobiological effects and radiation risk according to ICRP Publication 103, The 2007 Recommendations of the International Commission on Radiological Protection.

Such quantitative estimates are extremely important to define the whole possible range of harmful effects, favorable and unfavorable times for discharge during maintenance and other activities, specification of resources and intervention criteria set out in the emergency plan, evaluation of extreme impacts in case of unfavorable combination of various factors, optimization of the radiation control, etc.

Depending on the technological and meteorological parameters, the concentration and the exposure to radiation in the environment vary in a very wide range. Even when given technological parameters, the mentioned range is very wide due to meteorological reasons.

The main meteorological elements are:

- ✓ wind;
- ✓ classes of atmospheric stability (Pasquill-Turner);
- ✓ specific humidity;
- ✓ atmospheric pressure;
- ✓ temperature;
- ✓ precipitation quantity.

The meteorological data processing is performed in compliance with the international standards adopted in Bulgaria – American National Standard for determining meteorological information at nuclear power Sites ANSI/Ans 2-5-1974 and Commission for instruments and methods of observation WMO Brussel 1989.

The complex meteorological parameters obtained as a final result provide a unique to the area climate information, taking into account its specific micro meteorological characteristics. It is used for detailed solving a wide range of environmental tasks associated with the spread of radio nuclides and determination of the radiation exposure in different scenarios, the concentration for emergency planning, etc. Thus, when certain region-specific meteorological parameters are used, the task can be solved for determination of the aggregate exposure dose of the facility throughout the period of operation (subject to various scenarios), which is an important integral-regulatory parameter.

The resulting frequency distributions - information for the annual recurrence of the distribution of the wind speed, the stability class of the atmosphere and the wind direction are presented by wind roses:

- ✓ of the wind;
- ✓ of atmosphere stability;
- ✓ combined;
- ✓ precipitation quantity.

The wind rose shall be prepared for the entire period for which data are available from weather stations, per seasons, annual and day/night.

The wind roses, the stability classes and the precipitation allow determination of four-component distribution " wind direction and speed - stability class - precipitation", which is unique to the area meteorological pre-processing, required for solving a wide range of tasks related to environmental status of the plant.

The data shall be presented in the format required by the program SHIELD Normal operation for calculation of the doses from gaseous discharges, developed by Eco Program OOD. The data recorded in these tables are input data for the modeling program developed on the basis of the model CREAM (Consequences of Releases to the Environment Assessment Methodology) Radiation Protection 72 –Methodology for assessing the radiological consequences of routine releases of radio nuclides to the environment.

During the operation of the new nuclear unit, impact on human health is possible, and therefore the EIA report shall assess the biological impact of ionizing radiation.

The biological effect of the ionizing radiations is considered in four aspects: physical, physical-chemical, chemical and biological. The biological effect of the ionizing radiation on the human body depends on many factors, the most important of which are: type of radiation, uptake dose and its power, size and localization of the exposure, reactivity of the organism and exposure time. As a result of all the processes at the molecular, cellular, tissue and organ level, the ionizing radiation in the body causes the following radiation damage:

3.11.3.1 DETERMINISTIC EFFECTS /NON-STOCHASTIC/

Early somatic effects. These are also called **deterministic**, since the severity of the damage is proportional to the dose rate after a certain threshold for clinical expression is exceeded. The presence of a threshold dose for expression of a certain effect is explained by the fact that the damage from ionizing radiation in small sub-threshold doses in the body triggers healing processes, which compensate for the damage. At doses exceeding the threshold, the severity of the damage is increased in proportion to the uptake dose due to the fast destruction rate of the cells, compared with the rate of their reproduction. For single whole-body brief exposure of humans, the threshold dose is 0.2-0.3 Sv. With this dose, the irradiated individuals do not feel sick, but there are disturbances in the functioning of many radiosensitive organs (red bone marrow, lymph nodes, spleen, gonads, mucous membranes of the digestive tract and the respiratory system, etc.. The threshold dose for an early damage in humans is defined by reducing the number of the leukocytes. The systems for restoration of the body are able to compensate for these damages resulting from exposure to low doses (0.3 Sv). However, at higher doses, these compensatory options are limited. In humans this occurs at doses of 1 Sv, at which symptoms of acute radiation sickness are observed. At doses of about 4 Sv (called LD50) 50% of the exposed individuals die. Doses above 6-7 Sv (LD100) are in almost all cases, deadly.

The occurrence of deterministic effects in different individuals is different. They depend on the characteristics of the radiation and the dose of radiation and also on the physiological condition of the body.

The deterministic effects are: acute radiation sickness - threshold 0.25Gy; visual impairment - threshold 0.5 Gy; permanent infertility in women - threshold 2.5-6 Gy; temporary sterility in men - threshold 0.15 Gy. These effects are totally dependent on the dose and therefore no permissible dose limits can be discussed.

3.11.3.2 STOCHASTIC EFFECTS

The stochastic effects (non-threshold) are such effects, for which the probability of occurrence (rather than their severity) is a function of **the dose.**

- → ***Somatic (cancer):***
  - Late somatic effects – these occur years and decades after the irradiation.
- → ***Genetic (hereditary) -*** affecting the generations of the exposed individual.

These include the late somatic effects and the genetic effects. There, a modification of the normal cells under the influence of low doses of ionizing radiation is observed, but this cell retains its ability to reproduce. These effects are not dose-determined and no exceeded threshold can be discussed, leading to their occurrence**.** In terms of the dose-effect relation, a stochastic (probabilistic) distribution of cases occurs, i.e. the increase of the dose increases the probability for disease and not its weight, as in the deterministic effects. Therefore, these effects are considered as a *radiation risk*. The stochastic effects are random in nature and their occurrence depends on the physiological specifics of the organism. Since the modified cells preserve their fertility, they are able to create their population. This population can be destroyed by the body's defense mechanisms. But when this does not happen due to a number of reasons, the stochastic effect occurs after a latent period. The probability of its occurrence depends on the number of modified cells, which occurred after the irradiation and the larger their number, the higher the probability of their survival.

3.11.3.2.1 Late somatic effects

These include malignant neoplasms (various forms of cancer and leukemia). It is typical of such stochastic effects that they occur after a long latency period - from several years to decades. The mechanisms of malignancy are not known. The decisive point is the occurrence of inherited variation in the genetic apparatus of the cell. The assessment of the carcinogenic risk is very difficult due to the high incidence of spontaneous tumors and its annual fluctuations. The establishment of carcinogenic diseases due to effects of ionizing radiation is possible if their number is greater than the average fluctuation. The risk assessment is carried out by monitoring the groups receiving higher doses, because only in these groups an increased incidence of malignant neoplasms has been found after years of research. The results of these observations allow creation of models of the relation "dose-additional risk" that can be extrapolated to low doses.. At high doses, the relation dose-risk is linear, non-threshold, i.e. the additional risk is proportional to the dose. For the more common fatal malignant diseases, the hazard ratio is determined, taking into account the risk due to exposure to a determined single dose for the rest of the life of the irradiated persons (risk ratio for life). At very high doses and irradiation power, the relation dose-risk is linear-quadratic, i.e. the additional risk decreases more rapidly with reduction of the dose.

3.11.3.2.2 Genetic effects

These are due to the irradiation of the germ cells before or during the reproductive age, resulting in additional mutations that are transmitted to the offspring. The ionizing radiation is a powerful mutagen and the most common genetic damages caused by it are gene mutations and chromosomal aberrations. The assessment of the genetic risk from exposure to ionizing radiation is very difficult due to the high spontaneous incidence of genetic damages. There too applies the linear non-threshold relation typical for the dose-genetic risk relation. The genetic risk assessment is carried out in two ways. In the first, the genetic risk is expressed by the frequency of the genetic damages per unit dose. In the second, the genetic risk is expressed by the dose that doubles the natural mutation rate.

Recently, there has been an increase of the doses doubling the spontaneous mutation, meaning that the genetic risk has decreased in comparison with the past. The risk of serious fatal genetic damages for the first 10 generations is 1 case per 125 persons irradiated with a dose of 1 Sv.

The term "genetic risk" means the probability for adverse genetic effects occurring in the offspring of the population exposed to radiation. The assessment treats the problem in relation with three main factors:

- ability of the ionization radiation to induce mutations;
- ability for transfer of the induced mutations;
- gene mutations and chromosomal aberrations occurring spontaneously and becoming a reason for the hereditary pathology.

These effects are expressed in exceeding of the background incidence of genetic diseases in the population per unit of radiation dose with low LET (**linear energy transfer**) at chronic exposure to low doses.

The program will give the risk ratios for the reproductive part of the population and for the total population estimated for two generations, as well as the risk ratios only for the first generation after the irradiation.

3.12 CULTURAL HERITAGE

3.12.1 CURRENT STATUS

The territory of the present NPP has never been subject to any research and archaeological monitoring during construction works and subsequent reconstruction of Kozloduy NPP, the laying of communications in the area, etc., and no information is available about the artifacts and objects found or registered near the plant.

Opinion № 4800-2/15.01.2013 of the National Institute of Immovable Cultural Heritage and Letter № 33-НН-81/19.02.2013 mention generally around 300 architectural and structural, historical and archaeological sites in municipalities around the plant.

The archive of the National Institute of Immovable Cultural Heritage included two historical sites (locality of Kozloduyski Bryag and Mateev Geran) and two archaeological sites (fortress in the locality of Chetate and Regiana ancient fortress in the locality of Piatra Magura). The automated system "Archaeological Map of Bulgaria" (AIS-AKB)[141] contains registration cards of 18 sites located within the municipality. Most of them are in the village of Harlets located east of the mouth of Ogosta River and linked to the Roman camp and the city of Augustae, which is studied through archaeological excavations (proclaimed "national antiquity" since 1927 (promulgated in State Gazette, issue 69/1927) and "archaeological preserve of national significance"[142]. There are also 4 sites located in the western end of the town's territory.

A letter to the Regional History Museum in Vratsa (Outgoing reference № 135/27.12.2012) mentioned mound necropolis near sites 1 and 2, and another cemetery near Site 3. Some of these mounds are shown on a map of the area at 1:25 000[143].

Among them "Roman Fortress Regina" and the associated structures face certain risk of damage (road, necropolis, industrial equipment, residential facilities) spreading on a property of unspecified area between Site № 3 and the boundaries of the present town[144].

At Site 4, located entirely within the construction limits of Kozloduy NPP preserved archaeological structures are not expected (irrevocably damaged during construction works and operations).

In the event that the implementation of the investment plan (especially for sites 1, 2, 3) potentially threatens any previously unknown archaeological sites (immovable cultural

[141] http://naim-bas.com/akb/

[142] Decision of the Bureau of the Council of Ministers № 14 of 25.06.1984

[143] D. Dimitrova. Archeological monuments in the region of Vratsa. Sofia. 1985. (№ 101).

[144] It was proclaimed immovable cultural property in State Gazette (issue 90/1965) with a specific monument status of "national relevance." No limits and modes established thereupon.

property under the Cultural Heritage Act) the provisions of Article 161 of the Cultural Heritage Act shall apply.

3.12.2 PREDICTION OF THE IMPACT

Excavation works and disturbance of the original ground and natural topsoil deposits pose an irreversible threat to the remains of life contained therein from various historical periods, archaeological structures and artefacts. The same goes for backfilling works. It is valid for specific sites, and for new access roads and communications.

In order to reduce the devastating impact on immovable cultural heritage (archaeological sites and structures), the provisions of Article 161 the Cultural Heritage Act shall apply: field inspection for recording and conducting rescue excavations directly threatened by construction (Ordinance on H-00-0001/14.02.2011). If during construction works any unregistered monuments are revealed, follow-up activities will be in accordance with the Cultural Heritage Act (CHA). Excavations works should be carried out under supervision of a specialist archaeologist.

The absence of targeted searches for real cultural values (archaeological sites) on the current NPP site and the land surrounding it require purposeful gathering of information from archival sources, publications, museum collections. It is imperative to visit and inspect the terrain to update currently available and earlier submitted information.

4 RELEVANCE OF ENVIRONMENTAL IMPACT, DETERMINATION OF PERMANENT, UNAVOIDABLE ENVIRONMENTAL IMPACTS FROM CONSTRUCTION, OPERATION AND DECOMMISSIONING OF THE INVESTMENT PROJECT SITE THAT MAY BE SIGNIFICANT AND SHOULD BE DISCUSSED IN DETAIL IN THE REPORT OF ENVIRONMENTAL IMPACT ASSESSMENT (REIA)

4.1 NATURE OF IMPACTS

In determining the type of impacts an overall approach will be applied that takes into account both the requirements of the Bulgarian legislation and international best practice to assess environmental impacts and risk to human health by:

1. **Probability of impact** occurrence – expected, not expected;
2. **Territorial scope** of influence within: the site of the investment project, Kozloduy NPP site, the 30 km zone for urgent protective action;
3. **Type of impact** - positive / negative and direct / indirect, primary and secondary;

4. **Level (relevance) impact** in five stages: 1 - very low, 2 - low, 3 - moderate, 4 - high, 5 - very high;
5. **Characterization of impact:**
6. **Frequency** - permanent, temporary;
7. **Duration** - short, long;
8. **Cumulativity**- effects that work together and affect the same environmental component / factor,
9. Reversibility of impact - reversible, irreversible.

The impact on components / environmental and human health factors in the investment project implementation will be determined based on the Environmental Impact Assessment (EIA):

- Data on types and quantities of wastes and emissions expected as a result of the investment project implementation;
- Current data on the environmental components / factors;
- Expected changes in components and environmental factors in the project implementation;
- Health and hygiene aspects of the risk to the environment and human health.

Special attention will be given to measures to reduce, limit or prevent the expected negative effects on components / factors of the risk to the environment and human health.

4.1.1 DURING CONSTRUCTION WORKS

It is expected to have impact on the following components and environmental factors:

- **AMBIENT AIR QUALITY** - impacts are expected during construction works - temporary, negative, limited in compliance with the legal requirements and the measures envisaged, reversible after this stage;
- **ATMOSPHERIC RADIOACTIVITY** - not expected;
- Expected impacts during operation;
- **SURFACE WATER (NON-RADIOACTIVE ASPECT)** - probability of impact during construction works is expected due to lack of treatment and disposal of non-radioactive waste water organised to discharge that is regulated under the environmental law. Scope of impact directly and negatively with low impact, limited in compliance with the legal requirements and the pre-set measures. Characteristics of impact: temporary, of short duration and without cumulative effect of regional sensitivity. Reversible after this stage;

- **SURFACE WATER (radioactive aspect) –** impact is not expected;
- **GROUNDWATER (radioactive aspect)** - impact during construction works is expected due to excavation, used machinery and ancillary activities within the selected site, directly negative low-impact, limited in compliance with the legal requirements and the pre-set measures. The impact is temporary, short-term, without cumulative effect and reversible after this stage;
- **GROUNDWATER (radioactive aspect) -** impact during construction works is not expected;
- **EARTH INTERIOR AND SUBSURFACE NATURAL RESOURCES** - during construction works at sites 2 and 4 impact on the Earth interior is not expected. At sites 1 and 3 drainage events around the site will be needed. The effect is long-lasting, permanent and irreversible at the groundwater level;
- **TOPSOIL** - topsoil will change its function not only on the areas of construction, but also on the terrain because of direct excavation and backfilling works - construction of buildings, service roads, canals, etc. The effects are irreversible, direct, negative. These impacts will be almost the same on any of the sites, except site № 4, where the greater part of the topsoil is sealed under the pavement or destroyed during previous construction. Excavation works will take place not on land but on building materials, foundations and Earth interior.

  During the construction of the new nuclear power unit as a result of construction activities no radiation impact on topsoil is expected. This is valid for the four sites in consideration;
- **LANDSCAPE –** the landscape structure of all surveyed sites will change. The following landscape components will be affected: geological base, topsoil and vegetation. The excavation works will have a direct impact on geological components. Impact is assessed as direct, irreversible, negative within the sites of consideration. Topsoil is subject to mechanical dredging and backfilling and the humus layer will be temporarily stored in the depot within the selected site. Vegetation of these areas will be destroyed. The impact on the landscape components such as topsoil and vegetation is assessed as direct, negative, reversible, local;
- **FLORA** and **FAUNA –** potential impacts on 4 sites considered are as follows:

  Site 1:

  <u>Direct impacts</u> - possible destruction of species, species habitats, dwellings of vertebrates, change of the natural characteristics of hunting habitats, recreation areas and feeding grounds for partial or complete destruction of vegetation on the site;

Indirect impacts - possible deterioration of habitats and habitats of species introduction and spread of invasive species of flora and fauna;

Secondary impacts - not expected.

Site 2:

Direct impacts - possible destruction of species, habitat types, changes in the natural habitat characteristics;

Indirect impacts - possible deterioration of habitats and habitats of species introduction and spread of invasive plant species;

Secondary impacts - not expected.

Site 3:

Direct impacts, possible destruction of species, species habitats, havens of vertebrates, change of the natural characteristics of hunting habitats, recreation areas and feeding grounds, changing habitats and deterioration of ecological status of aquatic ecosystems.

Indirect impacts - possible deterioration of habitats and habitats of species introduction and spread of invasive species;

Secondary impacts - not expected.

Site 4:

Direct impacts - are not expected;

Indirect impacts - are not expected;

Secondary impacts - not expected.

→ **WASTE (non-radioactive) –** expected impacts are direct, local, periodic, and low because construction and hazardous waste at this stage will be transferred for further treatment to persons possessing a permit, integrated license or a registration document pursuant to the Waste Management Act (WMA) or recovery organizations so authorized under Article 35 of the Waste Management Act (WMA). For household waste separate collection of packaging waste will be provided for, according to Article 33, paragraph 4 of the Waste Management Act (WMA);

→ **WASTE (radioactive)** – impacts are not expected;

→ **HAZARDOUS SUBSTANCES** - basic types of hazardous substances used at this stage are fuels and lubricants. It is expected that in case of environmentally sound management, their impact would be negligible;

→ **HARMFUL PHYSICAL FACTORS** - impacts of physical factors are short-lasting and reversible. The degree of impact is limited by the use of personal protective equipment;

→ **NOISE** - the effects are limited providing compliance with the legal requirements and the pre-set measures and reversible after the construction period. Works carried out at the site of the new nuclear power unit are not noise source for the residential areas in the area, due to the large distance. The noise impact from the construction equipment are expected in the industrial zone of KNPP. The noise from the construction traffic will affect the settlements in the area, when the traffic passes through them as well as the plant's site. The expected noise impact on areas with regulated noise regime can be generally defined with regards to: territorial scope - the sites of NPP and the new nuclear power unit; type - negative, direct, primary; level - low to medium (expected exceedings of hygiene standards); duration - temporary (only during daylight), short-term (until completion of works), cumulative (total), reversible;

→ **HEALTH AND HYGIENE ASPECTS** - the expected impact is negative (within the site), direct primary, temporary, short-term (daily only during the period of completion of works), without cumulative effect and reversible;

→ **CULTURAL HERITAGE** - expected effects only when rescue excavations are needed.

The Report of Environmental Impact Assessment (REIA) will examine in detail the scope of the environmental impact and human health risks, taking into account the specifics of the investment project.

4.1.2 DURING OPERATIONS

→ **AMBIENT AIR QUALITY** - insignificant impacts are expected during operations of the diesel generator stations and transport associated with the supply of necessary raw materials to the new nuclear power unit;

→ **ATMOSPHERIC RADIOACTIVITY** - impacts are expected during operations, which will be detailed in the Environmental Impact Assessment (EIA);

→ **SURFACE WATER (NON-RADIOACTIVE ASPECT)** - probability of impact during operations is expected only due to unforeseen failures of collecting, processing, and transportation of radioactive waste water discharges and potential spill from pipeline of injured or damaged equipment for collection or storage. The projected impact within the selected site is direct, negative, moderate, limited in compliance with the legal requirements and the pre-set measures;

→ **SURFACE WATER (non-radioactive aspect)** - probability of impact during operations is expected only due to unforeseen failures of collection, transportation, storage and handling of radioactive liquid waste and potential spill from a pipeline of injured or damaged equipment for collection or storage. The projected impact within the selected site is direct and negative, moderate, limited in compliance with the legal requirements and the pre-set measures;

→ **GROUNDWATER (radioactive aspect)** - probability of impact during operations is expected only due to unforeseen failures of collection, transportation, storage and conditioning of radioactive waste and the potential spill from a pipeline of injured or damaged equipment for collection or storage. The estimate of the impact within the selected site is direct, negative, moderate, limited in compliance with the legal requirements and the pre-set measures;

→ **GROUNDWATER (radioactive aspect)** - probability of impact during operations is expected only as a result of unforeseen failures of collecting, transporting, storing and handling of radioactive waste and potential spill from a pipeline of injured or damaged equipment for collection or storage. The impact in compliance with legal requirements and the measures is limited within the selected site, direct, negative, of medium significance;

→ **EARTH INTERIOR AND SUBSURFACE NATURAL RESOURCES** – during operations it is in principle possible to have migration of radio nuclides in groundwater. At sites 2 and 4 migration is less likely due to the low level of this water and the expected construction of silt-conrete foundation pad to prevent subsidence or filtration . At sites 1 and 3 migration is possible in case of radiation release through the protective barriers;

→ **TOPSOIL** - during the operation the negative effects on topsoil are significantly less than those in the stage of construction. From natural topsoil much smaller areas will have remained - green spaces and protected areas. The effects are temporary – due to traffic from the internal transport liquid spills, waste, etc. The degree of impact on topsoil for all sites during operations is low[145].

During normal operation of the new nuclear power unit and compliance with all technical and engineering requirements. no significant impacts associated with radioactive contamination of the topsoil can be expected. Information shall be provided on the monitoring of topsoil, which will be carried out following the introduction of new facilities in operation, according to letter of the Regional

[145] Vassilev, G., Radio-ecology. Sofia. Tita Consult, 2005, pages 574

Inspectorate for Environment and Water (RIEW) - Vratsa, ref. № V2975/10.01.2013;

→ **LANDSCAPE –** the stage of operation is not associated with impacts on the landscape of the four sites in consideration. No significant negative cumulative impacts are expected;

→ **FLORA and** FAUNA – potential impacts on the 4 sites in consideration are as follows:

Site 1:

Direct impacts - Possible permanent change of habitat and hunting areas;

Indirect impacts - possible risk of radioactive contamination, fragmentation of habitats, and habitats of species;

Cumulative impacts - potential negative impact on the habitats and habitats of species;

Secondary impacts - not expected.

Site 2:

Direct impacts - lasting change is possible in the characteristics of the natural environment;

Indirect impacts - possible risk of radioactive contamination, possible negative cumulative impacts on habitats and habitats of species

Cumulative impacts - potential negative impact on the habitats and habitats of species;

Secondary impacts - not expected.

Site 3:

Direct impacts - possible lasting change in the characteristics of the natural environment;

Indirect impacts - possible risk of radioactive contamination, fragmentation of habitats and habitats of species;

Cumulative impacts - potential negative impact on the habitats and habitats of species;

Secondary impacts - not expected.

Site 4:

Direct impacts - are not expected

Indirect impacts - are not expected

Secondary impacts - not expected.

- **WASTE (non-radioactive) –** expected to be direct, local, low, periodic effects because all construction, non-hazardous and hazardous waste generated at this stage will be transferred for further treatment to operators possessing a permit, integrated license or registration document pursuant to the Waste Management Act (WMA) or recycling organisations, waste operators, while for municipal waster separate collection of packaging from waste will be provided, in accordance with Article 33, paragraph 4 of the Waste Management Act (WMA), while the rest will be disposed of at a landfill regulated for the purpose as follows: Waste from protected area of the new nuclear unit shall be transported to the DNHIW, and waste outside this area - to the regional landfill in the town of Oryahovo;
- **WASTE (radioactive)** - expected impacts during operations are similar to the effects of liquid and solid radioactive waste generated by existing nuclear facilities at Kozloduy NPP, they will be detailed in the REIA.
- **HAZARDOUS SUBSTANCES** - basic types of hazardous substances used at this stage are fuel, lubricants, chemical substances and mixtures used as auxiliary materials in a series of preparatory processes. It is expected in accordance with the established practice at Kozloduy NPP EAD and the regulatory framework for environmentally sound management that their impact would be negligible;
- **HARMFUL PHYSICAL FACTORS** - the impact of the exposure of staff to electromagnetic fields and radio and industrial frequencies is expected to be long, but with low significance, in accordance with the requirements of the regulations. No impact on the population in terms of power frequency EMF emitted by sources in Kozloduy NPP. Cumulative impacts are not expected;
- **NOISE –** the expected noise impact is similar in nature to the one during the construction phase, but with very low magnitude of impact (exceedance of the hygienic noise levels at the point of impact is not expected);
- **HEALTH AND HYGIENIC ASPECTS** - expected radiological impact on human health is of low importance, based on the recommendations of the International Commission on Radiological Protection, without cumulative effect and reversible;
- **CULTURAL HERITAGE** - no impact expected.

4.1.3 DURING DECOMMISSIONING

Given the legal requirements, the process of decommissioning of a nuclear power facility is based on the concept to execute the justification and selection of the optimum and safe option for the key activities and stages of their implementation during the decommissioning process. The option chosen for the decommissioning of the nuclear power facility is developed, justified and presented as part of the nuclear power facility decommissioning plan.

The decommissioning process takes at least 8-10 years as the set of decommissioning activities requires first the implementation of comprehensive safety assessment and the development of other specific strategies, such as requirements related to radioactive waste management .

Expected impact on the following components and environmental factors:

- → **AMBIENT AIR (non-radioactive aspect)** - expected impacts during decommissioning are similar to the impacts during construction works, but with a much lower level of significance;
- → **AMBIENT AIR (radioactive aspect)** - expected impacts during the decommissioning are similar to impacts during operations, but at a much lower level of significance;
- → **SURFACE** WATER **(non-radioactive aspect)** - probability of impacts during the decommissioning expected only due to unforeseen emergencies or natural disasters. Impact within the selected site will be direct, negative, low, limited and complian with the legal requirements and the pre-set measures and reversible;
- → **SURFACE** WATER **(radioactive aspect)** - expected impacts during decommissioning are similar to impacts during operations with low significance in compliance with legal requirements;
- → **GROUNDWATER (non-radioactive aspect)** – given the legislative requirements, the alternative opted for decommissioning of nuclear facilities is optimal and safe in compliance with the requirements and is not expected to have a negative impact on groundwater. Possible impacts during decommissioning are expected only as a result of unforeseen accidents or natural disasters. Impact within the selected site will be direct, negative, of low significance, reversible;
- → **GROUNDWATER (radioactive aspect)** - possible impacts during decommissioning are expected only due to unforeseen emergencies or natural hazards. Impact within the selected site is direct, negative, of low significance, limited if compliant with the legal requirements and the pre-set measures and reversible;
- → **EARTH INTERIOR AND SUBSURFACE NATURAL RESOURCES** - during decommissioning significant effects on the subsurface are expected.

→ **TOPSOIL** - during decommissioning topsoil impacts are the same as impacts during decommissioning of any other industrial enterprise - demolition of buildings, removal of waste in a repository for nuclear waste, land encapsulation and topsoil monitoring. The degree of impact will be low to moderate;

→ **LANDSCAPE –** the decommissioning phase of the investment project includes activities that are not related to effects on landscape components;

→ **FLORA AND FAUNA** - impacts on biodiversity during the decommissioning of the nuclear unit in terms of the 4 sites in consideration are expected to be similar to those during construction works;

→ **WASTE (non-radioactive)** - impacts are expected to be direct, local, periodic, low. All construction, non-hazardous and hazardous waste generated at this stage will be transferred for further treatment to operators possessing a permit, an integrated license or a registration document pursuant to the Waste Management Act (WMA) or recovery organizations and companies holding permits under Article 35 of the Waste Management Act (WMA). For household waste, we will introduce separate collection of packaging from waste, according to Article 33, paragraph 4 of the Waste Management Act (WMA) and the rest will be deposited at a regulated landfill;

→ **WASTE (**radioactive**)** - expected effects are similar to those during the operations, but at a much lower level of significance;

→ **HAZARDOUS SUBSTANCES –** given that there is compliance with the established practice at Kozloduy NPP and the legal framework for environmentally sound management, their impact would be negligible;

→ **HARMFUL PHYSICAL FACTORS** - the effects would be similar to impacts during construction works, but with very low significance;

→ **NOISE** - the stage of decommissioning is connected with the construction of new and reconstruction of existing buildings, removal of equipment and activities on waste management and waste transportation. Machinery used for the various activities will be source of noise. The Environmental Impact Assessment (EIA) will assess the expected noise emissions in the environment and their impact on areas with regulated noise regime in the studied area using data on the type of the machinery and its noise characteristics. During this stage noise impacts, similar to the one generated during the construction phase are expected;

→ **HEALTH AND HYGIENIC ASPECTS** - the expected impact will be similar to the impact during construction works, negative (within the site), direct primary, temporary, short-term (only during the day until completion of decommissioning), without cumulative effect and reversible;

→ **CULTURAL** HERITAGE - No impact.

As part of the operator's responsibility for all aspects of safety and environmental protection during all phases of decommissioning, the requirements of the IAEA, Decommissioning of Facilities Using Radioactive Material, IAEA Safety Standards Series No. WS-R-5, Vienna (2006) and the Regulation on the Safety decommissioning of nuclear facilities (2004) shall be followed.

Impacts during this extended period are manageable and are expected to be insignificant.

4.2 ASSESSMENT OF POTENTIAL IMPACTS

The Report of Environmental Impact Assessment (REIA) will evaluate the potential impacts on each component of the environment and human health, according to ***Table 4.2-1:*** *Matrix to assess the potential impacts of the implementation.*

TABLE 4.2-1: MATRIX TO ASSESS THE POTENTIAL IMPACTS OF THE INVESTMENT PROJECT

Component/ Factor	Stage	Probability of impact occurence[1]	Territorial scope of impact[2]	Type of impact			Level of impact[3]	Characteristics of impact			Reversa-bility[7]
				Positive/ Negative	Direct/ Indirect	Secondary		Frequency[4]	Duration[5]	Cumulative effect[6]	
SITE 1, 2, 3 and 4											
1.1. Ambient air	Construction works										
	Operations										
	Decommissioning										
1.2. Surface water	Construction works										
	Operations										
	Decommissioning										
1.3. Groundwater	Construction works										
	Operations										
	Decommissioning										
1.4. Earth interior	Construction works										
	Operations										
	Decommissioning										
1.5. Topsoil	Construction works										
	Operations										
	Decommissioning										
1.6. Landscape	Construction works										
	Operations										
	Decommissioning										

Component/ Factor	Stage	Probability of impact occurence[1]	Territorial scope of impact[2]	Type of impact			Level of impact[3]	Characteristics of impact			Reversa-bility[7]
				Positive/ Negative	Direct/ Indirect	Secondary		Frequency[4]	Duration[5]	Cumulative effect[6]	
1.7. Non-radioactive solid waste and hazardous substances	Construction works										
	Operations										
	Decommissioning										
1.8. Solid and liquid radioactive waste	Construction works										
	Operations										
	Decommissioning										
1.9. Flora	Construction works										
	Operations										
	Decommissioning										
1.10. Fauna	Construction works										
	Operations										
	Decommissioning										
1.11. Noise	Construction works										
	Operations										
	Decommissioning										
1.12. Vibration	Construction works										
	Operations										
	Decommissioning										
1.13. Radiation	Construction works										
	Operations										

Component/ Factor	Stage	Probability of impact occurence[1]	Territorial scope of impact[2]	Type of impact			Level of impact[3]	Characteristics of impact			Reversa-bility[7]
				Positive/ Negative	Direct/ Indirect	Secondary		Frequency[4]	Duration[5]	Cumulative effect[6]	
	Decommissioning										
1.14. Staff	Construction works										
	Operations										
	Decommissioning										
1.15 Population	Construction works										
	Operations										
	Decommissioning										
1.13. Cultural heritage	Construction works										
	Operations										
	Decommissioning										

[1] expected, not expected;

[2] selected site Kozloduy NPP site, easement area, local, transboundary;

[3] **1** – very low, **2** – low, **3** – moderate, **4** – high, **5** – very high;

[4] permanent, temporary;

[5] short-term, medium-term, long-term;

[6] no/yes;

[7] reversible, irreversible.

Italic font- elements of the matrix with positive effects.

Underlined font- elements of the matrix, which are not expected to have impact or elements of expected minor negative impact.

Bold font - elements of the matrix of expected significant negative impact.

5 CUMULATIVE EFFECT

In accordance with the recommendation of the Ministry of Environment and Water (MEW) outlined in a letter of outgoing reference № OBOC-220/09.01.2013 on the necessity of establishing a separate section entitled "Cumulative effect" as part of the Report of Environmental Impact Assessment (REIA), this Chapter of the Terms of Reference (ToR) is to outline the objectives, scope, approach to be applied to the assessment of potential cumulative impacts of the investment project implementation.

5.1 KEY TASK

The main task of assessing the cumulative impact as part of the Environmental Impact Assessment (EIA) will provide an analysis and assessment of the potential cumulative effect of the investment project implementation and operations of other (present and future) facilities at the site of Kozloduy NPP and beyond it that would could arise from the summation of effects from implementation and operation (operation of units 5 and 6 of NPP with increased thermal power output to 104%), the decommissioning of units 1 ÷ 4, the dry spent fuel storage, the wet spent fuel storage and the national disposal facility for radioactive waste storage).

To achieve this objective **the scope of assessing the cumulative effects** will include an analysis of potential cumulative impacts in terms of:

- → Each of the sites evaluated separately;
- → Each component (factor) of the environment separately and in combination;
- → All identified and studied past, present and future actions on the site of Kozloduy NPP and in the urgent protective action zone with a radius of 30 km.

5.2 APPROACH

The approach that shall be applied to the assessment of cumulative effects is based on the common methodological framework presented in ***Table 5.2-1:*** .

TABLE 5.2-1: METHODOLOGICAL FRAMEWORK FOR THE ASSESSMENT OF CUMULATIVE IMPACTS

Main stages of the assessment of cumulative effects	Objectives of the evaluation of the cumulative impacts at different stages
Stage 1: Scoping the assessment of cumulative effects	• define the components and environmental factors that could be affected by a possible cumulative effect; • identify projects that are either existing, approved or in the process of approval

Main stages of the assessment of cumulative effects	Objectives of the evaluation of the cumulative impacts at different stages
	and/or development; • identify potential impacts of identified objects.
Stage 2: Analysis of cumulative impacts and determining their relevance	• assess the cumulative impact of all identified existing, approved or in the process of approval and/or development projects on the environmental components / factors; • assess the relevance of potential cumulative impacts.
Stage 3: Definition of measures to reduce, limit or prevent potential cumulative impacts	• recommend the application of specific measures to reduce, limit or prevent cumulative impacts.
Stage 4: Determining the need for follow-up actions	• identify the need to broaden the scope of the monitoring under way.

Specific approaches to be applied to the assessment of the cumulative impact of the construction of the new nuclear unit include the following:

Stage 1: Scoping the assessment of cumulative effects. At this stage the following approaches shall be applied:

→ *Identification of the components and environmental factors* that could be affected by a possible cumulative effect of the investment project:

→ *Determination of existing, approved or in the process of approval and/or development projects*, including the identification of all the objects that have spatial, functional, technical, logistical and other similar associations with the investment project within the territory of Kozloduy NPP and within the 30 km zone for urgent protective action.

→ *Identification of potential impacts of identified objects on each environmental component / factor.* This assessment will be based on an analysis of:

- ✓ Location and characteristics of existing, approved or in the process of approval and/or development sites (occupied territory, manufacturing process and technology, operation, contaminants, etc.)
- ✓ Main and supporting infrastructure (roads, railways, waterways, etc.);

- ✓ Lifetime and status of sites - research, construction, commissioning, latest plans for modernization or expansion, decommissioning, etc.;
- ✓ Permits for operation modes.

Sources of information to identify potential impacts of the sites will be:

- ✓ Spatial development plans, local and regional development plans;
- ✓ Written consultations held with the legal entities of the sites, representatives of regulatory bodies, local authorities, etc.;
- ✓ Expert reports, findings and other information.

Stage 2: Analysis of cumulative impacts and determining their significance

During this stage, the assessment will cover the potential cumulative impacts of existing, approved or in the process of approval and/or development projects on the environmental components / factors and the analysis will include:

- → Cumulative effects - the overall effect of different effects on each environmental component / factor;
- → Overlay effects:
  - ✓ accumulation of **the same** effects that can result in a new significant impact,
  - ✓ accumulation of **different** effects, which can result in a new significant impact,
- → effects over time - an assessment of possible impacts that could arise at various stages of the site implementation (construction, operation and decommissioning), which may result in a new significant impact.

The assessment of cumulative impacts and their relevance will be made taking into account the level of impact on environmental components / factors.

5.3 MAGNITUDE OF CUMULATIVE EFFECTS

The magnitude of the impact will be expressed using a matrix **- Table 5.3-1:** *Matrix to assess the cumulative impact of the construction of a new nuclear unit at Kozloduy NPP*

In order to assess the cumulative effect a 5-point scale will be applied to asses the importance of impact defined in three main groups:.

- → Red colour marks the effects of strong relevance (i.e. unacceptably high impacts);

- → Green colour marks the effects of moderate relevance (i.e. impacts that affect the component / factor, but are not damaging to it. For such impacts measures will be proposed to reduce, limit or prevent cumulative impacts;
- → Yellow colour marks effects of low relevance, as they will also be accompanied by proposed measures to reduce, limit or prevent cumulative impacts.

TABLE 5.3-1: MATRIX TO ASSESS THE CUMULATIVE IMPACT OF THE CONSTRUCTION OF A NEW NUCLEAR UNIT AT KOZLODUY NPP

RELEVANCE of impacts	LEVEL OF IMPACT				
	Very Low (VL)	Low (L)	Moderate (M)	High (H)	Very High (VH)
Very Low (1)					
Low (2)					
Moderate (3)					
High (4)					
Very High (5)					

Stage 3: Defining measures to reduce, limit or prevent potential cumulative impacts

This stage of the cumulative impact assessment of the investment project refers to the provision of measures and ways to prevent potential impacts, wherever it is impossible to have certain measures to reduce and/or limit possible cumulative impacts.

In determining the measures an iterative approach will be applied to include:

- → Assessment based on the characteristics of the investment project and all identified existing, approved or in the process of approval and/or development projects;
- → Assessment of residual impacts after the implementation of the proposed measures.

Stage 4: Determining the need for follow-up action

Based on the results and conclusions from previous stages of this phase the need will be identified to broaden the scope of the monitoring undertaken.

In terms of topsoil for the assessment of cumulative effects the following criteria shall be used:

- → In accident conditions, the limit of cesium-137 in the atmosphere, which does not impose long-term limitations on the use of topsoil and water in the Surveillance Zone is 30 TBq. The combined release of radio nuclides other than isotopes of cesium should not cause in the long run, starting three months after the accident, a greater risk than as determined by cesium in that limit;
- → The frequency of large radioactive releases to the environment in which case it is necessary to take urgent protective measures for the population should not be greater than 1.10^{-6} events per nuclear power plant a year.

In terms of waste, by comparative analysis the cumulative impacts shall be evaluated of waste generation and waste expected from the new nuclear unit. As regards radioactive waste (RAW), based on a comparative analysis of the expected radioactive waste of the investment project and the existing waste streams generated, the Report of Environmental Impact Assessment (REIA) shall estimate the expected environmental impacts, including cumulative effects, and suggest specific measures to reduce and minimize these impacts. The evaluation will cover the impact of the treatment of radioactive waste within Kozloduy NPP and the capacity of the existing storage facilities for storage and processing, including the analysis of the necessity of building new ones.

Assessing cumulative effects of environmental contamination with radio nuclides during normal operation will be carried out using a software product based on the EU-approved methodology CREAM (Consequences of Releases to the Environment Assessment Methodology) Radiation Protection 72 –Methodology for assessing the radiological consequences of routine releases of radio nuclides to the environment.

- → To assess the dose of the population from liquid releases the software program DARR-CM will be used, as adapted to the hydrology of the area of Kozloduy NPP, applying a conservative assessment of exposure dose to the critical group of the population;
- → To assess the public dose in the 30 km urgent protective action zone (UPAZ) from gaseous releases – the software program LEDA-CM, "SHIELD Normal operation" will be used as adapted to the geographical and meteorological characteristics of the area of Kozloduy NPP. The methodology takes into account both the external and internal impact of radioactive releases and the estimated annual individual effective dose, annual individual dose equivalent and the dose to critical group, as well as the collective dose to the population by age groups.

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

The modeling will use the following input data:

- → Demographic data for the area of Kozloduy NPP
- → Meteorological data;
- → Emissions into the atmosphere;
- → Emissions to water.

For air emissions it will use

- → For normal operation of the nuclear power plant: Radioactive noble gases (RNG); long-lived aerosols (LLA); I-131 (Iodine-131); H-3 total (Tritium); C-14 total (Carbon-14);
- → Average annual values of decommissioning of 1 ÷ 4 units: long-lived aerosols (LLA); Co-60; Sr-90; Cs-134; Cs-137; Pu-239, 240; Am-241;
- → Average annual values in the atmosphere from the plasma melting facility: Mn-54; Co-58; Fe-59; Co-60; Nb-95; Ag-110m; Cs-134; Cs-137.

For emissions from liquid releases into the Danube river the following will be used

- → During normal operation of Kozloduy NPP: nuclides (without H-3), Tritium (H-3);
- → Annual averages during the decommissioning of units 1 ÷ 4: nuclides (without H-3) Tritium (H-3).

After preparation of the models and their analysis there will be a summary on the readout data of the annual effective dose for the population within a radius of 30 km around Kozloduy NPP.

6 DESCRIPTION OF THE ENVIRONMENTAL HAZARDS FROM POTENTIAL ACCIDENTS AND INCIDENTS

In accordance with the basic norms for radiation protection (BNRP-2012) and the internationally accepted definitions of the events in nuclear power plants, any unplanned event (including operation error, damage to devices or equipment or other incident) as a result of which the impact (or potential impact) cannot be ignored in terms of protection and safety, and which can lead to potential exposure, is defined as an accident.

Assessment of the impact of environmental risks as a result of the investment project will be made in respect of:

- ✓ ***Design basis accident*** - in accordance with the Ordinance to ensure the safety of nuclear power plants (2004) it is an accident for which a nuclear power plant is designed according to established design limits, including the degree of damage to the fuel and the release of radioactive substances into the environment. To manage events of this class safety systems are designed;

- ***Major accident*** - in accordance with the Ordinance to ensure the safety of nuclear power plants (2004) it is an accident that causes significant damage to the core.

This chapter shall discuss radiation and non-radiation risks associated with the operation of the new nuclear unit. For the purposes of the Environmental Impact Assessment (EIA) it will study information and data submitted by the Contracting Authority on the following:

- Analysis of the sustainability of the investment project at events associated with ultimate loss of heat sink, and complete loss of external power supply, taking into account the requirements of ENSREG to stress tests in the light of the Fukushima events;
- Evaluation of the probability of core damage (with frequency of significant core damage of the new reactor lower than 1.10^{-5} events per nuclear power plant per year);
- Assessment of the probability of large radioactive release (as in frequency of large radioactive releases it is lower than 1.10^{-6} events per nuclear power plant per year);
- Evaluation of plant behavior in case of a major accident, so that for all the design basis accidents and major accidents reviewed, the changes in core geometry shall be limited in such a way as to ensure conditions for long-term fuel cooling;
- Description of technical measures in accident management;
- Comparative analysis of the proposed sites in terms of nuclear safety and radiation protection;
- Analysis of proposed sites in terms of nuclear safety and radiation protection, while taking into account the following:
  - influence of factors of technogenic and natural origin on the safety of the facility;
  - radiological impact of the nuclear power facility on the population and the environment;

- the specific characteristics of the site that are important for the migration and accumulation of radioactive substances;
- capacity to implement measures to protect the public in case of an accident at the nuclear power facility;
- • промяна на размерите на на зоните за аварийно планиране.

6.1 Radiation risks due to accidents and incidents

6.1.1 Normal and abnormal operations

In normal and abnormal operation of the new nuclear unit, as regards the critical group of the population the threshold dose for a total release of radioactive substances according to BNRP-2012 should not be exceeded.

6.1.2 Emergency situations

Assessment of emergency situations includes assessment of design basis accidents and of major accidents. These two types of emergency situations differ not only in their probability of occurrence, but also in terms of development and severity.

The potential severity of the radiological consequences of accidents is related to the level of activity of radioactive fission products inside the reactor and the level of damage to the barriers designed to ensure safety, prevent release of radioactive substances into the environment. Products of fission are located in the cooling system of the primary circuit. The total activity of the fission products in the core during operations of the reactor depends primarily on the amount of fuel in the combustion zone and the timing of the accident. In the cooling system, including the products of fission, mostly isotopes of noble gases, iodine and cesium are found, but their activity in the cooling system is one hundred thousand times lower than that of the fuel. Other isotopes, for example of Sr, Te, La, Ce, Ba, etc., are found in the cooling system in trace amounts. Therefore, the severity of radiation effects depends on the type of accident.

Design basis accidents can lead to release of radioactive substances from the cooling system of the primary loop, but activity is negligible compared to the total list of radioactive materials contained in the core. Therefore, the possible consequences of design basis accidents, compared with the consequences of major accidents, are much lower. Under the INES scale (see below), they are classified as level 3 and 4.

Major accidents result in serious damage to the reactor core. In water pressurized reactors it denotes the occurrence of an accident, which leads to melting of nuclear fuel and hence to release of radioactive substances from the reactor core containment, and subsequently into the environment. Under the international INES scale these accidents are rated as 5 to 7 level.

Requirements applicable to the design of NPP with reactors of Generation III and III +, significantly differ from reactor projects of older generation by providing expanded use of passive and special protective equipment for the prevention of major accidents and dealing with their consequences, including a corium capture concept. A major accident is only possible after repeated collapse of the power plant systems at various independent levels of protection, for example failure of the primary cooling system and subsequent prolonged failure of the external and then internal sources of electricity. New nuclear units are designed so that the probability of major accidents should be lower than 10^{-5} per reactor per year. The system of containment is designed so that during operational states and in accident conditions involving the release of radio nuclides, including major accidents, to reduce these releases to the environment, so that the radiation effects remain within acceptable limits. Due to the design and reactor containment systems, the primary loop and all related equipment, which are relevant to the nuclear and radiation safety, located in the containment to be protected against external events, the occurrence of which can not be excluded with sufficient probability. The containment system also acts as a biological shielding.

A widely recognized international standard for limiting significant release of radioactive substances into the environment is the probability of such circumstances that should be less than every one million years, i.e. 10^{-6} per reactor per year, which for the types of reactors concerned is secured by at least a tenfold margin.

Possible radiological consequences of a major accident are limited by safety requirements for new nuclear power sources in such a way that the leak of radioactive substances should not cause any serious health damage or radiation to the population in the immediate vicinity of the nuclear power plant, and should not lead to the emergence of long-term and large area effects on food chains, in the use of land or water areas. Limiting radiological consequences should lead to a situation where even in case of a major accident the new build and the need for evacuation from the area of specific protection measures and implementation of other emergency protective measures (shelters, iodine prophylaxis) outside the emergency planning zone of the nuclear power plant.

6.1.3 Characteristics of events according to the International Nuclear Events Scale INES

The International Nuclear Events Scale was introduced in 1990 by the International Atomic Energy Agency (IAEA) to facilitate reporting of safety information in case of nuclear accidents.

The scale has seven levels (degrees) of danger and one zero level, meaning no danger. The scale (***Table 6.1-1:*** *International Nuclear Events Scale INES*) is logarithmic, like the Richter scale, and each level indicates an accident, approximately 10 times more severe than the previous (lower) level.

TABLE 6.1-1: INTERNATIONAL NUCLEAR EVENTS SCALE INES

Level	Risk assessment criteria		
	People and the Environment	**Radiological Barriers and Controls**	**Defense-In-Depth**
Level 7 ***Major accident***	Major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures.		
Level 6 ***Serious accident***	Significant release of radioactive material to the environment likely to require implementation of planned countermeasures.		
Level 5 ***Accident with wider consequences***	Limited release of radioactive material likely to require implementation of some planned countermeasures. Several deaths from radiation.	Severe damage to reactor core. Release of large quantities of radioactive material within an installation with a high probability of significant public exposure. This could arise from a major criticality accident or fire.	
Level 4 ***Accident with local consequences***	Minor release of radioactive material unlikely to result in implementation of planned countermeasures other than local food controls. At least one death from radiation.	Fuel melt or damage to fuel resulting in more than 0.1% release of core inventory. Release of significant quantities of radioactive material within an installation with a high probability of significant public exposure.	
Level 3 ***Serious incident***	Exposure in excess of ten times the statutory annual limit for workers. Non-lethal deterministic health effect (e.g., burns) from radiation).	Exposure rates of more than 1 Sv/h in an operating area. Severe contamination in an area not expected by design, with a low probability of significant public exposure.	Near accident at a nuclear power plant with no safety provisions remaining. Lost or stolen highly radioactive sealed source. Misdelivered highly radioactive sealed source without adequate procedures in place to handle it.
Level 2	Exposure of a member of the	Radiation levels in an	Significant failures in safety

Incident	public in excess of 10 mSv. Exposure of a worker in excess of the statutory annual limits.	operating area of more than 50 mSv/h. Significant contamination within the facility into an area not expected by design.	provisions but with no actual consequences. Found highly radioactive sealed orphan source, device or transport package with safety provisions intact. Inadequate packaging of a highly radioactive sealed source.
Level 1 ***Anomaly***			Overexposure of a member of the public in excess of statutory annual limits. Minor problems with safety components with significant defense-in-depth remaining. Low activity lost or stolen radioactive source, device or transport package.
Level 0 ***Below scale***	No safety significance		

Until now (by 2011) there has been one accident of the seventh level (Chernobyl accident) and one accident of sixth level (accident at the Mayak nuclear complex). On 12 April 2011 the Japanese Agency for Nuclear and Industrial Safety announced "temporarily" the incident in Fukushima NPP as an incident of the seventh level.

Herein below, ***Figure 6.1-1:*** *Events on the INES Scale occurred at „Kozloduy" NPP and reported to the Nuclear Regulatory Agency*, shows the number of events for the period 2007-2011

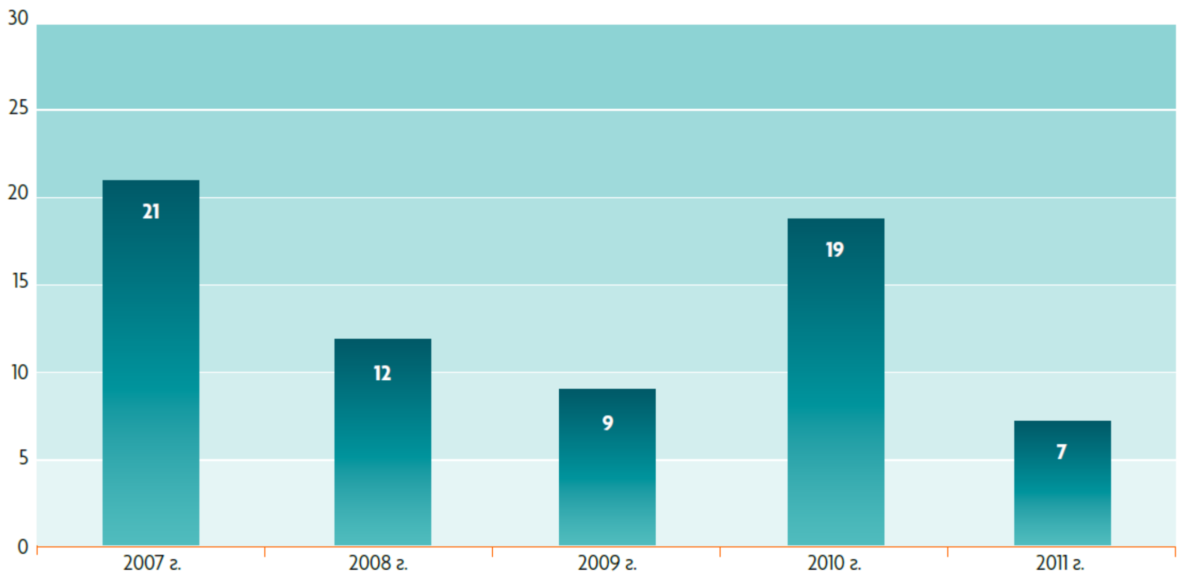


FIGURE 6.1-1: EVENTS ON THE INES SCALE OCCURRED AT „KOZLODUY" NPP AND REPORTED TO THE NUCLEAR REGULATORY AGENCY[146]

These events are as follows:

- ✓ In 2011, all seven events pertain to level "0" – Below 0;
- ✓ In 2010, all 19 events pertain to level "0" - Below 0;
- ✓ In 2009, there were nine operational events, including 7 reported at "0" (tolerance) under the INES scale, and 2 events off the scale. No events listed at "1" (anomaly) or higher on a INES scale.;
- ✓ In 2008 - one of 12 reported operating events is estimated "Below" the International nuclear events scale INES, and 11 were classified as level "0" (tolerance) – under the INES scale;
- ✓ In 2007 - a total of 21 operational events were registered, two were rated "off" scale, and 19 were classified as level "0" (tolerance) - in INES scale.

For the entire period of operation of the existing facilities (about 150 reactor / years) at Kozloduy NPP, no events have been registered higher than level 2 under the INES scale. Generally, the recorded and reported events total 52 of Level 1, and two Level 2 events. No additional radiological impacts off-site Kozloduy NPP have been established for all these events.

6.1.4 CHARACTERISTICS OF THE RADIATION RISK TO THE ENVIRONMENT

After release of radioactive material from a nuclear power facility, the population is directly threatened by the moving cloud of leaked radioactive gases and aerosols. The cloud is the source of both external and internal radiation, which can be reached as a result of inhalation of radioactive substances.

The movement of the cloud leads to gradual deposition of radioactive aerosols and topsoil contamination. The extent of topsoil contamination also depends on whether during the cloud movement there is rain. Contamination of surface aerosol radio nuclides has the potential to cause long-term contamination of the environment. In terms of risk to public health, the probability of transfer of nuclear activity in the food chain should be taken into account, resulting in internal radiation through the so-called ingestion – i.e. primarily through consumption of contaminated agricultural products.

The risk associated with the possible consequences of radiation event (i.e. the event having the effect of uncontrolled release of radioactive substances into the environment)

[146] Annual reports of Kozloduy NPP EAD for 2007, 2008, 2009, 2010 and 2011.

can be assessed within the scope of the necessary measures to protect the endangered population and according to the degree of contamination in the affected environment.

Limitation of human exposure and environmental radiological situation is through the provision of protective measures, such as:

- ✓ immediate protective measures, including the use of shelters, iodine prophylaxis and evacuation;
- ✓ further protective measures, including evacuation, limiting the use of contaminated food, water and forrage.

Urgent protective measures should always be considered justified if the assumed exposure of an individual may lead to imminent danger for his health.

The actions planned for Kozloduy NPP site are included in the emergency response plan of the plant.

The EIA-R shall assess the extent of the required update of the Emergency Plan as a resuls of the construction of a new nuclear facilitiy.

6.1.5 ACCIDENT EVALUATION METHODS

The methodology of accidents evaluation consists of the steps listed below - determination of the source of radiation and analysis of the spread and impact of radioactive substances on components and environmental factors. Data and information required for this assessment will be provided by the Contracting Authority.

6.1.5.1 SOURCE ELEMENT

For the purpose of safety analyses, the current conservative approach requires that the source element is defined so that the radiological consequences will have sufficient safety margin. For the purpose of the Environmental Impact Assessment (EIA) the assumption of radiological consequences can be more general, given that it would be done with an adequate margin and a detailed evaluation of the specific design solution will be made in the Preliminary Safety Report.

6.1.5.2 QUALITATIVE DETECTION

From the results of international studies of accidents where the proportion of individual radio nuclides in radiological consequences is estimated, the following main groups of decay products should be taken into account:

- noble gases (mainly Xe-133 with half-life of 5.2 days) - a source of external humanexposure from the radioactive substances cloud spreading,; it is not so significant;
- iodine (mostly I-131 with half-life of 8.0 days) - enters the body through breathing, deposited mainly in the thyroid gland and its share is significant in terms of short and medium term effects of the accident unless its deposition in the thyroid gland is blocked by timely intake of potassium iodine;
- cesium (mainly Cs-137 with half-life time of 30 years) – it is the main long-term source of external and internal exposure of persons involved in accidents as a result of contamination of the ground and the other environmental elements (water, flora), and contamination of certain foods from the food chain;
- other products of radioactive decay (especially Te, Sr, La, Ce, Ba) and actinides in smaller quantities, are negligible indesign basis accidents, and in case of major accidents they are less relevant than cesium, yet, especially during the first year after the accident, their share in the exposure of persons and environmental elements and food should be taken into account.

Given the above, it can be concluded that it is important for the comprehensive assessment of the immediate threat to human health in the vicinity of the nuclear power facility, to add to the source elements representatives of all groups of radio nuclides, such as: Xe-133, I-131, Cs-137 , Te-131m, Sr-90, La-140, Ce-141 and Ba-140. Calculations made will render it possible to assess the radiological consequences of potential accidents for a given source and region.

For the characterization of environmental risk in terms of long-term environmental burden to the environment, particularly in the case of a design basis accident, a suitable simple element of this source is formed only by the following radio nuclides: I-131, Cs-137, possibly Sr-90 as well.

The source element in this case is based on the extraction of decay products and activation products from nuclear reactions in the fuel with UO_2, enriched with U-235, which is used in all PWR reactors. The presence and proportions of various important radio nuclides are determined by objective laws of physics and are independent of the particular design of the reactor or its suppliers. It is possible, before the completion of the selection procedure for a specific model for the new nuclear unit, to determine the radionuclide groups whose presence in the source will be decisive for the safety analysis results. This will allow sufficient accuracy to assess the radiological consequences of the entire list of radio nuclides released into the environment as a result of the accident.

Release of decay products from molten fuel in case of a major accident depends mostly on their chemical and physical form. It is assumed that in the high temperature of the molten fuel in the containment, fuel will release up to 75 - 100% of noble gases, iodine and cesium (in design basis accidents - from 1,000 to 100 times lower), while for other radio nuclides – the release is 10,000 to 1000 times lower. Only a fraction of the activity of the fuel decay products may be released in the environment in case of a major accident with intact containment, depending on a number of factors (technical, structural).

The total amount of radioactive substances that could leak into the environment depends on the quality of individual engineering barriers and their current status at the time of the event.

With all units surveyed, the containment is equipped with a special system so that it does not result in the loss of integrity even in major accidents. Core cooling and heat removal from the containment is provided so that the containment remains intact during the accident and for hours afterwards.

6.1.6 RELATION TO CURRENT EMERGENCY PLANNING ZONES

The investment project for the construction of the new nuclear unit provides for PWR units of Generation III and III+ , with a degree of safety barriers that in the event of a radiation accident, which may occur with probability 10-6/year, the possible release of radioactive substances at a distance greater than 800 meters from the reactor does not require evacuation of the population.

Specific conditions in the area of Kozloduy NPP, such that the closest populated area significantly exceeds the perimeter of 800 meters from the future reactor building depending on the final siting, distances reach about 3 kilometers. Hence, the area where the greatest threat could reach is not populated. Within the territory of Kozloduy NPP there are zones for emergency planning (dose), which are defined and supported by procedures and measures in the emergency plan of the plant. In addition, the analysis of the operational experience of Kozloduy NPP indicates that the plant has established a high administrative capacity, including its response to accidents and incidents. Kozloduy NPP documents have been produced, which regulate procedures and responsibilities for reporting, analysis of operational events, and assigning and monitoring the implementation of corrective measures in accordance with the rights, duties and responsibilities of Kozloduy NPP, arising from the Safe Use of Nuclear Energy Act (SUNEA), the Ordinance of the Nuclear Regulatory Agency concerning the procedures for notification of NRA of events for nuclear facilities and sites with sources of ionizing radiation (hereafter referred to as Ordinance), and as a "nuclear operator" and "license holder for the operation of nuclear facilities." Procedures for the use and dissemination of operating experience have been developed and implemented to regulate the terms of:

- dissemination and use of information from internal and external operating experience (OE);
- to inform the nuclear community of events occurring in Kozloduy NPP through the World Association of Nuclear Operators (WANO).

The Environmental Impact Assessment (EIA), based on the analyses conducted, will assess whether it is necessary to make changes to the boundaries of the preventive and protective action zone.

6.1.7 6.4.1. Radiation hazards during the preparation and the investment project implementation

Construction and structural activities during the preparation and the investment project implementation for the new nuclear unit have the character of radiation activity.

The Environmental Impact Assessment (EIA) shall assess whether the nuclear safety of these units of the new nuclear power capacity will not be affected in the course of building and structural works.

6.1.8 Radiation hazards during decommissioning of the new nuclear power capacity

With the decommissioning of the new nuclear unit, nuclear fuel will first be shifted to the reactor pool. The systems will be gradually cooled and released from pressure, dried and decontaminated, which will limit the potential sources of risk from radiation contamination. Activities carried out during decommissioning will take place to ensure nuclear safety, radiation protection, emergency preparedness and physical protection, based on the applicable / relevant at the time permits and applicable laws. In this regard, the risk to the environment and human health compared to the previous operation of the new nuclear unit is expected to be significantly lower.

6.2 Non-radiation risks from accidents and incidents

6.2.1 Non-radiation risks during the operation of the new nuclear unit

Operations of the new nuclear unit after the extension of the nuclear power plant, are not a risk factor in the probability of emergency occurrence that could have significant negative consequences on the environment and the population.

In connection with the operation of the new nuclear unit, certain emergency situations related to leakage of polluted waste water should not be excluded (in case of a damage of the sewerage sealing, or disfunction of the treatment plants and equipment), leakage of stored substances (chemicals, combustible materials, lubricants, cleaners and the like) from the tanks or pipelines for transport. There is a risk of fire incidents as well.

The abovementioned risks for the occurrence of emergency situations are characterised with low probability of impact. Nevertheless, the Report of Environmental Impact Assessment (REIA) will assess the need for the implementation of specific preventive or recovery measures beyond those which are customary or specified by the relevant construction, safety, fire, transportation or other regulations.

6.2.2 NON-RADIATION RISKS DURING THE PREPARATION AND IMPLEMENTATION OF THE NEW NUCLEAR UNIT

The above described risks during the operation of the new nuclear unit may relate to the period of preparation and implementation of the investment project. Standard risks in the performance of construction works, respectively, structural works, are eliminated by resources and other requirements typical for this type of activities.

6.2.3 NON-RADIATION HAZARDS DURING DECOMMISSIONING OF THE NEW NUCLEAR UNIT

Risks during decommissioning of the new nuclear unit will not outweigh the risks during the preparation and implementation of the investment project, and in this case it should not be expected to apply different than the usual measures.

7 MONITORING

Monitoring (surveillance) as a mechanism is directly related to the management, development and decision-making related to the activities of each economic entity. Environmental monitoring as part of other governance programs is a proven tool in the modern understanding of good planning and efficient operation of any production.

7.1 NON-RADIATION MONITORING

Kozloduy NPP has introduced and successfully operates its own non-radiation monitoring, radio-ecological monitoring, and control plant environmental monitoring. The purpose of the non-radiation monitoring is to maintain compliance with regulatory requirements and the conditions in the permits issued by the Ministry of Environment and Water, Executive Environment Agency (EEA), and River Management Basin Directorate and the Regional Inspectorate for Environment and Water (RIEW) in Vratsa. The KNPP developed and established its own Program to control non-radiation monitoring. It covers 20 indices for the quality of discharged waste water from the plant as per the international environmental standards, also stated in the issued permits by the Basin Directorate, and for the indicators of groundwater. The results show that there is no upward trend in the values of the controlled parameters and no significant excesses were registered above the permissible limits. Values are comparable in recent years. Annual reports are available in the Executive Environment Agency (EEA) and the Regional Inspectorate for Environment and Water (RIEW) in the town of Vratsa. Corporate control is undertaken through regular inspections and internal controls. Institutional control of non-radiation monitoring is performed throughout the year by authorities of the Ministry of Environment and Water (MEW), Danube River Basin Directorate and the Regional Inspectorate of Vratsa.

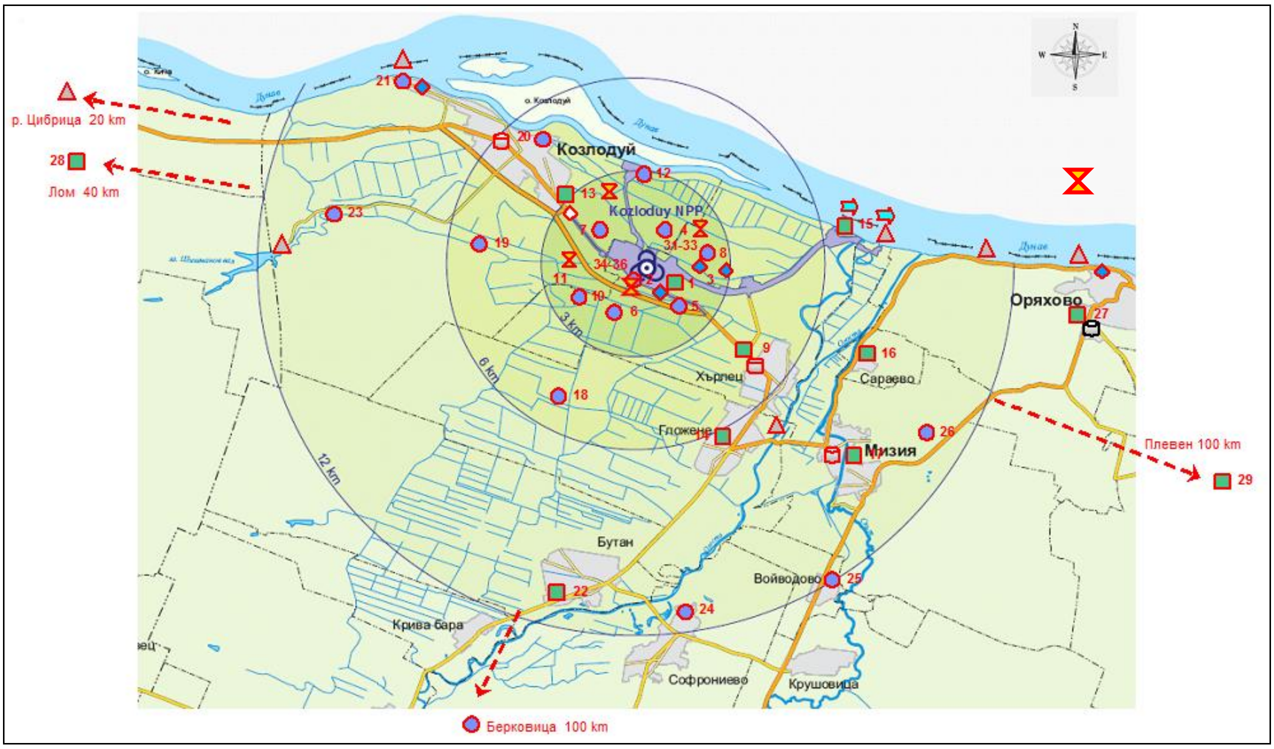
Under a schedule approved by the Ministry of Environment and Water for automatic mobile stations (MAS) for further measurements in areas where there is none or a limited number of fixed points, the Pleven Regional Laboratory takes measurements for air quality monitoring in ROUKAV North / Danube of Kozloduy Municipality every few years - the latest measurements were taken in 2008 and in 2011.

7.2 RADIATION MONITORING

The radioecological monitoring performed by Kozloduy NPP covers all environmental components - air, water, topsoil, vegetation, crops, typical foods produced in the area, etc.

European requirements for the application of Article 35 of the Euratom Treaty for monitoring levels of radioactivity in the environment for the assessment of radiation exposure of the population as a whole is regulated by the European Commission Recommendation 2000/473/Euratom, 08.06.2000, as this recommendation is essential to standardize and unify the applied practices of radioecological monitoring in EU member states. It defines the terms and general requirements and the types of monitoring, network monitoring and sampling (dense and diluted), frequency of testing, monitoring and volume requirements for sampling and analysis of the main objects of the controlled environment. Regulated are also the volume of the supporting information to the sample, the management and communication of monitoring data.

The institutional radiation monitoring of the environment is governed by the long-term environmental radiation monitoring program of Kozloduy NPP. The program is based on the legal requirements in this sector, as well as on international best practice and the operational experience of the Radiation Monitoring Department. The program is coordinated by the Ministry of Environment and Water (MEW0, the Ministry of Health (MH) and the Nuclear Regulatory Agency (NRA) and is in line with international recommendations in the field, namely Article 35 of the Euratom Treaty and Recommendation 2000/473/EURATOM. To ensure independent control, radiation monitoring programs are implemented by the control authorities of the Executive Environment Agency (the Ministry of Environment and Water (MEW) and the National Center of Radiobiology and Radiation Protection (NCRRP) / the Ministry of Health.



Description:

– outpost type "A": aerosols, atmospheric deposition, topsoil, vegetation, gamma background (TLD) - 11 units

– outpost type "B": atmospheric deposition, topsoil, vegetation, gamma background (TLD) – 15 units

– outpost type "C": water, sediments, algae, gamma background – 7 units

food chain products: - drinking water; - milk; fish; - cereals

FIGURE 7.2-1: LAYOUT OF RADIATION MONITORING STATIONS AROUND KOZLODUY NPP

To locate and assess the possible impact of Kozloduy NPP on the environment and the population around the plant there are two distinct zones of control with different radii: Preventive Protective Action Zone - the area of specific protection measures (2 km); and Supervised zone (30 km). The monitoring covers the industrial site itself. Sampling and measurements are carried out for comparison at benchmark stations within up to 100 km around KNPP, where no influence of the plant operations is expected. Laboratory and automated control is performed on the environmental components.

In the 30km protective action zone there are 36 control outposts for terrestrial ecosystem and 7 stations for the water ecosystem, where the sampling for laboratory analysis and measurement of the activity of technogenic radio nuclides in the samples take place. Samples of the air, topsoil, vegetation, water and bottom sediments are analysed and the radiation background is measured. Beyond those stations, samples of drinking water, milk, fish, agricultural grain crops and forage crops in the region are analysed. The location and type of control outposts is given in ***Figure 7.2-1:*** *Layout of radiation monitoring stations around Kozloduy NPP.*

Besides radioecological monitoring within the 100 km zone around the nuclear power plant radiation measurements are carried out on the industrial site. Subject to control are the radiation background, groundwater, air, atmospheric deposits, vegetation and topsoil.

Water samples from more than 115 boreholes are analysed four times a year for total beta activity and tritium content.

The frequency of sampling is consistent with the design requirements and the long-lastingexperience in radio-ecological monitoring of KozloduyNPP and the international practice of other countries.

Benchmark radio nuclides are fission products and activated corrosion products whose ingestion through the ambient air, drinking water and food or objects from falling into the environment (the food chain) would cause additional internal exposure of the population.

The methods used are standardised and validated by practical methods, such as gamma spectrometry, low background radiometry of total beta activity and radio chemically isolated radiostrontium, liquid scintillation spectrometry of tritium and alpha spectrometry trans-uranium elements. Generally, these are methods well tested in practice, organised in analytical procedures for environmental samples used by leading laboratories worldwide and recommended by IAEA.

Practice shows that the results of radioecological monitoring have values significantly lower than those established by the regulations. For this reason, the current results are compared against those obtained from previous years of operation, and the results measures before the commissioning of the nuclear power plant. This approach allows recording and analysing even the smallest change in the trends of radiation background.

Implementation of the radiation monitoring program has been verified by self-assessment criteria - fulfillment of the pre-set volume, with guaranteed reproducibility and accuracy of results. The accuracy of the analysis is verified repeatedly in national and international prestigious laboratory comparisons of the World Health Organisation (WHO), the Federal Office for Radiation Protection of Germany (BfS), the International Atomic Energy Agency (IAEA) and the National Physical Laboratory in the UK (NPL). The results of plant radiation monitoring are annually verified by independent research and by the National Center of Radiobiology and Radiation Protection (NCRRP) with the Ministry of Health (MH). The main findings are published for the general public.

In pursuance of the provisions of Article 15 of the Ordinance on the procedures for determining areas with special status around nuclear facilities and sites with sources of ionizing radiation, approved by Decree of the Council of Ministers № 187 of 28.07.2004, KozloduyNPP has built an automated information system for radiation monitoring (AISRM) of settlements within the 30 km zone of the plant. The system covers 13 villages, and at appropriate public places stationary information boards are placed to show the real-time dose rate of local gamma background. Local measuring stations (LMS) are located in urban areas: the town of Kozloduy, village of Harlets, village of Glozhene, village of Butan, town of Mizia, village of Oryahovo, village of Selanovtsi, village of Tarnava, village of Hayredin, village of Mihaylovo, town of Valchedrum, village of Zlatiya and village of Stanevo. The data is automatically transmitted via a GPRS channel to the server at Kozloduy NPP, which manages and archives information and provides access for visualization and references at the NPP (Radiation Monitoring Department) and to the Executive Environment Agency (EEA) with the Ministry of Environment and Water (MEW).

The results of the automated information system radiation monitoring (AISRM) of urban settlements within the 30 km protection zone around the plant indicate a gamma background in the normal range of natural background radiation for the region. Pooled results for the settlements located nearest to KozloduyNPP for 2011 are given in ***Table 7.2-1.***

TABLE 7.2-1: DATA FROM AISRM OF THE RADIATION BACKGROUND IN THE 30 KM ZONE IN 2011

Radiation gamma background, μSv/h

Period	Local monitoring station – Kozloduy	Local monitoring station– Harlets	Local monitoring station– Glozhene	Local monitoring station– Butan	Local monitoring station– Mizia
I quarter 2011	0.098	0.099	0.076	0.104	0.081
II quarter 2011	0.098	0.097	0.075	0.103	0.078
III quarter 2011	0.097	0.097	0.074	0.103	0.075
IV quarter 2011	0.098	0.098	0.075	0.103	0.080
2011, min-max	0.07 ÷ 0.13	0.07 ÷ 0.14	0.05 ÷ 0.12	0.07 ÷ 0.13	0.05 ÷ 0.12

In conclusion it can be said that the results of measurements of the radiation background in the control outposts and urban settlements within the 30 km area within natural background for this geographic area - 0.05 ÷ 0.15 μSv/h.

The Ministry of Environment and Water performs a surpa-institutional radiological monitoring in the 30 km area around KozloduyNPP. The radiological monitoring consists of continuous and periodic monitoring of the following indicators:

- Radiation gamma background;
- Atmospheric radioactivity;
- Content of technogenic radio nuclides in arable topsoil;
- Radiological indicators in surface waters in the 30km protection zone around KozloduyNPP and treated water discharges from the plant;
- Content of technogenic radio nuclides in bottom sediments.

7.2.1 ON-LINE MEASUREMENTS OF THE RADIATION BACKGROUND

Background radiation data are obtained in real time from local monitoring stations of the National automated continuous monitoring of radiation background.

The system has integrated 8 automatic stations from the environmental monitoring of KozloduyNPP, located within 1.8 km radius from the plant, and thus ensuring continuous monitoring of the background radiation levels in the area.

Monitoring of stations within the 30 km zone: Hayredin, Valchedram, Oryahovo and within the 100 km zone of Vratsa, Montana and Knezha, shows that the average monthly values of the dose rate in 2009 ranged from 67 nGy/h (Oryahovo) to 99 nGy/h (Vratsa) and did not exceed the background levels typical for the stations.

The radiation situation in the area is stable and unchanged due to impact from KozloduyNPP.

7.2.2 ATMOSPHERIC RADIOACTIVITY SPECIFICATION

The Ministry of Environment and Water measures twice a month aerosol samples (volume> 900 m3), obtained by way of automatic sampling in Vratsa and Montana to analyse the specific radioactivity of long-lived radio nuclides (LLA).

The analysis of data from automatic stations **has not found** above-background rates of measured radionuclide values typical of the surface air in this geographical area, while the technogenic data for ^{137}Cs are within the MDA. No presence of other anthropogenic radio nuclides has been indicated.

The Executive Environment Agency receives monthly reports of ongoing departmental monitoring of gaseous releases from KozloduyNPP in the environment.

The plant aerosol monitoring by KozloduyNPP includes a study of radioactivity in the ambient air twice a month in 11 outposts within the 100 km zone around the nuclear power plant and 3 control outposts on the industrial site. Radioactivity of the ambient air is controlled by a new generation of high-tech devices for continuous high capacity aerosol sampling (80÷100 m3/h), digital control and storage. For comparability, results are translated to standard atmospheric conditions. Analysed aerosol filters for large volumes of the ambient air (10,000 ÷ 20,000 m^3) show results well below the established standards (Ordinance-BNRP 2012). Technogenic radioactivity of ^{137}Cs in aerosols of control outposts within the 100 km area with background values below the minimum detectable activity (MDA) - an average of 2.8 μBq/m3. Registered radioactivity of ^{137}Cs in the ambient air is about 105 ÷ 106 times lower than the reference values (^{137}Cs according to BNRP-2012 was 3.2 Bq/m3). Until April 2009 the total beta activity of aerosol samples was surveyed. For 2009, average total beta activity in long-lived aerosols for various positions was in the range 0.50 ÷ 0.68 mBq/m3. The results are consistent in a narrow range over the years.

Radioactivity of atmospheric deposition (sludge) is examined monthly in 33 control outposts within the 100 km zone around the plant. In 2011, total beta radioactivity of atmospheric deposition for all 33 stations ranged 0.058 ÷ 1.96 Bq/(m2.d), with an average 0.43 Bq/(m2.d). The measured values by sector and the benchmark positions within the 100 km zone are very low, in the range of 0.1 x 1.8 mBq/(m2.d) versus the average of 0.7 mBq/(m2.d) for all 33 outposts. The gamma spectrometric measurements show values for background levels of radioactivity of ^{137}Cs to 0.024 Bq/(m2.d).

All in, the radioactivity of ambient air (aerosols and deposition) within the 30 km protection zone to the 100 km area has normal background levels.

7.2.3 *RADIOLOGICAL MONITORING OF TOPSOIL*

The Ministry of Environment and Water (MEW) has examined surface, arable topsoil layer (0 ÷ 5 cm) at quarterly intervals to determine the specific activity of natural and anthropogenic radio nuclides in the 26 control outposts of the surveillance zone of the plant. The measured specific activity of technogenic radionuclide 137Cs in the surface layer at these points ranged from 0.5 Bq/kg (Mizia) to 51.2 Bq/kg (village of Selanovtsi) and is assessed as a result of the global deposition after the Chernobyl accident. During the year there was no presence of other technogenic radio nuclides.

A comparative analysis with observations from previous years and outposts from other regions of the country found that no impact on the radiation status of topsoil has been reported resulting from the operations of the Kozloduy Nuclear Power Plant.

Radioactivity of the topsoil in the vicinity of KozloduyNPP is subject to detailed and systematic studies since the plant commissioning in 1974 to date. Under the Departmental Radio-Ecological Monitoring Program sampling is carried out within the

100 km zone and analysis is performed on topsoil from 36 control outposts. Sampling is done near the control outposts, possibly from non-arable land, 5 cm from the surface layer. It examines the contents of long-lived anthropogenic radio nuclides typical for WWER reactors - ^{90}Sr, ^{134}Cs, ^{137}Cs and others, of air-dry weight (a.d.w.).

For 2011, the results for ^{90}Sr are within 0.22 ÷ 3.97 Bq/kg a.d.w., while the annual average content for all 36 control outposts is 1.33 Bq/kg a.d.w. The activity of ^{137}Cs in the studied topsoil ranged from 1.55 to 45.4 Bq/kg a.d.w., the average value for 2011 was 13.1 Bq/kg a.d.w. It is observed that in some of the stations, the ^{137}Cs content is significantly lower than the average. This occurs when the land is partially or fully cultivated. The registered technogenic activity in the environment area of the 100 km zone has a transboundary nature due to the global depositions and is relatively low compared to other regions in the country. It is the result of natural self-cleansing of the atmosphere following nuclear weapons tests and the nuclear accident at the Chernobyl NPP.

7.2.4 RADIOLOGICAL MONITORING OF VEGETATION

Vegetation (grass) is examined four times a year in the outposts in the town of Kozloduy, and the villages of Harlets and Oryahovo (gamma spectrometry and ^{90}Sr), twice a year at the plant site (gamma spectrometry) and in the stations in Lom, Pleven and Berkovitsa (gamma spectrometry, ^{90}Sr once a year). Sampling is done very close to the places where topsoil samples are taken. Samples are analysed on air-dry weight (a.d.w.).

In 2011, the results obtained for the content of ^{90}Sr in vegetation are within 0.23 ÷ 1.15 Bq/kg a.d.w., with an average 0.54 Bq/kg a.d.w. The activity of ^{137}Cs in vegetation in 2011 is within 0.78 <MDA <2.55 Bq/kg a.d.w. Radioactivity in samples is within normal rates for these species.

7.2.5 RADIOLOGICAL MONITORING OF SURFACE WATER

The plant radioecological monitoring examines the radioactivity of water along the Danube river and inland rivers and ponds near the nuclear power plant - Ogosta, river, Tsibritsa river and Kozloduy dam. As a recipient of the liquid releases from the nuclear power plant, particular attention is paid to the Danube river, along the course of which there are 4 control outposts - one upstream, and 3 downstream the nuclear plant.

Weekly sampling of water is done from the three control outposts along the water intake of the Danube river, then pooled monthly samples are analysed. Samples from the locality of Batatovets along the Danube river are taken twice a year, and on inland waters - once a year.

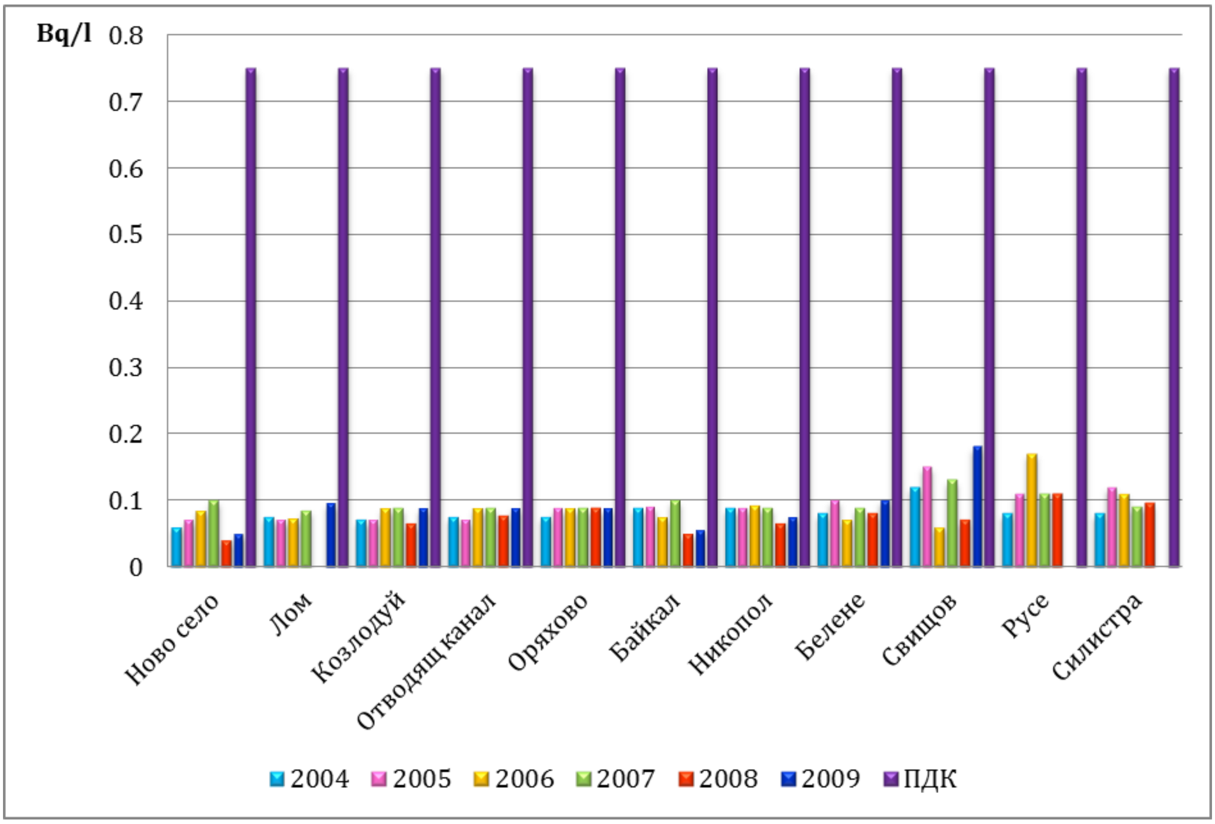
The results are within normal limits typical of natural waters: total beta activity <0.012 ÷ 0.15 Bq/l, average yearly - 0.056 Bq/l, activity of ^{90}Sr - 0.9 ÷ 3.9 mBq/l, average yearly

- 1.8 mBq/l, activity of ^{3}H - <4.0 ÷ 22.3 Bq/l, average yearly - 7.2 Bq/l, activity of ^{137}Cs - <0.3 ÷ 1.1 mBq/l, average yearly - 0.6 mBq/l. The total beta activity measured in the open water reservoirs is only 30% of the control level (0.5 Bq/l, Ordinance № N-4/2012 years). For the Danube river, the maximum measured value is 0.087 Bq/l.

Operations of KozloduyNPP have had no perceptible impact on the radioecological status of the water of the Danube river and other waterways in the area. The results are within normal limits for natural water bodies, many times below the established norms.

The Ministry of Environment and Water monitors the radiological parameters in the water of the following rivers: Danube, Osam, Iskar, Leva, Ogosta, Timok, Tsibritsa flowing within the 100 km zone of the plant.

Data analysis for total beta activity of water from the Danube river (from Novo Selo to Silistra), compared with the results of the outlet canal of Kozloduy NPP in the period 2004-2009 (***Figure 7.2-2:*** *Total beta activity of the Danube river in the period 2004-2009, Bq/l*), showed values significantly below the limit specified in the regulations for the quality of surface water (0.750 Bq/l). This conclusion applies to the other studied rivers in the area.



Source: Executive Environment Agency

FIGURE 7.2-2: TOTAL BETA ACTIVITY OF THE DANUBE RIVER IN THE PERIOD 2004-2009, BQ/L

Subject to monthly control are the treated water discharges from units 5 and 6 - clean and radiologically controlled area, the treated water discharges from units 1÷4, water from the intake and outlet canals, water from the old canal "Valyata", the new "Valyata" canal, and water from the Danube river, upstream and downstream the plant – at the ports of respectively Kozloduy and Oryahovo.

The Executive Environment Agency receives monthly reports on the size and activities of treated water discharges as a result of the ongoing plant radiological monitoring.

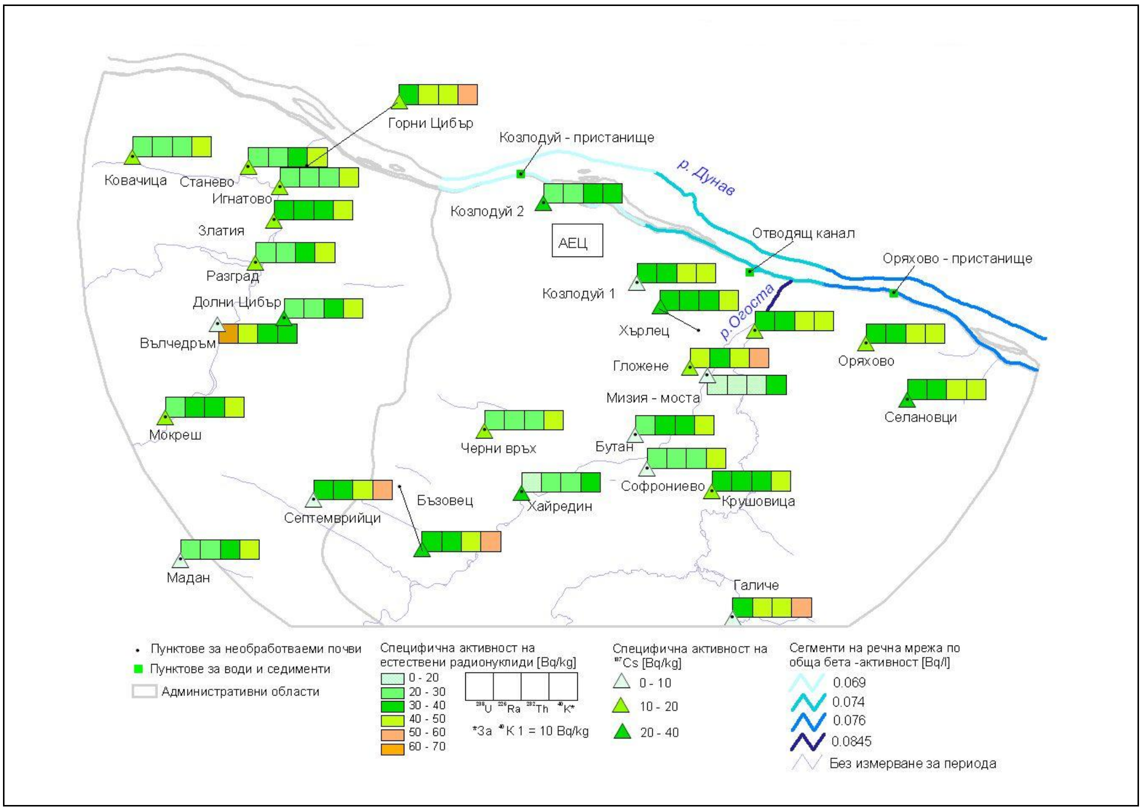
Analysis results are commensurate with data reported in previous years and show no change in the radiological characteristics of the Danube river on Bulgarian territory, due to the activity of KozloduyNPP.

7.2.6 RADIOLOGICAL MONITORING OF SEDIMENTS

Specific activities of natural and artificial radio nuclides in sediments are identified every three months at outposts located along the Danube river - from Novo Selo to Silistra, including the "outlet" channel of NPP – at the locality of "Batatovets." The measured values of the specific activity of the technogenic ^{137}Cs in these samples during the year ranged from 0.46 Bq/kg (Baykal) to 12.3 Bq/kg (Oryahovo).

During the year there was no presence of other anthropogenic radio nuclides in sediments.

The radiological monitoring performed by the Ministry of Environment and Water (MEW) in 2009 in the 30 km protection of KozloduyNPP is indicative of the overall status of the radiation environment in the region (***Figure 7.2-3:*** *Radiological status of the environment in the 30 km protection area of KozloduyNPP for 2009*).



Source: Executive Environment Agency

FIGURE 7.2-3: RADIOLOGICAL STATUS OF THE ENVIRONMENT IN THE 30 KM PROTECTION AREA OF KOZLODUYNPP FOR 2009

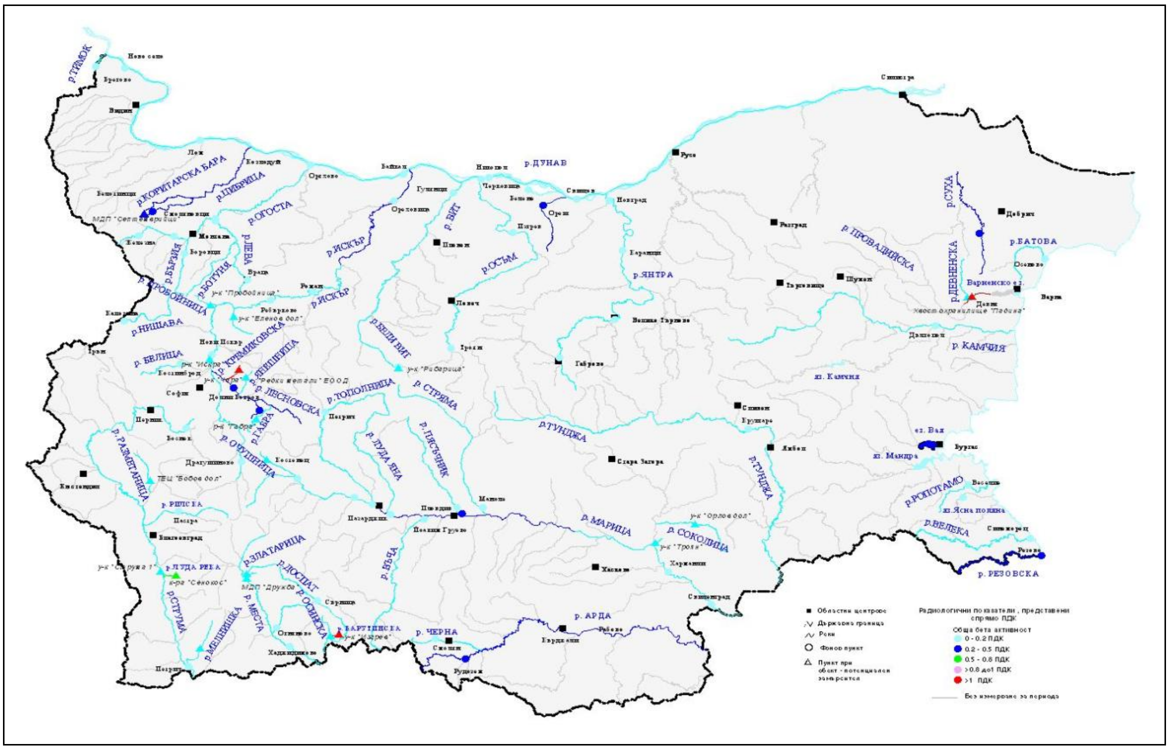
Data for 2009, compared with the radiological monitoring outcomes from previous years, showed no adverse trends in the radiation and environmental status of the environment resulting from the plant operation.

In 2010, systematic monitoring of the radiation situation was carried out in 84 outposts in the basins of major rivers and other water bodies in the country and in eight outposts along the Danube river.

Data analysis for total beta activity of water in the Danube river and other major rivers, dams and lakes found values significantly below the maximum permissible concentration (MAC) (Ordinance № 7/1986 on the benchmarks and standards for determining the quality of running surface water MAC-0.75 Bq/l).

The trend shows that radiological indicators, as compared against those in previous years, have preserved their values specific to the particular monitoring station in the country. This is indicative of the lack of contamination of this environmental component.

Radiological characteristics data of surface water, resulting from the ongoing radiological monitoring carried out by the Executive Environment Agency in 2010, are presented in ***Figure 7.2-4:*** *Total beta activity in surface waters in 2010, Bq/l.*



Source: Executive Environment Agency

FIGURE 7.2-4: TOTAL BETA ACTIVITY IN SURFACE WATERS IN 2010, BQ/L

Analysis results are commensurate with data reported for previous years and show no change in the radiological characteristics of the Danube river on Bulgarian territory due to the activity of KozloduyNPP.

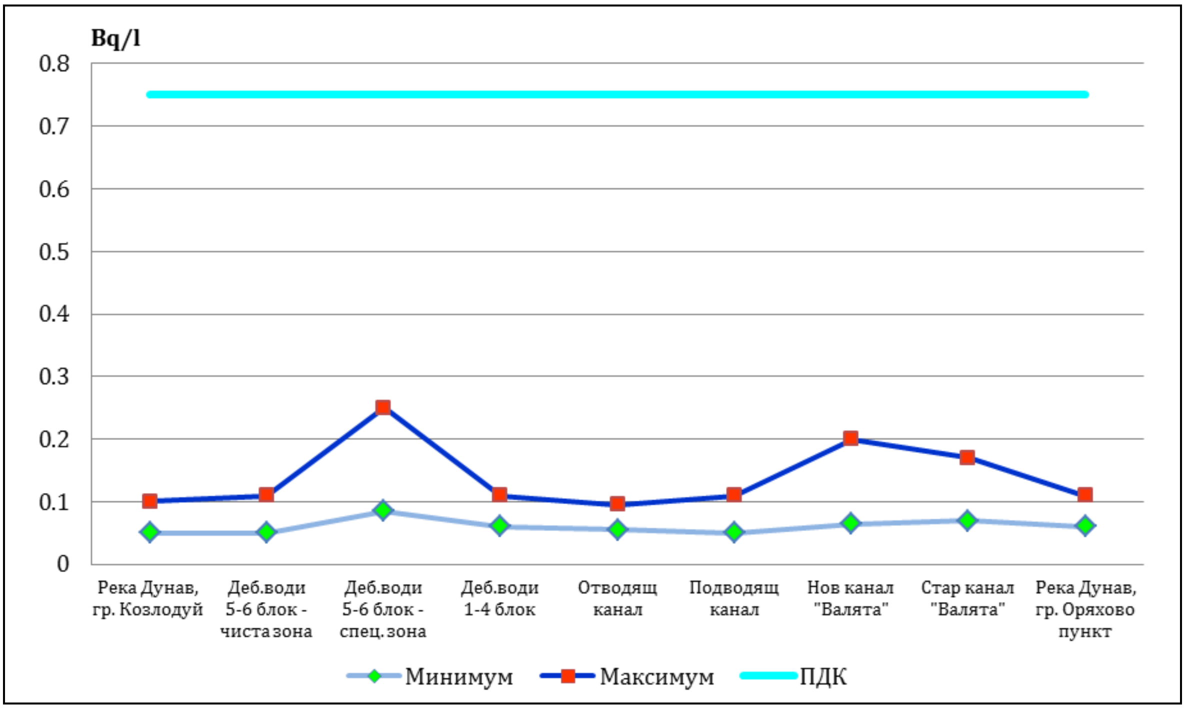
In 2010, no presence of other technogenic radio nuclides in sediments was observed.

7.2.7 GASEOUS RADIOACTIVE AEROSOL RELEASES

To assess the impact of gaseous releases, objects of the terrestrial ecosystems and the inland river ecosystem in the region of KozloduyNPP are monitored. During the whole period of observation no noticeable qualitative changes in the radioecological status have been recorded as a result of gaseous radioactive releases from the plant. Technogenic radioactivity of environmental objects is due to the presence of ^{90}Sr and ^{137}Cs at concentrations typical of the natural background due to global atmospheric deposition and contamination of the environment as a result of the Chernobyl accident.

7.2.8 LIQUID RADIOACTIVE RELEASES

All the deviations observed from the normal radiation status have been negligible in absolute terms, and an upward trend was not reported. In 2010, no presence of technogenic radio nuclides of reactor origin was registered - ***Figure 77.2-1***: *Total beta activity of trteated water dischargesfrom KozloduyNPP for 2010, Bq/l*



Source: Executive Environment Agency

FIGURE 77.2-1: *TOTAL BETA ACTIVITY OF TRTEATED WATER DISCHARGESFROM KOZLODUYNPP FOR 2010, BQ/L*

7.2.9 RADIOLOGICAL MONITORING OF AGRICULTURAL PRODUCTION

The plant monitoring of KozloduyNPP covers surveying of major types of forrage crops produced within the 3km area – including barley, wheat, corn, sunflower, etc. All samples are subject to separate analyses of grain and straw (heads, cobs). The analysis methodology is similar to that used in the analysis of vegetation. The total beta activity dominates in straw (heads, cobs) and varies within normal range - 98.7 Bq/kg a.d.w. in grain maize to 1083.0 Bq/kg a.d.w. in sunflower heads. Higher values measured in silage (straw, heads, cobs) than in the grain core of the analysed products is determined by the distribution of radio nuclides in different parts of the crops.

The results of the gamma spectrometric measurements show that the registered total beta activity in samples is almost entirely due to natural ^{40}K - 550 Bq/kg a.d.w. on average. In 2011, like in previous years, excessive background activity of ^{137}Cs was not reported, nor for other anthropogenic radio nuclides (for ^{137}Ss norms are 0.23 <MDA <1.75 Bq/kg a.d.w.). Registered activity of ^{90}Sr is in the range 0.073 ÷ 1.54 Bq/kg a.d.w. The results for 2011 are consistent with data from previous years for the same types of crops.

7.2.10 RADIOLOGICAL MONITORING OF MILK, MEAT AND FISH

Milk as a typical food product is an indicator of a possible radioactivity uptake in the food chain. The institutional radio-ecological monitoring program in 2011 surveyed the monthly radioactivity of cow's milk from three farms in the area of ”Kozloduy” NPP –in the town of Kozloduy, and in the villages of Harlets and Mizia. Samples were analysed for total beta activity and gamma spectrometry for radionuclide content.

The total beta activity in samples of cow's milk varies from 20 ÷ 55 Bq/l, with an average content of 37.8 Bq/l. With an average potassium content per liter of cow milk from 1.3 g/l, the specific activity of ^{40}K is about 40 Bq/l. Results show that virtually all measured total beta activity is due to the natural isotope ^{40}K.

Gamma-spectrometric measurements of milk in 2011, like in previous years, indicated no activity of ^{137}Cs, with the results varying as follows (0.048 <MDA <0.13 Bq/l). In 2011, the activity of radiostrontium varied in the range of 4.6 ÷ 18 mBq/l, an average of 8.9 mBq/l.

Pork samples were analysed at the local pig-breeding farm in the town of Kozloduy in the period 1993-1999. Afterwards, due to the farm’s closure analyses of this kind of sampling was suspended. Samples were gamma spectrometry identified per fresh weight (f.w.). Technogenic radioactivity ranged within MDA (^{137}Cs: 0.06 ÷ 1.04 Bq/kg f.w., average 0.42 Bq/kg f.w.).

Sampling was carried out on the ichthyofauna in the region of BPS (bank pumping station). Catches were taken at the access pint of the intake canal (before the NPP) and at the outlet of the outlet canal (after the NPP) along the Danube river. The aim is to analyse the impact of liquid releases from KozloduyNPP on fish in the area. Fish bones and meat are analysed separately, while in meat sub-samples gamma spectrometric radiocesium is defined and bone sub-samples are analysed for ^{90}Sr. The analysed samples of fish in 2011 showed radiocesium activity in meat respectively: ^{137}Cs in the range 0.09 ÷ 0.29 Bq/kg fw with average 0.15 Bq/kg fw, and ^{134}Cs below MDA (<0.07 ÷ <0.17 Bq/kg fw). The activity of ^{90}Sr in bones varies 0.42 ÷ 0.84 Bq/kg fw.

Therefore, radioactivity showed low background levels in the food chain.

7.2.11 ADDITIONAL DOSE OF THE POPULATION WITHIN THE 30 KM PROTECTION AREA AROUND KOZLODUYNPP

To estimate the additional public dose caused by radioactive emissions from nuclear power plants in the environment, verified and validated model evaluation programs are used on the basis of the EU-approved CREAM methodology adapted to the geographical and hydrological characteristics of the area of Kozloduy NPP.

For 2011, the overall assessment of the maximum individual effective dose of the population critical group, received from liquid releases and gaseous releases into the atmosphere, taking into account the contribution of ^{14}C and ^{3}H, was 7 μSv/a, which is negligible compared to the population norm per year (1,000 μSv) according to BNRP-2012. The collective dose to the population within the 30 km protection zone around Kozloduy NPP is 0.039 manSv. Normalized collective dose of 0.022 manSv/GW.a is comparable to the average indicators for PWR reactors worldwide. Over the past five years the value of the maximum individual effective dose to the population ranges 4 ÷ 7 μSv/a, which is below the control margin of 10 μSv/a under BNRP-2012. Additional radiation exposure of the population in the 30 km protection area is on average 500 times lower than that received from natural background radiation (2400 μSv).

In the Environmental Impact Assessment (EIA), the developed and functioning monitoring system in all its aspects will be analysed in detail and evaluated with regard to the investment project, the specific requirements of nuclear facilities and the need for its development and improvement.

7.2.12 NOISE

In the operation phase, noise monitoring will be carried out in accordance with the methodology for determining the total sound power of the enterprise emitted into the environment and determination of the noise level at the site of impact, Ministry of Environment and Water (MEW), 2012.

8 TRANSBOUNDARY IMPACT ASSESSMENT

The ***approach to assessing*** the impact of investment project on the environment in a transboundary context, which will be implemented, includes:

- → Establishing the potential transboundary environmental impact on the territory of another state or states as a result of implementing the investment project for the construction of a new nuclear unit at Kozloduy NPP site
- → Paying particular attention to the aspects of transboundary impact and proposing specific measures for the prevention and mitigation thereof.

This chapter of the Terms of Reference (ToR) **aims to identify the scope and content of the assessment of environmental impact in a transboundary context,** according to the procedure as laid down in the applicable Bulgarian legislation and in particular Article 98, Paragraph 1 of the Environmental Protection Act and Article 25 of Ordinance on the terms and conditions of the Environmental Impact Assessment (EIA), and in accordance with the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention). The Convention was established in 1991 at a time when the European Community had several years of experience in the application of Directive 85/337/EC on the assessment of environmental impact. The Convention provisions envisage the extension of the national Environmental Impact Assessment (EIA) procedure with respect to the subject of assessment, the stakeholders and the duties of the competent authorities.

The Bulgarian internal mechanisms for implementing the Espoo Convention are regulated in Article 98 of the Environmental Protection Act (EPA) and Chapter Eight (Article 23-26) of the Ordinance on the conditions and procedures for environmental impact assessment.

Article 24 of the Ordinance on the conditions and procedures for environmental impact assessment envisages that the Minister of Environment and Water shall be the competent authority for carrying out the Environmental Impact Assessment (EIA) procedure in a transboundary context.

Article 25 of the Ordinance on the conditions and procedures for environmental impact assessment describes the steps of the Environmental Impact Assessment (EIA) procedure in a transboundary context where Bulgaria is a country of origin, as is the current case.

In addition, the competent authority - the Minister of Environment and Water – shall consider whether the investment project may have the expected significant environmental impact in another country / countries. In this case, the investment project falls within the scope of Annex I, paragraph 2 of the Espoo Convention and pertains to the category of investment projects, which under the national law provides for mandatory Environmental Impact Assessment (EIA) - paragraph 2.2 of Annex 1 to Article 92, sub-paragraph 1 of the Environmental Protection Act (EPA). At the time of development of these Terms of Reference (ToR), the competent authority has specified the Republic of Romania as an affected party, more so the location of the investment project is the Danube river, which runs along the border of the Republic of Bulgaria with Romania. Decision to notify the other party is entirely the prerogative of the Minister of Environment and Water - Article 3 of the Espoo Convention.

In order to provide relevant information to the competent authority for the expected transboundary impact of the investment project on the environment, this chapter presents data and information on the operation of the facilities at KozloduyNPP.

8.1 PRELIMINARY ASSESSMENT OF POTENTIAL TRANSBOUNDARY IMPACTS

As described in Chapter 1 of the Terms of Reference (ToR): Characteristics of the investment project to build at KozloduyNPP six nuclear units of Russian design WWER type. Units 1 ÷ 4 are WWER-440, while units 5 and 6 are respectively WWER-1000 type. The main characteristics of the six units are presented in ***Table 8.1-1.***

TABLE 8.1-1: MAIN CHARACTERISTICS OF THE SIX UNITS

Блок		Type of reactor, power in MW	Year of connection to the energy grid	Fuel campaigns	Shutdown of units
Unit 1		WWER-440	1974	23	31.12.2002
Unit 2		WWER-440	1975	24	31.12.2002
Unit 3		WWER-440	1980	22	31.12.2006
Unit 4		WWER-440	1982	21	31.12.2006
Unit 5	Opertional life 2017*	WWER - 1000	1987	18	N/A
Unit6	Operational life 2021*	WWER - 1000	1991	17	N/A

** provided that the lifetime extension program fails to prolong the operational life.*

During the years of operation of KozloduyNPP, as described in Chapter 7 of the Terms of Reference (ToR): Monitoring, continuous monitoring is carried out on the impact of the nuclear power plant operations on the population and the environment. The equivalent dose power is evaluated. Also, assessment is made of radiation exposure from radioactive gaseous and liquid emissions from Kozloduy NPP within the 30 km surveillance zone [147].

The results of radiation monitoring for the period 1998-2002 when units 1 ÷ 6 were in operation as well as all other nuclear facilities on-site (the Wet Storage Facility and the facilities of the State Enterprise Radioactive Waste), the main components of the monitoring are shown in ***Table 8.1-2:*** *Radiation monitoring data for the period 1998 – 2002, and 2011.* For comparison, the results of the shutdown units 1 ÷ 4 for 2011 were added. To ensure the production of a sufficiently reliable comparative analysis on the real impact, the table was expanded with the regulatory restrictions and the pre-operation results of measurements in the area of Kozloduy NPP taken in the period 1972-1974 by the National Center of Radiobiology and Radiation Protection (NCRRP) (then NIRRH). These results are summarised in the expert report published at the commission of the Confederation of Independent Sindicates in Bulgaria in 1993[148].

[147] Results of the environmental radiation monitoring for the period 1998-2002, 2011 – УБ-РКОС-008/009/010/011/012

[148] V. Marinov etc., Influence of Kozloduy NPP on the environment, the working environment, and the health status of the population and workers, Expert report, CITUB, Sofia, 1993, G. Vassilev, V. Bliznakov Influence of Kozloduy NPP on radioecology, exposure and health status of the population and workers BalBok, Sofia, 1994.

TABLE 8.1-2: RADIATION MONITORING DATA FOR THE PERIOD 1998 – 2002, AND 2011

Component	Statutory norm	Reference benchmarks of 1971-1974	1998-2002 min-max	2011 min-max
Radiation gamma background (in the range up to 100 km), μSv/h	-	0.06 – 0.17 *(natural gamma background)*	0.056-0.11	0.05-0.11
Ambient air - ^{137}Cs [μBq/m^3]	3200000	-	0.4-9.7	0.8-10
Natural water - Total beta activity, [Bq/l] - Tritium [Bq/l]] - ^{90}Sr [mBq/l] - ^{137}Cs [mBq/l]	0.75 70000000 20000 80000	0.25-0.42 - 7.0-12.0 4.0-10.0	0.040-0.44 <MDA 1.6-14.9 0.5-9.2	0.012-0.087 <MDA 0.9-3.9 0.3-1.1
Drinking water -Total beta activity. [Bq/l] -^{137}Cs – [mBq/l] -^{90}Sr – [mBq/l]	1 11000 1900	-	<0.068-0.18 <MDA 1.2-5.3	0.024-0.088 <MDA 0.8-2.3
Topsoil -^{90}Sr–[Bq/kg a.d.w.]	2^{-6}**	7.6±0.6	0.19 – 5.18*	0.22-3.97
Milk -^{137}Cs – [Bq/l] -^{90}Sr – [Bq/l]	470 35.7	0.13±0.011 0.11±0.015	<MDA 0.003-0.055	<MDA 0.0046-0.018

Component	Statutory norm	Reference benchmarks of 1971-1974	1998-2002 min-max	2011 min-max
Agricultural products (wheat) -90Sr [Bq/kg a.d.w.] -137Cs [Bq/kg a.d.w.]	35700 470000	0.25±0.02 0.15±0.01	0.058-2.01 < MDA	0.073-1.54 <MDA
Dose effects of emissions (liquid and gaseous), IED [Sv] (% of the limit 1.10^{-3} Sv)	1.10^{-3}	-	$2.68 - 3.76.10^{-7}$ (0.027-0.038%)	$6.98.10^{-6}$*** (0.7%)

* These values are also used for reporting pollution from nuclear weapons testing and the nuclear accident at Chernobyl NPP

** Typical content of ^{90}Sr in Bulgarian topsoil

*** Higher value for the maximum individual effective dose (IED) is due to the greater conservatism of the estimates obtained with the newly introduced software "Shield - normal operation", which takes into account the EU-approved methodology CREAM.

In analysing and comparing data from two reference periods (with operational six units (1998-2002) and operational two units (2011) the following conclusions can be made:

- ✓ The results of measurements of the radiation background, taken in points from the fence of the NPP and outposts and settlements within the 100 km area are fully comparable, and within the natural background radiation;
- ✓ The results of the aerosol monitoring over the years provide a realistic assessment of the negligible impact of KozloduyNPP on the airborne aerosol activity. In practice, this parameter has remained unaffected by the operation of the plant. The maximum values obtained or ^{137}Cs are thousands of times lower than the statutory limit;
- ✓ The radiation status of drinking water in the region has no impact from the operation of KozloduyNPP and fully complies with sanitary norms. The maximum values obtained for ^{137}Cs and ^{90}Sr are thousands of times lower than the statutory limit;
- ✓ No impact was found on the radioecological status of topsoil in the environment from the operation of KozloduyNPP. The values for ^{90}Sr content are typical for Bulgarian topsoil;
- ✓ The radiation status of crops has typical natural levels. The maximum values measured for ^{137}Cs and ^{90}Sr are thousands of times lower than the statutory limit;
- ✓ Total activity measured in milk is within typical natural limits and is entirely due to the natural isotope ^{40}K. No impact was found from the operation of KozloduyNPP as regards the radiation purity of milk produced in the area. The maximum values measured for ^{137}Cs and ^{90}Sr are hundreds of times lower than the statutory limit;
- ✓ During these periods of operation the maximum individual effective dose to the population from liquid and gaseous releases in the 30 km zone varies in the range 4 ÷ 7 μSv/a, which is not more than 0.7% of the normal rate for the population (1 mSv) and below the clearance limit of 10 μSv/a, BNRP-2012;
- ✓ Radiobiological effects and radiation risk[149].

    a. *Deterministic effects*

    There is no risk of deterministic effects on the population in the surveillance zone (100 km) of KozloduyNPP.

    The maximum individual effective dose per person of the critical population group is 6.98 $.10^{-6}$ Sv. Individual doses of gas-aerosol

[149] Results of radiation monitoring of the environment in 2011 - 12.РМ.ДОК.111

emissions are within 1.22.10-8 - 2.72.10-6 Sv. (These doses are much lower than the threshold as set under Article 10 of BNRP on the limit for annual effective dose, which is 1 mSv per capita).

On that basis it can be argued that there is no risk of deterministic effects on the population in the surveillance zone around the NPP.

b. *Stochastic effects*

The risk of stochastic effects is negligible.

The risk of radiation-induced cancer in the whole population is $2.65x10^{-8}$, while the probability of hereditary diseases is $9.64x10^{-10}$.

In support of these findings, for the purposes of assessing the impact of the operations of KozloduyNPP on the population near the plant, an independent expert assessment was carried out on the content of technogenic radio nuclides in the body of 150 children living near the plant. The survey was conducted in 2003 by the Laboratory "Radiation measurements, internal dosimetry and expertise" at the National Center of Radiobiology and Radiation Protection (NCRRP). The results clearly show no indications for the presence of anthropogenic radio nuclides in the body of the persons measured and of **^{131}I** in the thyroid gland[150].

Based on the outcome of **KNPP own non-radiation monitoring** in the period 2007-2012[151], the following conclusions and general findings can be formulated:

- ✓ Water abstraction and use of water bodies for discharge of waste water is performed in accordance with the annual limits as specified in the permits;
- ✓ Extracted groundwater meet the quality standard as defined in Annex № 1 of Ordinance № 1 of 2007 concerning the study, use and protection of groundwater;
- ✓ During the period there has been no exceeding of the individual emission limits (IEL) for different parameters of water in outlet canal - 1 and outlet canal - 2, the amount of waste water discharged is less than allowed;
- ✓ All registered values of discharged water through the trapezoidal channel, Open Switchgear and Ø1000 are below the individual emission limits established for these flows in the waste water discharge permit, except for the results for the "*boron* indicator ";
- ✓ Taking into account the analysis results it can be summarized that only waste

[150] Independent expert review of the distribution of technogenic radio nuclides in the bodies of 150 children living in the vicinity of Kozloduy NPP - NCRRP, 2003

[151] Annual reports on the results of its own non-radiation environmental monitoring around KNPP 2007, 2008, 2009, 2010 and 2012

water discharged into the main drain canal (MDC) has registered small values for the indicator "*boron*", but they are within the values reported in the drinking water of the town of Kozloduy;

- ✓ As regards groundwater at the site and in the vicinity of KozloduyNPP, distinct exceeding of limits for the quality standard of certain indicators has been observed occasionally as compared against the standard quality defined in the Ordinance for study and protection of groundwater;
- ✓ During the reference period, the depot for non-radioactive household and industrial waste has received mainly non-recoverable household and industrial waste;
- ✓ As a result of the overwhelming amount of waste and the higher rate of occupancy of the design capacity, the depot for non-radioactive household and industrial waste has been filling up at a slower pace than anticipated in the project, and for eleven years of service only 85% of Stage I has been occupied;
- ✓ As regards waste water, the depot for non-radioactive household and industrial waste has not shown tendency of change in the controlled parameters;
- ✓ In 2011, as in previous years, there are prevalent cases of stable and neutral state of the atmosphere - Class DE. Very unstable conditions are rare in the area of both the NPP and the depot for non-radioactive household and industrial waste, being observed primarily during the warm summer months when there is intense sunlight.

The analysis of the operational experience of Kozloduy NPP EAD indicates that the plant has a strong administrative management capacity, including in terms of response to accidents and incidents.

Kozloduy NPP has produced a variety of documents, which regulate the procedures and responsibilities for reporting, analysis of operational events, commissioning and monitoring of the implementation of corrective measures in accordance with the rights, duties and responsibilities of Kozloduy NPP arising from the Safe Use of Nuclear Energy Act (SUNEA), the Ordinance of the Nuclear Regulatory Agency on procedures for notifying the NRA for events at nuclear facilities and sites with sources of ionizing radiation (hereinafter referred to as the Ordinance) and as a "nuclear operator" and "license holder for the operation of nuclear facilities."

The principles to be followed in determining the ultimate goals for reporting and analysis of operational events and providing feedback from internal operational experience are as follows:

- ✓ protection of human life and health and of the environment has a priority over energy production and cannot be subject to any compromise;

- ✓ There is a constant enhancement of the level of safety, quality and safety culture through implementation, analysis and development of a system of methods and tools for self-control, self-assessment and feedback regarding the operating experience;
- ✓ Compliance is assured with the requirements for nuclear safety, radiation protection, protection of the population and the environment arising from the international conventions and treaties ratified by the Republic of Bulgaria.

The main requirements governing the criteria and actions as described in the documents arise from:

- ✓ requirements of the Bulgarian legislation on safe use of nuclear energy;
- ✓ IAEA requirements.

The Kozloduy NPP has already developed procedures for use and dissemination of operating experience. These procedures aim to regulate the terms of:

- ✓ dissemination and use of information from internal and external operating experience (OE);
- ✓ informing the nuclear community of events occurring at Kozloduy NPP through the World Association of Nuclear Operators (WANO).

For the entire period of operation of existing facilities (about 150 reactor years) on the site of Kozloduy NPP no events higher than level 2 on INES scale[152] have been reported. In general, a total of 52 events of Level 1 have been recorded and reported and two events of Level 2. As regards all these events no additional off-site radiological impacts of KozloduyNPP have been established.

Expected impact of the joint operation of existing and planned for commissioning nuclear power facilities at Kozloduy NPP and nearabout [153].

Currently, the following nuclear facilities are in operation at the site of the Kozloduy NPP:

1. In industrial operation, WWER-1000 units 5 and 6 with total installed capacity of 2000 MWe;
2. Wet Storage FAcility (WSF);
3. Management facilities for radioactive waste operated by the Kozloduy Radioactive Waste Specialised Division

[152] The INES scale is a globally recognised International Nuclear Event Scale, effective since 1990 by the IAEA to facilitate communication of safety information in case of nuclear accidents. The scale has seven levels (degrees) of danger and a zero level meaning no danger. The scale is logarithmic, and each level indicates an accident, which is approximately 10 times more severe than the previous (lower) level.

[153] Requirement by the MEW, pursuant to letter Ref. № OBOC-220/09.01.2013

4. Units 1-4 as facilities for radioactive waste management, subject to decommissioning.

New nuclear facilities scheduled for commissioning on the site of KozloduyNPP:

1. A new nuclear unit of the latest generation compliant with the current safety requirements for nuclear reactors of Generation III;
2. Plasma Melting Facility for low and intermediate level radioactive waste (RAW) (Category 2a) with high volume reduction factor;
3. 3. Dry storage facility for spent nuclear fuel.

In addition to Kozloduy NPP site boundary is located the Radiana site, where the National disposal facility for low and intermediate level radioactive waste shall be built.

Assessment of the potential impacts of the nuclear facilities planned for commissioning:

1. 1. When building a new nuclear power capacity, according to the Bulgarian legislation and those of EUR, the operational impact of the reactors of Generation III, under operational conditions and design basis accidents, are confined to the site of the nuclear power facility (0.8 km), and in case of major accidents within the 3 km zone. [EUR Volume 2];
2. The implementation of a plasma melting facility for low and intermediate level radioactive waste (RAW) of KozloduyNPP makes use of advanced technology to purify liquid and gaseous exhaust emissions which as a result of does not significantly increase the off-site radiation risk, while the impact on a critical population group is considered negligible and far from the regulatory requirements for radiation exposure. The contribution to the dose outside the building at ground level during normal operation of the facility is 0.003 ± 0.002μSv/h; [ISAR PMF];
3. The construction of a national disposal facility for low and intermediate level radioactive waste will not result in a substantial increase in radiation risk at the site, as assessed in the REIA. In the operation phase and after its closure, during the control period, migration of radioactive substances from the disposal facility is not expected.
4. The dry storage spent fuel facility at Kozloduy NPP is designed to include a passive cooling system and uses the concept of storage in 'zero leak' cask , which ensures high reliability and very low radiation risk.

Conclusion

Given that the decommissioning of units 1 ÷ 4 of KozloduyNPP and the removal of nuclear fuel from their reactor pools results in significantly lower radiation risk on the site and the expected low potential impacts (limited within the 3km zone) from the new nuclear unit planned for commissioning, the combined impact on the components of environment and population cannot be expected to be greater than that of simultaneous operation of six power units of the second generation assessed above.

8.2 REQUIREMENTS OF THE MINISTRY OF ENVIRONMENT AND FORESTS OF THE REPUBLIC OF ROMANIA

In accordance with the requirements contained in the letter from the Ministry of Environment and Forests of Romania with Outgoing reference № 3672/RP/18.10.2012 as provided by the Contracting Authority, the scope of the Report of Environmental Impact Assessment (REIA) will include the results of all studies, analyses and forecasts made as part of the Environmental Impact Assessment (EIA) to identify areas at risk for significant impact on the territory of the Republic of Romania as an affected party as per the definition of the Espoo Convention.

In this context, ***the subject of the assessment of transboundary impacts*** within the Environmental Impact Assessment (EIA) will study the possible impacts on the environment and human health due to the implementation of the investment project in the surveillance zone (30 km radius around the site of KozloduyNPP), which on Romanian territory includes 18 settlements in total. In the evaluation process a joint team of both Bulgarian and Romanian experts will be involved in order to guarantee the process of collecting and analysing the information required for the objectivity of the evaluation.

The Evaluation of Environmental Impact Assessment in a Transboundary Context will follow the requirements of the Bulgarian, European and international legislation on Environmental Impact Assessment (EIA) in a Transboundary Context, and will be designed so as to meet the general and specific requirements of the Republic of Romania in Letter of outgoing reference № 3672/RP/18.10.2012 In this regard, the Report of Environmental Impact Assessment (REIA) will include:

8.2.1 MAIN REQUIREMENTS

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1.	**The Report of Environmental Impact Assessment (REIA) will include:**	
1.1.	Information on the sites characteristics that may have implications for	The main characteristics of the sites are described in detail in Chapter 1: Characteristics of the project, Section 1.6.: Description of the physical

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	nuclear safety	characteristics of the investment project and the areas needed as per this Terms of Reference (ToR). It presents four alternative siting locations and the existing infrastructure built on them. Additional information is provided in Chapter 2 of the Terms of Reference (ToR): Alternatives for the investment project 2.1.: Alternatives by location and 2.2.: Alternatives for supporting infrastructure during construction works and operations. Chapter 6 of the Terms of Reference (ToR): Characterization of the risks to environment in case ot potential accidents and incidents, presents the selected approach for assessing the risk of accidents (internal impacts), accidents caused by human error, impacts caused by natural hazards, external impacts of human origin. The Report of Environmental Impact Assessment Report (REIA) will present in detail the characteristics of the site, which may be relevant to nuclear safety, as established in the applicable Bulgarian and European legislation (Appendix 1). Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, presents that part of the information which is relevant for the territory of Romania, including the assessment of the environmental impact on the area.
1.2.	Information on accident analysis, including severe accidents (especially the probability and radiological consequences on Romanian territory). The source term in air and in Danube waters are required to be known, as well as the appropriate dose for each scenario	Chapter 6 of the Terms of Reference (ToR): Характеристика на рисковете за околната среда при потенциални аварии и инциденти, presents the selected approach for assessing the risk of accidents (internal impacts), accidents caused by human error, impacts caused by natural disasters, external impacts of human origin. Section 6 of the Environmental Impact Assessment (EIA): Характеристика на рисковете за околната среда при потенциални аварии и инциденти, will provide information for the analysis of accidents, including major accidents.

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		In Section 3.11 of the Terms of Reference (ToR): Radiation risk for the population for release during normal operation, there is a narrative of the current situation, and an outlook for the impact as well as models and software to evaluate the effects of radiobiological effects and radiation risk per reference individual and for the assessment of doses to the population of liquid and gaseous radioactive emissions into the environment. Section 4.11 of the Environmental Impact Assessment (EIA): Radiation risk for the population in radioactive releases, will present the acceptable dose for every possible emergency scenario, in the air and water of the Danube river, under the applicable Bulgarian and European legislation (Appendix 1). Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, will present that part of the information from the Environmental Impact Assessment (EIA), which refers to the territory of the Republic of Romania, including information on analysis of accidents, including major accidents (especially the probability of radiological consequences on Romanian territory) and the acceptable dose for every possible emergency scenario, in the air and water of the Danube river.
1.3.	Information regarding emissions in air and in the Danube during normal operation of the new unit	Section 1.8.2. of the Terms of Reference (ToR): Emissions – non-radioactive and radioactive, contains information about the type and amount of estimated emissions from the new nuclear unit during normal operation. Section 3.1 of the Terms of Reference (ToR): Climate and ambient air, and Section 3.2. of the Terms of Reference (ToR): Surface and groundwater, present the current situation and an outlook of the expected impact in the implementation and operation of the new nuclear unit. Section 3.9. of the Terms of Reference (ToR) presents the current situation and an outlook of the thermal impact on the Danube river from the implementation and operation of the new nuclear unit.

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		Sections 3.1 and 3.2. will present the current situation in terms of emissions to air and water. Sections 4.1. and 4.2. of the Report of Environmental Impact Assessment (REIA) will present a narrative, analysis and evaluation of the likely significant effects on air and water in radiation and non-radiation aspect on Bulgarian territory as a result of the investment project and harmful emissions during normal operation and in emergency situations. Section 4.9.4 of the Environmental Impact Assessment (EIA) will reflect on the expected heat impact on the Danube river during the implementation, operation and decommissioning of the new nuclear unit. Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, will present that part of the information from the Environmental Impact Assessment (EIA), which refers to the territory of the Republic of Romania, including information on analysis of accidents, including information on emissions to air and water of the Danube river during normal operation of the new power facility.
2.	**On both banks of the Danube sector comprised arount Kozloduy, there are Natura 2000 sites. On the Romanian bank there are the following Natura 2000 sites protected under the the Habitats Directive and the Birds Directive**	
	ROSPA0010 Bistret river ROSPA0023 Jiu river-Danube River Confluences ROSCI0045 Corridor of Jiu River; ROSPA00135 Sands from Dabuleni	In terms of assessing the impact of the new nuclear unit on NATURA 2000 sites located within the territory of the Republic of Romania in the area of impact of the investment project (30 km zone) the potential impacts will be analysed in the following areas protected respectively by the Habitats Directive and the Birds Directive: ✓ ROSPA0010 Bistret river; ✓ ROSPA0023 Jiu river-Danube River Confluences; ✓ ROSCI0045 Corridor of Jiu River; ✓ ROSPA00135 Sands from Dabuleni. The analysis will be based on studies carried out in accordance with the Ordinance on the conditions

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		and procedures for assessing the compatibility of plans, programs, projects and investment projects with the subject and objectives of the protected areas conservation (adopted by Decree of the Council of Ministers № 201 of 31.08.2007, promulgated in State Gazette, issue 73 of 11 September 2007). In a separate report (Annex 15.2. to the Environmental Impact Assessment (EIA)) there will be an evaluation of the potential adverse effects resulting from the investment project implementation on biodiversity and protected areas within the 30 km zone in the Republic of Romania and Bulgaria, by type, probability, duration, territorial scope, frequency, cumulative effect.
3	**The Report of Environmental Impact Assessment (REIA) will include the following issues:**	
3.1.	Impact on biodiversity on both sides of the Danube river within the assessment of the environmental impact (30 km zone) outside protected areas of NATURA 2000	Section 3.6. of the Terms of Reference (ToR): Biodiversity, provides information on the current situation in terms of flora and wildlife within the supervised zone (30 km) on Bulgarian territory. Section 3.6. of the Environmental Impact Assessment (EIA) will present information regarding the current situation of biodiversity in the 30 km zone on the Bulgarian side, outside the Natura 2000 network. Section 4.6. of the Report of Environmental Impact Assessment (REIA) will present an analysis of the impact on biodiversity of the implementation, operation and decommissioning of the new nuclear unit. Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, will present the current situation in terms of biodiversity in the 30 km zone of the Romanian side, outside the Natura 2000 network. In addition to an analysis of the impact on biodiversity of Romanian territory of the implementation, operation and decommissioning of the new nuclear unit.
3.2.	The cumulative impact of other projects implemented	Chapter 5 of the of Reference (ToR): Cumulative effect, presents the approach of evaluation of the

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	at Kozloduy NPP and its surroundings, which can have harmful effects on the natural capital of both countries	cumulative effects of all components and environmental factors, including biodiversity. Chapter 5 of the Environmental Impact Assessment (EIA): Cumulative effect, will analyse and assess the possible cumulative effect of the implementation, operation and decommissioning of the new nuclear unit and other current and future facilities of KozloduyNPP and elsewhere in the context of potential impacts, including on biodiversity. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impact, will make an assessment of the potential cumulative effect for the territory of Romania in the 30 km zone, including on biodiversity.
3.3.	Measures to mitigate the impact on biodiversity and impact assessment after their application	Based on the analysis, prediction and evaluation of impacts of the biodiversity issue within the 30 km zone of the Environmental Impact Assessment (EIA), Chapter 8: Description of the measures, envisages to prevent, reduce and wherever possible to offset any significant adverse effects in radiation and non-radiation environmental aspect, and the plan for the implementation of these measures will propose specific measures (technical, procedural and administrative measures) to reduce and/or prevent potential impacts both during construction works and during operations of the new nuclear unit. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impacts will present all the proposed measures, which relate to the territory of the Republic of Romania, including biodiversity.
4.	The names of geographical localities on maps should be written in the Latin alphabet and the maps must contain Romanian localities included in the assessment	Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts will be developed and presented as a separate item in accordance with instructions given by letter of outgoing reference № OBOC-220/09.01.2013 of the Ministry of Environment and Water. This chapter will be accompanied by maps and graphic material, providing in Latin alphabet the names of geographical objects and Romanian localities included in the assessment.

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5.	Taking into account that in the influence area (30km around Kozloduy NPP on Romanian territory) there is a resident population of 77,197 inhabitants in 18 settlements in the counties of Dolj and Olt, the environmental impact study must contain an assessment of the radiological impact on human health.	Chapter 1 Terms of Reference (ToR): Characteristics of the investment project, describes the existing nuclear facilities, and general plant facilities of KozloduyNPP, while presenting the main characteristics of the production process of the new nuclear unit – technology, type and quantity of materials used, expected waste, emissions and harmful radiation. Chapter 3 Terms of Reference (ToR): Characteristics of the environment in which the investment project is implemented and outlook of the impact of key data and information on the expected impact factors and components. Sections 3.10. and 3.11. discuss the health and hygiene aspects and radiation risk for the population in case of radioactive releases during normal operation of the new nuclear unit. In addition, Chapters 5 and 6 of the Terms of Reference (ToR) also consider issues related to the assessment of human health risk in terms of cumulative effects, the risk of accidents and incidents. Given the complexity of the approach for assessing the risk to human health in an Environmental Impact Assessment (EIA), the same pattern of presentation of information will be followed, respectively, Chapter 1 of the Environmental Impact Assessment (EIA) will publish an abstract of the investment project for construction, activities and technologies, while Chapter 3 of the Environmental Impact Assessment (EIA) will provide a description and analysis of components and environmental factors, including as regards the health and hygiene aspects of the risk to the environment and human health (sections 3.10 and 3.11). In addition, chapters 5 and 6 of the Environmental Impact Assessment (EIA) will also consider issues related to the assessment of risk to human health in terms of cumulative effects, the risk of accidents and incidents. Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, will present all the information relating to the territory
6.	The assessment of impacts on human health must evaluate the excess risk generated by normal operation of the new nuclear unit, as well as in cases of accidents, based on the recommendations of the International Commission on Radiological Protection (ICRP 103/2007), for diseases associated with exposure to ionizing radiation (incidence and mortality rates from malignant disease, birth defects, developmental defects). These estimates should cover both the situation in normal operation of the plant and in the event of nuclear accident.	
7.	Taking into account the levels of contamination of the elements of the environment (air emissions, emissions in ground and surface water), it is necessary to study the synergistic effect of their impact on the local	

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	population, both during the construction of the new power capacity and during its operation.	of the Republic of Romania in the Danube river within the 30 km zone of the assessment, including: ✓ Assessment of the radiological impact on human health; ✓ Assessment of impacts on human health in the event of accidents, based on the recommendations of the International Commission on Radiological Protection from diseases associated with exposure to ionizing radiation; ✓ Assessment of the health impact of the combined adverse effects during the construction works and operations of the facility; ✓ Estimates of the cumulative increase in risk to human health from the operation of all systems of the nuclear power plant; ✓ The evaluation will include the situation in the normal operation of the reactor and in case of emergencies. Given the levels of contamination in environmental media (air emissions, groundwater, surface water) as part of the scope of the Environmental Impact Assessment (EIA) in a Transboundary Context, it will assess the impact on the health of the local population, as well as synergistic effects, both during the construction of the new nuclear unit, and during its operation and decommissioning. The study of the health impact of KozloduyNPP on the Romanian population will take into account the existence of the same site of the old units 1 ÷ 4 of Kozloduy NPP, which are currently in the process of decommissioning, and the radioactive waste to be generated in the future. Thus, the Environmental Impact Assessment (EIA) study will provide a cumulative effect on the Romanian population living in the zone of impact - the surveillance zone of 30 km.
8.	The study of the health impact of the Romanian population in the NPP Kozloduy area should take into account the existence on the same site of the old units 1-4 of Kozloduy NPP, currently in the process of decommissioning expected to generate nuclear waste in the future. This means that it is necessary to examine the cumulative effect on the Romanian population living in UPAZ.	
9.	It is necessary to calculate the cumulative excess risk to human health from the operation of these systems.	

8.2.2 SPECIFIC TECHNICAL REQUIREMENTS

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1.	Presentation of the technological characteristics of the new nuclear unit which will be implemented at Kozloduy NPP, comparing them with the latest requirements for post-Fukushima nuclear safety, and the essential differences from the current technology, that give the project title "Nuclear Reactor of the Next Generation."	Chapter 1 Terms of Reference (ToR): Characteristics of the project, describes the existing nuclear and common nuclear facilities on the site of KozloduyNPP, presents the main characteristics of the production process of the new nuclear unit (NNU) – technology, type and quantity of raw materials used, expected waste, emissions and harmful radiation. Chapter 6 of the Terms of Reference (ToR): Характеристика на рисковете за околната среда при потенциални аварии и инциденти, presents the selected approach for assessing the risk of accidents (internal impacts), accidents caused by human error, impacts caused by natural disasters, external influences of human origin. In the relevant chapters of the Environmental Impact Assessment (EIA) /see Chapter 9 of the Terms of Reference (ToR): Structure of the Report of Environmental Impact Assessment (REIA)/ the effects of the implementation, operation and decommissioning of the new nuclear unit will be analysed and evaluated, including in terms of nuclear safety: ✓ Systems embodied in the concept of defense-in-depth in all operational modes; ✓ Basic safety functions - control of reactivity, heat removal from the reactor core, holding radioactive substances within the prescribed limits under all operating conditions and emergency conditions; ✓ Technical means to exclude human errors and/or limit their consequences; ✓ Degree of resistance to internal and external factors, including earthquakes, aircraft crashes, floods, etc.; ✓ Safety and control functions regarding the status of the power plant in the event of fire; ✓ Passive safety systems; ✓ Technical tools and solutions to manage the design basis accidents and minimize their effects; ✓ Additional solution to the corium capture concept;
2.	Presentation of the design and nuclear safety, which form and define the structural framework of the new nuclear unit integrated into a multi-units site (for example, safety concepts and principles, essential safety functions, regulatory requirements, integrated management)	
3.	Presentation of protective and support systems, including administrative measures designed to ensure the safety and security of nuclear units, including the justification of the specific requirements for nuclear safety	

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		✓ Burnable absorber to extend the nuclear fuel. lifetime Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts will present a summary of the basic descriptions and analyses presented above, including: ✓ The technological characteristics of the new nuclear unit which will be implemented in KozloduyNPP, comparing them with the latest requirements for nuclear safety after the Fukushima accident, and the essential differences with the current technology, resulting in a project entitled "Nuclear Reactor Of Next Generation"; ✓ Design and nuclear safety, which form the structural framework and define a new nuclear unit (NNU) to be implemented on the site with several existing facilities (for example, concept and principles of safety, key safety features, regulatory requirements, Integrated Management); ✓ protective and auxiliary systems, including administrative measures designed to ensure the safety and security of nuclear units, including the justification of specific nuclear safety requirements.
4.	Presentation of technical specifications (known as Limiting Conditions for Operation - LCOs), highlighting their importance as supporting licensing documentation and during the nuclear unit operating modes	In accordance with NS-G-2.2 "Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants", OLCs are developed based on the results of safety analyses, whereas it is recommended that the initial development is jointly operated by the designer and the operator. For the purposes of the Environmental Impact Assessment (EIA) thresholds of EUR will be used and the Bulgarian legislation and regulations, which shall be limiting to the new nuclear unit. Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, will present the above-described information.
5.	A brief but comprehensive presentation of the relationship between the essential requirements of	In terms of the Environmental Impact Assessment (EIA) in a Transboundary Context it will be noted that the investment project for the construction of a new nuclear unit at Kozloduy NPP is entirely

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	European agreements or other international recommendations (for example, IAEA, US-NRC), ratified by Bulgaria, concerning nuclear safety, safe management of radioactive waste and spent nuclear fuel, environmental assessment in a transboundary context information, public participation in decisions, etc., and their coverage in the applicable Bulgarian laws, rules and standards	consistent with the requirements for nuclear safety to the observance of which Bulgaria is committed as an active participant in international cooperation in developing nuclear energy for peaceful purposes. Bulgaria is among the founders of the IAEA and its full-fledged member since 1957. In this regard, the country has participated in many international and regional initiatives and projects of the IAEA and the EU: ✓ INPRO - International Project on Innovative Nuclear Reactors and nuclear fuel cycle initiated by the IAEA. INPRO activities cover the following areas: methodology for evaluation of nuclear energy systems, sustainable nuclear energy, innovative nuclear technology, innovations in institution building. The results of INPRO activities are being used by all member states of the IAEA, including Bulgaria; ✓ WENRA - Participation in the development of benchmarks for safe management of radioactive waste (RAW) and Spent Nuclear Fuel; ✓ ERDO (European Organisation for the development of repositories for disposal of radioactive waste) This Working Group aims to reach a consensus on a uniform model of repository for radioactive waste (RAW), based on the current project SAPIERR for the development of European regional storage locations; ✓ EU nuclear Decommissioning Assistance Program (NDAPC) and the Kozloduy International Decommissioning Support Fund (KIDSF); ✓ IFNEC (International Framework for Nuclear Energy Cooperation). The main tasks are IFNEC development and use of modern technologies in the nuclear fuel cycle in order to significantly reduce nuclear waste, simplify storage and disposal and to reduce the amount of spent nuclear fuel from civilian applications in a safe and secure manner, protected from illegal proliferation of nuclear materials.

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		Safe management of spent fuel and radioactive waste is a complicated and complex problem. Through exchange of information, experience and technologies, Bulgaria has been actively participating in international cooperation for improving the management of radioactive waste and spent nuclear fuel, which is performed on the basis of the EURATOM Treaty, Code rules for transportation of radioactive waste (IAEA) and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. It is this international experience, which forms the backbone of the investment project for the construction of a new nuclear unit at Kozloduy NPP. Chapter 11 of the Environmental Impact Assessment (EIA): Transboundary impacts, will presented a list of international documents ratified by the Bulgarian state and their integration in the Bulgarian legislation. The same information will be presented in Appendix 15.4. to the Report of Environmental Impact Assessment (REIA).
6.	Presentation of radioactive waste management system, including information on spent nuclear fuel, the classification of details on where and how they are transported, and the specification of transport containers	Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impact Assessment, will explain in detail the "Strategy for spent nuclear fuel and radioactive waste" adopted in 2011. It will also present the system of radioactive waste management at KozloduyNPP.
7.	Description of nuclear and radiological safety performance characteristics, in the context of the implementation of the Integrated Management System (safety management, quality management, safeguards and security, environmental protection, health and occupational safety, financial	To achieve its objectives, "Kozloduy NPP" has developed and introduced a management system, which integrates all aspects of management and ensures consistency in the implementation of safety, health and safety, environmental, security, quality and economy so as to ensure the highest priority on safety. The management system of "Kozloduy NPP" is designed in accordance with GS-R-3 "System management facilities and activities" with regard to the requirements of BS EN ISO 9001 "Systems of quality management. Requirements.", ISO 14001:2004 "Systems for Environmental

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	arrangements)	Management" and OHSAS 18001 "Systems for managing health and safety at work." Kozloduy NPP as an organisation operating nuclear facilities, has created conditions for the development and continuous improvement of safety culture in which safety has the highest priority. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impacts, will describe the nuclear and radiological characteristics in terms of safety of the plant, in the context of the implementation of the Integrated Management System (safety management, quality management, safeguards and security, environmental protection environment, health and safety at the workplace, financial agreement).
8.	Analysis of the results of the operational impact assessment of the new nuclear unit on existing and functioning untis (and vice versa) at the site of the nuclear power plant as a whole	Chapter 5 Terms of Reference (ToR): Cumulative effect, presents the approach to evaluate the cumulative effects of all components and environmental factors. Chapter 5 of the Report of Environmental Impact Assessment (REIA): Cumulative effect, will analyse and assess the possible cumulative effect of the implementation, operation and decommissioning of the new nuclear unit and other current and future facilities of KozloduyNPP and beyond, in the context of potential impacts. The main task of assessing the cumulative impact as part of the Environmental Impact Assessment (EIA) will be the opportunity to provide an analysis and assessment of the potential cumulative effect of the investment project implementation and the operation of other facilities at Kozloduy NPP and off the site, that might arise resulting from the summation of the implementation and operation effects (operations at units 5 and 6 of Kozloduy NPP) decommissioning of units 1 ÷ 4, the DSF and the WSF, disposal and facilities operated by the State Enterprise Radioactive Waste. To achieve this objective, the assessment of the cumulative effects should include an analysis of potential cumulative impacts in terms of:

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		✓ Each of the sites being evaluated separately; ✓ Each component (factor) of the environment separately and in combination; ✓ All identified and studied past, present and future activities on the site of KozloduyNPP and within the 30km surveillance zone.
9.	Presentation of the main aspects of the environmental monitoring in accordance with international, European and national nuclear regulations.	Chapter 7 of the Terms of Reference (ToR): Monitoring existing system, presents the existing system for radiation and non-radiation environmental monitoring, by components and factors. In Chapter 9 of the Report of Environmental Impact Assessment (REIA), the developed and functioning monitoring system in all its aspects will be analysed in detail and evaluated with regard to the investment project, the specific requirements of nuclear facilities and the need for its development and improvement. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impacts, will present the main aspects of the environmental monitoring in accordance with international, European and national nuclear regulations.
10.	Drawing up a detailed list of possible emergency scenarios, including Design Basis Accidents (DBA) and Beyond Design Basis Accidents (BDBA) plus severe accidents	Chapter 6 of the Terms of Reference (ToR): Характеристика на рисковете за околната среда при потенциални аварии и инциденти, presents the selected approach for assessing the risk of accidents (internal impacts), accidents caused by human error, impacts caused by natural disasters, external impacts of human origin, including a classification of accidents – design and major. Chapter 6 of the Report of Environmental Impact Assessment (REIA): Характеристика на рисковете за околната среда при потенциални аварии и инциденти, will identify all events (design and severe), which may occur as a result of this project implementation. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impacts, will present a detailed list of possible emergency scenarios, including design basis accidents (Design Basis Accidents - DBA) and major accidents.

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		As regards the assessment of **beyond design basis accidents** it should be stressed that at this early stage of project development (feasibility study) the survey does not include the full set of data required in terms of assessment in the context of specific technical requirements as set by the Republic of Romania – they will be available at a later stage, when the specific reactor model has been selected and when the relevant documents have been produced relating to the licensing of the investment project in accordance with harmonized legislation in the field of the safe use of nuclear energy for peaceful purposes. These documents include the Safety Analysis Report (SAR), Probabilistic Safety Analysis (PSA) and Technical Specifications (TP). They will be prepared at the level of technical design for the specific PWR model of the latest generation conforming to the particular conditions on the site of Kozloduy NPP. In this regard, it will be stated that despite the limited information available at this stage of the project, there is sufficient information to evaluate the Transboundary impact of the cumulative effect of the operation of nuclear facilities NPP Kozloduy.
11.	Analysis of the main results of the nuclear safety probabilistic assessment, with emphasis on beyond design basis accidents, BDBA postulated initiating events, and a description of severe accidents	Chapter 6 of the Report of Environmental Impact Assessment (REIA): Характеристика на рисковете за околната среда при потенциални аварии и инциденти will provide for an assessment of the possible consequences of accidents, including: ✓ The extent to which the setting of passive and active design systems to bring the reactor of a certain type (as per selected alternatives for equipment) in the sub-critical condition with stable residual heat removal, with no release of radioactivity outside the containment spaces in the event of accidents; ✓ Analysis by types of accident regarding exposure dose limits and defined restrictive parameters for a particular type of reactor (under the chosen alternative equipment); ✓ The probability of a major accident with a major release as a key indicator for assessing the safety in terms of the environment and the population in the area around Kozloduy NPP

№	Requirement	Comments
		✓ Capacity to update the existing emergency plan at Kozloduy NPP in view of the operation of a new nuclear unit. As regards the assessment of **beyond design basis accidents** it should be stressed that at this early stage of project development (feasibility study) the survey does not include the full set of data required in terms of assessment in the context of specific technical requirements as set by the Republic of Romania – they will be available at a later stage, when the specific reactor model has been selected and when the relevant documents have been produced relating to the licensing of the investment project in accordance with harmonized legislation in the field of the safe use of nuclear energy for peaceful purposes. These documents include the Safety Analysis Report (SAR), Probabilistic Safety Analysis (PSA) and Technical Specifications (TP). They will be prepared at the level of technical design for the specific PWR model of the latest generation conforming to the particular conditions on the site of Kozloduy NPP. In this regard, it will be stated that despite the limited information available at this stage of the project, there is sufficient information to evaluate the Transboundary impact of the cumulative effect of the operation of nuclear facilities NPP Kozloduy.
12.	Discussion of the main results of the hazard analysis of events such as earthquakes, floods, fires, explosions, extreme weather, missile, plane crashes, human activities in the vicinity of the plant, etc.	In Chapter 6 Terms of Reference (ToR): Характеристика на рисковете за околната среда при потенциални аварии и инциденти, presents the selected approach for assessing the risk of accidents (internal impacts), accidents caused by human error, impacts caused by natural disasters, external influences of human origin. Chapter 6 of the Environmental Impact Assessment Report (EIA R): Характеристика на рисковете за околната среда при потенциални аварии и инциденти will assess and analyse the risk of events such as earthquakes, floods, fires, explosions, extreme weather, missile, plane crashes, human activities in the vicinity of the plant, etc. Chapter 11 of the Report of Environmental Impact

№	Requirement	Comments
		Assessment (REIA): Transboundary impact will produce a summary of the results: ✓ hazard analysis of events such as earthquakes, floods, fires, explosions, extreme weather, missile, plane crashes, human activities in the vicinity of the plant, etc. ✓ assessment of the radiological impact on the Romanian territory, both during normal operation and in emergency situations, ✓ probabilistic assessment of nuclear safety, with an emphasis on design basis accidents (DBA) and the events causing them.
13.	Presentation of various dose limits (for example, individual, collective, annual, etc.) and the resulting emission levels of radioactive substances in the ambient air and water during normal operation and accidents compared to European standards, taking into account the impacts on the environment and the population in the Republic of Romania. Clarify the validity of the assumptions used in the calculations, the method of determining the resulting emission limits, definition of of critical groups; scenarios and descriptions of exposure paths for the population.	Sections 3.11.1. and 3.11.2. of the Terms of Reference (ToR) present the current condition and expected impact of the new nuclear unit and the current doses of gas-aerosol and liquid releases. It also presents the projected scenarios leading to the exposure of the population. In addition, Section 3.11.3. of the Terms of Reference (ToR) describes the reliability of the assumptions used in the calculations, the method of determining the resulting emission limits, identification of critical scenarios for the populations and descriptions of routes of exposure of the population. In detail this information will be presented in section 3.11. and section 4.11. of the Report of Environmental Impact Assessment (REIA). Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impact, will provide information directly concerning the Romanian territory in the 30 km zone of the evaluation.
14.	Identification, presentation and analysis of environmental factors affected by the construction of a new nuclear unit.	Factors and components of the environment, which should be assessed in the Report of Environmental Impact Assessment (REIA), as defined by the Environmental Protection Act (EPA) (of 2002, last amended on 15.02.2013), and specified in the Ordinance on the conditions and procedures for assessing the impact environmental (of 2003, last amended on 30.11.2012) and the instructions given by the Ministry of Environment and Water (MEW) regarding the notification of the investment project

№	Requirement	Comments
		(letter of outgoing reference № OBOC-220/05.07.2012 of the Ministry of Environment and Water) and additional information on the notification letter of outgoing reference № OBOC-220/09.01.2013. The presentation and analysis of these environmental factors and components on the territory of the Republic of Romania, will be made in Chapter 11 of the Report of Environmental Impact Assessment (REIA).
15.	Summary (list) of the basic software (programs and software) used in the analysis of safety (deterministic and probabilistic) and referencing the methodologies and acceptance criteria of accidents consequences and probabilities analyses results	The list of software (programs and software) used in the analysis of safety (deterministic and probabilistic) and a description of the methodologies and criteria for acceptance of the results of the analysis of the consequences and probabilities of accidents which will be used in the development of the Report of Environmental Impact Assessment (REIA) are presented in Appendix 11.2. to the Terms of Reference. The final list will present the relevant components in the Report of Environmental Impact Assessment (REIA). Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary Impact, will sumamrise the models used for simulation and description of the authenticity of assumptions.
16.	Reporting on the use and management of toxic and hazardous non-radioactive chemicals in the plant, as well as information on how effective legislative requirements in force will be applied to reduce the environmental impact	Section 3.8. The Terms of Reference (ToR) describes the situation and the expected impact of the new nuclear unit on the use and management of toxic and radioactive chemicals in the plant, accompanied by safety data sheets, as per the Bulgarian legislation,. To complete Sections 3.8. and 4.8. of the Report of Environmental Impact Assessment (REIA) detailed information on this issue will be submitted, while evaluating the impacts on the environment, workers and the population. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impact, will provide information on the potential impact on the Romanian territory in the 30 km zone, describe the

№	Requirement	Comments
		requirements which are in force and will be applied to reduce their environmental impact.
17.	Presentation of the cumulative environmental effects of the plant in the short, medium and long run and how to change the emergency planning zone, which includes the Romanian territory.	Chapter 5 Terms of Reference (ToR): Cumulative effect, presents the selected approach to evaluate the cumulative effects of all components and environmental factors, including biodiversity. Chapter 5 of the Report of Environmental Impact Assessment (REIA): Cumulative effect, will analyse and assess the possible cumulative effect of the implementation, operation and decommissioning of the new nuclear unit and other current and future facilities on- and off-site KozloduyNPP, in the context of potential impacts, including on biodiversity. Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impact, will include an assessment of the potential cumulative effect for the territory of Romania in the 30 km zone, including whether and how to change the emergency planning zone, which includes the Romanian territory.
18.	Description of the results of the radiological impact of the Romanian territory, both during normal and emergency operating modes: design and beyond design basis accidents, including severe accident	See section 10 hereinabove.
19.	Description of the technical, procedural and administrative measures designed to reduce trans-boundary impacts both during construction works and during operation	See section 3.3. hereinabove.
20.	Modeling the spread (dispersion) of pollutants in the ambient air (Dispersion modeling study for air pollutants) under unfavourable	See section 3.11 of the Terms of Reference: Models and software products of radiobiological effects and radiation risk per reference individual and for the assessment of doses to the population of liquid and gaseous radioactive emissions into the environment, present the modeling programs that are based on

№	Requirement	Comments
	weather conditions and the impact on Romanian territory	assessment methodologies for radiobiological effects and radiation risk, according to ICRP Publication 103, The 2007 Recommendations of the International Commission on Radiological Protection - model CREAM. These models are adapted to the Bulgarian conditions, using detailed weather data (for a period of more than 10 years) from the investment project area. The results of this modeling will be presented and analysed in section 4.11. of the Report of Environmental Impact Assessment (REIA). Chapter 11 of the Report of Environmental Impact Assessment (REIA): Transboundary impacts will present data and their analysis for the Romanian territory within the 30 km area of evaluation.

8.3 Requirements of the Federal Ministry of agriculture, forestry, environment and water management of Austria

The Federal Ministry of AFWM of Austria has submitted a letter with Ref. № 99-00-68/19.03.2013 to the MEW, whereby Austria addresses a request to Bulgaria to submit information on the Investment proposal, in accordance with the Convention on EIA in a transboudanry context (Espoo Convention). Austrial is willing to receive the Notification and the documentation related to the EIA scope, which should provide an opportunity to determine whether there is probability for significant unfavorable impacts on the environment in its territory. When the Austrian party submits any questions, they will be assessed and commented upon in the EIA-R.

9 STRUCTURE OF THE REPORT OF ENVIRONMENTAL IMPACT ASSESSMENT (REIA)

CONTENTS OF THE REPORT OF ENVIRONMENTAL IMPACT ASSESSMENT (REIA)

Introduction

Details of the Contracting Authority

1. **Summary of the investment project for construction works, activities and technologies.**
   1.1. *Need of investment project;*
   1.2. *Description of the physical characteristics of the investment project and the land areas necessary;*
   1.3. *Description of the main characteristics of the production process.*
2. **Location alternatives studied by the Contracting Authority (with sketches and coordinates of the coordinate system characteristic points established in the country) and/or technology alternatives and the reasons for the choice of study, considering the environmental impact, including "zero alternative".**
   2.1. *Alternatives by location;*
   2.2. *Alternatives by supporting infrastructure during construction works and operations;*
   2.3. *Alternative options for building new nuclear unit.*
   2.4. *Zero alternative.*
3. **Description and analysis of components and factors of the environment and the material and cultural heritage that will be significantly affected by the investment project and the interaction between them.**
   3.1. *Climate and ambient air*
   3.2. *Water:*
      3.2.1. Surface water;
      3.2.2. Groundwater.
   3.3. *Land and topsoil:*
      3.3.1. Land;
      3.3.2. Topsoil.

3.4. Earth interior and underground natural resources:

3.4.1. Earth interior;

3.4.2. Underground natural resources.

3.5. Landscape

3.6. Biodiversity:

3.6.1. Flora;

3.6.2. Wildlife (fauna);

3.6.3. Protected areas.

3.7. Waste:

3.7.1. Non-radioactive waste;

3.7.2. Radioactive Waste.

3.8. Hazardous substances

3.9. Harmful physical factors:

3.9.1. Noise;

3.9.2. Vibration;

3.9.3. Radiation;

3.9.4. Thermal impacts on the Danube river

3.10. Health and hygienic aspects of the environment and risk to human health:

3.10.1. Operating environment;

3.10.2. Affected population.

3.11. Radiation risk for the population in case of radioactive releases

3.12. Immovable cultural heritage

4. Description, analysis and evaluation of the likely significant effects on the population and environment, radiation and radiation aspects, resulting in the investment project implementation, the use of natural resources, emissions of harmful substances during normal operation and in emergencies, generation of waste and discomfort.

4.1. Climate and ambient air:

4.1.1. During construction works;

4.1.2. During operations;

4.1.3. During decommissioning.

4.2. Water:

4.2.1. Surface water:

4.2.1.1. During construction works;

4.2.1.2. During operations;

4.2.1.3. During decommissioning.

4.2.2. Groundwater:

4.2.2.1. During construction works;

4.2.2.2. During operations;

4.2.2.3. During decommissioning.

4.3. Land and topsoil:

4.3.1. Land:

4.3.1.1. During construction works;

4.3.1.2. During operations;

4.3.1.3. During decommissioning.

4.3.2. Topsoil:

4.3.2.1. During construction works;

4.3.2.2. During operations;

4.3.2.3. During decommissioning.

4.4. Earth interior and underground natural resources:

4.4.1. Earth interior:

4.4.1.1. During construction works;

4.4.1.2. During operations;

4.4.1.3. During decommissioning.

4.4.2. Underground natural resources:

4.4.2.1. During construction works;

4.4.2.2. During operations;

4.4.2.3. During decommissioning.

4.5. Landscape:

4.5.1. During construction works;

4.5.2. During operations;

4.5.3. During decommissioning.

4.6. Biodiversity:

4.6.1. Flora:

4.6.1.1. During construction works;

4.6.1.2. During operations;

4.6.1.3. During decommissioning.

4.6.2. Wildlife (fauna):

4.6.2.1. During construction works;

4.6.2.2. During operations;

4.6.2.3. During decommissioning.

4.6.3. Protected areas:

4.6.3.1. During construction works;

4.6.3.2. During operations;

4.6.3.3. During decommissioning.

4.7. Waste:

4.7.1. Non-radioactive waste:

4.7.1.1. During construction works;

4.7.1.2. During operations;

4.7.1.3. During decommissioning.

4.7.2. Radioactive waste:

4.7.2.1. During construction works;

4.7.2.2. During operations;

4.7.2.3. During decommissioning.

4.8. Hazardous substances:

4.8.1. During construction works;

4.8.2. During operations;

4.8.3. During decommissioning.

4.9. Harmful physical factors:

4.9.1. Noise:

4.9.1.1. During construction works;

4.9.1.2. During operations;

4.9.1.3. During decommissioning.

4.9.2. Vibration:

4.9.2.1. During construction works;

4.9.2.2. During operations;

4.9.2.3. During decommissioning.

4.9.3. Radiation:

4.9.3.1. During construction works;

4.9.3.2. During operations;

4.9.3.3. During decommissioning.

4.9.4. Thermal effects of the Danube river:

4.9.4.1. During construction works;

4.9.4.2. During operations;

4.9.4.3. During decommissioning.

4.10. Health and hygienic aspects of the environment and risk to human health:

4.10.1. Operating environment:

4.10.1.1. During construction works;

4.10.1.2. During operations;

4.10.1.3. During decommissioning.

4.10.2. Affected population:

4.10.2.1. During construction works;

4.10.2.2. During operations;

4.10.2.3. During decommissioning.

4.11. Radiation risk for the population in case of radioactive release

4.1. Immovable cultural heritage:

4.1.1. During construction works;

4.1.2. During operations;

4.1.3. During decommissioning.

5. Cumulative effect

6. **Characterization of the environmental hazards in case of potential accidents and incidents**
7. **Information on the methods used to estimate and evaluate the environmental impact. Justification of the chosen alternative**
8. **Description of the measures envisaged to prevent, reduce and wherever possible to offset any significant adverse effects, both in radiation and non-radiation aspects, including on the environment, and drafting a plan for the implementation of such measures**
9. **Monitoring**
10. **Standpoints and opinions of the public concerned, the competent authority regarding the decision-making on Environmental Impact Assessment (EIA) or officials authorised thereby and other specialised agencies and interested countries in a transboundary context, as a result of consultations held.**
11. **Transboundary Impact Assessment**
12. **Conclusion made by the team and the manager authors of the Environmental Impact Assessment (EIA).**
13. **Description of the difficulties (technical reasons, deficiencies or missing data) in the collection of information for drafting the Report of Environmental Impact Assessment (REIA).**
14. **Other information at the discretion of the competent authority or a person authorised by him.**
15. **Appendixes**

15.1. Appendix 1: Non-technical (executive) summary;

15.2. Appendix 2: Report on the assessment of the investment project compatibility (IPC) with the subject and objectives of protected areas conservation;

15.3. Appendix 3: Terms of Reference for the scope and content of the Report of Environmental Impact Assessment (REIA) ;

15.4. Appendix 4: Legislation framework;

15.5. Appendix 5: Methodology used;

15.6. Appendix 6: References (bibliography);

15.7. Appendix 7: Consultations held;

15.8. Appendix 8: Input information;

15.9. Appendix 9: Visual materials (maps, charts, etc.).

15.10. Other.

10 CONSULTATIONS

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
1.	**Ministry of Environment and Water (MEW), outgoing reference №OBOC-220 of 05.07.2012**	Conduct the Environmental Impact Assessment (EIA) procedures, assessment of compatibility with the subject and objectives of the protected areas conservation and the requirements of the Convention on Environmental Impact Assessment in a Transboundary Context.	Adopted	The said letter is a mandatory element of the procedure and all recommendations and requirements will be fully consistent with the Environmental Impact Assessment (EIA)
2.	**Ministry of Environment and Water (MEW), outgoing reference №OBOC-220 of 09.01.2013**	Consultations on determining the scope of the Environmental Impact Assessment (EIA), specific recommendations are expressed such as differentiation of independent points "Transboundary Impact Assessment" and "Cumulative Effect". It was recommended to expand the list of addressees for consultation.	Adopted	Recommendations are according to the Terms of Reference
3.	**Ministry of Environment and Forestry (MEF) (Republic of Romania) with outgoing reference №3672 RP of 18.10.2012**	As regards the content of the Report of Environmental Impact Assessment (REIA), which the Contracting Authority (by selecting Contractor) should produce as an official document required for the analysis and evaluation of the environmental impact in a Transboundary context, the Romanian authorities consider that it is important and should pay special attention to the following environmental aspects of nuclear safety and security. **Main requirements:** 1. The Report of Environmental Impact Assessment (REIA) should also include: • Information on the characteristics of the site that may be relevant to nuclear safety;	Partially adopted	Analysis and assessment of the transboundary impact of the construction of the new nuclear unit in Kozloduy NPP will comply with the requirements as defined in the Letter of the Ministry of Environment and Forests of Romania with Outgoing reference № 3672/RP/18.10.2012, as to the specific technical requirements it will take into account all the information available at this early stage of project development (pre-feasibility study). It should be clarified that it does not include the full volume of data required in terms of assessment in the context of specific technical requirements put forward by the Republic of Romania – they will be made available at a later stage, when the specific reactor model has been

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		• Information analysis of accidents, including major accidents (especially the possibility of radiological consequences on Romanian territory). It is necessary to specify the acceptable dose for every possible emergency scenario in the atmosphere and in the water of the Danube river; • Information on emissions in the ambient air and water of the Danube river during normal operation of the new power facility. 2. On both banks of the Danube river, near the town of Kozloduy, there are NATURA 2000 sites. On the Romanian coast there are the following NATURA 2000 sites protected respectively by the Habitats Directive and the Birds Directive: • ROSPA0010 Bistretriver; • ROSPA0023 Jiuriver-DanubeRiverConfluences; • ROSCI0045 Corridor of JiuRiver; • ROSPA00135 Sands from Dabuleni. It is imperative to conduct a proper evaluation study of the natural capital in accordance with Article 63 of Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. 3. The Report of Environmental Impact Assessment (REIA) should also include the following topics: • The impact on the flora and fauna on both banks of the Danube river in the investment project area located within and outside protected areas; • The cumulative impact in combination with other projects implemented at the proposed site and its surrounding areas, which can be harmful to the natural capital of both countries;		selected and when the relevant documents relating to the licensing of the project have been issued according to the harmonized legislation in the field of the safe use of nuclear energy for peaceful purposes. These documents include the Safety Analysis Report (SAR), Probabilistic Safety Analysis (PSA) and Technical Specifications (TS), and the same will be prepared at the technical design project for the specific model PWR of the new generation consistent with the particular conditions on the site of KozloduyNPP. In this regard, it will be stated that despite the limited volume of information available at this stage of the project implementation, it is sufficient to prepare the evaluation of the Transboundary impact of the cumulative effect from the operations of nuclear facilities on the site of KozloduyNPP.

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		• Measures to reduce the impact on biodiversity and the impact of residual effects after implementation thereof. 4. It is required that names of geographical locations on maps are written in Latin letters and maps should contain the Romanian sites included in the assessment. 5. It should take into account the fact that the zone of impact (30km around the Kozloduy NPP in Romania) has a population of 77,197 inhabitants in 18 settlements in the districts of Dolj and Olt, it is necessary that the environmental impact assessment includes an assessment of the radiological impact on human health. 6. It is required that the impact assessment for human health should assess the additional risk generated by the normal operation of the new nuclear unit, as well as in case of incidents, based on the recommendations of the International Commission on Radiological Protection (ICRP 103/2007) regarding diseases of exposure to ionizing radiation (morbidity and mortality rates from cancer, birth defects, developmental defects). These assessments should include both the situation in normal operation of the facilities and in case of nuclear accidents. 7. Taking into account the pollution levels of the environmental elements (air emissions, groundwater, surface water), it is necessary to perform studies on the health impact of their synergistic effect on the local population, both during the construction of power facility and during its operation. 8. In addition, the health impact research of the Romanian population in the area of Kozloduy NPP		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		should take into account the existence, on the same site, of the old units 1-4 of the Kozloduy nuclear power plant, currently undergoing decommissioning, which will generate nuclear waste in the future. It means that it is necessary to examine the cumulative effect on the Romanian population living in the zone of impact. 9. It is necessary to calculate the cumulative increase in risk to human health from the operation of these systems. **Specific technical requirements:** 1) Introduction of new technologies used in the new nuclear unit at Kozloduy NPP, comparing them with the new nuclear safety requirements after the Fukushima incident, and the essential differences with the current technology, resulting in entitling the project "nuclear reactor of NEXT GENERATION ". 2) Presentation of the design and objectives of nuclear safety, which form and define the structural framework integrated in the new nuclear unit on a site containing several capacities (for example, safety concept and principles, key safety features, regulatory requirements, integrated management); 3) Presentation of protective and auxiliary systems, including administrative measures designed to ensure the safety and security of the nuclear reactor, including the justification of specific nuclear safety requirements; 4) Presentation of the technical specifications (known as Limiting Conditions for Operation - LCOs), highlighting their importance as supporting		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		documentation for licensing and during the operational modes of the nuclear unit; 5) Brief but comprehensive presentation of the relationship between the essential requirements of European treaties or other international recommendations (for example, IAEA, US-NRC), ratified by the Bulgarian state, in the field of nuclear safety, safe management of radioactive waste and spent nuclear fuel, environmental assessments in a Transboundary context information on public participation in decisions, etc., and their coverage by the Bulgarian laws, rules and standards; 6) Identification and presentation of the radioactive waste management, including information on spent nuclear fuel, classification of its details on where and how it was transported, and the characteristics of transport containers; 7) Identification and specification details related to the processes and the nuclear and radiological characteristics in terms of plant safety, in the context of the implementation of the Integrated Management System (safety management, quality management, safeguards and security, environmental protection environment, health and safety at the workplace, financial agreement); 8) Discussion of the results of the impact assessment of the operation of new nuclear power facility on existing and operational capacities (and vice versa) and on the nuclear power plant in general; 9) Presentation of the main aspects of the environment monitoring system in this context to ensure compliance with the regulatory		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		requirements; 10) Drafting of a detailed list of possible emergency scenarios, including design basis accidents (Design Basis Accidents - DBA) and beyond design basis accidents (Beyond Design Basis Accidents - BDBA plus major accidents); 11) Discussion of the main results of the probabilistic assessment of nuclear safety, putting the emphasis on Beyond Design Basis Accidents (BDBA), postulated commissioning events and major accidents; 12) Discussion of the main results of the hazard analysis of events such as earthquakes, floods, fires, explosions, extreme weather, missile, plane crashes, human activities in the vicinity of the plant, etc. 13) Presentation of the limits and restrictions of doses and the derived emission limits for radioactive contamination release in the waste air and waste water during normal operation and in case of accidents; comparing these values with European levels, taking into account the effect on the environment and on the Romanian population. Explaining the considerations used to calculate various assumptions, clarifying the method of calculating the derived emission limits and determination of critical groups, scenarios and directions of irradiation are key aspects of such a report; 14) Identification, presentation and analysis of the development of environmental factors affected by the construction of the new nuclear unit; 15) Summary (list) of the basic computer code /		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		programs used in the safety analysis (deterministic and probabilistic) and references to the methodologies and criteria for acceptance of the results of the accidents analysis; 16) Brief presentation of information on the use and management of toxic and radioactive chemicals in the plant and details of how the requirements will be met, as regards the currently effective environmental effects; 17) Presentation of the considerations on the assessment of cumulative impacts of the plant on the environment in the short, medium and long term, and on the establishment of emergency planning zones and the inclusion of Romanian territories therein; 18) Description of the results of the radiological impact on the Romanian territory, both during normal operation and in emergency procedures, and during emergency conditions (design basis accidents and beyond design basis accidents), including in case of major accidents; 19) Details of technical, procedural and administrative measures designed to reduce Transboundary impacts, both during construction works and during operations of the nuclear power facility; 20) Taking into account the potential Transboundary impacts we require a dispersion modeling study of the ambient air pollutants (Dispersion modeling study for air pollutants) under adverse conditions and their effect on Romanian territory		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		(considering all the weather factors).		
4.	**Basin Directorate "Danube Region", Pleven – outgoing reference №3804/06.2012**	The competent authority shall provide information on the water bodies within the scope of the investment project and the measures as set out in the River Basin Management Plan. A reasoned assessment of the impact of the investment project has been made stating that the same new nuclear unit (NNU) and have a negative impact on aquatic ecosystems and water is permitted under the so-called environmental objectives and measures to achieve good water status as enshrined in the River Basin Management Plan, provided that due measures are taken to prevent direct and indirect pollution. It is necessary to provide for monitoring of radiation and non-radiation status of surface and groundwater in the area, and of groundwater, rainwater and waste water on the site of the investment project.	Adopted	Information provided by the Basin Directorate "Danube Region" was used to develop the Terms of Reference (ToR) and is key in defining the scope and content of the sections "Surface Water" and "Groundwater".
5.	**Basin Directorate "Danube Region", Pleven – outgoing reference №3804/08.01.2013**	The Environmental Impact Assessment (EIA) should pay particular attention to surface and ground water bodies and areas to protect them from possible interference from the linear infrastructure; to ensure compliance with the measures to avoid pollution of groundwater during construction works; to describe the need and methods of water supply during all stages of the investment project; to plan measures according to the SMP and to provide monitoring of radiation and non-radiation status of surface and groundwater in the vicinity of the site.	Adopted	Recommendations and requirements are included in Sections "Surface water" "Groundwater" and monitoring of Environmental Impact Assessment (EIA)
6.	**Ministry of Agriculture and Food (MAF), Regional Directorate „Agriculture“ – town of Vratsa, outgoing reference**	The Regional Directorate had no objection to the investment project implementation, as it is a matter of national importance. If during the siting procedure, property of State Land Fund is concerned, it is necessary to apply for prior approval from the Minister of Agriculture and Food (MAF), and to conduct the relevant	Adopted	The recommendations are consistent in defining the scope of Sections "Spatial Planning Parameters" and "Land and Topsoil" of the Environmental Impact Assessment (EIA)

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
	№2457/08.01.2013	procedure for changing the use of land		
7.	**Ministry of Health, National Centre of Radiobiology and Radiation Protection, outgoing reference №РД-02-08-17/04.01.2013**	In addition to Article 10, paragraph 3 of the Ordinance to ensure the safety of nuclear power plants (2004), the Terms of Reference (ToR) must also consider the requirements of Annex I of the Commission Recommendation of 11 October 2010 on the application of Article 37 of the Euratom Treaty by clarifying the extent of the impact and the risk to human health. The Environmental Impact Assessment (EIA) to determine the criteria for siting selection in accordance with the Ordinance to ensure the safety of nuclear power plants.	Partially adopted	There is a separate project siting criteria in EUR. The requirements of Article 37 of the Euratom Treaty, the requirements of Annex I of the Commission Recommendation of 11 October 2010 are reflected in the Terms of Reference and will be reported in the development of the Report of Environmental Impact Assessment (REIA) in assessing the extent of exposure and risk to human health. The site selection is subject to an associated project, which is being implemented in parallel with this Environmental Impact Assessment (EIA) of the investment project for new nuclear unit. The assessment in the Report of Environmental Impact Assessment (REIA) will be made pursuant to Article 25, paragraph 1 of the Ordinance to ensure the safety of nuclear power plants (2004), where it is said that favourable sites for deployment of an NPP are sites which meet the following conditions: compliance with environmental protection legislation, radiation protection, fire safety and physical protection requirements.
8.	**Regional Health Inspectorate-Vratsa, outgoing reference №КД-04-3513/09.01.2013**	The Regional Health Inspectorate provided specific guidance on the assessment scope regarding the risk to human health, including information relating to assert places and sites subject to health protection, identification of potentially affected populations and territories, data sources and sanitary protection; assessment of nuclear safety and radiation defense; risk factors for human health damage at all stages of the	Adopted	The requirements of the Regional Health Inspectorate are included in the development of the Terms of Reference and are considered of key importance in defining the scope and content of the sections “Health and hygienic aspects of the environment and risk to human health” and "Water"

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		investment project; assessment of the health risk and individual risk factors; assessment of the combined, complex or cumulative effects.		The siting selection is subject to an associated project, which is being implemented in parallel with this Environmental Impact Assessment (EIA) of the investment project for a new nuclear unit. The assessment in the Report of Environmental Impact Assessment (REIA) will be made pursuant to Article 25, paragraph 1 of the Ordinance to ensure the safety of nuclear power plants (2004), where it is said that favourable sites for deployment of an NPP are sites which meet the following conditions: compliance with environmental protection legislation, radiation protection, fire safety and physical protection requirements.
9.	**Bulgarian Nuclear Society, outgoing reference №1/09.12.2012**	It expressed satisfaction with the fact that the company was involved in the consultations on the Environmental Impact Assessment (EIA). Due to lack of time, the company has failed to examine in detail the summary of the investment project.	Adopted	The Bulgarian Nuclear Society will be involved in subsequent stages of the procedure.
10.	**District Governor, Vratsa District, outgoing reference №2600-15-(1)/07.01.2013**	The District Governor has no specific requirements other than those laid down in the Regulation on Environmental Impact Assessment (EIA).	Adopted	
11.	**Regional Museum of History, Vratsa, outgoing reference №135/27.12.2012**	The Regional Museum of History informed that within sites №1 and №2 archaeological immovable cultural property (burial mounds) with unspecified coordinates and area have been reported. The terrain of Site № 3 is located next to another necropolis also of unspecified coordinates and area. There is no evidence of cultural values within Site № 4. It is recommended to conduct field studies to specify the exact coordinates and boundaries of mounds and clarify their level of	Adopted	During the development of the Report of Environmental Impact Assessment (REIA) field studies will be performed to clarify the boundaries, size and degree of vulnerability of the said immovable cultural property.

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		vulnerability.		
12.	**Directorate-General for Fire Safety and Protection of Population, District Directorate of Vratsa, outgoing reference №45/03.01.2013**	Documentation received in the District Directorate of Vratsa was forwarded by competence to the Directorate-General "Fire Safety and Protection of Population" with the Ministry of Interior, city of Sofia.		
13.	**Agency for Exploration and Maintenance of the Danube River, outgoing reference №VIII-2-6/02.01.2013**	At this stage the Agency has no additional guidelines and recommendations, other than those set out in the Ordinance on the Environmental Impact Assessment (EIA).		
14.	**Municipality of the village of Harlets, outgoing reference №450/27.12.2012**	The investment project will contribute to the positive development of the local economy. When siting is carried out it is recommendable to comply with and assess the potential impacts on the catchment area – Pumping Station Harlets 1, SHK 1 and SHK 2;	Adopted	The requirements are included in the development of Terms of Reference (ToR) and are taken into account in determining the scope and content of the section "Groundwater."
15.	**Mayor of Kozloduy Municipality, outgoing reference №43-00-63/1/02.08.2012**	The municipality has failed to ensure conditions for equal access to the public notice on the investment project; there are no opinions, complaints and/or suggestions received from the public regarding the investment project.	Adopted	Provided that additional standpoints and opinions are received, they will be reflected in the Report of Environmental Impact Assessment (REIA).
16.	**Kozloduy Municipality, outgoing reference №73-00-128/1/03.01.2013**	1. The description and the manner of treatment by type and quantity of expected waste streams should be strictly in line with the new Waste Management Act and relevant regulations. 2. At the construction stage of the facility it may become necessary to clear trees and shrubs from the site. It is therefore necessary to pay attention to how bio-waste and composting is being treated. 3. Taking into account the fact that the investment	Adopted	All recommendations and considerations brought to the attention of the municipal government are used to develop the Terms of Teference and will be reviewed and evaluated in the Environmental Impact Assessment (EIA).

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		project will be implemented near protected sites under NATURA 2000, it is recommended that individual elements (flora and fauna) be studied separately. 4. The section related to the description of quality characteristics of ground and surface water should present the impact on groundwater and options for drinking water supply to production facilities, scheduled for construction under the investment project. 5. To examine the effect and impact of investment project on the current communication and transport infrastructure of the town of Kozloduy in view of the fact that the ring road is not completed yet, which would otherwise reduce traffic congestion in the town and directly and indirectly affect the cleanliness of the local ambient air.		
17.	**District Forestry Service - Oryahovo, Outgoing reference №813/09.01.2013**	The proposed sites do not affect land in forest areas; the Report of Environmental Impact Assessment (REIA) must comply with the environmental characteristics and the degree of impact thereupon.	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA).
18.	**State enterprise "Radioactive Waste", outgoing reference №П-06-00-43/11.01.2013**	The State Enterprise Radioactive Waste endorses and supports the investment project and agrees with the proposed draft Terms of Reference (ToR) reflecting the legal requirements	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA).
19.	**Bulgarian Society for the Protection of Birds, outgoing reference №5/09.01.2013**	Detailed information was provided on the subject and availability of protected areas within the investment project area and the subject and purpose of protecting them. They expressed specific requirements and recommendations to the Report of Environmental Impact Assessment (REIA) and the Report of the Impact on Natura 2000 sites, for example analysis of the risk of mortality of large birds due to collision with electrical	Adopted	This opinion will be considered and taken into account when developping the Report on the Environmental Impact Assessment (EIA).

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		wiring; likely deterioration of the food base, etc.		
20.	**Ministry of Health, with outgoing reference №26-00-2370/11.01.2013**	The Ministry of Health recommended, along with the requirements of Article 10, paragraph 3 of the Ordinance on Environmental Impact Assessment (EIA), that the Terms of Reference should take into account the requirements of Annex I of the Commission Recommendation of 11 October 2010 on the application of Article 37 of the Euratom Treaty by clarifying the extent of the impact and risk to human health. The criteria for site selection shall comply with the requirements of the Ordinance to ensure the safety of nuclear power plants.	Partially adopted	There is a separate project on siting criteria in EUR. The recommendations of Article 37 of the Euratom Treaty, the requirements of Annex I of the Commission Recommendation of 11 October 2010 are reflected in the Terms of Reference (ToR) and will be subject to the Report of Environmental Impact Assessment (REIA) in assessing the extent of exposure and risk to human health.
21.	**Ministry of Environemnt and Water (MEW), Regional Inspectorate of Environment and Waters – Vratsa, outgoing reference №B2975/10.01.2013**	I. The structure of the Terms of Reference (ToR) generally follows the requirements of Article 10, paragraph 3 of the Ordinance on conditions and procedures for assessing the environmental impact (Ordinance on Environmental Impact Assessment (EIA)). II. In preparing the Environmental Impact Assessment (EIA) it shall use actual data, scientific knowledge and methods of assessment, in accordance with Article 11, paragraph 1 of the Ordinance on Environmental Impact Assessment (EIA). III. Comply with Article 14, paragraph 1, sub-paragraph 5 - "Plan for implementation of measures ..." it shall ne developed in tabular form, under Annex № 2a of the Ordinance on Environmental Impact Assessment (EIA). IV. It should address the requirements of Article 95, paragraph 3 of the Environmental Protection Act /EPA/ - to be consulted with the affected community and the results will be reflected in the	Adopted	Recommendations (I-VII) have been incorporated in the Terms of Reference (ToR) and will be subject to the Report of Environmental Impact Assessment (REIA) Recommendation VIII-t. 5 is incorporated in the Terms of Reference (ToR) - the topsoil compartment and will be subject to the Report of Environmental Impact Assessment (REIA). Recommendation p.3-Waters is incorporated in the Terms of Reference (ToR) and will be taken into account in the Report of Environmental Impact Assessment (REIA).

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		Report of Environmental Impact Assessment (REIA). To notify Kozloduy Municipality of the investment project and take their standpoint into consideration. V. The report should examine the evaluated alternatives pursuant to Article 96, Paragraph 1, sub-Paragraph 2 of the Envrionmental Protection Act (EPA). VI. According to article 9, paragraph 5 of the Ordinance on Environmental Impact Assessment (EIA) it should produce and enclose a referemce statement of the consultations carried out and the reasons for any adopted and rejected comments and recommendations, as well as evidence of their conduct. VII. In the Report of Environmental Impact Assessment (REIA) you must comply with the following recommendations: 1. Protected Areas: the investment project does not affect protected areas under the Protected Areas Act. The nearest protected area is Protected Area "Kozloduy" - about 10 km from the site. It should provide information on the impact of the implementation and operations of your investment project, including the cumulative effect on the protected area. 2. Natura 2000: As regards the Impact Evaluation Report (IER), which is enclosed as an annex to the Environmental Impact Assessment (EIA): The nearest protected areas to the site of the nuclear power plant are: BG0002009 "Zlatiyata" - located about 500 m from the site, BG0000614 "Ogosta River" - about 7,00 km		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		and BG0000533 "Kozloduy Island" - about 3,00 km from the site of the investment project implementation. The Impact Evaluation Report (IER) should take into account the vicinity of these areas, particularly the area for the conservation of wild birds BG0002009 "Zlatiyata" in assessing the impact of the investment project on natural habitats and habitats of species subject to protection therein. When preparing the Impact Evaluation Report (IER), it should meet the requirements of the Ordinance on the conditions and procedures for assessing the compatibility of plans, programs, projects and investment projects with the subject and objectives of the protected areas conservation /Ordinance on the environment/ (promulgated in State Gazette, issue 73 of 2007) on the structure and content thereof. It should pay particular attention to the cumulative impact on the said protected areas, which will occur in the realization of this investment project, combined with the impact of other investment projects on the existing site of Kozloduy NPP, and near it. 3. Component - **Water**: • Water supply for the needs of the technological processes - cooling, fire water, spray ponds, etc., and household water supply. • Estimated volume of waste water - cooling, industrial and residential. • Methods of treatment / waste water		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		treatment, depending on its specifics. • Options for use of the main drainage channel for discharge of the newly generated waste streams. • Option to use the existing sewerage system of the nuclear power plant site and options for building a new system as part of the existing one or as standalone. • Option to use the existing waste water treatment plant to the EP-2 and option with the construction of a standalone waste water treatment plant on the new site for a nuclear reactor. • Program for carrying out own radiation and non-radiation emission control of waste water. • Systems for management of waste water leakages in case of potential emergencies, radioactivity (primary circuit) and non-radioactive zone (secondary circuit). • • Please note that licenses issued (water abstraction and discharge) so far by the River Basin Management Directorate - Pleven are in favor of the permit holder Kozloduy NPP EAD whereas the new entity Kozloduy New Build EAD has no such rights. 4. **Waste**: For each piece of waste generated during construction works and operations of the site, including industrial, hazardous, municipal and construction waste, the type		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		should be indicated, as well as quantity, method of storage and disposal in accordance with the applicable regulations. Provisions should be in place to identify ways to reduce or eliminate the negative impact of waste on the environment. 5. **Topsoil**: provide information on the monitoring of topsoil, which will be carried out following the introduction of new facilities in operation. 6. To be included in the Report of Environmental Impact Assessment (REIA): • Description, analysis and evaluation of the likely relevant effects on the population and the environment as a result of the investment project implementation • Measures envisaged to prevent, reduce and as fully as possible offset any adverse effects of the investment project implementation on the environment • Evaluate the application of best available techniques /BAT/	Not adopted	Nuclear power plants do not fall within the scope of the developed reference manuals for best available techniques (BAT) by the European Commission (Institute for Prospective Technological Studies - Seville, Spain) "Integrated Prevention and Pollution Control" (IPPC). Requirements for compliance with the so-called best available techniques (BAT) in this case can be replaced with the recommendations of the International Atomic Energy Agency (IAEA - Vienna) and EURATOM, and with the national law standards in this field.
22.	**Ministry of Environment**	Due to the specifics of the investment project, the	Adopted	

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	and Water (MEW), Executive Environment Agency (EEA), with outgoing reference №26-00-8 of 14.01.2013	emphasis in the development of the Report of Environmental Impact Assessment (REIA) should be placed on: • radiation effects playing a dominant role in the assessment of risk to the environment and the population in the area of KozloduyNPP • assessment of cumulative impacts from the operation of the new nuclear unit while using actual data; • modification of climate zones with special status around the nuclear power facility; • measures to prevent or reduce significant radiation effects due to operation; • detailed and reasoned consideration of anticipated operational conditions and design basis accidents in the facility. These four sites subject to the investment project do not fall within protected areas under the Protected Areas Act (PAA) or within protected sites of NATURA 2000, under the Biological Diversity Act. The 30-kilometer zone around the investment project has the following *protected territories* - Ibisha reserve and protected areas of Kozloduy, Daneva Mogila, Tsibar Island, Koritata, monastic city of Topolite, Kochumina and Gola Bara and *protected areas* designated under the Directive on the conservation of habitats and of wild fauna and fauna – Zlatiya BG0000336, Tsibar BG0000199, Skat River BG0000508 and Kozloduy BG0000527;, *protected areas* designated under the Directive on the conservation of wild birds - Ibisha Island BG0002007 and Island to Gorni Tsibar BG0002008. The investment project is subject to a compatibility assessment procedure with the subject and purpose of conservation of protected areas cited above. It is in the		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		Report of Environmental Impact Assessment (REIA) to assess the impacts of the investment project on the aforementioned protected areas.		
23.	**National Electricity Company, with outgoing reference №73-01-7 of 16.01.2013**	I hereby inform you that after a review of the documents attached to the above letter and in particular Annex 1: "Investment project for the construction of a new nuclear unit ..." and Appendix 4: "Example content of the Terms of Reference (ToR) on the scope of the Report of Environmental Impact Assessment (REIA)", we have the following general comments and remarks: 1. There is no narrative of the specific information as required by Annex № 2 to Article 6 of the "Ordinance concerning the conditions and procedures for assessing the environmental impact" (Title amended – State Gazette, issue 3 of 2006), namely "Information to assess the need for an Environmental Impact Assessment (EIA)." It should be made available before awarding the development of "Terms of Reference (ToR) on the scope of the Report of Environmental Impact Assessment (REIA)", while its absence does not allow NEC making specific guidelines and recommendations as required in your letter. Such missing specific information should have been presented with a written request to the Ministry of Environment and Water from Kozloduy New Build EAD in accordance with Article 6 of the "Ordinance concerning the conditions and procedures for assessing the environmental impact" and in connection with Article 93, paragraph 1 of the Environmental Protection Act (EPA). 2. The draft Terms of Reference (ToR) you have presented there is no requirement for:	Consistent	The determination of the applicable Environmental Impact Assessment (EIA) and actions to be taken by the Contracting Authority within the procedure are fully vested in the competent environmental authority - the Ministry of Environment and Water. The investment project individually falls within the scope of paragraph 2.2 of Annex № 1 of the Environmental Protection Act (EPA) and pursuant to Article 92, paragraph 1 in conjunction with section 2 of the Environmental Protection Act (EPA), the investment project is **subject to mandatory assessment** of the environmental impact (EIA). Respectively for the case the following stage of the Environmental Impact Assessment (EIA) is not applicable - preparation of information to assess the need for Environmental Impact Assessment (EIA). Some remarks of NEC concern certain procedural steps that are required according to the Ordinance on Environmental Impact Assessment (EIA), including in a Transboundary Context. At the stage

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		• presentation of specific information as required under the Convention to assess the environmental impact in a transboundary context; • addressing the provisions of Chapter II, Article 4, paragraph 3 of the "Ordinance concerning the conditions and procedures for assessing the environmental impact"; • addressing the provisions of Chapter I, Article 9, paragraph 1 to 13 of the "Regulation № 4 of 21.05.2001 on the scope and content of investment projects"; • description of the Electrical Part of the NPP in relation to the "Ordinance № 4 of 21.05.2001 on the scope and content of investment projects" and Article 2, paragraph 1, sub-paragraph 1 of "Ordinance № 6 of 09.06.2004 concerning the accession of electricity producers and consumers to transmission and distribution networks"; • description of the infrastructure of the sites identified under the "Ordinance concerning the conditions and procedures for assessing the environmental impact" (Title amended - State Gazette, issue 3 of 2006) • addressing the provisions of the "Rules of the Grid Management Code" issued pursuant to Article 21, paragraph 1, sub-paragraph 7 of the Energy Act by the Chairman of the State Energy and Water Regulatory Commission, Annex to paragraph 1 of Decision № P-5 of 18.06.2007, promulgated in State Gazette, issue 68 of 21.08.2007		of the Environmental Impact Assessment (EIA) procedure regarding the current investment project, all procedural requirements are met.

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		• addressing the provisions of all applicable and enforceable in Bulgaria regulations, directives of the European Commission, international conventions to which the Republic of Bulgaria is a party and the IAEA standards in the field of nuclear energy. They should be presented as a list in the Terms of Reference (ToR) and also be required to prepare an analysis of the compliance of the investment project with them.		
24.	**Bulgarian Energy Holding, with outgoing reference №02-0064 of 17.01.2013**	The letter stated that in connection with the requirements of the Ministry of Environment and Water, conveyed in a letter of the Ministry of Environment and Water of 05.07.2012, Kozloduy NPP - New Build EAD has launched a consultation process with selected institutions, including the Bulgarian Energy Holding AD. The actions specified for Kozloduy NPP - New Build EAD to conduct the Environmental Impact Assessment (EIA) procedure are described in part I of the above letter of the Ministry of Environment and Water. Paragraph 1 states the need to assign to the development of Terms of Reference (ToR) on the scope and content of the Environmental Impact Assessment (EIA), while Paragraph 2 states that it is necessary to organise consultations on the Terms of Reference (ToR). The instructions correspond to the requirements of Article 10, paragraph 5 of the Ordinance on the terms and conditions of the Environmental Impact Assessment (EIA). The presented Appendix № 4 "Sample content of the Terms of Reference (ToR) on the scope of the Report of Environmental Impact Assessment (REIA)" refers to the provision of Article 10, paragraph 4 of the Ordinance.	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA)

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		According to Article 10, paragraph 5 of the Ordinance on the terms and conditions of the Environmental Impact Assessment (EIA), the Contracting Authority must hold consultations on the draft Terms of Reference (ToR). The draft of Terms of Reference (ToR) was not presented. In paragraph 2 of the said letter, the Ministry of Environment and Water listed the authorities recommended to be involved in the consultation process. We believe that "specialised institutions" are institutions that carry out functions related to the evaluation of certain aspects of the investment project within the EIA procedure, excluding Bulgarian Energy Holding AD. In connection with the foregoing, we expect that Kozloduy NPP - New Build EAD, a company part of the group of Bulgarian Energy Holding AD, would submit for consideration the draft Terms of Reference (ToR) on the scope of the Report of Environmental Impact Assessment (REIA).		
25.	**Ministry of Interior, Fire Safety and Protection of the Population, with outgoing reference №ПО-398 of 17.01.2013**	We suggest that: Paragraph 4 of "Example content of Terms of Reference (ToR) on the scope of the Report of Environmental Impact Assessment (REIA)", should include a section on analysis and recommendations for emergency planning of the new nuclear unit to be made on the basis of possible contamination, types of discharges, these perimeters and discharges contaminants under the expected design and beyond design basis accidents.	Partially adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA) All information available at this early stage of project development (feasibility study) does not include the full volume of data required in terms of the assessment of beyond design basis accidents. They will be available at a later stage, when the specific model of the selected reactor is developed and when the relevant documents relating to the investment project licensing according to the harmonized legislation in the field of the safe use

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
				of nuclear energy for peaceful purposes are produced.
26.	**Ministry of Economy, Energy and Tourism, with outgoing reference №26-A-10 of 22.01.2013**	Directorate for "Security of Supply" has no proposal to supplement the proposed scope of the document and believes that it is in full compliance with the requirements of the Ordinance on Environmental Impact Assessment (EIA).	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA).
27.	**Water & Sanitation – Vratsa, with outgoing reference №53 of 22.01.2013**	During the site inspection held on 21.01.2012 together with your representative - Borislav Zlatanov, we found that the four proposed sites for construction of the new nuclear units do not affect our networks and water supply facilities. For this reason, "Water & Sanitation" Ltd, Vratsa, approves the four proposed sites.	Adopted	
28.	**Ministry of Culture, National Institute of Immovable Cultural Heritage, with outgoing reference №4800-2 of 25.01.2013**	According to the information kept at the State Records Service of the National Institute of Immovable Cultural Heritage, the municipalities of Kozloduy, Valchedram Hayredin, Mizia, Lom, Slatina and Oryahovo / in that 30-kilometer zone/ contain nearly 300 pieces of architectural, construction, historical, artistic and archaeological cultural property values. Near the Kozloduy NPP there is the "Roman fortress" Regina" – architectural and construction immovable cultural property under the category of "national relevance", as promulgated in State Gazette, issue 90/1965, and the Archeological Reserve - Ancient Fortress "Augusta", village of Harlets, locality of "Kaleto", declared with Decision of Council of Ministers № 14/25.06.1984. The land of Kozloduy Municipality is characterized by a high density of archaeological cultural property values. As seen on topographic maps, in the direct vicinity of Kozloduy NPP there are several necropolises likely to be affected by the implementation	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA)

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		of the investment plan. By Order of the Council of Ministers № 1711 of 22.10.1962, all settlement and burial mounds and medieval ramparts are declared monuments of the category "national relevance." Due to the specifics of immovable archeological cultural property it is assumed as possible that within the proposed four alternative sites for the new nuclear power capacity, unregistered objects may appear of "national cultural value" as per Article 146, paragraph 3 of the Cultural Heritage Act. The National Institute of Immovable Cultural Heritage requires: 1. The part of the Report of Environmental Impact Assessment (REIA) concerning immovable cultural heritage to be drafted by a professional archaeologist and be based on a preliminary survey of the sites that will be affected by the construction of the new nuclear unit and inbound technical infrastructure. The purpose of such survey is to determine the presence or absence of immovable cultural property in these areas and how the investment plan will have a negative impact on existing immovable cultural property. A written report of the results of the inspection should be sent to the Ministry of Culture. 2. If any adverse effects on immovable cultural property are found in the implementation of the investment plan, the Report of Environmental Impact Assessment (REIA) should be submitted for consideration to the Ministry of Culture, and follow-up actions should comply with the requirements of Article 161 of the Cultural Heritage Act and must be coordinated with the		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		Ministry of Culture under Article 83 and Article 84 the Cultural Heritage Act.		
29.	**Institute for Nuclear Research and Nuclear Energy, with outgoing reference №1-1 of 25.01.2013**	The Institute for Nuclear Research and Nuclear Energy with the Bulgarian Academy of Science (BAS) submitted its guidelines and recommendations on the Terms of Reference (ToR) on the scope and content of the Environmental Impact Assessment (EIA) of the investment project for the construction of a new nuclear unit at Kozloduy NPP. Attached we send the contents of the Report of Environmental Impact Assessment (REIA) (*Note: Report of Environmental Impact Assessment (REIA) of* ***"Reconstruction and conversion of the research reactor IRT-2000 for its transformation into a civic low-power reactor (200 kW) and further application in medicine (neutron cancer therapy) – city of Sofia, Mladost residential district)***	Adopted	
30.	**Ministry of Agriculture and Food (MAF), Executive Forestry Agency, with outgoing reference №ИАГ-4791 of 31.01.2013**	The information presented contains no data if the investment project affects land in forest areas. If forest areas are indeed affected, within the consultations held pursuant to the provisions of Article 10, paragraph 7 of the Ordinance on Environmental Impact Assessment (EIA), the Executive Forest Agency has the following suggestions complementing the content of the information submitted: 1. **The scope of the Report of Environmental Impact Assessment (REIA) should be consistent with the specific land properties** in forest areas where the investment plan will be realized. The Terms of Reference for the preparation of the Report of Environmental Impact Assessment (REIA) should attach a draft sketch or sketches of the investment project properties under the cadastral	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA)

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		map and an extract of the cadastral register containing property data or an extract from the recovered property map and lots of them representing areas of forest areas. The following procedures under the **Forest Act (FA)** are inevitably associated with the matching of land subject to change of land use or where limited estate rights will be incorporated (right to build and easement) on landed properties that are within the scope the Environmental Impact Assessment (EIA). It is recommendable to describe the properties under the following procedures: ○ Those subject to change of land use - pursuant to Article 73 of the Forest Act; ○ Those subject to establishment of an easement - pursuant to Article 61 or Article 64 of the Forest Act; ○ Those subject to establishment of a right to build without change of land use - pursuant to Article 54 of the Forest Act; ○ Those subject to lease - pursuant to Article 43 of the Forest Act. 2. The **administrative decision** issued by the Ministry of Environment and Water **should refer to the land properties** in forest areas where different facilities shall be implemented. To complete the procedures for change of land use (except in cases of Article 73, paragraph 1, sub-paragraph 5), the establishment of right to build or easements under the Forestry Act shall apply in different order that is associated with the issuance of administrative acts and entering into agreements.		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
31.	**Ministry of Defense, with outgoing reference №11-00-13 of 01.02.2013**	Pursuant to Article 95, paragraph 3 of the Environmental Protection Act and Article 9, paragraph 1 of the Ordinance on the conditions and procedures for assessing the environmental impact, we inform you that the Ministry of Defence has no remarks, guidelines or recommendations on Terms of Reference (ToR) on the scope and content of the Environmental Impact Assessment (EIA) for the investment project for the construction of a new nuclear unit at the site of Kozloduy NPP.	Adopted	
32.	**Kozloduy NPP EAD, Safety and Quality Directorate, with outgoing reference №Д „Б и К" 190/8.02.13**	1. Provide an assessment of the cumulative impact of the new investment project on existing and future proposals located at the NPP site or in its vicinity thereof. 2. Activities in terms of water use, discharge and radioactive waste activities comply with the environmental programs at KozloduyNPP. 3. Comply with the terms of the environmental licenses issued to Kozloduy NPP. Kozloduy NPP – New Build EAD should be requested, upon preparation of each new version of the Terms of Reference, to forward the document to Kozloduy NPP EAD for review and comments.	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA)
33.	**Ministry of Agriculture and Food (MAF), with outgoing reference №70-148 of 13.02.2013**	1. Out of all four alternative sites proposed, the most favourable under the Protection of Agricultural Land Act, in case that it is designed to be the successor of a new nuclear unit, considered to be site№ 4 - within the expropriated land of NPP. In case that a choice should be made among the other proposed alternatives, more favourable are those that affect less productive farmland.	Partially adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) and will be consistent with the Report of Environmental Impact Assessment (REIA)
34.	**Nuclear Regulatory Agency, with outgoing**	In response to your letter № 252/05.12.2012 we inform you that in accordance with the transitional provisions of	Adopted	This opinion is taken into account in section 1.8.2.1.2 Emissions of radioactivity in the ambient

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
	reference №47-00-171 от 12.02.2013	§ 3 paragraph 2, sub-paragraph 2 of the Ordinance to ensure the safety of nuclear power plants, for existing nuclear power plants at the time of entry into force of this Ordinance the annual individual effective dose per capita of the population, caused by the impact of liquid and gaseous releases into the environment under all operating conditions should be less than 0.25 mSv. According to Article 37, paragraph 2 of the Ordinance concerning the procedure for issuance of licenses and permits for safe use of nuclear energy, whenever it provides for a nuclear power facility to be located at a site already built and another nuclear power facility be commissioned, the preliminary report on the safety analysis should consider the possible safety impact on the proposed new nuclear power facility and other facilities at the same site. The requirement of 0.25 mSv applies to all buildings and facilities, which are located and will be located at the site of Kozloduy NPP. At present, the nuclear facilities are units 1-6, the Wet Storage Facility and the National Disposal Facility for Radioactive Waste. The limits of gaseous releases from all Kozloduy NPP stacks are identified based on an individual effective dose of 0.05 mSv per year per capita of the population. Based on operational experience, the release limits for the entire site are distributed between stacks of Units 1÷6 and the Wet Storage Facility. For liquid releases a quota dose 0.05 mSv is adopted per year. After the final shutdown of Units 1÷4, the Nuclear Regulatory Agency has not received applications for permits for changes in theoverall limits for gaseous and liquid releases from Kozloduy NPP. Permit № HX-3593 of 04.05.2012 issued by the Nuclear		air, and will be taken into account in the Report of Environmental Impact Assessment (REIA) in Chapter 4.11 - Radiation risk for the population in radioactive releases

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		Regulatory Agency to design a nuclear power facility for radioactive waste management - a national disposal facility for radioactive waste, provides for a pre-condition that the permit holder should provide in the investment project for the appropriate technical and organisational measures that the annual individual effective dose for the critical group of the population as a result of normal operation of the facility after its closure, be limited to 0.1 mSv. Based on the foregoing, in accordance with existing regulations and licensing practices it can be assumed that for a new nuclear power facility on the site of Kozloduy NPP, the annual individual effective dose per capita of the population, caused by the impact of liquid and gaseous releases into the environment under all operating conditions should be limited to 0.05 mSv. In calculating the dose per capita of the population it is necessary to take into account all radio nuclides in liquid and gaseous releases as specified in Recommendation 2004/2/Euratom. On the issue of the need to assess the cumulative effect of all nuclear facilities in design basis accidents, according to the current regulations and regulatory guides, it is not required to allow the imposition of simultaneous occurrence of a design basis accident for all facilities on the site given the specific safety reasons at this level of defense-in-depth. However, it is necessary to pay attention to the fact that as a result of the stress tests on European nuclear power stations following the accident at Fukushima - Daiichi, one of the resulting measures is reporting emergency action plans for a concurring major accident at all facilities on the site.		

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
35.	**Ministry of Culture, with outgoing reference №33-НН-81 of 19.02.2013**	According to the information kept at the State Records Service of the National Institute of Immovable Cultural Heritage, the municipalities of Kozloduy, Valchedram Hayredin, Mizia, Lom, Slatina and Oryahovo (in that 30-kilometer zone) contain nearly 300 pieces of architectural, construction, historical, artistic and archaeological cultural property values. Near the Kozloduy NPP there is the "Roman fortress" Regina" – architectural and construction immovable cultural property under the category of "national relevance", as promulgated in State Gazette, issue 90/1965, and the Archeological Reserve - Ancient Fortress "Augusta", village of Harlets, locality of "Kaleto", declared with Decision of Council of Ministers № 14/25.06.1984. The land of Kozloduy Municipality is characterized by a high density of archaeological cultural property values. As seen on topographic maps, in the direct vicinity of Kozloduy NPP there are several necropolises likely to be affected by the implementation of the investment plan. By Order of the Council of Ministers № 1711 of 22.10.1962, all settlement and burial mounds and medieval ramparts are declared monuments of the category "national relevance." Due to the specifics of immovable archeological cultural property it is suggests as possible, within the proposed four alternative sites for the deployment of new nuclear power capacity, to come across unregistered objects possessing the status of "national cultural value" under Article 146, paragraph 3 of the Cultural Heritage Act. **The Ministry of Culture has the following requirements to the "Terms of Reference (ToR) for the scope and content of the Environmental Impact Assessment (EIA) for the investment**	Adopted	This opinion is taken into account when preparing the Terms of Reference (ToR) in sections 3.12 and 4.12 and will be reflected in the Report of Environmental Impact Assessment (REIA)

№	Consultations held (municipality, department, regulatory body, other)	Description of expressed opinions / recommendations / observations	Adopted/ Not adopted	Reasons
		project for the construction of a new nuclear unit of the latest generation in Kozloduy NPP, town of Kozloduy": 1. The part of the Report of Environmental Impact Assessment (REIA) concerning immovable cultural heritage to be drafted by a professional archaeologist and be based on a preliminary survey of the sites that will be affected by the construction of the new nuclear unit and inbound technical infrastructure. The purpose of such survey is to determine the presence or absence of immovable cultural property in these areas and how the investment plan will have a negative impact on the existing immovable cultural property. A written report of the results of the inspection should be sent to the Ministry of Culture. 2. If any adverse effects on immovable cultural property are found in the implementation of the investment plan, the Report of Environmental Impact Assessment (REIA) should be submitted for consideration to the Ministry of Culture, and follow-up actions should comply with the requirements of Article 161 of the Cultural Heritage Act and must be coordinated with the Ministry of Culture under Article 83 and Article 84 the Cultural Heritage Act. This opinion is prepared on the basis of: 1. Opinion of the National Institute of Immovable Cultural Heritage, 2. Documentation available.		

11 LIST OF REQUIRED APPENDIXES, LISTS AND OTHERS

11.1 APPENDIX 1: LEGISLATION FRAMEWORK

11.2 APPENDIX 2: METHODOLOGIES USED

11.3 APPENDIX 3: REFERENCES AND INPUT DATA

11.4 APPENDIX 4: CONSULTATIONS HELD

12 STAGES AND TERMS OF DEVELOPMENT OF THE REPORT OF ENVIRONMENTAL IMPACT ASSESSMENT (REIA)

The stages/phases and the timing of the development of the Report of Environmental Impact Assessment (REIA) are as follows:

	Phase/Stage	**Date of completion**
Phase 1 - Development of Environmental Impact Assessment (EIA), Environmental Assessment Report and Transboundary Impact		
1	Preparation of the Report of Environmental Impact Assessment (REIA)	**third quarter, 2013**
2	Preparation of Environmental Assessment Report	
3	Report on the Transboundary Impact.	
Phase 2 - First review by the competent authorities		
4	Receiving comments from the Ministry of Environment and Water (MEW), compliance witht the comments of the Ministry of Environment and Water (MEW), approval of reports by the Ministry of Environment and Water (MEW)	**third quarter, 2013**
Phase 3 - Public discussion and conclusions from the public consultation		
5	Preparation and conduct of public discussion, organisation of public debate, public discussion, procession of public consultation protocols, observations on the proposals, opinions and recommendations and the outcomes of the public consultation.	**fourth quarter, 2013**
Phase 4 - Final approval by the competent authorities		

6	Submission of EIA documentation for conducting Environmental Impact Assessment (EIA) to the Supreme Expert Environmental Council (SEEC)	**fourth quarter, 2013**
Expected resolution on the Environmental Impact Assessment (EIA)		

13 OTHER CONDITIONS OR REQUIREMENTS

In connection with the determination of the Transboundary impact from the IP, data are required on the territory of the Republi of Romania that falls under the 30 km Monitored area. The Contractor puts the needed efforts to gather this data, insofar as possible.

The current Terms of Reference comprises ana analysis of the whole available information at the time it was prepared, and effort was made to base the forecasts and the additional analyses and evaluation that shall be performed within the EIA-R preparation, on actual, reliable, and up-to-date information. To that end the EIA-R shall incorporate information also from the following projects:

1. STUDY AND SITING OF A NEW NUCLEAR UNIT AT KOZLODUY NPP SITE;
2. FEASIBILITY STUDY FOR THE CONSTRUCTION OF A NEW NUCLEAR UNIT AT KOZLODUY NPP SITE.

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APPENDIX 1: LEGISLATIVE FRAMEWORK

No.	Name of the legal instrument	Date of promulgation	Date of last change
1.	Safe Use of Nuclear Energy Act	Promulgated State Gazette, issue 63 of 28 June 2002	Amended and supplemented State Gazette, issue 15 of 15 February 2013
2.	Regulation on safety assurance of spent nuclear fuel management	Promulgated State Gazette, issue 71 of 13 August 2004	Not applicable
3.	Regulation on safety during radioactive waste management	Promulgated State Gazette, issue 72 of 17 August 2004	Not applicable
4.	Regulation on basic norms of radiation protection	Promulgated State Gazette, issue 76 of 05.10.2012	Not applicable
5.	Regulation on he conditions and procedure for establishing of zones with special status around nuclear facilities and sites with sources of ionizing radiation	Promulgated State Gazette, issue 69 of 06.08.2004	Amended State Gazette, issue 5 of 19 January 2010
6.	Ordinance No. 9 of 1991 on admissible limitation levels of electromagnetic fields in populated areas and determining the exclusion zones around radiation emitting sites	Promulgated State Gazette, issue 35 of 3 May 1991	Last amended State Gazette, issue 8 of 22 January 2002
7.	Regulation on emergency planning and emergency preparedness in case of nuclear and radiological emergencies	Promulgated State Gazette, issue 71 of 13 August 2004	Not applicable, repealed State Gazette, issue 94 of 29 November 2011
8.	European utility requirements for LWR Nuclear Power Plants. V.1, 2, 4 Power generation Plants Requirements		Rev. D, October 2012
9.	IAEA Fundamental Safety Principles	IAEA, Safety Standards Series no. SF-1 Vienna, 2006	
10.	General safety terms (ОПБ-73)	1973	Later updated with "Rules for Nuclear Safety of NPP" (ПБЯ-04-74)
11.	General safety rules (ОПБ-82)	1982	
12.	Radiation Protection Norms (НРБ-76) of the former USSR.	1976	
13.	Ordinance No. 6 on the environmental noise indicators, accounting for the degree of discomfort at different times of the day, the limit values of environmental noise indicators, methods for assessment of noise performance levels and harmful effects of noise on public health (Ministry of Health, Ministry of Environment and	26.06.2006	Not applicable

No.	Name of the legal instrument	Date of promulgation	Date of last change
	Water, State Gazette issue 58/2006)		
14.	Methodology for determining the general sound power levels in the environment from industrial plants and determining the noise level at the site of impact, Ministry of Environment and Water, 2007.	2007	2012
15.	EN ISO 9613-1,2 Acoustics. Attenuation of sound during propagation outdoors.	1996	
16.	Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise	2002	
17.	Cultural Heritage Act	Promulgated State Gazette, issue 19 of 13 March 2009	Amended State Gazette, issue 15 of 15 February 2013
18.	Ordinance No. H-00-0001 of 14 February 2011 on the performance of archaeological excavations	Promulgated State Gazette, issue 18 of 1 March 2011	Amended State Gazette, issue 101 of 18 December 2012
19.	Decree No. 1711 / 10.22.1962 of the Council of Ministers - for declaring all local and burial mounds, medieval ramparts to be monuments of national importance		
20.	Waste Management Act	Promulgated State Gazette, issue 53 of 13.07.2012, effective since 13.07.2012	Not applicable
21.	Ordinance No. 3 of 1.04.2004 on the classification of waste	Promulgated State Gazette, issue 44 of 25.05.2004	Amended and supplemented, issue 23 of 20.03.2012
22.	Regulation on construction waste management and use of recycled building materials	Adopted with Decree of the Council of Ministers No 277 of 5.11.2012, promulgated State Gazette, issue 89 of 13.11.2012, effective since 13.11.2012	Not applicable
23.	Protection from the Harmful Impact of Chemical Substances and Mixtures Act	Promulgated State Gazette, issue 10 of 4.02.2000, effective since 5.02.2002	Amended and supplemented, issue 84 of 2.11.2012, effective since 2.01.2013

No.	Name of the legal instrument	Date of promulgation	Date of last change
24.	Regulation on the order and conditions of storage of hazardous substances and mixtures	Adopted with Decree of the Council of Ministers No. 152/30.05.2011, promulgated State Gazette, issue 43 of 7 June 2011	Not applicable
25.	Regulation on the requirements for quality of liquid fuels, conditions, terms and manner of control	Promulgated State Gazette, issue 66 of 25.07.2003, effective since 1.10.2003	Amended State Gazette, issue 69 of 23.08.2005, amended State Gazette, issue 78 of 30.09.2005, amended State Gazette, issue 40 of 16.05.2006, amended State Gazette, issue 76 of 21.09.2007, amended State Gazette, issue 93 of 24.11.2009, amended State Gazette, issue 103 of 28.12.2012
26.	Regulation on the treatment and transportation requirements of industrial and hazardous waste	Adopted with Decree of the Council of Ministers No. 53 of 1999, State Gazette, issue 29/1999	Not applicable
27.	Regulation for safety assurance of nuclear power plants	Adopted with Decree of the Council of Ministers No. 172 of 19.07.2004 Promulgated State Gazette, issue 66 of 30 July 2004	State Gazette, issue 5 of 19 January 2010
28.	Ordinance No. 7 for collecting, storing, processing, storage, transportation and disposal of radioactive waste in Bulgaria	State Gazette, issue 8/1992	Repealed by Regulation on Safety during Radioactive Waste Management – State Gazette, issue 72 of 17 August 2004
29.	Ordinance No. 46 on transportation of radioactive substances	Promulgated State Gazette, issue 53 of 2 July 1976	Not applicable
30.	Ordinance No. 40 of the Ministry of Health for individual dosimetry monitoring of external exposure of persons working with sources of ionizing radiation.	Promulgated State Gazette, issue 99 of 10 November 1995	Repealed by Ordinance No. 32 of 7 November 2005 for the terms and conditions for performing individual dosimetry monitoring of persons working with sources of ionizing radiation - State Gazette, issue 91 of 15 November 2005
31.	Instruction No. 1 of 12.12.1994 of the Committee on the Use of Atomic Energy for Peaceful Purposes (CUAEPP) on the procedure for treatment of radioactively	State Gazette, issue 104/1994	

No.	Name of the legal instrument	Date of promulgation	Date of last change
	contaminated materials, equipment and waste from the elimination of uranium mining sites		
32.	Occupational Health and Safety Act	Promulgated State Gazette, issue 124 of 23 December 1997	Amended State Gazette, issue 15 of 15 February 2013
33.	Labour Code, Chapter 13	Promulgated State Gazette, issue 26 of 1 April 1986	Amended State Gazette, issue 15 of 15 February 2013
34.	Ordinance No. 1 on norms of the goals for radiation protection and safety targets in eliminating the consequences of uranium mining	Promulgated State Gazette, issue 101 of 23 November 1999	Amended State Gazette, issue 63 of 17 July 2001
35.	Ordinance No. 25 of 6 June 2007 on the conditions and order for sampling and laboratory research, analysis and expertise for the purpose of public health control	Promulgated State Gazette, issue 48 of 15 June 2007	Not applicable
36.	Ordinance No. 6 on emission norms for the admissible levels of dangerous and harmful substances in wastewater discharged into water bodies	Promulgated State Gazette, issue 97 of 28 November 2000	Amended State Gazette, issue 24 of 23 March 2004
37.	Ordinance No. 7 of the indicators and norms for determining the quality of running surface water	12.12.1986	Repealed State Gazette, issue 22 of 05.03.2013
38.	Council Regulation (EEC) No. 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station	1990	
39.	IAEA, Vienna, TRS No73, 1967	1967	
40.	IAEA, Vienna, TRS No 207, 1981	1981	
41.	Ordinance No. 1 of 10 September 1996 on the design of flat foundation	Promulgated State Gazette, issue 85 of 8 October 1996, effective since 08.01.1997	Not applicable
42.	EN 1998 (Eurocode 8) Design of structures for earthquake resistance	1998	
43.	Ordinance No. РД-02-20-2 on the design of buildings and facilities in seismic areas	Promulgated State Gazette, issue 13 of 14 February 2012	Corrected State Gazette, issue 23 of 20 March 2012
44.	**International Atomic Energy Agency.** *Dispersion of Radioactive Material in Air*	2002	

No.	Name of the legal instrument	Date of promulgation	Date of last change
	and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants Safety Guide Series No. NS-G-3.2, IAEA, Vienna, 32 p.		
45.	**International Atomic Energy Agency.** *Site Evaluation for Nuclear Installations. Safety Requirements. NS-R-3, IAEA, Vienna, 28 p.*	2003	
46.	**International Atomic Energy Agency.** *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants Safety Guide Series No. NS-G-3.6, IAEA, Vienna, 53 p.*	2004	
47.	**International Atomic Energy Agency.** *Seismic Hazards in Site Evaluation for Nuclear Installations Specific Safety Guide Series No. SSG-9, IAEA, Vienna, 60 p.*	2010	
48.	**International Atomic Energy Agency.** *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations Specific Safety Guide Series No. SSG-18, IAEA, Vienna, 146 p.*	2011	
49.	WATER ACT	28.01.2000 Promulgated State Gazette, issue 67 of 27 July 1999	Amended State Gazette, issue 82 of 26 October 2012
50.	Ordinance No. 1 of 10 October 2007 on the study, use and protection of groundwater	30.10.2007 Promulgated State Gazette, issue 87 of 30 October 2007	Amended and supplemented State Gazette, issue 15 of 21 February 2012
51.	Ordinance No. 3 of 16.10.2000 on the terms and conditions for research, design, validation, and operation of exclusion zones around water sources and facilities for drinking water and sources of mineral waters used for therapeutic, prophylactic, drinking and hygiene needs	Promulgated State Gazette, issue 88 of 27.10.2000	Not applicable
52.	Ordinance No. 1 of 11.04.2011 on water monitoring	Promulgated State Gazette, issue 34 of 29.04.2011, effective since 29.04.2011	29.04.2011, last amended State Gazette, issue 22 of 05.03.2013
53.	Ordinance No. 9 of 16.03.2001 on water quality for household drinking purposes	Promulgated State Gazette, issue 30 of 28.03.2001	Amended, issue 15 of 21.02.2012, effective since 21.02.2012
54.	Environmental Protection Act	Promulgated State Gazette, issue 91 of 25.09.2002,	Amended State Gazette, issue 15 of 15 February 2013
55.	Water Framework Directive	Effective since 22 December 2000	
56.	Council Directive 80/68/EEC of 17 December 1979 on the protection of	17.12.1979	17.12.1979

No.	Name of the legal instrument	Date of promulgation	Date of last change
	groundwater against pollution caused by certain dangerous substances. Official Journal of the European Union, L 20		
57.	EU (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal of the European Union, L 327/1	23.10.2000	23.10.2000
58.	EU (2006). Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. Official Journal of the European Union, L 372/19.	12.12.2006	12.12.2006
59.	Energy Act	Promulgated State Gazette, issue 107 of 9 December 2003	Amended State Gazette, issue 23 of 8 March 2013
60.	Forestry Act	Promulgated State Gazette, issue 19 of 8 March 2011	Amended State Gazette, issue 15 of 15 February 2013
61.	Ordinance No. H-4 on characterization of surface water	Promulgated State Gazette, issue 22 of 5 March 2013	Not applicable
62.	Ordinance No. 2 on the issue of permits for wastewater discharge into water bodies and setting individual emission limits for point sources of pollution	Promulgated State Gazette, issue 47 of 21 June 2011	Amended and supplemented State Gazette, issue 14 of 17 February 2012
63.	Regulation on standards for environmental quality for priority substances and certain other pollutants	Promulgated State Gazette, issue 88 of 9 November 2010	Not applicable
64.	Regulation on the use of surface water	Promulgated State Gazette, issue 56 of 22 July 2011	Not applicable

No.	Name of the legal instrument	Date of promulgation	Date of last change
65.	Ordinance for the Conditions and the Order for Implementing Environmental Impact Assessment	Promulgated State Gazette, issue 25 of 18 March 2003	Amended and supplemented State Gazette, issue 94 of 30 November 2012
66.	Regulation on ensuring the physical protection of nuclear facilities, nuclear material and radioactive substances	Promulgated State Gazette, issue 77 of 3 September 2004	Amended State Gazette, issue 44 of 9 May 2008
67.	Ordinance No. 4 of 21 May 2001 for the scope and content of investment projects	Promulgated State Gazette, issue 51 of 5 June 2001	Amended State Gazette, issue 96 of 4 December 2009
68.	Ordinance No. 6 of 9 June 2004 on the accession of producers and consumers of electric power to the electricity transmission and distribution networks	Promulgated State Gazette, issue 74 of 24 August 2004	Amended State Gazette, issue 25 of 5 March 2008
69.	Ordinance No. 7 of 3 May 1999 on the assessment and management of air quality	Promulgated State Gazette, issue 45 of 14 May 1999	Not applicable
70.	Ordinance No. 13 of 30 December 2003 on the protection of workers from risks related to exposure to chemical agents during work	Promulgated State Gazette, issue 8 of 30 January 2004	Amended State Gazette, issue 2 of 6 January 2012
71.	Regulation on the conditions and order for implementing assessment of the compatibility of plans, programmes, projects and investment proposals with the subject and goals of conservation of protected areas (Adopted with Decree of the Council of Ministers No. 201 of 31.08.2007, promulgated State Gazette, issue 73 of 11 September 2007)	Promulgated State Gazette, issue 73 of 11 September 2007	Amended and supplemented State Gazette, issue 94 of 30 November 2012

No.	Name of the legal instrument	Date of promulgation	Date of last change
72.	Regulation on safety during decommissioning of nuclear facilities	Adopted with Decree of the Council of Ministers No. 204 of 05.08.2004 Promulgated State Gazette, issue 73 of 20 August 2004	Not applicable

APPENDIX 2: METHODOLOGY USED

No.	Name of methodology	Year of last update, if applicable
1.	Methodologies under Ordinance No. 6 on the environmental noise indicators, accounting for the degree of discomfort at different times of the day, the limit values of environmental noise indicators, methods for assessment of noise performance levels and harmful effects of noise on public health (Ministry of Health, Ministry of Environment and Water, State Gazette issue 58/2006)	2006
2.	Methodology for determining the general sound power levels in the environment from industrial plants and determining the noise level at the site of impact, Ministry of Environment and Water, 2007.	2012
3.	Methodologies for physiographic and landscape zoning, Georgiev. M Physical Geography of Bulgaria, "St. Kliment Ohridski" University Publishing House	1991
4.	Basic principles of landscape differentiation, Petrov P., Geography of Bulgaria, Bulgarian Academy of Science (BAS), Sofia, pp. 340-345;	1997
5.	Basic principles and methods of landscape zoning, Petrov P., Geography of Bulgaria, Bulgarian Academy of Science (BAS), Sofia, pp. 345-356.	1997
6.	Guidelines for basic characterization of waste and application of waste acceptance criteria at different classes of landfills, Ministry of Environment and Water, Sofia	2011
7.	Guidelines for preliminary treatment of waste prior to disposal, Ministry of Environment and Water, Sofia	2005
8.	Guidelines for determining the number and type of vessels and equipment necessary for the collection and transportation of waste, Ministry of Environment and Water, Sofia	2004
9.	National Strategic Plan for the management of construction and demolition waste on the territory of Bulgaria for the period 2011-2020, Ministry of Environment and Water, Sofia	2011
10.	Guidelines for Evaluation Of a nuclear power plant site, Nuclear Energy Licensing Board, Ministry of Science, Technology and Innovation, Batu 24, Jalan Dengkil, 43800 Dengkil Selangor Darul Ehsan	2011
11.	Comparative analysis of collected and existing data of soils at the site	

No.	Name of methodology	Year of last update, if applicable
	in bibliographical terms, in relation to their fertility and category of agricultural land.	
12.	Terrain and route studies of the affected areas within the territory.	
13.	Methodology for low-background determination of natural and artificial gamma emitters in soil, water and other agricultural units.	2006
14.	Methodologies for radiochemical determination of Strontium-90 in soil, water and agricultural projects	2007
15.	ISO 18589-2,3:2007; Part 3: Measurement of gamma-emitting radionuclides	2007
16.	ISO 18589-2,3:2007; Part 2: Guidance for the selection of the sampling strategy, sampling and pre-treatment of samples;	2007
17.	Galabov M., Penchev P., et al., "Methodological Guidance: Determination of groundwater resources", Ministry of Environment and Water.	1999
18.	Methodology of quantitative risk assessment for groundwater pollution by hazardous and noxious substances (pursuant to Article 2, paragraph 1, items 3, 4 and 5, and Article 93, paragraph 2, item 4 of Ordinance No.1/07.07.2000 on the study, use and protection of groundwater – State Gazette, issue 57 of 14.07.2000), Ministry of Environment and Water, 2001.	2001
19.	Guidance No. 26A. Conceptual model for groundwater. Common Implementation Strategy of the Water Framework Directive	РД-768/10.10.2012
20.	CIS Guidance Document No. 17, 2007: Guidance on preventing or limiting direct and indirect pollution in the context of the Groundwater Directive 2006/118/EC. Technical Report 2007 - 012	2007
21.	CIS Guidance Document No. 18, 2009: Guidance on the status of groundwater and assessment of trends. Technical Report 2007 - 026	2009
22.	CIS Guidance Document No. 16, 2007: Groundwater in Drinking Water Protected Areas. Technical Report 2007-010.	2007
23.	CIS Guidance Document No. 15, 2007: Guidance on Groundwater Monitoring. Technical Report 2007-002.	2007
24.	CIS Guidance Document No. 20, 2009: Guidance on Exemptions to the environmental objectives. Technical Report 2009-027.	2009
25.	Guidelines for evaluation of a nuclear power plant site	

APPENDIX 3: REFERENCES TO BIBLIOGRAPHY AND INPUT DATA

I. References to bibliography

No.	Name of bibliographical source	Date of publication
1.	Strategy for spent nuclear fuel and radioactive waste management	January 2011
2.	Terms of reference for the implementation of Environmental Impact Assessment (EIA) of the investment proposal for the construction of a new nuclear unit at the Kozloduy NPP site.	„Kozloduy NPP – New Build” 20.09.2012
3.	Minutes No. 618, No. 621 of the Regional Inspectorate for Environment and Waters (RIEW) – city of Pleven	13.09.2010
4.	Petrov, P. Landscape Science. University Press "Kliment Ohridski".	1990
5.	Petrov, P. Landscape Structure IN: "Geography of Bulgaria." Academic Publishing House "Professor Marin Drinov". Sofia.	1997
6.	Materials delivered by the Investor	
7.	Environmental Impact Assessment Report (EIAR) for the decommissioning of units 1-4 of „Kozloduy” NPP	2013
8.	Decision 05-ДО-72-01 of 12.06.2008 of Vratsa Regional Inspectorate on the temporary storage of waste prior to disposal	2008
9.	Decision 05-ДО-72-00 of 24.01.2006 and effective until 31.12.2010, and the last modification and amendment of the permit is valid until 31.12..2015	2006
10.	Non-radioactive Waste Management Programme during the operation of „Kozloduy” NPP	2005
11.	Rules to ensure safety during non-radioactive waste management.	
12.	Koynov, Kabakchiev Iv. and K. Boneva, 1998. Atlas of soils in Bulgaria. Zemizdat Publishing House. Sofia.	1998
13.	http://www.soils-bg.org/soilmap/bul_soils/att/SMUTMBG_2793.html)	
14.	Vassilev G., Radioecology, Sofia, Theta Consult, p. 574	2005
15.	Misheva L., Yordanova I., Staneva D., Bineva Tsv.- Practical	2012

	guide for conservation and use of agricultural production in case of radiation emergency, Ministry of Agriculture and Food, p. 29	
16.	Naydenov M., Misheva L., Yordanova I ., Staneva D., Dureva L., Compendium of methodologies for the determination of alpha-, beta- and gamma- emitting radioactive isotopes in environmental sites, National Center for Agrarian Sciences (NCAS), Sofia	2001
17.	Naydenov, M., D. Staneva, Research reports and communications, Agricultural Academy, Sofia, volume I, page 63	1987
18.	Радиоактивные изотопы в почвах и растениях, Сборник трудов по агрономической физике, Вп.18, Ленинград / Radioactive isotopes in soils and plants. Symposium on agronomical physics, Leningrad	1969
19.	Ivanka Yordanova, Lidia Misheva, Martin Banov, Donka Staneva, Tsvetanka Bineva "Radioactivity in Virgin Soils and Soils from some Areas with closed Uranium mining Facilities in Bulgaria" European Geosciences Union - General Assembly Vienna, Austria, session SSS9.1, Radioactive Chemical Species in Soil: Pollution and remediation.	2012
20.	Ivanka Yordanova, Donka Staneva, Lidia Misheva, Tsvetanka Bineva, Martin Banov, "Radioactivity in Bulgarian Soils and Behaviour of Some Man-made Radionuclides in Different Soil Types", International Symposium on Managing Soils for Food Security and Climate Change Adaptation and Mitigation,. Vienna, Austria, Synopses ,171-172.	2012
21.	ISO 18589-3, 2007, Measurement of Radioactivity in the environment – Soil, Part 3: Measurement of gamma-emitting radionuclides, Annex B	2007
22.	Maier D. & Scholl W. 90Sr-Bestimmung in böden und pflanzlichen material (Determination of 90Sr in soils and plants), Landwirtsch. Forschung. 35(3-4):269-274	1982
23.	Najdenov M., Content of Men-made Radionuclides in Soils from the region around “Kozlodouy” NPP”, Collection “Scientific Reports and Announcements”, Sofia, Agricultural Academy: pp. 50-68	1986
24.	Najdenov M., Staneva D., Composition and Specificity of the Contamination on the territory of the country after the accident in Chernobyl’s NPP”, Collection “Scientific Reports and Announcements”, Sofia, Agricultural Academy, I: pp. 63-69	1987
25.	Pimpl M. and Schüttelkopf H. The measurement of Pu in environmental samples and in gaseous and liquid effluents of	1986

	nuclear installations, Swedish University of Agricultural Sciences, Uppsala, Report SLU-REC-61:53-62	
26.	Schüttelkopf H., Development of an analytical method for Pu determination in the femtogram/gram region and its application on environmental samples, Nuclear Research center, Karlsruhe, KfK-Report 3035	1981
27.	Talvitie N. A., Radiochemical determination of Pu in Environmental and Biological Samples by Ion Exchange – Anal. Chem.43, 1827	1971
28.	Tarpanova Hr. & Najdenov M., Adapted procedure for determination of 90Sr in soils, Proceedings XIV colloquium Physics in the protection of man and environment. Gjolechitsa, Bulgaria, June 19-21	1992
29.	Tsvetkov Ts., Bachvarova Sv., Djoreva M., Zlatev At., Poynarova M., Bineva Ts., Staneva D., Yordanova I., Misheva L., Hristozova J., Stoev S. & Marinov V. Twenty Years after the Chernobyl accident , DiMax, Sofia, 238 pp	2006
30.	Shimmack W., Bunzl K.,. Mobility of Chernobyl-derived Radiocaesium in the soil", Proc. of the International Symposium on Radioecology, Ten years Terrestrial Radioecological Research Following the Chernobyl Accident, 22-24 April, Vienna, p. 11-18	1996
31.	UNSCEAR, In: Ionizing Radiation: Sources and Biological Effects Annex E, (New York)	1982
32.	UNSCEAR, In: Sources and Effects of Ionizing Radiation, Report of the General Assembly with Scientific Annex B, (New York)	1993
33.	UNSCEAR, In: Sources and Effects of Ionizing Radiation, Report of the General Assembly with Scientific Annexes, vol. 1 (New York)	2000
34.	UNSCEAR,. In: Sources and Effects of Ionizing Radiation, Report of the General Assembly with Scientific Annexes, vol. 1I (New York)	2008
35.	UNSCEAR,. In: Sources and Effects of Ionizing Radiation, Report of the General Assembly with Scientific Annexes, vol. 1I (New York)	2010
36.	*Report on Geotechnical and Hydro Geological Studies at the site of units I and II of „Kozloduy" NPP.* **Scientific Project Research Institute for Energy Engineering „Energoproekt"**	1967-1968
37.	*Foundations, cladding and screens of reinforced loess soils.* **Minkov, M., D. Evstatiev, Technika**	1975
38.	*"Results of borehole and laboratory tests in connection with the micro seismic zoning at „Kozloduy" NPP",* **Energoproekt**	1978
39.	*"Geotechnical and Hydro Geological Studies of the "North" sites (units V and VI)",* **Energoproekt**	1979-1981
40.	*"Clarification of the dispersion characteristics of soil and water environment in the area of „Kozloduy" NPP site for the purpose of analyzing the possible pathways for migration of radionuclides from the nuclear power plant in soil and hydrosphere".* **Aquaterre, Sofia**.	1992
41.	*"Implementation Report on the Contract of* **the Geological**	2003

	Institute *with Kozloduy NPP PLC., No. 21371061 in three stages.”* – assessment of the geological conditions for long-term storage of radioactive waste at the site of and around „Kozloduy” NPP and comprehensive analysis and feasibility assessment of the possibility of long-term storage of conditioned radioactive waste at the site of and in the vicinity of „Kozloduy” NPP.	
42.	*“Pleistocene and Holocene in the Danube valley”* **Y. Evlogiev**	2006
43.	Report on the results of geological, geophysical, geotechnical, hydrogeological, hydrological and laboratory studies on the subject "*Confirmation of the site "Radiana "for the construction of National Radioactive Waste Repository."* **Geotechnics ABC Ltd and Geological Institute, Bulgarian Academy of Science (BAS).**	2009
44.	Study on the options to construct a deep geological repository. Task 4, performed by the **Geological Institute with the Bulgarian Academy of Science** *"Analysis and regionalization of the territory of Bulgaria, identification of the potential host geological units for deep burial of radioactive waste."* Report under a contract of **Risk Engineering Ltd.** with State Enterprise "Radioactive Waste" (SERAW)	2010
45.	*„Preparation of geological and hydrogeological profiles from the plateau through the "Radiana" site* to the Danube River. **Geotechnical scientific research base of the Geological Institute, Bulgarian Academy of Sciences**	2012
46.	Report "Selection and characterization of sites for the construction of a new nuclear unit at the site of Kozloduy NPP. **Risk Engineering Ltd and University of Mining and Geology**	2013
47.	*Identification and review of capable faults in the area of „Kozloduy” NPP.* **Geological Institute of the Bulgarian Academy of Sciences**	2013
48.	*The Pliocene and the Quaternary from the western Dacian Basin.* **Petru Enciu,** Bucuresti	2009
49.	Penchev et al., "Hydrogeology and basics of engineering geology", Technika Publishing House, Sofia;	1990
50.	River Basin Management Plan for the Danube River Water Management Region	2006
51.	Fank J. et al., 1993: "Hydrogeology and groundwater model" Leibnizer feld"	1993

II. References to input data

1. Letter of the River Basin Management Directorate, attached to letter of Ministry of Environment and Water, outgoing reference No. ОВОС-220/05.07.2012;
2. Letter – Response by the Mayor of Kozloduy in connection with Article 4, paragraph 2 of the Regulation on environmental impact assessment (EIA); copies of statements of opinion received as a result of the notification;
3. Format adopted by decision I/4 at the First Meeting of the Parties on the Convention on Environmental Impact Assessment in Transboundary Context;
4. Cover Letter to the letter of the Republic of Romania regarding the participation in the EIA procedure, Bulgarian and English versions;
5. Environmental Impact Assessment Report (EIA Report) for Kozloduy NPP, 1999;
6. EIA Report for the Dry Spent Fuel Storage Facility at Kozloduy NPP, 2005;
7. EIA Report for the construction of a National Repository for low and intermediate level waste (National Repository for Radioactive Waste), 2011;
8. Copy of the title page and table of contents of the approved emergency action plan;
9. Strategy for management of spent nuclear fuel and radioactive waste by 2030;
10. Programme for management of spent nuclear fuel, identificationc No.ДОД.ЯГЦ.ПМ.283/03;
11. Report – Site Selection for the construction of a new nuclear power plant in Bulgaria, Energoproekt, 1980;
12. Geotechnical and hydrogeological conditions within units V and VI, Detail Design stage, Scientific Project Research Institute for Energy Engineering, Energoproekt, 1980;
13. Seismic assessment of Kozloduy NPP, August 1991;
14. Initial Data of Seismic Input and Soil Conditions of Kozloduy Site, October 1993;
15. Report on Contract "Research and activities to improve the security of Kozloduy NPP", Volume AI, December 1991;
16. Analysis of the possibility for construction of another unit at „Kozloduy” NPP using equipment supplied for „Belene” NPP, Energoproekt, 1991;
17. Report - Additional geomorphological, neotectonic and seismological studies and activities, Geophysical Institute, 1992;
18. Report on Contract "Research and activities to improve the security of Kozloduy NPP" - Experimental studies on the dynamic characteristics of earth layers, 1992;
19. Analysis of the conditions for liquefaction of sands under the SFSF building, Part I, Geotechnical, hydrogeological and geomechanical conditions, Energoproekt, 1995;
20. Zoning of loess sand and preliminary assessment of the conditions for conversion into thixotropic state, Geotechnical, hydrogeological and geomechanical conditions, Construction site, Detailed Design phase, Energoproekt, 1997;
21. Geotechnical and hydrogeological conditions in the water supply area for the Training Centre, 1982;
22. Geological and geotechnical studies for the construction of a dry SFSF;

a. Further geotechnical studies of the site - Stage Ia;
b. Geotechnical studies of the site - Stage II;
c. Geophysical survey of the site 2 - Lavatrade Ltd, 2009;
d. Geotechnical conditions at the site Energoproekt, 1996.

23. Reports – Registration, analysis, processing and interpretation of seismic data from the local seismological network in the area of „Kozloduy” NPP and Bulletins for the period 1997 - 2012;
24. Initial data of seismic input and soil conditions of KNPP site; 1993;
25. Project BUL9012;
26. Report – Performance of seismic surveys to clarify changes in the velocity of propagation of seismic waves at the construction site, Energoproekt, 1992;
27. Studies of geophysical fields in the vicinity of the nuclear power plant; December 1991; Seismological Centre at the Bulgarian Academy of Science (NIGGG-BAS)
28. Report on Contract "Research and activities to improve the security of Kozloduy NPP" - Volume B - Meteorology 1991;
29. Reassessment of the maximum level of flooding. Part II /Phase II/. Sofia, March 1993. "Enegroproekt"
30. „Kozloduy” NPP Plc., city of Kozloduy, Hydrotechnical Facilities and Civil Structures Department, Elevation of the Danube water level on the rack of Coastal Pump Station-1 (БПС-1) at 687 km in meters for the period 1980-2011;
31. Energoproekt - Update to the geotechnical and hydrological and meteorological studies - new service water supply to „Kozloduy” NPP 1, 2, 3, Volume II, October 1987;
32. Energoproekt - „Kozloduy” NPP, Additional supply of process water, Geotechnical and hydrological studies of the Danube River water level for the period 1941-2003. Update as of May 2004;
33. Energoproekt. Existing hydro-technical channels. Part Hydrogeological Studies in the lowland area between the dual canal and the Danube River. Detailed Design - December 1990;
34. Energoproekt - „Kozloduy” NPP, Open canals CK2 and TK2. Geotechnical surveys. General note. December 1989;
35. IKO INVEST –Kozloduy NPP. Additional supply of service water; Geomorphology - rasters 8 pieces drawings from TEC. 378 1 to 8. August 1989;
36. Future opportunities to build new units at the site of Kozloduy NPP, 1978 Part V;
37. Investment feasibility study on the opportunities of deployment of units 7 and 8 at the site of "Kozloduy" in 1991;
38. Report on Contract "Research and activities to improve the security of Kozloduy NPP" - Volume E;
39. Report on Contract "Research and activities to improve the security of Kozloduy NPP" - Volume F;
40. "Clarification of the dispersion characteristics of topsoil and water environment in the vicinity of „Kozloduy” NPP for the purpose of analyzing the possible

pathways for migration of radionuclides from the nuclear power plant in soil and hydrosphere," 1991;

41. Summary and analysis of research studies on the resistance and stress state of the levees and the base of the dual canal, Volume III;
42. Report on Contract "Research and activities to improve the security of Kozloduy NPP" - Human activities outside the plant's site, 1993, 1994;
43. Report on Contract "Research and activities to improve the security of NPP Kozloduy" – Extraordinary events as a result of human activities, Energoproekt 1992 – 1994
44. Report "Clarification of the dispersion characteristics of topsoil and water environment in the vicinity of „Kozloduy" NPP for the purpose of analyzing the possible pathways for migration of radionuclides from the nuclear power plant in soil and hydrosphere", 1991.
45. Documentation of the Preventive Protective Measures Area (PPMA)
    a. Terms of Reference (ToR) for the Environmental Assessment of the Specialized Urban Development Plan referring to the Safeguard Measures Zone around „Kozloduy" NPP (12.УК.ТЗ.157);
    b. Schedule of consultation under the Environmental Assessment;
    c. REPORT on determining the scope and content of the project-related Environmental Assessment of the Specialized Detailed Spatial Development Plan of the PPMA around Kozloduy NPP
    d. Decision N 3-2012 of the Ministry of Environment and Water;
46. Local meteorological conditions in the area of „Kozloduy" NPP, Reports 1997 - 2011;
47. Data from the Automated Meteorological Station 2000 - 2011;
48. Information on gaseous and liquid radioactive discharges from „Kozloduy" NPP
49. Results of radio-ecological monitoring of „Kozloduy" NPP - Annual Report, March 2012;
50. Results of environmental radiation monitoring around „Kozloduy" NPP, Annual Reports, 2008, 2009, 2010 and 2012;
51. Annual reports on the results of the own non-radiation environmental monitoring around „Kozloduy" NPP, 2008, 2009, 2010 and 2012;
52. Information on allowed intake for discharge and water use;
53. Programme for own non-radiation monitoring of waters during operation of „Kozloduy" NPP, Identification No. УК.УОС.ПМ.013/04;
54. Radiation monitoring program of environmental exploitation of „Kozloduy" NPP Identification No. УБ.МОС.ПМ.262/03;
55. Annual report on the results of the own non-radiation environmental monitoring around the Kozloduy NPP in 2011;
56. Programme for environmental protection of Kozloduy Municipality for the period 2010-2013;

57. Summary report for radiation monitoring of the industrial site of „Kozloduy” NPP respectively for 2009, 2010., 2011;
58. Programme for own monitoring of Non-Radioactive Household and Industrial Waste Depot, Identification No. УК.УОС.ПМ.011/03;
59. Programme for non-radiation water monitoring during operation of „Kozloduy” NPP, Identification No. УК.УОС.ПМ.013/04;
60. Programme for minimization of radioactive waste from EP-2 of „Kozloduy” NPP, Identification No. 30.РАО.ОО.ПР.23 / 2;
61. Test Protocol N 06-0085-19.04.2012;
62. Test Protocol N 06-0086-19.04.2012;
63. Summarised results of physical and chemical tests of wastewater and groundwater in the area of „Kozloduy” NPP, 2011;
64. Volume and frequency of testing wastewater and groundwater at „Kozloduy” NPP
65. Programme for in-house non-radiation water monitoring during operation of „Kozloduy” NPP, Identification No. УК.УОС.ПМ.013/04;
66. Gaseous and liquid radioactive discharges from „Kozloduy” NPP
67. Analysis of health status of Kozloduy NPP staff for the period 2006 - 2008;
68. Analysis of health status of Kozloduy NPP staff for the period 2009 - 2011;
69. Technical Report - Feasibility study for the construction of a new nuclear power unit using equipment supplied for Belene NPP - Energoproekt 1999. Volumes 1, 2, 3, 4;
70. Pictures from Sites 1, 2, 3, 4;
71. Location of the 10 measurmenet stations in the area around the PPMA of Kozloduy NPP;
72. Automated information system for radiation monitoring at the industrial site of Kozloduy NPP ;
73. Record of measurements of the mobile automatic stations (MAS) for controlling ambient air quality in River Basin Management Directorate “North” / Danube River, performed by Regional Laboratory-Pleven in 2011 in " Kozloduy NPP" for 52 days;
74. Measurements of Ambient Air Quality with the MAS by the Pleven Regional Laboratory
    a. Record No. 243/28.03.2008 for the period from 24.03.2008 to 28.03.2008
    b. Record No. 787/30.09.2008 for the period from 26.09.2008 to 30.09.2008 of concentrations of sulphur and nitrogen oxides (nitric oxide and nitrogen dioxide), ozone, hydrogen sulphide, benzene, methane, ammonia, non-methane hydrocarbons and carbon oxide in the atmospheric surface layer.
75. Groundwater quality (with the exception of the Danube river) and hydrological data (including groundwater levels, filtration area parameters, running flow direction and groundwater drainage);

76. Reports on the environmental state in 2007 – 2011, Regional Inspectorate of Environment and Waters (RIEW), Vratsa
77. Data from monitoring of biological indicators of the rivers of Ogosta and Zlatiya for the period 2007 - 2011;
78. National Mid-Winter Waterfowl Census 2011 § 2012;
79. Terms of Reference for the study and siting of a new nuclear power unit at the site of Kozloduy NPP;
80. Terms of Reference for a feasibility study to justify the construction of a new nuclear power plant at the site of Kozloduy NPP;
81. „Belene” NPP (Units 1, 2) - Technical Design - Interim Safety Analysis Report
82. Characteristics of the site;
83. Annual Report (2008 - 2011) of the International Commission for Protection of the Danube River;
84. Regulation on hazardous chemicals subject to prohibition or restrictions on the marketing and use;
85. Main technical characteristics of existing systems for processing of radioactive waste (RAW) - productivity, types of radioactive waste, final packaging; II - General description of planned treatment facilities, temporary storage and disposal of radioactive waste - capacity, type of RAW, type of packaging; III - Current status of existing storage facilities for temporary storage of radioactive waste and envisaged future load;
86. Environmental Impact Assessment Report (EIAR) for the investment proposal for the construction of „Belene” NPP;
87. Terms of Reference (ToR) for the scope and content of the Environmental Impact Assessment - Gas pipeline "South Stream" - Bulgarian section;
88. Environmental Impact Assessment Report for a new nuclear source located at Temelin (TEMELÍN), including redirecting of power to the substation (KOČÍN);
89. Kozloduy NPP Emergency Plan
90. Results of the environmental radiation monitoring of Kozloduy NPP, Annual reports for 1998, 1999, 2000, 2001, 2002;
91. List of Level 1 events (inclusive) on the INES scale, and higher for 1-4 and protocols (18 units)
92. Complex programme for radiation waste management at Kozloduy NPP;
93. Summary report for radiation monitoring of the industrial site of Kozloduy NPP in 2011;
94. Annual Report for 2011 Occupational exposure in Kozloduy NPP;
95. Report for the activities of the "Nuclear Safety and Radiation Protection" Department in 2011;
96. Report "Independent expert review for the content of artificial radionuclides in the bodies of 150 children living in the area of Kozloduy NPP;
97. Record on analysis of common plant event, 1994;

98. Information on estate (land and buildings) falling in the territory of Site 2 and Site 4;
99. Layout representation of the onsite facilities on the Master Plan „Kozloduy" NPP and description thereof;
100. Letter on staffing;
101. Report on Environmental Impact Assessment Report for "Reconstruction and conversion of the research reactor IRT-2000 for its conversion into a civil type low power reactor (200 kW) and further application in medicine (neutron cancer therapy) – city of Sofia, Mladost residential district);
102. Public health and demographic indicators (mortality causes, structure of morbidity, prevalence - children, adult population and in total, per 100,000 capita) for the Municipality of Kozloduy for the last three years;
103. Annual public health and demographic analysis of the Regional Health Inspectorate in Vratsa for the last three years, including information on item 1 for Vratsa District;
104. Structure of cancer morbidity incidence and prevalence for the region and in case of availability at Kozloduy Municipality for the last three years;
105. Public health reporting data from the Multiprofile Hospital for Active Treatment in Kozloduy over the last three years;
106. Terms of Reference (ToR) defining the scope and content of the environmental impact assessment of the investment proposal for construction of a national repository for low and intermediate level waste (NRRAW);
107. Analysis of the radiation exposure of the population in the 30km surveillance area of Kozloduy NPP for gaseous and liquid radioactive discharges into the environment in the process of decommissioning of units 1-4 and emissions from the operation of the plasma incineration facility under Project 5c;
108. Input data, letter from NB No. 118 of 31.01.2013;
109. Input data, letter from NB No. 74 of 21.01.2013;
110. Guidelines for evaluation of a nuclear power plant site;
111. External events caused by human activity, in evaluating the site for construction of a nuclear power plant;
112. European Utility Requirements;
113. European stress tests on power plants - NATIONAL REPORT OF BULGARIA, December 2011;
114. "Contract Implementation Report of the Geological Institute and „Kozloduy" NPP, No. 21371061 in three stages." - Assessment of the geological conditions for long-term radioactive waste storage at the site of and around „Kozloduy" NPP and complex analysis and feasibility study of the opportunities for long-term storage of conditioned radioactive waste at the Kozloduy NPP site and in close proximity to it, Project Manager Professor D. Evstatiev, 2003;
115. Report on civil contract of State Enterprise "Radioactive Waste" (SERAW) with Professor Yordan Evstatiev, Head of the Geotechnical Research Base at the

Geological Institute with the Bulgarian Academy of Sciences, "Development of geological and hydrogeological profiles in the area of the plateau "Radiana" to the Danube River, 2012;

116. Geotechnica ABC Ltd and Geological Institute, Bulgarian Academy of Sciences (BAS), 2009. Report on the results of geological, geophysical, geotechnical, hydrogeological, hydrological and laboratory studies on the project "Confirmation of the site "Radiana" for the construction of National Radioactive Waste Repository" (NRRAW);
117. "Feasibility study on the opportunities for construction of a deep geological repository. Task 4, performed by the Geological Institute, Bulgarian Academy of Sciences (BAS), "Analysis and zoning of the territory of Bulgaria, identification of potential host geological units for deep disposal of radioactive waste";
118. Instructions for safe storage of dangerous and potentially harmful substances and materials in the "Shipping and Warehousing" Department;
119. List of enterprises in operation in the 30km zone around „Kozloduy" NPP within the territory of Vratza district, which are emitters of wastewater and waste gas from point sources into the air;
120. Data on the route of the Nabucco pipeline and Risk Assessment of the "Nabucco" pipeline in the area of „Kozloduy" NPP - interim report prepared by RISK ENGINEERING Ltd.;
121. Data on the route of the South Stream pipeline and letters from "NPP Kozloduy" Plc. with statements of opinion on the documentation;
122. Draft Master Plan for the project: "High pressure gas pipelines in ARGS from Chiren UGS to Kozloduy and Oryahovo" provided by Bulgartransgaz Plc.;
123. Programme for non-radioactive waste management activities;
124. Clarification Letter by "Kozloduy NPP - New Build" PLC. with outgoing No. 236/11.03.2013;
125. Letter No. 45 dated 29.01.2013 by the Legal Division of "Kozloduy NPP" Plc., Attachments 1, 2 and 3.