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Company "Energoatom"

Information and analytical survey of the materials

**“KHMELNYSTKA NPP. FEASIBILITY STUDY OF POWER
UNITS 3,4 CONSTRUCTION”**

Kyiv –2011

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LIST OF ACRONYMS AND ABBREVIATIONS

BDBA	Beyond Design-Basis Accident
BUDEPP	Back-UP Diesel Engine Power Plant
CA	Control Areas
CIP	Construction and Industrial Personnel
CP	Cooling Pond
DBE	Design-basis earthquake
ECCS	Emergency Core Cooling System
EDR	Exposure Dose Rate
FA	Fuel Assembly
FS	Feasibility Study
GWL	Groundwater Level
HLW	High Level Waste
HP ECCS	High Pressure Emergency Core Cooling System
HPSPP	Hydroelectric Pumped Storage Power Plant
IAEA	International Atomic Energy Agency
IAS	Information and Analytical Survey
ICG	Inert Concentration Gases
IPS	Integrated Power System
IRS	Ionizing Radiation Sources
KIEP	Kyiv Science & Research and Design Institute “Energoproekt”
KNPP	Khmelnyska Nuclear Power Plant
KNPP-1,2	Power Units № 1,2 of Khmelnyska NPP
KNPP-3,4	Power Units № 3,4 of Khmelnyska NPP
LP ECCS	Low Pressure Emergency Core Cooling System
LRW	Liquid Radioactive Waste
MCC	Main Circulation Circuit
MCP	Main Circulation Pipelines
MCPU	Main Circulating Pump Unit
MDBA	Maximum Design-Basis Accident
MDE	Maximum Design Earthquake
MPV	Maximum Permissible Value
NAEK Energoatom/Energoatom	State Enterprise “National Nuclear Energy Generating Company “Energoatom”
NDUH	Normal Banked-Up Horizon
ND	Normative Documents
NF	Nuclear Facilities
NMC	Neutron Measurement Channels
NOC	Normal Operational Conditions
NRBU-97	Norms of Radiation Safety of Ukraine 1997
OS	Outside switchgears
OVOS	Environmental Impact Assessment
PC	Public Consultations
PEZ	Potential Earthquake Sources
PCRAS	Passive Core Reflooding Additional System
PHRS	Passive Heat Removal System
PS	Pressurizer System

QBES	Quick Boron Entry System
RB	Reactor Building
RC	Reservoir-Cooler
RC	Reactor Compartment
RDPP	Reserve Diesel Power Plant
RF	Reactor Facility
RNG	Radioactive Noble Gases
RW	Radioactive Waste
SA	Supervised Area
SAB	Startup Auxiliary Boiler
SB	Special Building
SBDP	Standby Diesel Power Plant
SCN	State Construction Norms
SG	Steam Generator
SNF	Spent Nuclear Fuel
SP	Suppression Pool
SRW	Solid Radioactive Waste
SRWS	Solid Radioactive Waste Storage
SSTC ERCS	State Enterprise “State Scientific and Technical Center for Emergency Response Control Systems”
SUB	Start-Up Boiler
SWPDG	Standby Whole Plant Diesel Generator
TC	Thermocouples
TF	Turbine Facility
TH	Turbine House
UAH	Ukrainian Hrivna
WANO	World Association of Nuclear Operators
WEB	Water Economy Balance

1 INTRODUCTION

1.1 Reference information

1.1.1 Design of new nuclear power units is regulated by international agreements [1-4], ratified by Ukraine, by Ukrainian laws [5-11], by normative legal acts [12-19], by IAEA recommendations [20] and by other documents. In line with the requirements of the national legislation, elaboration of the Feasibility Study (FS) of the power units 3,4 construction is a mandatory stage of the design of these objects.

1.1.2 FS was elaborated by Kyiv Science & Research and Design Institute “Energoproekt” (KIEP, Kyiv) to request of the State Enterprise “National Nuclear Energy Generating Company “Energoatom” (NAEK Energoatom, Kyiv).

1.1.3 Participation of the public, provided for by the law [3,4,6,11,16], in the process of the environmentally significant decisions making, discussion of the planned activity with the interested public institutions and individuals at the stage of the decision taking, contributes to the verification of the completeness of the environmental impact assessment, to the prevention of the unfavorable consequences of the taken decisions, to the improvement of the investments efficiency etc.

Before FS elaboration in 2008, the “Statement on the intentions to construct power units 3, 4 on the site of Khmelnytska nuclear power plant” was made and distributed. In connection with the completion of the FS elaboration, a new cycle of Public Consultations (PC) is planned.

1.1.4 This document is an Information and Analytical Survey (IAS) of the FS materials, prepared for the public review of its basic provisions, including the forecasted social, sanitary, ecological and other consequences of the construction, commissioning, operation and decommissioning of the power units 3, 4 of Khmelnytska NPP (KNPP-3,4). The document was prepared by the SE “State Scientific and Technical Center for Emergency Response Control Systems” (SSTC ERCS, Kyiv) to request of NAEK Energoatom.

1.1.5 The IAS gives a short summary on the reference data and on the substantiations, describes basic technical decisions and results of the analysis, assessments and forecasts, presented in 23 volumes of the FS [21-43], including the Environmental Impact Assessment (OVOS)[33].

1.1.6 IAS is a document of the survey nature. It doesn't contain any additional data, special assessments or independent conclusions and it is based completely on the information, presented in FS. At the same time, for better readability, the presentation of the information was slightly changed

in comparison with the FS structure.

Information, given in the Par. 1.2-1.5 of the Section 1 of IAS is detailed in the FS materials [21,25,32,33].

1.2 Previous activity in construction and operation of KNPP

1.2.1 Construction of a big nuclear power plant in the central regions of Ukraine was specified by the Council of Ministers of USSR Resolution of 16.03.1971. Based on the results of the comparison of possible variants of NPP location, prepared by the Kyiv department of the institute “Teploelectroproject” (later on reorganized into KIEP), Ministry of Energy of USSR took a decision №80 of 17.04.1975 on the construction of the Western-Ukrainian NPP №2. The choice of the Neteshyn point in Khmelnytska oblast as a site for the construction of this new NPP and its name – Khmelnytska NPP were defined by the act of the government commission of the Council of Ministers of Ukrainian SSR №2 of 22.07.1975, approved by the Resolution of the State Plan of the Ukrainian SSR №56 of 14.08.1975 and approved by the Council of Ministers of Ukrainian SSR Resolution № 536 of 10.12.1975.

Technical design of the KNPP comprised of four power units with the total capacity 4000 MW was developed by the Kyiv department of the institute “Teploelectroproject” and approved by the USSR Ministry of Energy № 150 PS of 28.11.1979. Construction of the power units KNPP-1,2,3,4 was initiated accordingly in 1979, 1983, 1985, 1986.

Power unit KNPP-1 was commissioned in 1987.

Construction of power units 2,3 and 4 was terminated in 1990 due to the moratorium for construction of nuclear power units on the territory of Ukraine, set by the Supreme Council of Ukrainian SSR Resolution of 02.08.1990. By the moment of the construction termination, the infrastructure for NPPs with the design capacity 4000 MW was developed, including pipelines of the technical water of the group A services and spray ponds, auxiliary constructions and outside-the-site buildings, including the reservoir coolers for the full design capacity. Construction readiness of the KNPP-2,3 and 4 was 80-85%; 35-40%; 5-10% respectively.

Moratorium for the construction of NPPs on the territory of Ukraine was removed by the Supreme Council of Ukrainian SSR Resolution № 3538-XII of 21.10.1993. In 1993 works on the construction of power unit KNPP-2 were resumed. The construction was completed in 2004. The commissioning act of the KNPP-2 was signed by the State Acceptance Commission on 07.09.2005.

Beginning with 2008 at the facilities of the uncompleted construction – at KNPP-3,4 - preparatory works are ongoing.

1.2.2 At present 2 VVER-1000 power units are in operation at KNPP. Each power unit is comprised of the following main equipment:

- Thermal neutrons pressurized water energy reactor as a part of the B-320 reactor facility with the thermal capacity of 3000 MW (borated water

under the pressure of 15,68 MPa is used as a heat-transfer agent and as moderator; fuel for the reactor is the uranium dioxide enriched by the isotope uranium-235 to the level of 4,0-4,4%);

- Four steam generators PGV-1000 of the power 1470 t/h of the dry saturated steam of the pressure 6,27 MPa;
- Four main circulation pumps of the MCP-195M;
- One turbo unit of the K-1000-60/3000 type;
- One generator of the TVV-1000-2-UZ type of the power 1000 MW with the voltage on the terminals 24 kV.

Reactor, steam generators and other equipment, operating under the pressure of 15,68 MPa, are situated in the reinforced-concrete containment in order to prevent releases of the radioactivity into the environment during potential accidents.

Power units have a three-channel design of the safety systems. Each channel ensures transfer of the reactor facility into the safe condition during possible malfunctions of normal operation and design-basis accidents.

The scheme of the technical water supply of the non-essential services of the power units 1,2 is reverse with spray ponds. The scheme of the technical water supply is reverse with the off-river basin-coolant, constructed in the high-water beds of the rivers Horyn and Hnyloy Rog.

The power units' operation mode is basic. The power output into the system is specified at the voltages of 330 and 750 kV.

1.2.3 Safety and the high level of the operational reliability of the operating power units KNPP-1,2 are ensured by the implementation of the reference design solutions as well as by the measures in further safety and modernization improvement and confirmed by the inspections and expertise carried out by the national authorities and independent international experts (IAEA, Riskaudit, TACIS, WANO etc.).

1.3 Basic milestones of the life cycle and the stages of the new power units design

1.3.1 Basic milestones of the life cycle of nuclear power units correspond to the milestones, defined by the regulatory and legal framework for Nuclear Facilities (NF) [6,8,18]:

- Site selection;
- Design;
- Construction;
- Commissioning;
- Operation;
- Decommissioning.

1.3.2 In line with the SCN A. 2.2-3-2004[15], development of the project design documents for the objects of the highest category of complexity, where NP belong, shall be implemented in these stages:

- Feasibility Study (FS);
- Design;
- Working documentation.

Such approach enables at the next stages of the design to clarify FS decisions, taken with the consideration of the specified reference data, detailed selected technologies etc.

According to [15], FS is elaborated for the industrial facilities, which require detail substantiation of the respective decisions and the determination of variants and expediency of the facilities construction. Herewith in the FS the comprehensive impact assessment of the activity on the environment (OVOS) shall be performed; recommended FS decisions shall be substantiated by the OVOS results; OVOS materials, prepared as a special part (section) of the documentation is a mandatory part of the FS. Requirements to the OVOS scope and contents are regulated by SCN A.2.2-1-2003 [16].

1.4 Grounds for FS elaboration

1.4.1 Construction of power units 3,4 on the KNPP site is one of the priority tasks of the “Energy Strategy of Ukraine for the period up to 2030” (Strategy) [44].

1.4.2 Direct grounds for the FS elaboration of power units KNPP-3,4 construction are:

- CoM Order “On preparatory measures for construction of new KNPP power units” № 281-p of 21.07.2005. [45];
- Ministry of Energy and Coal Industry “On preparatory measures for construction of new KNPP power units” № 425 of 22.08.2005. [46];
- CoM Order “On approval of the Action Plan for 2006-2010 in implementation of the Energy Strategy of Ukraine for the period up to 2030” № 436-p of 27.07.2006. [47];
- CoM Order “On the priority measures in construction of KNPP-3,4” № 118 of 18.02.2009 г. [48].

1.5 Principle tasks of FS

1.5.1 Based on the tasks [44-48] and normative requirements [15, 16], the principle tasks of the FS elaboration are as follows:

- Necessity of the justification and the assessment of the economical expediency of KNPP extension;
- Confirmation of the compliance of the KNPP site with the requirements of the effective Normative Documents (ND) taking

into account KNPP extension;

- Substantiation of the main technical decisions of the power units 3,4 and NPP in whole;
- Assessment of the impacts of KNPP on the environment during normal operations and during accidents, taking into account its extension ;
- Assessment of basic technical and economical indicators of the power units 3,4 and of the NPP in whole;
- Preparation of the documentation for public consultations based on the elaborated FS.

2 JUSTIFICATION OF THE NECESSITY AND EXPEDIENCY OF THE KNPP-3,4 CONSTRUCTION

Information, given in this Part 2 of IAS is detailed in the FS materials [21,22,33,40-42].

2.1 Role of nuclear energy

2.1.1 Reliability, efficiency and environmental safety of the power generation at modern NPPs are recognized all around the world. During the last 40 years the share of the nuclear energy in the world production of the electric power has grown 20 times and as of today makes around 18%.

In the conditions of the increasing prices for organic fuel (gas, coal, oil) and instability of the world oil and gas markets, the capability of nuclear energy to cover growing demands of the population and of the industry in the relatively cheap electric power gains more and more acknowledgment.

Besides the lower net cost of production, the advantages of modern NPPs in comparison with the traditional sources are: 1) the lower impact on the environment; 2) the possibility to create the reserve of fuel for a long period, and 3) in the conditions of Ukraine also the availability of significant reserves of natural resources (uranium, zirconium etc.). Taking into account the limited national reserves of oil and gas, as well as the physical deterioration of the capital equipment of the thermal generation, nuclear energy as of today defines significantly the energy safety of Ukraine.

2.1.2 Operating organization of all operating Ukrainian NPPs (Zaporizhzhya, Rivne, Khmelnytska and South-Ukraine) is NAEK Energoatom. At present 15 power units of the VVER type are in operation at 4 operating NPPs. During last decade their share in the total electric power generation made 45-48%.

2.2 Need for additional nuclear capacities

2.2.1 Based on the international and national realities and tendencies, the planned share of NPPs for the period up to 2030 in the Strategy [44] makes about the half of the total electric power generation in Ukraine. In this connection, the priority tasks of the nuclear energy development in Ukraine are the service life

prolongation of the operating NPPs, preparation to their decommissioning and timely construction of new capacities in addition to or in order to replace the ones, which are to be decommissioned [44].

2.2.2 Based on the possibilities of the existing sites, construction of the first new nuclear power units is specified in [44] at the site of the operating Khmelnytska NPP (figure 2.2-1).

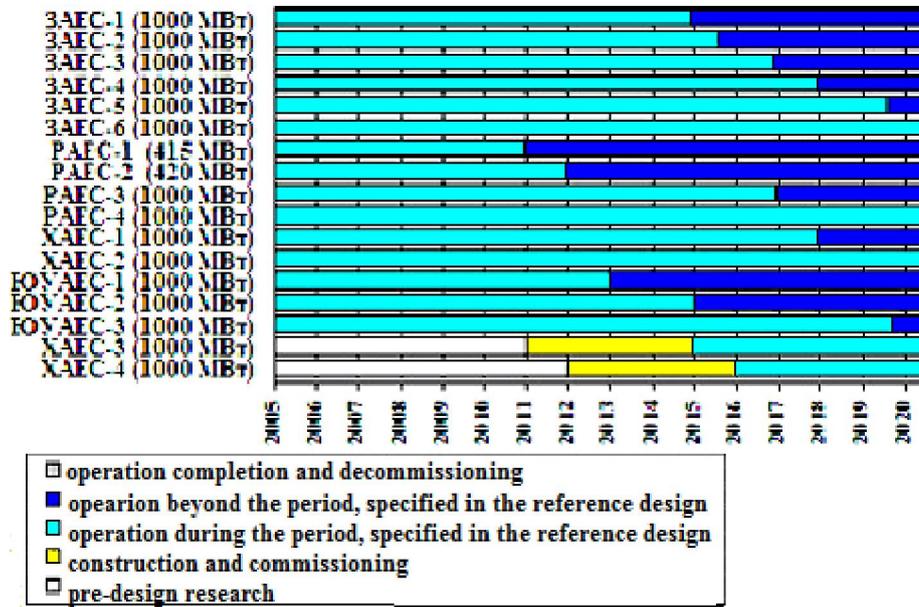


Figure 2.2-1 Unit-by-unit schedule of operation, service life prolongation and new construction in the period up to 2020, specified in the Strategy [44].

2.3 Economic efficiency of the KNPP extension

2.3.1 General conclusion of the FS about the economic necessity of the investments into the KNPP extension through construction of power units 3,4 was made based on the results of the performed analysis of the capacity and electric power balances for the period up to 2025, as well as on the assessment of the perspective electric power market up to 2065.

In [49], based on the received results, the conclusion was made that in the period up to 2020-2025 the South-Western Energy System is redundant even without taking into account commissioning of power units KNPP-3,4. In this period the possibility is foreseen to transmit the surplus energy, generated in the South-Western Energy System, into the Integrated Power System (IPS) of Ukraine through power links (VL-750, 330 kW) as well as its export to Russia, Belorussia, Moldova and to the European Union. In this way, electric power, generated by the power units KNPP-3,4 will have its outlet.

In line with [49], KNPP capacity increase up to 2020 will allow to enhance the reliability of the electric power supply in the peak hours of the appropriate region as well as of the IPS of Ukraine in whole (in case of the sufficient transfer capacity of grids). Besides, the power surplus, formed in the South-Western Energy System during the night decrease of load, taking into account the base-load operation of NPP, can be used for the charge of the Dnestr and Kanev HPSPP, commissioning whereof is planned in the period 2010-2020.

In the long-term perspective up to 2065, the growth of Ukrainian IPS demands in new capacities is forecasted due to the following reasons:

- After 2020 the negative phenomena in the economy of Ukraine and in the neighboring countries will be overcome, industrial growth and respectively the electric power consumption will increase significantly;
- Worn-out and outdated generating capacities at the thermal electric power plants of Ukraine and of the neighboring countries will be decommissioned, which will require their compensation.

Taking into account that the operation of the power units KNPP-3,4 is planned respectively up to 2065, 2066 (service life is 50 years), based on the results of [49] in FS, a comprehensive analysis was made that in the long-term perspective the electric power, generated by these power units, will have a stable and guaranteed outlet. Herewith, subject to the realities of the national economy, the electric power, generated by the power units, can be distributed between domestic and foreign markets.

2.3.2 In the present conditions, more and more attention is paid to the problems of economic efficiency and social expediency of the investments, especially when implementing technically complicated and capital-intensive projects, such as the construction of new nuclear power units.

As a part of the FS, the construction cost of KNPP-3,4 is defined according to the data of the estimated calculations of the construction design, prepared in the prices as of 2010. The total estimated cost of the KNPP extension project was defined in the FS, taking into account new and reconstruction of a number of existing ancillary and service facilities and makes together 25 186,753 million UAH (in the prices as of 2010, w/o VAT).

The payback period is defined in the FS taking into account the beginning of the project implementation in 2010:

- The payback period, calculated from the moment of the output of the power units KNPP-3,4 to full design capacity (2017) makes 12,8 years (19,3 years from the initiation of the investment);
- Internal rate of the return makes 8,96%, which is almost twice higher than the discounting rate of 5,3%.

2.3.3 Taking into account a number of uncertainties, related to the project implementation and influencing its efficiency, the project sensibility to the changes of different output parameters was analyzed, including:

- Construction cost (amount of investments);
- Electricity tariff (sales price);
- Production costs (total costs);
- Discounting rates

Results of the sensibility analysis indicate the sustainability of the investment project by possible deviations from the analyzed parameters from the baseline values. According to the financing scheme, accepted in FS, the project remains stable by 100% increase of the construction cost and production costs.

3 SUBSTANTIATION OF THE CONSTRUCTION OF NEW NUCLEAR POWER UNITS

Information, given in the Section 3 of the IAS, is detailed in the FS materials [21,24,33].

3.1 Selection of the location area and the construction site of new power units

3.1.1 Based on the governmental decision about the construction of nuclear power units 3,4 at the existing KNPP site [44,48], new alternative variants of generation and of new capacities location are not subject to the study in the FS.

As it was mentioned in Par.1.2.1, the existing KNPP site was selected and approved for the NPP with the capacity of 4000 kW in line with the law requirements, effective at the moment of the construction of the power unit № 1.

3.1.2 KNPP site is located in the north-west of the Slavuta rayon Khmelnytska oblast of Ukraine, 18 km to the west from the rayon center of the town Slavuta, 100 km to the north from the oblast center of the city Khmelnytsky, close to town of Neteshyn (NPP settlement). The area of the KNPP location and the borders of its Supervised Area (SA) are shown in the Figure 3.1-1.

SA of KNPP includes the territories of Khmelnytska oblast (lands of Izyaslav, Slavuta, Belogorsk and Shepetovka rayons) and Rivne oblast (lands of Ostrog, Goschan and Zdolbuniv rayons).

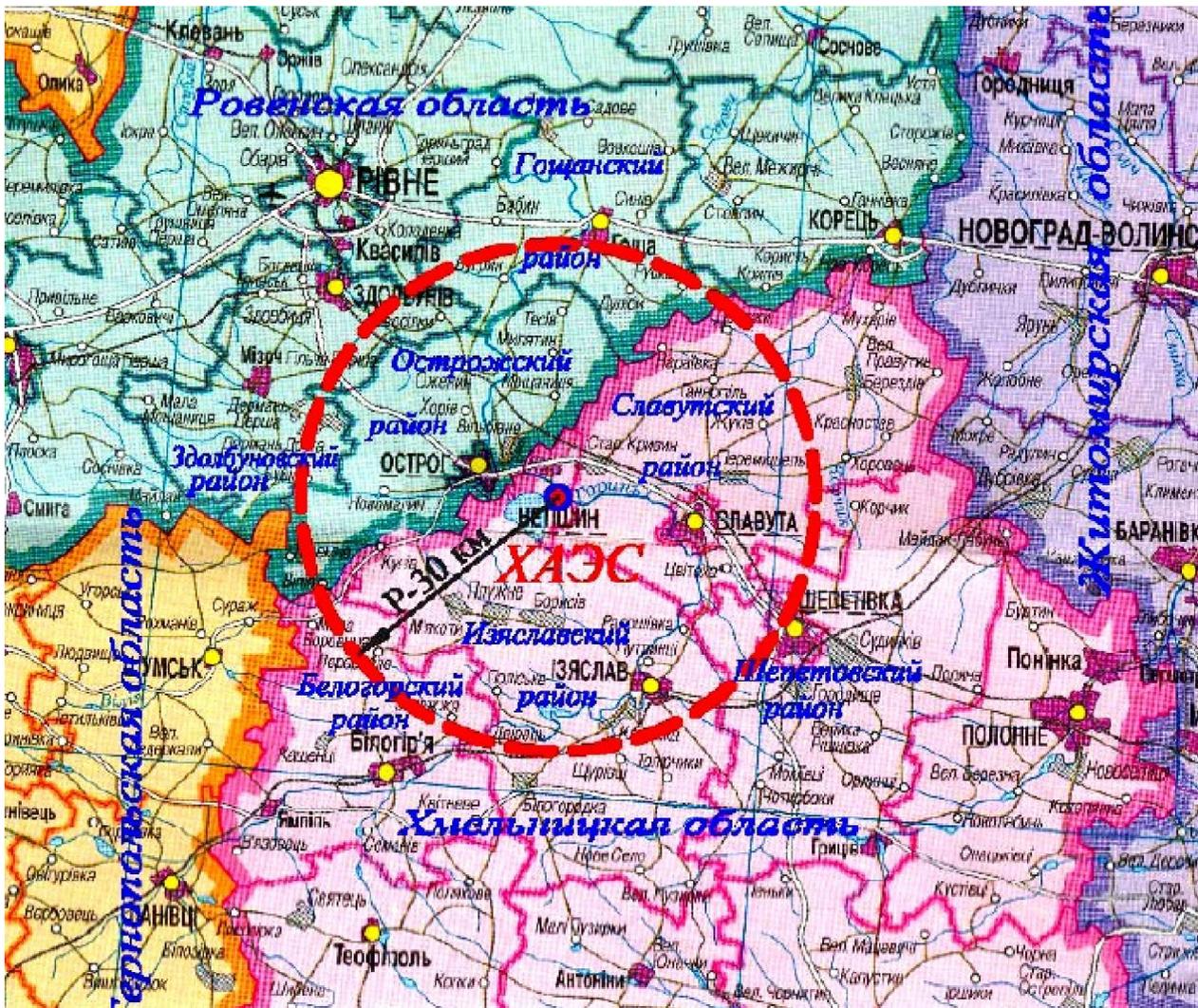


Figure.3.1-1 KNPP location.

3.1.3 Along the northern border of the village Krivin at the distance of 8.99 – 9.00 km there is a part of the railway trunk Shepetovka-Zdolbuniv-Lviv, where an intermediate station of the III class Krivin is located. The ballast 8.4 km long quarry driveway “Seltso” is adjoined to the station, with the bridge over the river Horyn. Before the bridge there is a station of the IV class Seltso, to which the NPP railroad was adjoined after its reconstruction.

The road of the national importance Berdichev-Shepetivka-Ostrog is going 6.3 km to the north from the site. The main entrance to the NPP site is through 6,3 km long road with the junction to the mentioned road of the national importance. Besides, there are other roads which ensure connection with the road Berdichev-Shepetivka-Ostrog. There is no water transport.

3.1.4 KNPP general location plan with its Control Areas (CA) is shown in the Figure 3.1-2.

- According to seismic characteristics, DBE= 5 points, MDE = 6 points (more than 8 points are not acceptable);
- According to soils condition – there are no karstic processes, subsidence and highly compressible soils;
- Maximum horizons of floods of melt waters and rain waters on the river Horyn are of no danger for the construction of NPP taking into account the planning marks of the site (206 m);
- Groundwater Level (GWL) is from 3 to 4 m (not less than 3 m is required);
- Repetition of light winds up to 2 m/sec – 26%, fogs – 26% (less than 40% is required) during the year.

Taking into account the recommendations [52], the rated accelerograms for MDE were standardized to the peak ground acceleration of 0,1g.

The natural conditions, which limit the NPP location, include the location of the site in the tornado hazardous area – $K_r=2.75$ (the factor is unfavorable, the location is allowed under the implementation of engineering activities). To be accepted technical decisions consider this factor. In particular, during construction of power unit 3,4 it is specified to equip the spray ponds of the cooling system of responsible services of the power units 3,4 reactor building with the protection against tornadoes.

3.2.3 According to the impacts of external factors of the anthropogenic nature, including the external fire and external explosion, the site is in compliance with the requirements and recommendations [18-20] and is qualified for the NPP location. In the FS the territorial location of the industrial enterprises, military objects, and transport constructions is studied, where accidents or external extreme impacts may happen. The performed analysis indicates the following:

- Fires, which may occur outside and on the territory of the NPP site, will have no impact on the facilities, significant for safety, which are located in the power units area;
- Analyzed external potential sources are of no danger, since the levels of impact of the shock wave exposure during accidents, which are followed by the explosion, are significantly lower than the rated values, accepted in the design for the Reactor Building (RB) and for the Back-UP Diesel Engine Power Plant (BUDEPP).

3.2.4 According to the environmental conditions, the site is in compliance with the requirements, specified in the standard documents [13,17-19]. In particular, in [50] based on the results of the inspection of the Reservoir-Cooler (RC), made by LvivORGRES and of the mathematical modeling of the processes in RC during operation of the four power units, made by the Kharkov Institute UkrNIIEP, recommendations were prepared on the improvement of the cooling capacity of RC in order to ensure stable operation of NPP at nominal capacity of the four VVER-1000 power units, including under unfavorable (hot) hydro meteorological conditions in summer time.

In accordance with the calculations of the hydro economic balance [51], the flow of the river Horyn in March-April of 95% provision is sufficient for the reservoir makeup during operation of the four KNPP power units.

For the utility and drinking water supply of the NPP and the residential settlement (Neteshyn) one source is foreseen – the artesian well. In line with the requirements of Construction Norms and Regulations [53], it is subject to the enlargement of the existing artesian well with the four reserve artesian wells (20% of the total number of wells). Horbashev water-bearing horizon, which is operated by Neteshyn water intake, is well-protected from the surface contamination by a powerful layer of tuff. There is no direct connection between the deeply-lying water-bearing horizon and ground waters. River of Horyn is the flowing water body and cannot be a source of contamination of a deeply-lying Horbashev water-bearing horizon. In order to prevent chemical and microbial contamination of the water-bearing horizon of the Neteshyn water intake, three zones of the sanitary protection are specified (I zone is a contamination control area, II, III zones are the zones of restrictions of economic activity).

3.2.5 According to special conditions the site is in line with the international recommendations [20]:

- Average density of population of the SA is 74 persons/km² (less than 100 persons/km² is recommended);
- There are no cities with the number of population from 100 thousand people within a radius of 30 km;
- Population of Neteshyn is 34.75 thousand people (less than 50 thousand people is recommended);
- There are no forest reserves of the national importance in the SA;
- Distance to the river Horyn is 1.90 km (more than 1 km is recommended);
- In the CA there are no houses, public buildings, children, health and recreational institutions, facilities of the utility and drinking water supply, industrial and subsidiary buildings, not related to KNPP;
- The territory is beautified and landscaped;
- When using soils and water reservoirs around NPP, the mandatory radiological monitoring shall be made.

3.2.6 Schemes and technologies of storage and transportation of fresh and spent nuclear fuel of new power units 3,4 will be similar to the ones, used at the operating power units KNPP-1,2. The system of RW management at new power units is similar to the current system. The possibility of the implementation and the sufficiency of protective measures in case of severe accidents are confirmed by the substantiation of the current accident plans at KNPP.

3.2.7 Based on the results of the analysis, the conclusion is made in the FS on the compliance of the KNPP site in whole with the requirements of the standard documents and international recommendations according to all factors, specified in the Par.3.2.1.

4 PRINCIPLE TECHNICAL DECISIONS

Information, given in the Section 4 of the IAS, is detailed in the FS materials [25-27,29].

4.1 General Information

4.1.1 The planned design service life of the power units KNPP-3,4 is 50 years and is subject to clarification at the stage “design”. The units are aimed at the electric power generation in the base-load operation with the possibility of their operation in the mode of the power control mode. Conditions of implementation and specific characteristics of such modes will be defined at the stage “design”.

4.1.2 Simplified principle scheme of the power units KNPP-3,4 is presented in the figure 4.1-1. Each power units comprises:

- Reactor Compartment (RC);
- Turbine House (TH), including turbine hall and deaerator department.

Besides, operation of power units requires the availability of auxiliary constructions (see Par.4.4 of this IAS).

4.1.3 Construction of power units 3,4 specifies that the existing structures of RC, Reserve Diesel Power Plant (RDPP) and other objects of the uncompleted construction shall be used. Herewith, at the facilities of the uncompleted construction the maintenance and renewal works are ongoing, the scope whereof is defined according to the results of the inspection and assessment of the technical condition of these facilities.

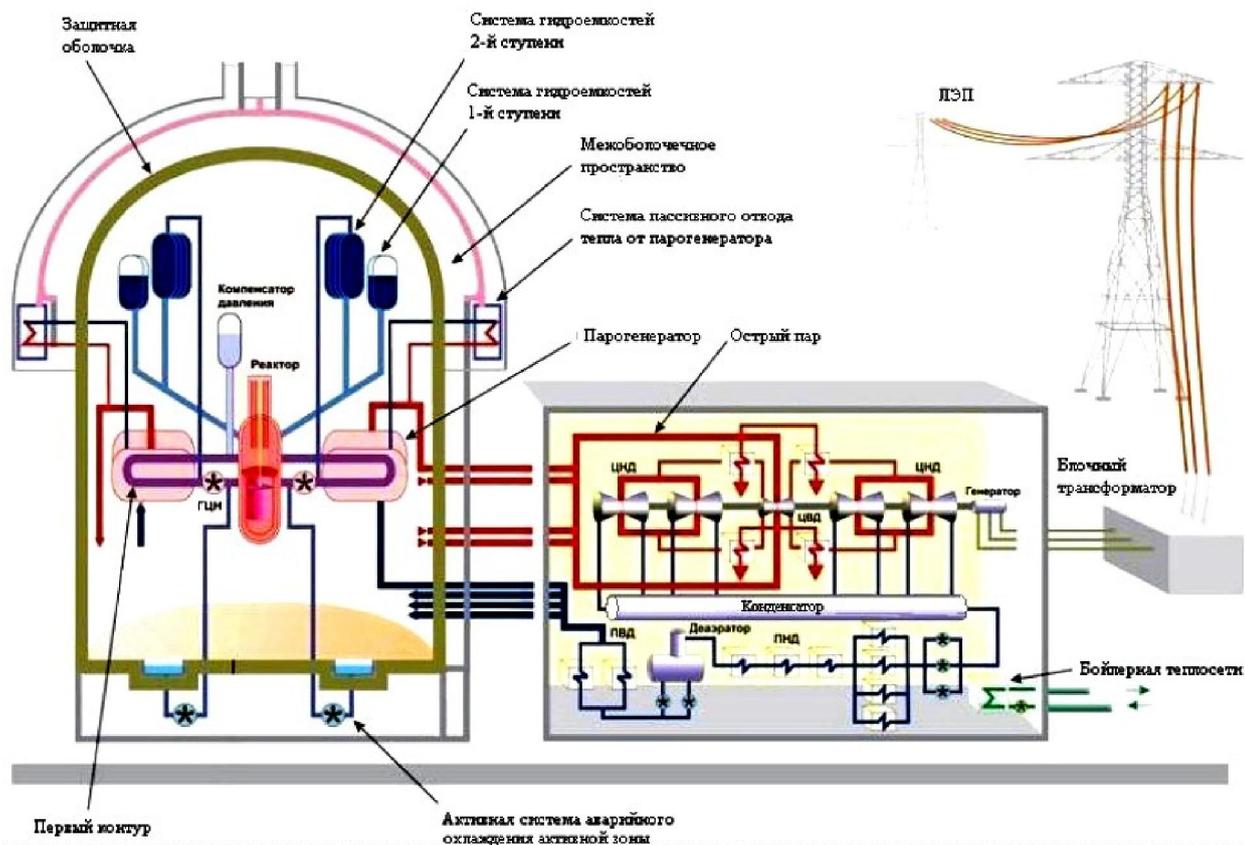


Figure.4.1-1 Simplified elementary diagram of a power unit.

4.2 Reactor Compartment

4.2.1. For RC of new power units 3,4 the technical decisions are used, similar to the ones, implemented at the operating power unit KNPP-2, taking into account changes and improvements, related to the new Reactor Facility (RF).

In accordance with the conclusions of the competition committee, recommendations of the scientific and technical board of the Ministry of Coal and Energy Industry [54], the reactor facility of the B-392 type is considered as RF for new power units.

4.2.2. Main technological equipment and systems of the primary circuit comprise:

- Main Circulation Circuit (MCC);
- Pressurizer System (PS);
- Normal operation items, important to safety;
- Safety Systems.

4.2.3. Main Circulation Circuit comprises:

- Nuclear energy reactor B-392 of the vessel type with water under pressure;
- Four circulation loops, each whereof comprises:
 - Steam Generator (SG) of the PGV-1000M type;
 - Main Circulating Pump Unit (MCPU) GNTTs-1391;
 - Main Circulation Pipelines (MCP), connecting loop equipment with the reactor.

Equipment and the pipelines of the RF are situated in the containment (Figure 4.1-1). The compact arrangement of the critical equipment of the MCC and the placement of the reactor supports, SG and MCPU at one level allows decreasing the thermal pressure in the MCP. Relative position of the equipment and of the RF pipelines enables ensuring reliable natural circulation under idle MCPUs. In order to restrict the equipment displacement and to prevent creation of flying objects, which can destroy the containment during the pipelines rupture, mounting hardware is specified, which prevents the pipelines and the mobile equipment from big displacements and from blows against the adjacent equipment.

The simplified elementary diagram of the nuclear energy reactor B-392 is presented in the Figure 4.2-1.

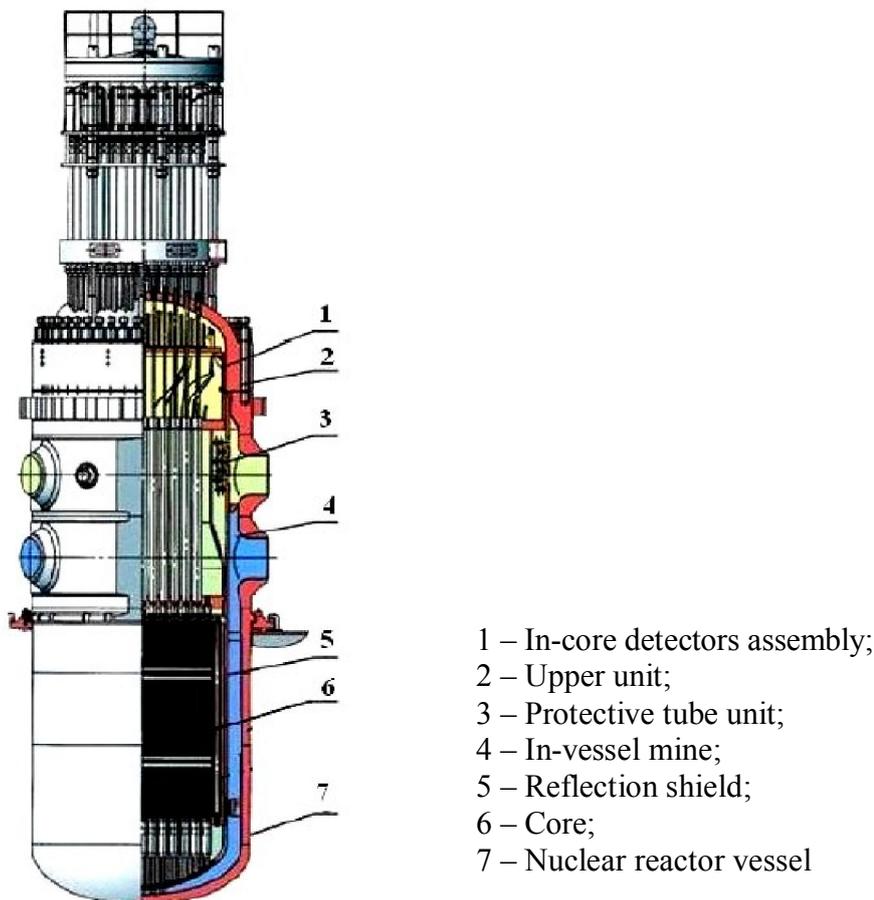


Figure.4.2-1 The simplified elementary diagram of the nuclear energy reactor B-392.

Pressurized water reactor on thermal neutrons is a cylindrical vessel, comprising the vessel and the removable upper unit with lid. In the vessel there are in-vessel devices and the reactor core, which consists of fuel assemblies.

Steam generator PGV-1000M is a single-shell regenerative heat exchanger of the horizontal type with the immersed matrix of the corridor arrangement and is designed to produce dry saturated steam. SG and collector vessels are made of the alloyed structural steel.

Main Circulating Pump Unit GTsNA-1391 is designed to create circulation of the coolant in the primary circuit. It is a vertical centrifugal single-stage pump with the hydrostatic shaft seal, cantilever impeller, axial water supply and external motor.

MCP consists of pipe elements with the inner diameter of 850 mm and thickness of 70 mm, made in a seamless way of a pearlite class low-alloy, carbon steel with the inner surface cladding of the corrosion-resistant steel.

4.2.4 The Pressurizer System comprises:

- Pressurizer;
- Bubbler tank;
- Pipelines, connecting the pressurizer and the bubbler tank between each other with the primary circuit;
- Reinforcement.

The system is designed to create and to maintain the pressure in the primary circuit in stationary mode, limitations of pressure deviations in the transitional and emergency modes and reduction of pressure in the shut-down cooling mode.

The pressurizer operates to maintain pressure in the primary circuit during malfunctions of the normal operation and in the design-basis emergency situations. Ratio of the water and steam volumes of the pressurizer is chosen based on the condition that at none of the design-basis modes there is steam reflux into the primary circuit from the pressurizer and the exposure of the pressurizer electric heaters.

4.2.5 Normal operation items, important to safety, comprise:

- Water cleaning systems;
- Primary circuit purge-makeup system, including boron control;
- Drainage and vent systems;
- Organized leakages system of the primary circuit coolant;
- Cooling pond aftercooling and spent nuclear fuel refueling systems;
- Nitrogen and gas blow down system;
- SG purging system.

4.2.6 Safety systems, planned at power units 3,4 can be relatively divided into two categories: systems, similar to the ones at the operating power units KNPP-1,2 with the RF of the B-320 type, and additional systems. The first category comprises:

- Primary circuit protective systems from overpressure;
- Emergency gas removal system;
- Passive part of the Emergency Core Cooling System (ECCS);
- High Pressure Emergency Core Cooling System (HPECCS);
- Low Pressure Emergency Core Cooling System (LPECCS);
- Secondary circuit protective systems from overpressure;
- Emergency drinking water supply system into SG.

Additional systems in comparison with the systems in the RF of the B-320 type, comprise:

- Passive Core Reflooding Additional System (PCRAS);

- Passive Heat Removal System (PHRS);
- ECCS Second Stage Accumulator System;
- Quick Boron Entry System (QBES).

PCRAS is designed for passive supply of the boric acid solution into the core with the aim of the long-term fuel cooling during accidents with the loss of the primary circuit coolant, which are accompanied by the ECCS active part failure. Pipelines of the PCRAS accumulators are connected to the MCC through ECCS pipelines. The system is put into operation to reduce pressure in the primary circuit.

PHRS is designed for long-term residual heat removal from the core during beyond design-basis accidents with the loss of all sources of the alternating current power supply by the dense primary circuit as well as by leaks in the primary or in the secondary circuit. In case of the leaks in the primary circuit the system operates together with the ECCS Second Stage Accumulators.

QBES is designed for functioning during emergency situations with the failure of the emergency protection (the need for the system is subject to clarification at the stage “design”).

4.3 Turbine House

4.3.1 The arrangement of the TH of the power units 3,4 is similar to the power units 1,2 except for the transition from high-speed to low-speed turbine facility (See par.4.3.3. of this IAS).

4.3.2 The main technological equipment and systems of the secondary circuit comprise:

- Turbine facility;
- Main steam line system;
- Main condensate system, including the cleaning system
- Feed water system;
- Heating unit;
- Turbine facility oil supply system;
- Chemically demineralized water and deaerator emergency feed water system;
- Nuclear reactor shut-down cooling through the secondary circuit;
- Technical water supply system.

4.3.3 In line with the recommendations of the scientific and technical board and with the decision of the competition committee of NAEK Energoatom, the FS considers as a turbine facility for new power units the facility based on the low-speed steam turbine K-1000-60/1500-2M produced by the JSC “Turboatom” with the nominal capacity 1000 MW (with the possible increase to 1100 MW) with the turbine generator of the TVV-1000-4UZ type, produced by the JSC “Elektrosila” with the capacity 1000 MW.

Turbine K-1000-60/1500-2M is a condensation four-cylinder turbine without the controlled steam extractions, with separation and with a single two-stage

steam intermediate overheating (bleed and fresh steam), with the rotating speed 1500 rev/min.

4.4 Auxiliary Constructions

4.4.1. The auxiliary constructions, necessary for the operation of power units 3,4, comprise:

- Special building;
- Standby Diesel Power Plant (SDPP);
- Standby Whole Plant Diesel Generator (SWPDG);
- Hydro technical constructions;
- Joint auxiliary building;
- Start-Up Boiler (SUB) with the joint oil and fuel oil sector;
- Outside switchgears (OS);
- High-voltage transmission lines.

4.4.2 The existing special building is common for all 4 KNPP power units. In the special building are located:

- Special water treatment systems:
 - Drain water treatment system;
 - Cooling pond and refueling pond water treatment system;
 - SG bleed water treatment system;
 - Boric acid regeneration system;
 - Special laundry and shower water treatment system;
- Liquid Radioactive Waste Management System (LRW);
- Solid Radioactive Waste Management System (SRW).

4.4.3 SDPP, as the system of emergency power supply is a supporting safety system. During normal NPP operation the SDPP is in the state of continuous readiness for launching (‘standby’ mode).

Three off-line channels of safety system in the technological part, and respectively three off-line systems of emergency power supply are specified in the design. Each channel comprises electrical equipment, diesel-generator, auxiliary systems, which ensure the diesel generator operation, and the instrumental panel equipment.

SDPP operation is functionally connected with the operation of the technical water system of essential services, with the heating and ventilation systems.

4.4.4 SWPDG is an off-line emergency source of power supply of the critical mechanisms of NPP power units, on which depend the keeping of all power units equipment in operable condition in case of total loss of the alternating current.

SWPDG can be used for power supply of the especially essential NPP services, on which depend the fast maintainability of the NPP after its major blackout.

SWPDG consists of two cells, situated in one building. In each cell one diesel-generator of the ASD-5600 type is placed with the capacity 5600 kW, with the voltage of 6,3 kW. The cells are equipped with the systems of fuel, oil, cooling

water, starting air, control, protection, alarm etc. There is no consolidation of different cells.

4.4.5 Hydro technical constructions comprise the following ones:

- Capital equipment cooling system;
- Group ‘A’ services cooling system;
- Group ‘B’ services cooling system;
- SWPDG-2 services water supply system.

Capital equipment cooling system must ensure water cooling of the turbines condensers, auxiliary mechanisms as well as the cooling of the condensers and auxiliary equipment of the turbo feed pumps. The cooling system is reverse with the reservoir-cooler (RC). Main constructions comprise: off-channel reservoir, supply channel, unit pump stations, feed and discharge circulation water lines, open outlet pipe channel, siphon structure, closed outlet channel, connecting constructions, additional water pump station.

Group ‘A’ services cooling system is a part of the supporting safety system. It consists of three independent from each other cooling channels and is isolated from other cooling systems. The coolant of each channel is the appropriate spray pond.

Group ‘B’ services cooling system is designed for cooling of inessential services, situated in the reactor compartment, turbine house and in the special building. The reservoir is the system coolant. Hydraulically the system is connected to the capital equipment cooling system.

SWPDG-2 services water supply system is reverse, similar to the capital equipment cooling system, with the common reservoir-cooler.

5 SAFETY ASSURANCE

Information, given in the Section 5 of IAS, is detailed in the FS materials [28,32,33,37,38].

5.1 Quality assurance

5.1.1 Quality control systems of the separated subdivision Khmelnytska NPP (KNPP), as an integral part of the quality control of the operating organization NAEK Energoatom, has been created, supported with the documents and is functioning according to the law requirements [18.55-57]. All activities, which influence the KNPP safety at all stages of service life, are the objects of this system. Key elements of the documentation of the specified systems are the quality assurance programs, which were elaborated and are in force at KNPP and in Energoatom.

5.1.2 Quality assurance program (manual for quality) for the service life stage “design” of the power unit №3 has been elaborated and put into operation at KNPP. Similar document is being elaborated for the power unit KNPP-4. Availability of quality assurance programs for the service life stages such as “construction”, “commissioning”, “operation”, “decommissioning” will be one of the conditions in order to receive respective licenses by the operating company.

5.1.3 Engineering, design, construction, repair, erection, adjustment organizations, organizations of the scientific and technical assistance, equipment producers and institutions which provide their services during design, construction, commissioning and operation of KNPP-3,4 also elaborate and implement quality assurance programs for their activities. The operating company provides the organization, coordination of the elaboration and implementation of the general and particular quality assurance programs of contractor organizations within the frameworks of the activity in assessment of the suppliers in line with the law requirements.

5.2 Nuclear Safety

5.2.1 In line with [18], the basic objective of the NPP safety is protection of the personnel, population and the environment from unacceptable radiation impact during commissioning, operation or decommissioning of NPP. This, in particular, can be achieved through implementation of technical and organizational measures, aimed at prevention and limitation of consequences of accidents at NPPs, including nuclear accidents. Such accidents include accidents, which result in the damage of fuel elements, which exceed the established limits of the safe operation, caused by:

- Malfunction of monitoring and control of the chain fission reaction in the RF core;
- Creation of critical mass during refueling, transportation and storage of nuclear fuel.

5.2.2 Nuclear safety is ensured by the system of technological and organizational means.

Nuclear fuel management before its loading and after its unloading from the RF core is organized in such a way, that the possibility of the chain fission reaction is excluded.

Technological means, which ensure the RF nuclear safety, are as follows:

- Use of properties of internal self protection of the RF;
- Use of safety systems, designed based on the principle of a single failure, diversity, redundancy and physical separation.

Nuclear safety during the exposure of the spent nuclear fuel in the Cooling Pond (CP) is ensured through:

- Exception of the spontaneous chain fission reaction in the CP in any situation mainly through the placement of Fuel Assemblies (FA) in the storage sells (shelves) at safe distance;
- Use of effective non-retrievable heterogeneous neutron absorbers, which ensure nuclear safety of the CP in case of water boiling;
- Use of the homogeneous absorber in the CP water, which provide additional guarantee of nuclear safety;
- Constructive assurance of stability of systems and CP equipment to

external impacts.

- Redundancy of CP cooling systems;
- Equipment of the CP with the safety systems (emergency CP feeding with sprinkler pumps from boron concentrate stock), designed to prevent accidents and limit their consequences.

5.2.3 Organizational means, which ensure nuclear safety, include:

- Use of the certified engineering practices;
- Keeping to the norms, regulations and standards of nuclear and radiation safety, as well as keeping to the requirements of the NPP design;
- Availability of necessary operational documentation;
- Performance of all works with fresh and spent nuclear fuel according to the approved plan;
- Keeping to and improvement of safety culture;
- Use of quality control systems at all stages of the service life of the nuclear facility;
- Ensure the appropriate staff qualification;
- Take into account the operating experience.

5.2.4 The basic document, which defines the safe operation of a power unit is the production procedure which contains rules and basic methods of a power unit safe operation, general procedure of the performance of operations, related to the power unit safety, as well as limits and conditions of safe operation. Specified procedures for the power units KNPP-3,4 will be elaborated upon the stage “design” based on the design documentation and on the safety analysis report.

5.3 Radiation Safety

5.3.1 In line with [18], the basic safety target (Par.5.2.1) according to the radiological aspects can be achieved through non-excess of the established sanitary norms of the radiation exposure limits on the personnel, population and the environment during normal operation, normal operation violations and design-basis accidents. Herewith it is necessary to ensure the conditions so that the specified radiation exposure is at the possibly minimum level taking into account economical and social factors.

5.3.2 In addition to the technological and organizational means to ensure nuclear safety (5.2), the radiation safety can be also ensured by:

- Use of the defense in depth concept;
- High reliability of the equipment, including the improved one, taking into account NPP operation experience during implementation of the alternative solutions, tested through the operation of nuclear facilities of different type with the prevention of failures, which have occurred;
- Low frequency of the initiating events, which violate normal operation;
- Decrease of the probability of the “severe” reactor core damage up to the level $5 \times 10^{-6} \text{ year}^{-1}$ [12].

- Decrease of the probability of the acceptable accident discharge outside the power unit (discharges, by the excess whereof the measures for the evacuation of the population outside the chosen area are to be taken), up to the level 10^{-7} year⁻¹[12].
- Increase of the time reserve for the personnel in controlling the beyond design basis accidents, during which the design characteristics of the protective barriers are ensured;
- Protection from failures due to general cause and personnel's error etc.

5.3.3 Defense in depth concept, implemented in the design RF B-392 is based on the use of the system of sequential physical barriers on the way of the spread of radioactive substances and ionizing radiation into the environment and of the system of technical and organizational measures to protect barriers and to maintain their efficiency, based on the protection levels.

Physical barriers system comprises the following elements:

- Fuel matrix;
- Fuel element cladding;
- Coolant circuit bound;
- Sealed enclosure of the reactor facility and biological protection.

System of technical and organizational measures constitutes five levels of the defense in depth:

- Level 1 (creation of conditions, preventing normal operation malfunction):
 - Assess and select the site, good for NPP location;
 - Develop the design based on the conservative approach with the developed property of the RF internal self-protection;
 - Ensure the required quality of NPP systems (elements) and of the performed works;
 - NPP operation in line with the requirements of the standard documents, production procedures and operating manual;
 - Maintain in good condition the systems (elements), important to safety, through the timely identification of defects, taking preventive measures; replace the overage equipment and organize the effectively operating system of the documentation of the results of works and monitoring;
 - Select the personnel and ensure the necessary level of its qualification for actions in the conditions of normal operation and normal operation violations, including emergency situations and accidents;
 - Form safety culture.
- Level 2 (prevention of design basis accidents through the normal operation systems):
 - Detect on time the deviations from normal operation and their

elimination;

- Perform control during normal operation violations.
- Level 3 (prevention of accidents through safety systems):
 - Prevent development of the equipment failures and personnel errors during design basis accidents, and the design basis accidents into the beyond design basis accidents using safety systems;
 - Reduce consequences of the accidents, which failed to be prevented, by retention of the released radioactive substances by the localizing safety systems.
- Level 4 (beyond design basis accidents management):
 - Prevent development of the beyond design basis accidents and reduce their consequences;
 - Protect the sealed enclosure from destruction during beyond design basis accidents and maintain its operability;
 - Bring NPP back to the controlled state, when the chain fission reaction ends, continuous cooling of the nuclear fuel and the retention of the radioactive substances within established levels are ensured.
- Level 5 (planning of measures for personnel and population protection):
 - Specify the control area and supervised area around NPP;
 - Prepare and implement (if necessary) action plans for the personnel and population protection.

5.4 Fire Safety

5.4.1 KNPP belongs to a group of objects, where fire can lead to the injury of people and of the surrounding area with the secondary signs of the hazardous fire factors, in the first place during discharge of the radioactive substances and materials outside the protective constructions.

In this connection, there is a militarized Fire Department of the Ministry of Emergency of Ukraine at KNPP, equipped with the necessary fire machines and means of fire extinguishing (stationary and mobile) with its necessary duplication.

5.4.2 In line with the requirements [58] and other regulatory and legal acts, fire safety of power units KNPP-3,4 is ensured by the subsystems of the fire prevention and fire protection.

Fire prevention can be achieved through prevention of the combustible medium formation and prevention of the ignition source formation in the combustible medium (or entering into it).

Fire protection is based on the principle of the defense in depth. The fire protection subsystem includes:

- Fire protection water supply system;
- Water supply sources, including external and internal networks;
- Fire alarm systems;

- Fire extinguishing systems;
- Smoke protection systems;
- Fire warning system and people evacuation management;
- Lightning protection and grounding;
- Primary means of fire extinguishing.

5.4.3 In line with the requirements [15], at the stage of the “Feasibility Study” the principle solutions to ensure fire safety of the power units KNPP-3,4 are defined, which are subject to clarification and detail at the next stages of the design (“design”, “working documentation”).

5.5 Labor Protection

5.5.1 In [59] and in other regulatory and legal acts in, the issues of labor protection the fundamental requirements have been defined for:

- Equipment, use whereof is specified in the design;
- Creation of technological schemes;
- Arrangement of the constructions and buildings premises in terms of safety of the production process and of the personnel, which performs NPP operation, repair and maintenance of the systems, equipment and their elements.
- Organizational activities, which ensure safety of the power plant staff during performance of the maintenance and repair of the equipment, systems, buildings and constructions.

5.5.2 The principle solutions in labor safety are specified in the FS, including:

- In general industrial safety, including the issues of:
 - Electrical safety;
 - Risk of consignment falling;
 - Risk of personnel injury;
 - Personnel safety during fire;
- In occupational sanitation, including the issues of:
 - Protection from noise;
 - Lighting;
 - Labor conditions;
 - Sanitary services;
- In radiation safety, including the issues of:
 - Sanitary and access control;
 - Medical control and hygienic rules;
 - Provision with the personal protection equipment;
- In management of toxic and aggressive substances.

Solutions, suggested in the FS, shall be subject to clarification and detail at the next stages of the design (“design”, “working documentation”).

5.5.3 It is specified that all existing at KNPP documents for labor safety and safety technique will be fully distributed at the power units 3,4 under construction, taking into account their specific characteristics.

5.6 Physical Protection

5.6.1 In line with the provisions of [60] and other regulatory and legal documents, NPP physical protection is aimed at the performance of the following functions:

- Limit to the minimum the number of people, having access to the nuclear material and nuclear facility;
- Prevent an unauthorized access on the territory of NPP, to the nuclear material, to the vital places;
- Detect on time and for certain the attempts of an unauthorized break-in into the restricted areas;
- Stop the violator’s intrusion;
- Arrest persons, whose actions can be targeted at committing or preparation of the nuclear terrorism act or theft of nuclear materials.

5.6.2 In order to implement the functions, specified in 5.6.1, at KNPP the physical protection layered system is created, which is based on:

- Organization of zones of restrict access, divided by the physical barriers, equipped with the devices of the intrusion detection and/or monitoring of the access at the borders of these zones;
- Implementation of the automated complex of engineering means of physical protection;
- Performance of organizational and legal measures.

5.6.3 It is specified in the FS, that for the power units 3,4 the current system of the physical protection at KNPP will be extended territorially at preserving the concept of its structure and functioning.

6 ORGANIZATION OF THE KNPP-3,4 CONSTRUCTION

Information, given in the Section 6 of IAS, is detailed in the FS materials [21,29,35,36].

6.1 Construction stages

6.1.1 Beginning of the uncompleted construction (See Par.1.2.1):

- Of the power unit № 3September 1985;
- Of the power unit № 4June 1986;

Construction and erection readiness of the power units KNPP-3,4 is respectively 28% and 10%.

6.1.2 Duration of the preparation period is defined taking into account the condition of the existing construction base and equals 18 months. The initiation of the preparation period shall be defined by the moment of the law adoption on construction of the power units KNPP-3,4 in line with [11].

6.1.3 Duration of the main construction period of the power units with the reactors VVER-1000 B-392 shall be defined by the period of the construction of main buildings. With the consideration of the final characteristics of the RC, duration of the main construction period of the power units KNPP-3,4 is 54 months (4,5 years), including for the power unit №3 – 42 months (3,5 years).

6.1.4 Estimated commissioning of the power units is:

- Power unit № 3.....2016;
- Power unit № 42017.

6.2 List of facilities of the start-up complex of the power units 3,4

6.2.1 List of facilities of the start-up complex of the power units 3,4 is given in the Table 6.2-1

Table 6.2-1 List of facilities of the start-up complex of the power units 3,4

№	Building, facility group / title
1	Preparation of the construction area
1.1	Organization of the drainage system at the site
2	Facilities of the main industrial purpose
2.1	Main building
2.2	Reactor compartment
2.3	Turbine house
2.4	Special building
2.5	Open transformer installation with transformer tracks
2.6	Power lines

№	Building, facility group / title
2.7	Open 330 kW switch yard with the autotransformer 330/110/35 kW, power supply of the KNPP auxiliaries outside the site
2.8	Open 750 kW switch yard consisting of 4 cells with the building equipment repair shop ORU-750 kW
2.9	Cable tunnels and channels
2.10	Stand-by diesel-generator power plant
2.11	Standby all-plant diesel generator №2
2.12	Industrial pipe-lines bridges
3	Technical water supply constructions
3.1	Unit pump station
3.2	Essential service spray installations, with the installation of two ponds and tornado protection
3.3	Transformer annex pipelines
3.4	Reservoir-cooler
3.5	Supply channel (debris deflector installation)
3.6	Discharge channels with the connecting construction and bridge
3.7	Earth dam
4	Auxiliary and service facilities
4.1	Combined auxiliary building (extension of the chemical water treatment and of the tank farm)

4.2	Engineering and technical building
4.3	Laboratory and social building № 2 with a canteen for 300 persons
4.4	Catwalk bridges
4.5	Combined oil and fuel oil sector with diesel fuel
4.6	Engineering and technical means of physical protection
4.7	Training point (simulator of the power units №3,4)
4.8	Fallout shelter for 1000 persons
4.9	Information center
4.10	Training center of the physical protection personnel
4.11	After-work sanatorium
5	Transport and communication services facilities
5.1	Internal communication and alarm system
5.2	External communication, alarm system and telemechanics
5.3	On-site railways
5.4	On-site roads
5.5	Outside roads
6	External networks and constructions of water supply, drainage, heat and gas supply
6.1	Networks and constructions of the household water supply
6.2	Networks and constructions of the fire fighting water conduit
6.3	Networks and constructions of the industrial and domestic drainage of the normally occupied area
6.4	Networks and constructions of the of the industrial and domestic drainage of the contamination control area
6.5	Networks and constructions of the drainage, polluted with petroleum oils
6.6	Networks and constructions of the production and rainwater drainage
6.7	Networks and constructions of the drainage waters
6.8	Networks and constructions of the sludge containing waters drainage
№	Building, facility group / title
6.9	Drainage cleaning constructions of the industrial and domestic flows, with the extensible part
6.10	Heat networks
7	Territory improvement and landscaping
7.1	Site improvement
7.2	External and security lighting
7.3	Site fence
8	Temporary buildings and constructions
8.1	Temporary buildings and constructions of the site
8.2	Housing and community facilities of KNPP

6.3 Scopes of main construction and erection works

6.3.1 Amounts of main construction and erection works (without repair works), evaluated in the FS according to the results of the inspection of the

facilities of the uncompleted construction, are given in the Table 6.3-1.

Table.6.3-1 Scopes of main construction and erection works

No.	Work type	Measurement unit	Total for construction
1	Excavation	Thousand of M ³	393,4
2	Earth fill and backfilling	Thousand of M ³	177,3
3	Filling with mined rock	Thousand of M ³	189,4
4	Filling with broken rock	Thousand of M ³	11,1
5	Sand filling	Thousand of M ³	114,4
6	Arrangement of solid-cast concrete and ferroconcrete structures	Thousand of M ³	107,67
7	Erection of the pre-fabricated solid-cast concrete and ferroconcrete structures	Thousand of M ³	67,55
8	Erection of construction iron	Thousands of tons	21,26
9	Erection of metal structures SPOT	Thousands of tons	0,62
10	Coating with corrosion-resistant steel	Thousands of tons	0,63
11	Erection of manufacturing equipment and pipelines	Thousands of tons	65,48
12	Erection of electrical equipment	Thousands of tons	25,50
13	Laying of power cable systems	km	9800
14	Laying of railways	km	1,10
15	Arrangement of roads and sites	Thousand of M ²	56,86
16	Silting of the jet dam	Thousand of M ³	600,0

6.4 Need for construction and erection personnel

6.4.1 A number of Construction and Industrial Personnel (CIP) according to the years of construction of the KNPP-3,4 is given in the Table 6.4-1.

6.4.2 CIP personnel includes the persons, engaged at the construction and erection works and in the auxiliary productions, as well as the personnel, engaged in the servicing and other sectors, related to the construction process. The following CIP structure during power units KNPP-3,4 construction is approved in the FS:

Workers..... 83,9
%; Engineers, technicians and employees
14,6 %; Junior service staff and guards
..... 1,5 %.

6.4.3 The construction is at 40% ensured by the local skilled construction and erection personnel. FS specifies the involvement of specialists from other regions:

- Involvement of personnel on continuing basis with the provision of temporary housing – 1100 persons;
- Recruitment and training of personnel from nearby settlements of the Izyaslav, Slavuta, Ostrog rayons – 1100 persons;
- Personnel, placed for the detached services by the related

organizations from other regions of Ukraine (YuTEM, YuEM, TEM etc.) with the provision of temporary housing – 540 persons.

Table 6.4-1 Number of construction and production staff

Years of construction	1st	2nd	3rd	4th	5th	6th
Builders	677	1232	1820	2010	1028	420
Heat equipment installers	72	130	1160	1280	720	300
Electricians	50	92	700	870	437	120
Ventilation equipment installers	25	46	248	273	257	100
Insulators	21	40	207	137	130	60
Total:	845	1540	4135	4570	2572	1000

6.5 Need for main structures, products and materials

6.5.1 Need for main structures, products and materials, evaluated in the FS based on the physical scope of works, specified in the Table 6.3-1, is given in the Table 6.5-1.

Table 6.5-1 Need for main structures, products and materials

No.	Structures and materials	Measurement unit	Total for construction
1	Pre-fabricated solid-cast concrete and ferroconcrete structures	Thousand of m ³	67,56
2	Construction iron	Thousands of tons	21,269
3	Metal structures SPOT	Thousands of tons	0,620
4	Reinforcement	Thousands of tons	21,01
5	Concrete	Thousand of m ³	190,98
6	Cement, brought to the M-400 type	Thousands of tons	68,1
7	Broken stone	Thousand of m ³	202,47
8	Sand	Thousand of m ³	227,05
9	Sand for jet dam	Thousand of m ³	600,00
10	Cables	km	9800
11	Mined rock	Thousand of m ³	189,40
12	Rails	Thousands of tons	0,144
13	Technological equipment and pipelines	Thousands of tons	65,485
14	Electrical equipment	Thousands of tons	25,500

6.6 Need for energy resources, water and gaseous working mediums

6.6.1 Need of the construction for the energy resources, water and gaseous working medium, evaluated in the FS, is given in the Table 6.6-1.

Table 6.6-1 Need of the construction in the energy resources, water and gaseous working mediums

No.	Resource	Measurement unit	Total for construction
1	Power energy (installed capacity of the current receivers)	KW•A	67,56

2	Hot water supply	Gcal/h	21,269
3	Technical steam	tons/h	0,620
4	Drinking water	m ³ /h	21,01
5	Technical water	m ³ /h	190,98
6	Oxygen	m ³ /h	68,1
7	Acetylene	m ³ /h	202,47
8	Propane-butane	m ³ /h	227,05
9	Argon	m ³ /unit	600,00
10	Carbon dioxide	m ³ /unit	9800
11	Freon	m ³ /unit	189,40
12	Compressed air	m ³ /min	0,144

7 KNPP-3,4 POWER UNITS OPERATION

Information, given in the Section 7 of IAS, is detailed in the FS materials [23,28,30,42].

7.1 Engineering and economical performance

7.1.1 At the stage “Feasibility Study” the final data from the manufactures of the capital equipment (RF and TF) are unavailable. Pre-evaluated in the FS basic engineering and economical performance of the power units 3,4, based on the similar facilities with the RF of the B-392 type, are given in the Table 7.1-1. Presented characteristics are subject to clarification at the stage “design”.

7.1.2 Service life of the power units KNPP-3,4 is 50 years and is subject to clarification at the stage “design”. The scheduled period of the final closedown is as follows:

Power unit № 3..... 2065;
Power unit № 4..... 2066.

Table 7.1-1 Basic engineering and economical performance of the power units KNPP-3,4

Indicator, measurement unit	Value
Rated reactor thermal power, MW (t)	3012
Installed (rated) electric power, MW	1047
Power unit availability ratio	0,85
Load factor	0,82
Hours of service of the installed (rated) electric power, T _{ust} , hours/year	8175
Hours of downtime due to repairs, hours	1320
Specific consumption of heat for the modernized turbounit based on the project K-1000-60/1500-2M, gross, kcal/KWh	2426,7
Reactor facility B-392B efficiency factor	0,99
Steam generator PGV-1000M efficiency factor	0,99
Average capacity of the power unit during the period, MW	1047
Electricity production, million KWh	7522
Electricity consumption for auxiliary needs, million KWh/year	372
Productive electric power production, million KWh/year	7150
Percentage consumption of electric power for auxiliary needs, %	4,95

Annual thermal energy production, Gcal/year	–
Power unit efficiency factor, net, %	31,87
Fuel assembly	FA-A
Burn-up fraction, MW/day/kg U	48

7.2 Provision with nuclear fuel

7.2.1 For production of thermal and electric power at the power units KNPP-3,4, as well as at other Ukrainian NPPs, the energy of nuclear fission ^{235}U is used, which is placed in the reactors in the form of uranium dioxide tablets (UO_2).

During operation of the reactor in the nuclear fuel, concentration of the fissile material ^{235}U decreases with the simultaneous accumulation of fission products and creation of new fissile materials, including plutonium isotopes.

The reactor core is collected from fuel assemblies having a hexagonal profile. The fuel assembly design is a reinforced frame, preventing deformation of the assemblies. Rigidity of the framework shall be provided by angular ribs and spacer grids. The ribs, the spacer grids and guide tubes are made of zirconium alloys.

7.2.2 Fuel FA-A, FA-2, FA-2M and other types of fuel can be used at the power units KNPP-3,4. The decision on the used fuel type will be specified at the stage “design”.

7.3 Provision with other fuel resources

7.3.1 For provision of the power units KNPP-3,4 with other fuel resources the following auxiliary constructions will be used:

- Storehouse for the delivered propane-butane, acetylene;
- Storehouse for fuels and lubricants;
- Oil, mazut and diesel sector.

7.3.2 Extension of diesel fuel storehouse by the reservoir with the capacity of 1000 m^3 is foreseen.

7.4 Provision with water resources

7.4.1 Brief summary on the cooling and technical water supply systems of the power units KNPP-3,4 is given in the Par. 4.4.5.

For the cooling of the main and auxiliary equipment of the KNPP, the off-channel reservoir-cooler is used, created trough construction of the water-retaining dam in the valley of the river Hnyloy Rog, as well as Suppression Pool (SP). The off-channel reservoir-cooler is rated based on the permissible temperature of the cooling water (not more than 33°C) for heat removal from the NPP equipment with the capacity 4000 MW taking into account schedules of the outages of the four power units.

7.4.2 Utility water supply of KNPP and Neteshyn is provided through the centralized water supply system, which also provides the fire protection needs on

the territory of the town. The water is supplied to the network by the pumps of the 2nd rise from the reservoirs of the clean water stock after its deferrization, fluorination and disinfection.

7.4.3 The source of the household water supply system is the artesian water intake of the linear type, which used to comprise 16 wells. The project of the artesian water intake extension foresees the creation of the four standby wells with the water intake increase from 14,5 up to 18 thousands m³/day. Herewith, the consumption directly for the KNPP site with the 4 power units will make 0,98 thousands m³/day.

Exploitation reserves of 18 thousands m³/day are secured. Implementation of the standby wells will decrease the load in the center of the water intake; herewith the changes in the hydrological environment with the increase of water intake are not forecasted.

7.4.4 In order to fill in the primary and secondary circuits of the power units KNPP-3,4 with the desalted water, as well as in order to compensate the losses during its operation, chemical water treatment will be used, which was commissioned together with the power unit № 1 and is designed for all four KNPP power units.

There are auxiliary needs tanks in the special building with the capacity of 200 m³. In order to secure the operation of the power units 3,4, the two condensate tanks with the capacity of 1000 m³ each will be assembled additionally.

7.5 Provision with chemical agents

7.5.1 Main chemical agents, necessary for the KNPP power units 3,4 operation are:

- Boric acid;
- Ammonia;
- Hydrazine hydrate;
- Lime;
- Potassium hydroxide;
- Caustic soda;
- Nitric acid;
- Sulfuric acid;
- Potassium nitrate;
- Potassium permanganate;
- Oxalic acid.

The listed chemical agents are meant for preliminary treatment, filters regeneration by the desalting installation of the chemical water treatment, filters regeneration of the unit desalting installations, filters and evaporators of the special water treatment in order to maintain the water-chemical regimes of the primary and secondary circuits of the power units, for decontamination etc.

7.5.2 The main ion-exchange resins, which are used in the desalting installation filters of the chemical water treatment, unit desalting installations and in the special water treatment, are as follows:

- strong-acid cation(-exchange) resins;
- strong-basic anion-exchange resin;
- weak-basic anion-exchange resin.

7.6 Need for personnel

7.6.1 During commissioning of the power units 3,4 the increase of the operating and maintenance staff of KNPP will be required. The number of the additional operating and maintenance staff is given in the Table 7.6-1.

Need for the increase and the number of the additional staff to ensure operation of the plant facilities, which will be commissioned together with the power units 3,4 (technical water supply building, laboratory and residential-grade complex-2 (LBK-2), diesel power plants, training points etc.) will be defined in the next stages of the design, based on the possible extension of the personnel service areas, equipment automation systems etc.

7.6.2 Preparation of the personnel of the power units 3,4 will be carried out in the training point taking into account its extension.

Table.7.6-1 number of the additional operating and maintenance staff of the KNPP power units №3,4

Title	Power unit №3 staff, persons	Power unit №4 staff, persons	Total additional number, persons
Operating staff:	53	50	1045
- <i>Operations personnel</i>		25	514
- <i>Assistant staff</i>		28	531
Maintenance staff	40	40	818
Total	93	90	1863

8 TECHNOLOGICAL WASTE MANAGEMENT

Information, given in the Section 8 of IAS, is detailed in the FS materials [27,28,30,33].

8.1 Spent nuclear fuel management

8.1.1 Technological solutions in the part of the SNF management for the power units №3,4 are specified by the similar power units №1,2.

Upon unloading from the reactor core, SNF is placed in the CP of the appropriate power units (See Par.5.2.2) for cooling in order to decrease its activity and the heat release up to the level, acceptable for transportation and technological storage of the SNF outside the power units. Such storage is foreseen in a separate centralized VVER SNF storage (outside the KNPP site) until the decision on the final stage of the SNF management (processing or disposal as RW) has been taken and implemented.

8.1.2 Amounts of the SNF formation at KNPP-3,4 will be defined by the type of the used fuel (See Par.7.2.2) and by the schedule of the core unloading.

8.2 Radioactive Waste Management

8.2.1 Liquid and solid radioactive waste management systems are located in the existing special building, common for four KNPP power units.

8.2.2 Liquid radioactive waste (LRW) management system comprises the LRW collection and storage system and the system of LRW processing.

LRW collection and storage system consists of two sub-systems:

- Intermediate center of collection and temporary storage of LRW (Liquid waste unit -1), commissioned together with the power unit №1 and which comprises:
 - Center for LRW acceptance and storage, containing two tanks of filter materials and one standby tank (with the capacity of 100m³ each), two tanks of the vat residue (200m³ each);
 - Center for LRW transportation, containing pumping unit, two hydraulic elevators, a booster pump (pulp washing pump).
- Enlargement of the tank farm (Liquid waste unit-2), commissioned together with the power unit №2 and containing three tanks with the capacity of 750 m³ each for acceptance of the vat residue and the drain water tank sump.

Reconstruction and modernization of the LRW collection and storage system with the commissioning of the power units №3,4 is not foreseen.

The main element of the existing LRW processing system is the installation of the deep evaporation UGU 1-500M, commissioned in 1990.

As the result of the operation of the UGU system, the vat residue is evaporated to the concentrate with a high salt content, which is then moved into the container-barrel where after cooling a solid salt product is formed (salt fusion).

With the commissioning of the power units 3,4 creation of the second line with the UGU 1-500M system is foreseen.

8.2.3 The existing Solid Radioactive Waste (SRW) management system comprises:

- SRW Storage of the Special Building (SB SRWS), commissioned together with the power unit № 1, consisting of 29 cells – ferroconcrete wells from 4,8 up to 18 m deep with the total capacity of 6368 m³, meant for the storage of the SRW of the 1st, 2nd and 3rd categories;
- RW Module storage in the containers of the “BB-cube” type, meant for the storage of 100 “BB-cube” containers in two tiers (each “BB-cube” container contains 12 container-barrels with the salt fusion of the same activity group);
- Storage unit of the SRWS building, consisting of the ferroconcrete 10m deep cells of a rectangular and circular cross-section and meant for the storage of the SRW of the 1st and 2nd category and processed LRW of the 2nd and 3rd categories;
- 1st category SRW management system;
- Management system with the spent Neutron Measurement Channels (NMC) and Thermocouples (TC), waste of the 2nd and 3rd categories and Ionizing Radiation Sources (IRS).

Procedure of the 1st category SRW management at each power unit is similar and includes:

- 1st group SRW collection in SRW collection points;
- Transportation of the containers-collectors with the 1st category SRW from the SRW collection points to the SB SRWS.

Procedure of the NMC and TC management, waste of the 2nd and 3rd categories and IRS at each power units includes:

- Transportation of the containers with NMC and TC from the reactor compartment of the power units 1-4 to the SB SRWS;
- Collection of the 2nd category SRW in the collection points and transportation of the containers with the 2nd category SRW from the SRW collection points to the SB SRWS;
- Transportation of the containers with the 3rd category SRW to the SB SRWS;
- Transportation of the high level IRS for the gamma-ray flaw detection with the isotope iridium -192 and delivery for disposal to the enterprises “Isotop” and “Radon”, or for storage in the SRWS cells;
- Transportation of the laboratory container with the spent high level IRS from the storage of the metrology laboratory sources storage to the SB SRWS;
- Transportation of the packaging set with the spent low-level IRS to the SB SRWS.

8.3 General industrial waste management

8.3.1 In the part of liquid and solid non-radioactive waste management at KNPP the existing solutions will be preserved. For waste formation, storage, placement, disposal and transportation the KNPP has special permits and established limits.

8.3.2 Liquid non-radioactive waste of KNPP includes greasy wastewater, non-greasy household wastewater and rainfall run-offs.

Greasy wastewater gets purified at the installation “Kristal”, located in the Startup Auxiliary Boiler (SAB). The waters, purified from oils and petroleum oils are moved to the off-take channel and the trapped petroleum oil for combustion into the SAB.

Utility wastewater treatment facilities are designed for the full biological purification of the sewage with the additional purification in the biological ponds. The purified wastewater is moved to the reservoir-cooler of the KNPP technical water supply system.

8.3.3 Aerobic stabilizers for treatment of the sediment from the primary clarifiers and activated sludge are foreseen as a part of the utility wastewater treatment facilities. Aerobically fermented and compacted sediment is moved to the sludge beds for drying and storage and then to the compost beds with the forced aeration and waterproof coating. Upon such processing the sludge compost can be used in the agriculture as fertilizer. Productivity of such compost beds is 2900 m³/year.

8.3.4 In the places, where solid non-radioactive waste is kept the chemical monitoring of the soils condition is carried out in line with the approved procedure. The sanitary waste field and the sludge reservoir are operated in the design mode.

9 KNPP POWER UNITS 3,4 DECOMMISSIONING

Information, given in the Section 9 of IAS, is detailed in the FS materials [31-33].

9.1 Decommissioning Strategy

9.1.1 In line with the requirements [18,61,62], decommissioning of the nuclear facility is performed in accordance with the its decommissioning project, which shall be developed and approved not later than its service life expires. Prior to the project development and approval, the document, which defines the activity of the operating organization in preparation for decommissioning is the nuclear facility decommissioning concept [61].

General approaches to decommissioning of the operating and perspective power units of the VVER type in Ukraine upon their service life expiration are defined in [63]. Preparation to decommissioning of the existing power units KNPP-1,2 is implemented in line with [64].

9.1.2 In [63] two variants of decommissioning of an individual nuclear power unit are defined:

- Immediate dismantling;
- Deferred dismantling.

Both variants have identical initial and final states, approximately the same orientation of works and measures, but they are different in the measures implementation period and cost-based characteristics. For the operating KNPP power units 1,2 the difference of the estimated costs for decommissioning

according to two specified variants does not increase 20%, and the implementation period is 22 and 44-45 years respectively for the variants of the immediate and deferred dismantling [64].

9.1.3 General principles of the choice of the optimal decommissioning variant for the power units KNPP-3,4, general provisions for safety assurance during decommissioning, tentative decisions in RW management and other decommissioning aspects are described in the FS. Detailing of the decommissioning strategy of the KNPP-3,4 will be made at the stage “design”.

9.1.4 Accumulation of funds for development and implementation of the decommissioning project at the KNPP-3,4, in line with the provisions of [61], will start from the moment of their commissioning.

9.2 RW management during decommissioning

9.2.1 Detail calculation of the amount and the activity of RW, formed during decommissioning, shall be made during decommissioning project based on the analysis of the design documentation and operation history, as well as on the data of the comprehensive engineering and radiation inspection.

According to preliminary estimates [63,64] solid radioactive waste, which belongs to the category of the High Level Waste (HLW) will be mainly formed by the reactor vessel and by its reactor vessel elements and non reactor vessel elements. Assessment of such HLW, formed as the result of the direct activation, for the RV of the VVER-1000 type makes around 1.14 thousand tones/unit. Activated particles will stay high leveled during a long period of time (dozens-hundreds of years).

9.2.2 Radioactive contamination of the equipment and of the structure elements, not related to their direct activation, is of a superficial nature. The main source of such contamination is direct contact of the elements and materials with the primary circuit coolant. Primary circuit water contamination by the activated products of the corrosion happens due to the contact with the reactor vessel, made of the austenitic stainless steel, fuel assemblies, made of the zirconium alloy, and other reactor vessel elements.

Cladding leaks lead to the release of the fission products into the coolant, which also contribute to the total contamination of the elements and materials, directly contacting with the primary circuit coolant.

9.2.3 The peculiarity of the power units №3,4 decommissioning is the fact that by the moment of their final closedown the older power units № 1,2 will be at the aging stage and will be getting ready for the dismantling. Thus, at the KNPP site by the moment of the power units №3,4 decommissioning the infrastructure in RW management, formed during decommissioning, shall be in operation.

9.2.4 Accumulation of funds for RW management from the decommissioning of the KNPP-3,4 in line with the provisions [7] will start from the moment of their commissioning.

10 ENVIRONMENTAL IMPACT ASSESSMENT

Information, given in the Section 10 of IAS, is detailed in the FS materials [24,28,33].

10.1 Initial information

10.1.1 During impact assessment on the environment of the planned activity in OVOS as a part of FS:

- Current environmental situation at the site of the facility construction and on the neighboring territories has been studied;
- All sources of the possible impacts of the facility on the environment have been defined;
- Assessment of the impacts on all components of the environment has been made.

The assessment showed, that the basic types of the impacts of the power units KNPP-3,4 on the components of the environment are radiation, thermal and chemical impacts.

10.1.2 Possible impacts on the following components of the environment for normal conditions and accidents are analyzed in the OVOS:

- Geological environment;
- Air environment;
- Water environment;
- Soils;
- Flora and fauna;
- Anthropogenic environment;
- Social environment.

10.1.3 For the analysis of accidents, the following accidents at one of the new power units were chosen in the FS:

- Maximum Design-Basis Accident (MDBA), conditioned by the guillotine rupture of the main circulation pipeline with the two-sided leak;
- Beyond Design-Basis Accident (BDBA), conditioned by the guillotine rupture of the main circulation circuit with the failure of the active systems of the emergency cooling of the zone and operating sprinkler system.

10.2 Short summary on the area and on the site of KNPP-3,4 location

10.2.1 KNPP site is located on the territory of Slavuta rayon, Khmelnytska oblast, 100 km to the north from Khmelnytsky and 45 km to the south-east from Rivne (Figure 3.1-1).

10.2.2 In the geological structure of the area the formation of the wide age range and composition take part – from loose deposits of the Quaternary to crystalline rocks of the foundation of the East-European platform of the Archean-Proterozoic age.

Crystalline basis surface within the studied territory lies in the depth from 60 m in the east to 1200 m in the west. Directly on the territory of KNPP the

depth of the crystalline rocks is 540-560 m.

Archean age rocks are represented by the ribs of the Dnister and the Bug series; this layer is composed of garnet-biotitic gneisses, sometimes with cordierites and sillimanites.

Early Proterozoic formations are represented by the Teterev series and the Novograd Volyn layer of the early Proterozoic.

The sedimentary layer is represented by the Upper Proterozoic and Meso-Cenozoic sediments. Formation of the sedimentary cover comprises three major structural and tectonic layers: Riphean (Upper Proterozoic), composed of sandstones, siltstones, mudstones of the Polissya series; Upper Proterozoic - Lower Paleozoic, represented by the volcano- genetic-sedimentary terrigenous and carbonate formations; Meso-Cenozoic, covering all of the underlying rocks and composed of terrigenous, carbonate and continental formations.

Structural and tectonic structure of the KNPP area is characterized by the clearly marked block structure. The following geological blocks of the 1st degree are: Polissya – in the north-west of the region, Osnitskiy – in the north and partially in the north-east, Lviv – in the west and south-west, Dubno – in the center, Ternopil – Novograd-Volynskiy – in the south and Podilya – in the south-east of the region. The abyssal snap zones of the 1st rank serve as the interblock bounds: Lutsk (Horyn), Kremenets (Suschany)-Perzhany, Teterev, Radekhov, Podilya and Central (Sarnevsko-Varvarovskaya). Besides, there are fractures of the 3rd rank and fractures of the 3rd degree.

In the neotectonic respect, the KNPP 30-km zone is situated in the central part of the Rivne neotectonic saddle, bounded in the west by the Rivne fracture zone and in the east – by the Shepetovka fracture, which have the submeridional strike. The central part of the territory, where the KNPP is located, is the Slavuta macro block, which is characterized by the lower quantitative indicators of the neotectonic activity.

The analysis of the findings of the neotectonic researches jointly with the geological and physical ones showed that practically none of the fractures in all its length can relate to the tectonic active ones.

In the geomorphological respect the KNPP site is situated in the margins of the link bank of the river Horyn watershed on the planned territory.

The principle buildings of the KNPP (main buildings, special buildings etc.) are located on the territory with the planning level of 206 m. In connection with the complex conditions of planning, the absolute levels of the planned surface within the site vary sharply (204,4-222,4 m).

The layer of grounds, which comprise the geological cut of the KNPP site, is divided into 14 engineering and geological elements. The base for the foundation can be the rocks of the siltstones and sandstones – they are and argillaceous layer – thin alternation of the argillics, siltstones. These are weakly compressible grounds.

Within the layer with the power more than 45 m there are no dynamic, unstable, greatly compressible, water-soluble grounds. The availability of the

active karst processes, tectonic active fractures, avalanches and landslides has not been detected.

10.2.3 The seismic hazard for the KNPP site come only from the earthquakes of the Vrancea zone (Romania) and from local potential zones of the Potential Earthquake Sources (PEZ).

During comprehensive geological and seismotectonic analysis close to KNPP 8 seismotectonic zones of the four levels of the potential seismic activity were defined: potential PEZ of the 1st and 2nd degree and the seismotectonic zone of the 1st degree, seismotectonic activity whereof is very low: DBE is 5 points, MDE is 6 points.

For specification of the seismicity depending on the local engineering and geological conditions the comprehensive engineering & geological and seismic researches of the KNPP site and of the territory 3 km around it have been carried out.

The final assessment of the seismic hazard taking into account the seismic microzoning of the KNPP site makes: DBE - 5 points, MCE - 6 points.

10.2.4 The KNPP site is situated in the north-western part of Ukraine on the territory of the Volyn Polisia, in the zone of the temperature continental climate with the positive moisture balance. This type of climate is characterized by relatively high temperatures and relative humidity in summer and low temperatures, relative humidity and snow in winter.

The average annual air temperature is 9.5 °C. The average temperature in winter is minus 4.3°C, in spring – 6.9°C, in summer – 17.5°C. The warmest month is July (18.2°C). The coldest month is January (minus 5.4°C). The absolute maximum temperature is 34.4°C, the absolute minimum temperature is minus 14.9°C.

The average annual relative humidity is 74%: maximum is 81-88% (November, December), minimum is 69-72% (April-May).

The annual total amount of precipitations is 710 mm. The daily precipitation maximum (observed) is 112 mm.

The average long-term value of the total evaporation a year is 538 mm, among which 452 mm are in the warm season and 86 mm in the cold season.

The predominant directions of the wind during the year are western direction (both in warm and in cold periods). The average annual wind speed is 3.5 m/sec.; in winter time the wind speed is 3.1-3.4 m/sec., in summer time – 2-5 m/sec. Maximum rated wind speed is with the probability of 0,01% -35 m/sec. Maximum observed wind speed is 38-40 m/sec.

Repetition of the light winds (up to 2 m/sec.) in the cold period is 32%, for the year is 26%.

The average repetition of fogs for the year is 15%; for the cold period – 28%.

Repetition of the ground temperature inversions for the year is 36%; repetition of the elevated inversions is 11.8%.

The area of the KNPP location is tornado hazardous. The rated class of

the tornado intensiveness is $K_r=2.75$. The annual probability of the tornado passing (P_s) across the western region is 14×10^{-7} .

According to the conditions of the ice formation the area belongs to the 3rd ice-covered region.

10.2.5 In the hydrogeological respect the KNPP is located in the eastern outskirts of the Volyn'-Podilya artesian basin.

Within the explored depth there are two water-bearing horizons at the site: Quaternary water-bearing horizon (ground waters) and the confined Upper Proterozoic (Vendian) horizon.

Grounds waters are spread widely. Water-bearing rocks are the made (sandy) grounds, fluvio-glacial argillo-arenaceous formations. Filtration ratio is $K_o=1$ m/day.

The groundwater regime was formed under the influence of the natural as well as anthropogenic factors, related in the first place to the creation of the KNPP reservoir-cooler with the Normal Banked-Up Horizon (NBUH) of 203m, construction of the inlet and outlet channels, construction of drainages and the general build-up of the territory.

Groundwater recharge occurs through infiltration of the atmospheric precipitations, as well as through the recharge from the bottom by the pressure waters. The nearest area of the recharge is the “buried valley”, located to the south-east from the site, in the immediate proximity to it. The groundwater level in the “buried valley” (in the central part) is at the absolute levels of 210-211 m. the waters of the “buried valley” are one of the sources of groundwater recharge as well as of the Upper Proterozoic horizon, lying lower.

Upper Proterozoic water-bearing horizon and groundwater are partially drained by the inlet and outlet channels. In the zone, adjacent to the channels, the slope of the piezometric surface of the Upper Proterozoic horizon is in the direction of the channels, which indicates the sufficient drainage capacity and stability of the hydrogeological conditions.

For the confining stratum between the first and the second water-bearing complexes the filtration ratio value is $K_o=10^{-3}$ m/day; for the waterproof layer between the second and the third water-bearing complexes it is $K_o=10^{-4}$ m/day.

The rated value of the radionuclides distribution in the system “groundwater” is $K_d = 5$ l/kg. The actual values are as follows:

- ^{137}Cs - $K_d = 1000-8000$ l/kg for clays, loams and aeolian soils;
- ^{137}Cs - $K_d = 100-1000$ l/kg for sands;
- ^{90}Sr - $K_d = 100-400$ l/kg for clays, loams and aeolian soils;
- ^{90}Sr - $K_d = 100$ l/kg for loamy sands;
- ^{90}Sr - $K_d = 4-50$ l/kg for sand.

10.2.6 The hydrographic network in the KNPP area are represented by the rivers of the river Horyn basin, as well as by lakes, ponds, reservoirs and soil-reclamation canal network.

Sources of the NPP technical water supply are the rivers Horyn and

Hnyloy Rog. Except these two rivers, within the NPP 30km zone there are the rivers Viliya – left bank and Tsvetokha –right bank feeders of the river Horyn as well as their feeders as well – less significant streams.

Total number of lakes in the KNPP area is 111. Total area of their water surface is 5.92 km. The biggest number of lakes is in the basin of the rivers Viliya (28 – 1.55 km²) and Tsvetokha (22 – 1.02 km²). Total amount of reservoirs in the KNPP zone is three; the biggest one is KNPP RC.

The annual motion of levels on the river Horyn and its feeders within the KNPP radiation-control area is characterized by the high rise of levels during the spring flood and low levels in the low-water season. During summer-autumn and winter low waters the short-term rises of levels are observed due to rain showers and winter thaws. The long-term amplitude of fluctuation of levels of the river Horyn and of its feeder – river Viliya – is 3-3.4 m; in small rivers it is in the range of 1-1.5m.

The rated level of the high water of the river Horyn with the probability 0.01% is 197.84 m, and of the freeze-up is 195.5m. The same values are for the river Hnily Rog respectively – 193.70 и 192.18m. Taking into account of the planning levels of the KNPP site, the maximum horizons of the floods of melt water and rainwater in the river Horyn are of no hazard for the NPP construction.

The water content of the reiver Horyn in the observed area is characterized by the following water consumption, m³/sec:

- Average annual water consumption is 15.80;
- Maximum water consumption with the occurrence:
 - p = 0,01% – 1260;
 - p = 0,1% – 850;
 - p = 1% – 507;
- Maximum average monthly water consumption with the occurrence of 95%:
 - Summer-autumn – 4.21;
 - Winter -14.16.

Based on the hydroeconomic balance of the river Horyn made in 2007, the conclusion was made in the FS on the availability of necessary volumes of water resources in order to meet water needs of the hydroeconomic complex of KNPP (taking into account the needs of the power units 3,4) and of other sectors of economy in the region. The rates showed that under the forecasted up to 2012 pace of the economic development in the region no deficit of the water resources is expected.

When analyzing the data, it was specified in the FS that the increase of mineralization of water sulfates, sodium and potassium in the river Horyn and Hnily Rog occurred in the 70-90s and stays at the reached level. In the last decade there is no tendency of the water pollution decrease in the water objects. In the river Hnily Rog the amount of magnesium has slightly increased, herewith its content in the water of the river Hnily Rog is higher, than in the RC. In general, according to the specified indicators the water quality in the water objects is in

compliance with the requirements of regulatory documents.

Information on the radionuclides in the water of the open reservoirs indicates the fact that their concentration in the KNPP RC and in the river Horyn are close to each other and significantly lower than their acceptable concentrations in the drinking water DK_{ingest} [12].

10.2.7 The structure of the soil of the KNPP supervised area is very diverse (45 types of soils and about 500 soil differences). It is conditioned by:

- humid and mild climate;
- by the inhomogeneity of the chemical and granulometric composition of the soil-forming rocks and substratum;
- by the well-developed meso-and micro-relief under the total flatness of the most of the territory (except for western, south-western and southern parts – in the radius from 20 to 30 km);
- by the close occurrence of groundwater;
- by the diversity of the plant formations and different (from the point of view of the intensity) influence of human activities.

Significant areas in the structure of soil are occupied by sod-podzol soils, which cover the outwash-alluvial and ancient alluvial plains, which sometimes are referred to ancient natural levees of the rivers. They can be found in the central and south-eastern part of the SA.

North-eastern, north-western and southern part of the KNPP SA are occupied by the podzolized soils, formed based on the aeolian soils and on the loess-like loams – light grey, grey or dark-grey forest soils.

Podzolized black earths were formed based on high, well-drained loess-like plains and comprise the dark-grey and grey forest soils, and sometimes typical black earths. They can be found in separate areas in the north-western, eastern and southern parts of the SA.

Typical black earths (thin and thick, slightly humic and thin-humus, their high-and deep boiling types) belong to the watershed drained aligned or slightly wavy territories, relatively flat plateaus and high loessial terraces. They can be found in the north-western, south-western and south-eastern parts of the SA.

In the group of hydromorphic soils the largest area is occupied by the grassland and alluvial meadow soils, meadow boggy soils and marsh soils.

Bog soils and peat bogs of various capacities in the KhNPP SA are represented only by low-lying types. They occupy the high-water beds, the pradolinas, back marshes, bottoms of the dRWs and lake basins.

According to the content of potassium, calcium and nitrogen a slight variation is observed only in the cespitose slightly podzolized sandy soils under the forests; in all other soils and under the natural vegetation, as well as on the agricultural lands the content of potassium, calcium and nitrogen ranges from 30 to 100% even within the limits of the same typological difference. Even more variable is the content of phosphorus, magnesium, exchange aluminum, combined acidity, total exchangeable bases and soil-absorbing capacity of the

complex.

Formation of the modern anthropogenic radioactive contamination of the KNPP SA soils occurred mainly under the influence of the “Chornobyl” accident depositions in 1986. Prior to the commissioning of the KNPP-1 the average annual Exposure Dose Rate (EDR) of the gamma-radiation at the distance of 1m from the surface was within 6-8 mR/h; in the region of the town Slavuta it was 12 mR/h (as of 1983). In 1987 due to the accident at the Chornobyl NPP, the EDR in several points increased 2-3 times. As of today the EDR values within the SA have stabilized and in the most control points are 1-3 mR/h higher than in 1983.

The average density of the surface contamination with the radionuclide ^{137}Cs of the ground in the SA compared with the initial state (prior to the power unit-1 commissioning) are given in the Table 10.2-1.

Table.10.2-1 Density of the surface contamination with the radionuclide ^{137}Cs of the ground in the KNPP SA, Bq/m²

Distance	1987	2007
Site	7,50E+02	3,42E+02
CA up to 3 km	7,99E+02	3,55E+02
SA up to 8 km	1,20E+03	8,61E+02
SA up to 15 km	1,10E+03	5,91E+02
SA up to 20 km	1,37E+03	6,26E+02
Inspection station of the town Mizoch	8,99E+02	2,04E+02

10.2.8 KNPP SA is located within the bounds of the Western-Ukrainian province of the forest-steppe zone of Ukraine, on the territory whereof three physiographic areas are specified: Volyn Elevation, Maloe Polisia and Northern Podilya. Two of the three physiographic areas are the areas of distribution of the forest-steppe landscapes, and the one is mixed forest.

10.2.9 According to the geobotanical zoning, the KNPP SA is on the border of the European broad-leaved and European-Siberian forest-steppe areas. Within the first area the territory belongs to three geobotanical districts and five geobotanical regions, and within the second area – to one district and two regions, indicating the wide variety of vegetation.

Farmlands and buildings occupy 63.2%, and vegetation - 36.2% of the territory. Among them forests – 26.4%, meadows – 8.1%, swamps – 1.2% and aquatic vegetation – 1.1%.

In the vegetation of the SA one can observe the predominance of pine and oak-pine forests due to edaphic factor. Hornbeam-oak, hornbeam-pine-oak forests cover smaller areas; relatively small areas are covered by alder and birch forests. Meadow vegetation is common for high-water beds, where swampy and peaty meadows. Among the marshes eutrophic tallgrass marshes are dominated.

The SA vegetation gen pool totals 178 associations and is characterized by wide variety: 86 forest, 39 meadow, 20 marshes, 27 water and coastal, 3 wasteland and 3 shrub associations.

Flora of the KNPP site area totals 1146 species, whereof 858 are the species of the natural flora (75%), 132 - weed species (11%), 156 – introduced species (14%).

Flora is basically holarctic, boreal.

General regularities of the anthropogenic changes of the SA vegetation are as follows:

- Reduction of the areas of marshes and meadows caused by drainage and further ploughing up;
- Transformation of the vegetation of the drained marshes in the direction of the gradual formation of the peat meadows;
- Transformation of these meadows as a result of overgrazing into peaty meadows;
- Transformation of meadows into marshes in the zone of RC submergence;
- Enlargement of the area of pine and spruce monocultures in the place of more complex forest communities.

10.2.10 According to the ecological and zoological zoning of Ukraine, KNPP SA belongs to the Bessarabsko-Podilya part of the zone of the broad-leaved and mixed forests. The SA is characterized by the significant variety of invertebrates and vertebrates species.

According to the tentative assessment, there are not less than 5 thousand species of insects in the SA area, belonging to more than 20 orders. According to the species diversity the dominant are: Diptera, Hymenoptera, Coleoptera, Lepidoptera, Homophera and Hemiphera. Most valuable are forest and meadow entomological complexes, where the biggest number of protected species is found.

In the KNPP SA there are about 3000 species, 30 genera, 5 classes of vertebrata, among them 19 species from the Red Book of Ukraine, 2 species from the European Red List (*Crex crex* and *Lutra*), and about 20 endangered species from the European Charter of Species.

The fauna of amphibians in the SA is represented by 11 species.

The fauna of reptiles in the SA is represented by 7 species.

The fauna of birds totals about 120 species. Some of them are migratory and passing. They visit the region seasonally and sporadically. Avifauna of the 30-km zone consists mainly from representatives of the forest, marsh, meadow and field complexes. More than 60 species nestle here.

The fauna of mammals in the region totals about 50 species. The most common members of the order Insectivora are: mole (*Talpa europea*), hedgehog (*Erinaceus europaeus*), common shrew (*Sorex araneus*) and pigmy shrew (*Sorex minutes*). Fauna Chiroptera of this region is represented by not less than 10 species of bats. The common ones are common noctule (*Nyctalus noctula*) and common pipistrelle (*Pipistrellus pipistrellus*). The most common representative of the Carnivora is fox (*Vulpes vulpes*). Sometimes one can find a wolf (*Canis lupus*), racoon dog (*Nyctereutes procyonoides*), regular, but not numeral badger (*Meles meles*), included into the Red Book of Ukraine. Also marked otter (*Lutra lutra*),

included into the Red Book of Ukraine. One can find mustelids: stone marten (*Martes foina*) and common marten (*Martes martes*), least weasel (*Mustela nivalis*), fitchew (*Mustela putorius*) – all included into the Red Book of Ukraine; steppe polecat (*Mustela eversmanni*), ermine (*Mustela erminea*) and European mink (*Mustela lutreola*). True hare (*Lepus europaeus*) is prevailing.

10.2.11 KNPP SA covers an area of seven rayons Khmelnytska and Rivne oblast (Par.3.1.2, Figure 3.1-1). The SA area is 2826 km², herewith 1024 km² – it’s the territory of Rivne and 1802 km² - Khmelnytska oblast.

According to the data of the departments of the environmental protection of Khmelnytska and Rivne oblast, in the KNPP SA there are 47 objects of the natural reserve fund of the different degree of nature protection, which area is more than 3000 ha. It is a little bit more than 1% of the SA territory.

10.2.12 There are 207 settlements in the SA with the population of 195.76 thousand people. Population density is 69.27 persons/km². Characteristics of the big settlements, nearest to KNPP, are given in the Table 10.2-2.

Table.10.2-2 Big settlements, nearest to KNPP

Name	Population, thousand persons	Direction	Distance, km
Zdolbunov	28,5	North-west	35
Iziaslav	18,8	South-east	21
Neteshyn	35,6	North	3,5
Ostrog	13,4	North-west	11
Rivne	245,0	North-west	45
Slavuta	38,3	East	13
Khmelnysky	260,0	South	100

10.3 Impact assessment on the geological environment

10.3.1 Geological environment of the KNPP site and station is characterized by the significant stability. Its negative impact on the functioning of the existing constructions of the plant and on the facilities of the power units 3,4 is not forecasted.

10.3.2 KNPP impact on the geological environment was almost fully implemented during construction and commissioning of the facilities, which comprise the power units 1,2 complex and was limited by the bounds of the KNPP site and station. Most of these facilities have the all-plant purpose and will be used for the power units 3,4 (RC, inlet and outlet channels, housing construction in Neteshyn etc.). For the period of the operation of the power units 3,4 the anthropogenic changes of the geological environment state under the impact of the KNPP facilities are not forecasted.

10.4 Impact Assessment on the air

10.4.1 Estimates of the surface concentrations of the non-radioactive contaminants in the air showed that after the commissioning of the power units 3,4

altogether the quantitative and the qualitative characteristics of the non-radioactive discharges does not change significantly and one can say, that their parameters will stay at the same level.

This, one can assert that the surface concentrations of the contaminants due to discharges of the KNPP according to all ingredients as well as according to the groups of summation will not increase the rated value for the settlements. Within the control area they are from 0.2 to 0.6 of the Maximum Permissible Value (MPV). Outside the control area the values of the maximum surface concentrations according to the groups of summation and according to any ingredient will not exceed 0.05 MPV.

10.4.2 With the increase of the heated water consumption, flowing into RC from 50m³/sec by the operation of one power unit up to 200m³/sec by the operation of the four power units and by the existing technology of the water cooling, the water loss for additional evaporation from the RC surface makes 53.1 million m³/year, from the SP – 0.876 million m³/year. Besides, from the SP the losses for the droplet entrainment will make 3.92 million m³/year.

Increase of the heat discharge to the RC will create a number of other conditions of the water exchange in the upper layer of the reservoir and heat exchange in the adjacent layer of air.

The cooling system will in the first place effect the microclimate of the airspace over the water area of the reservoir and will spread to a small area, adjacent to it.

During commissioning of the third and the forth power units the effect of the cooling system on the microclimate will be made on the increase of the additional evaporation and, therefore, of the air humidity. The air temperature shall not increase proportionally to the heat discharges, since the heat will be consumed for the additional evaporation, formation of the “steam fog”. Increase of the days with fog and glaze phenomena can be expected. The air temperature during operation of the four power units will change in the permissible limits in comparison to the ones which get registered during operation of the two power units. The RC impact zone will not exceed 1 km from the coastline.

Taking into account the permissible impact of the cooling system on the climate parameters, no special measures in limitation of these impacts during operation of the four power units are required.

10.4.3 For the assessment of the noise on the environment the following conditions were approved in the FS:

- Assessment of the additional sources of noise shall be made, which occur during commissioning of the power units 3,4.
- Since there are no permanent staff employed outside the operating buildings and constructions, the impact of noise shall be performed only inside these buildings and constructions;
- Since there are no residential or administrative buildings with the permanent presence of people there, who are not the NPP employees (population), for the assessment of the impact of noise, the limiting values of the sound pressure

for the jobs of the staff, who are there permanently or periodically, prescribed in the GOST 12.1.003-83, are accepted;

Depending on the purpose and the characteristic of the production facilities, for the decrease of the sound pressure level the thermal and sound insulation shall be made, sound proof booths shall be assembled, the use of headphones shall be provided for.

10.4.4 Ultrasound impacts from the operation of the heat-mechanic equipment during operation of the KNPP-3,4 are not expected. During maintenance by the ultrasound monitoring of the quality of the welded butt joints a short-term local ultrasound impact is possible.

10.4.5 Vibration impact can appear inside the production facilities and not extend to the environment.

10.4.6 In line with the sanitary norms, which meet the requirements of the “Rules for electrical equipment installation”, protection of the population from the impact of the electric field of the overhead transmission line with the capacity 220 kW and less is not required. For protection of the personnel from the impact of the electric field at the outdoor switchgear the stationary protection is provided for.

10.4.7 During the assessment of the radiation impact on the air due to gas-aerosol discharge of the KNPP for the normal operation mode during 45 years discharge from the ventilation pipes of the reactor compartments of the four power units and special buildings was taken into account.

The assessment considered 89 radionuclides with different periods of half-decay, discharge activity and, respectively, with the different contribution into the radiation dose. As the result of the made calculations, the densities of the contamination of ^3H , ^{137}Cs и ^{90}Sr and volume concentrations of the Inert Concentration Gases (ICG) ^{41}Ar , ^{85}Kr и ^{133}Xe in the surface atmosphere layer of the CA and SA during continuous normal operation of the four power units during 45 years were evaluated in the OVOS.

Made assessments showed that the main contribution into the dose from the gas-aerosol discharge during plant operation will be made by ICG due to radiation from the cloud. The findings of the assessment of the surface concentration of the more significant ICG - ^{133}Xe are given in the Figure 10.4-1. Concentrations of all ICG in the surface atmosphere layer during normal operation conditions of the power units are significantly less than the maximum permissible ones.

Thus, the impact of the gaseous radioactive discharge into the air is admissible. Power units 3,4 commissioning will not result in the excessive changes of the radiation situation at the KNPP site as well as in the SA.

10.4.8 During MDBA and BDBA the discharge of the radioactivity into the atmosphere shall be defined by the power unit containment leakage and by the period of the high pressure in it. The discharge into the air comprises ICG, radioisotopes of iodine, aerosols ^{137}Cs , ^{90}Sr and other radionuclides. The total activity of the discharge during MDBA and BDBA is about 3×10^{13} and 3×10^{15} Bq accordingly, including on the isotopes of iodine – about 3×10^{12} and 5×10^{14} Bq. Evaluated in the OVOS consequences of the spread of the radioactivity in the air to

the surface waters, soils, flora and fauna, as well as to the social environment during MDBA and BDBA are given below.

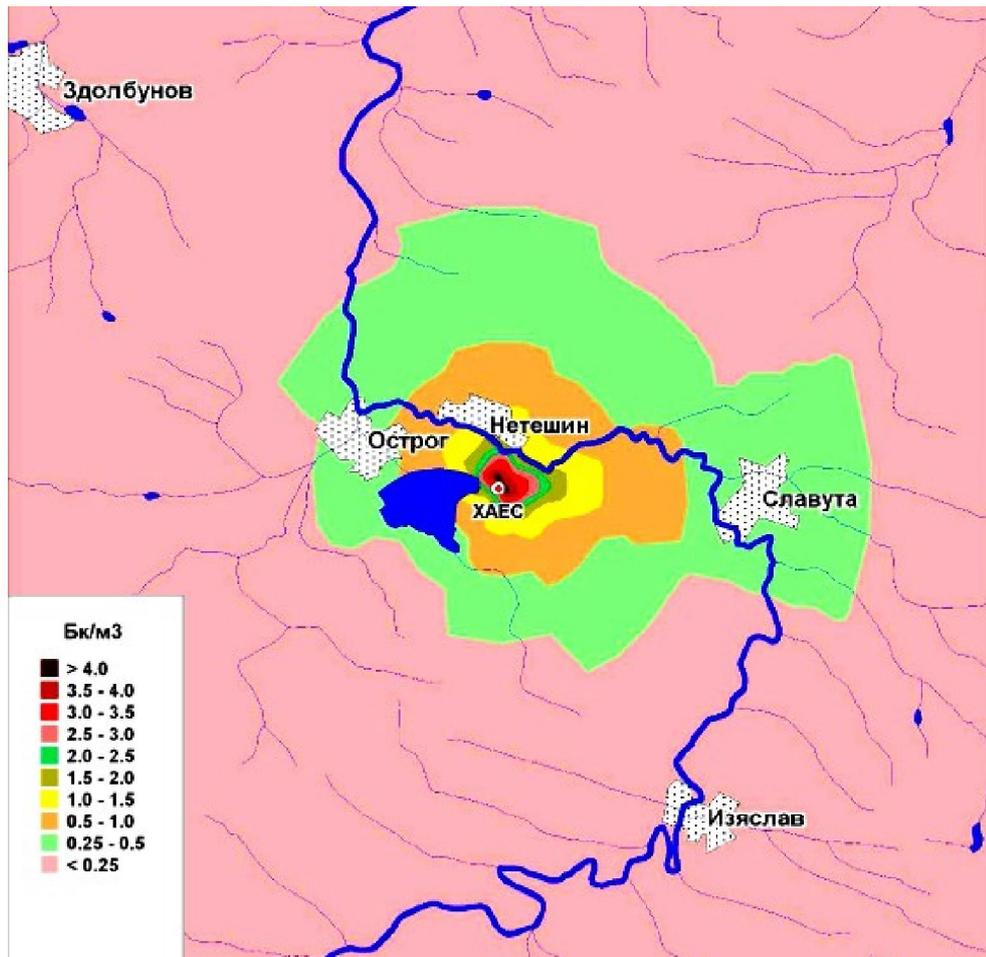


Figure 10.4-1 Volume concentration of ^{133}Xe in the surface atmosphere layer of the KNPP SA during normal operation of the four power units

10.5 Impact assessment on the surface and ground waters

10.5.1 During operation of the KNPP-1,2, as the result of the infiltration of production waters, changes occurred in several mode-forming groundwater. Hereupon at several parts temperature increase and groundwater mineralization, relatively stable over time, are recorded. However this process is local and it does not go outside the site. Commissioning of the power units 3,4 can have impact on the formed mode of groundwater under the influence of the local water temperature increase, its mineralization or slight level increase in the limited area. It will have no impact on the water in-take of the utility and drinking water supply.

Increase of the water supply of Neteshyn and of KNPP was justified during the reassessment of the underground artesian water stocks of the Neteshyn water intake area up to $18\text{m}^3/\text{day}$. The annual drinking water consumption of Neteshyn will make 6.57 million m^3/year , of KNPP (taking into account the four power units) – 0.36

million m³/year.

Radiation condition of the underground waters, including of the Neteshyn water intake area, is satisfactory. Concentration of the radionuclides in the water is lower than the ultimate level, regulated by the regulatory documents. In line with the FS conclusions, the aquifer complex, used for the water in-take, is characterized by the immunity from the surface chemical and radionuclide contamination; i.e. it belongs to the ecologically stable sources of the utility and drinking water supply.

Commissioning of the power units 3,4 and their operation during Normal Operational Conditions (NOC), during MDBA and BDBA will not lead to the excessive changes of the radiation condition of the underground waters.

10.5.2 During calculations of the Water Economy Balance (WEB) of the KNPP-3,4, the water loss for the additional evaporation was recorded 53.1 million m³/year, taking into account ratio of 0.82 of the use of the technical water capacity. Respectively, the deficit of the water resources (need for fresh technical water for the RC from the river Horyn) in the cross-section during operation of the four power units ranges from 3.23 to 41.92 million m³/year (within the limits of the high-water year 1% of the water supply and the low-water year 95% water resources supply). Replenishment of the water resources deficit is possible through the response of the useful volume of the NPP reservoir with its further replenishment with the flow of the rivers Hniloy Rogand Horyn (in March-April). River Horyn, not violating the fixed untouchable sanitary consumption (6 m³/sec), with the consideration of the need for fresh water for SP, chemical water cleaning and watering, is able to ensure the specified need.

10.5.3 Potential source of the water contamination in the KNPP SA is the RC. The water from the RC can come into the aqueous medium during the blow-off, as well as during the specified in the design “forced” water overflow across the automatic flood water outlet of the RC under the excess of the normal banked-up horizon during spring and rainfall floods.

Assessments, made in the OVOS, show that by the timely controlled blowing-offs of the RC in the flood period with the observance of the regulatory requirements, the chemical impact on the surface waters can be brought to the environmentally acceptable minimum, which excludes the chance of the violation of the sanitary norms requirements of the hydro chemical indicators.

10.5.4 Increase of the heat discharge in the RC will create a little bit different conditions of the water exchange in the upper later of the reservoir and heat exchange with the adjacent air layer to it. Model hydro-thermal calculations of the RC showed that the water temperature in it during operation of the four power units exceeds at 13.84°C the natural water temperature of the river Horyn. The rated average annual temperature of the cooled water for the meteorological factors of April is 22.04°C (month of the spring flood is the most probable month of the blow-off discharge) under the natural water temperature of the river Horyn of 8.2°C.

Taking into account the fact that during spring floods the water consumption in the river Viliya reaches from 10 to 100 m³/sec, and the consumption of the blow-off

discharge is regulated within wide limits (from 0 to 10m³/sec and more), the possibility to comply with the specified by the sanitary norms temperature modes in the rated cross-section through dilution of the bleed waters is obvious and can be monitored easily by the corresponding determinations of the water temperature.

10.6 Impact Assessment on vegetation

10.6.1 According to the results of the researches, made in the OVOS, the content of copper, zinc and cadmium in the soils of the territory, adjacent to the KNPP, is at the background level. Slight additional contamination with lead of the farmland soils, adjacent to the roads, is possible, which will not lead to MPV excess in the agricultural products.

Degradation processes of soils, related to the KNPP construction, are common only for the site territory. Their availability in the SA is practically not related to the plant operation.

In whole, the analysis of the physicochemical peculiarities of soils of the region showed that regardless the diversity of soils most of the soils have considerable buffer resistance to the anthropogenic loads. Landscapes of the nearest KNPP zone are the reliable barrier, preventing the extension of the primary contamination zone through migration.

10.6.2 Radiological situation in the area of the KNPP location at present is mainly defined by the radionuclides of the natural origin. Short-lived induced isotopes were not detected in the KNPP SA.

Contamination of the territory with ¹³⁷Cs (Figure 10.6-1) is at the level, close to the levels of the global contamination (about 3 kBq/m²).

Surface relief of the nearest zone of the plant and availability of the orographic barriers are considered during modeling of the dispersion of the gas-aerosol emissions during NOC, MDBA and BDBA.

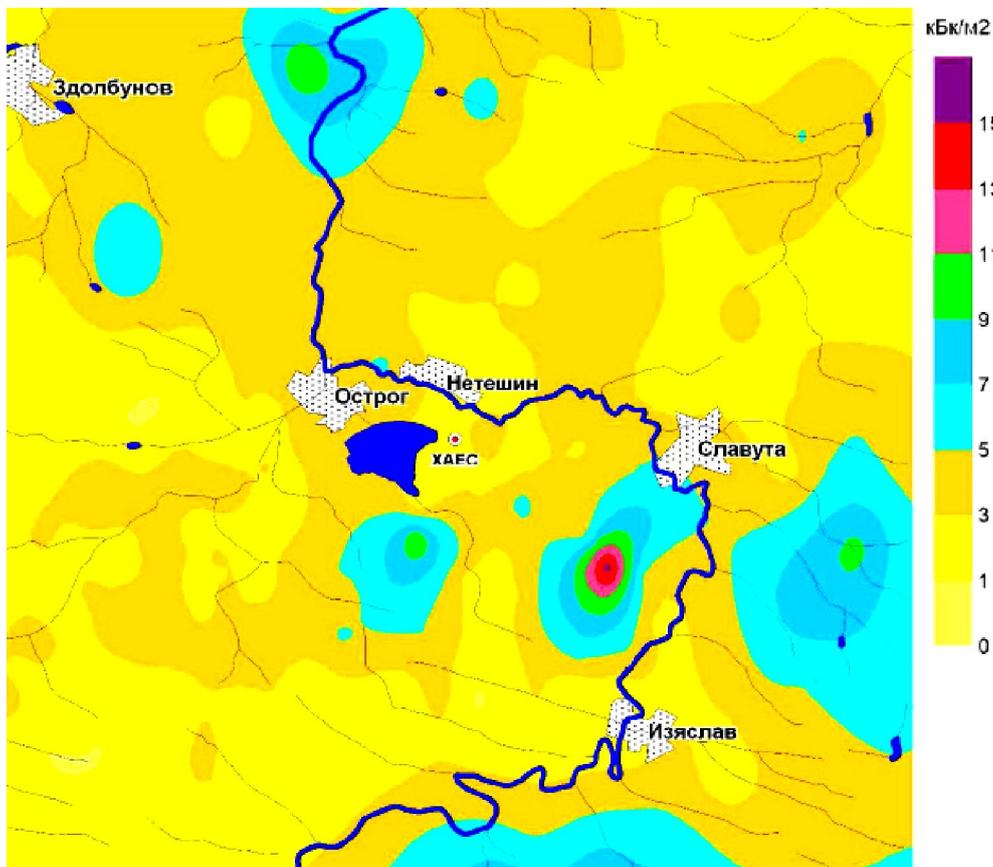


Figure.10.6-1 Observed density of the surface soil contamination with ^{137}Cs in the KNPP SA.

Forecasted distribution of the density of the surface soil contamination with ^{137}Cs within the KNPP SA during normal operation of the four power units during 45 years is shown in the Figure 10.6-2. In whole, during NOC the additional radioactive contamination of the territory through gas-aerosol discharge of the KNPP is negligibly in comparison with the existing contamination, related to the natural activity and global precipitations.

Radioactive contamination during MDBA and BDBA will not lead to any changes of the physicochemical and water physical peculiarities of the soil.

Forecasted during MDBA density of the additional contamination of the territory with ^{137}Cs outside the CA is comparable to the existing background contamination. Total contamination with the radionuclides of iodine within CA in the first weeks after the accident can reach dosens of MBq/m^2 . Several months after the accident the main contribution into the total density of the contamination will be made by the long-lived radionuclides ^{137}Cs , ^{90}Sr .

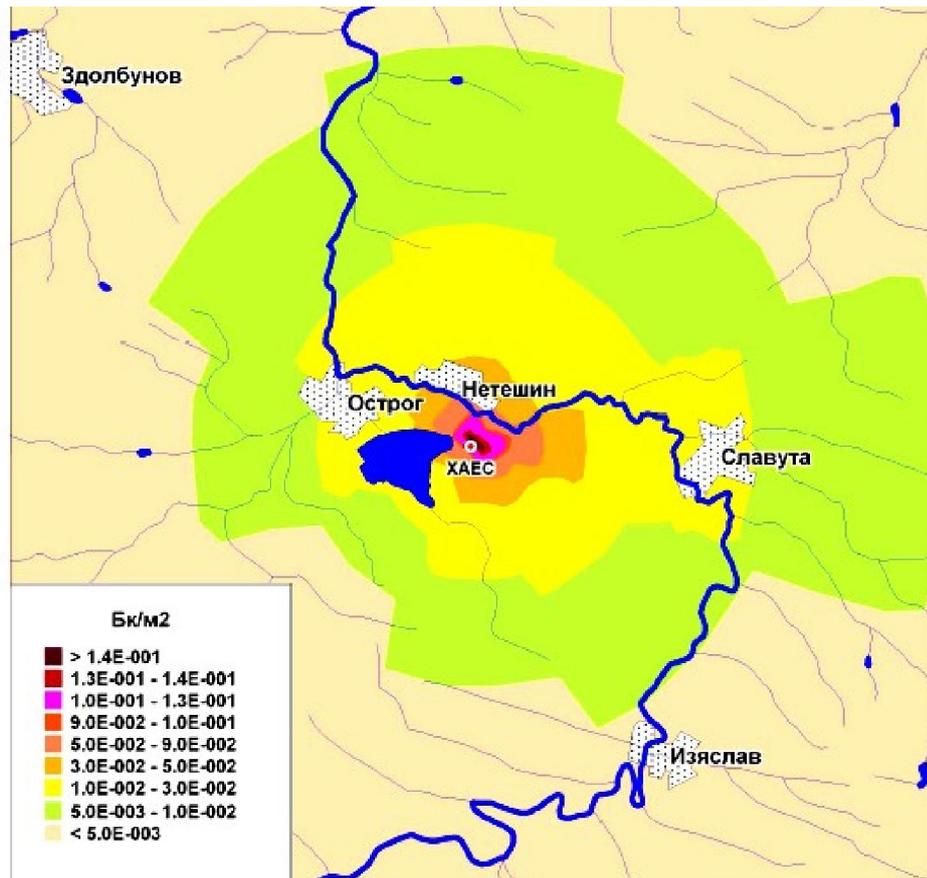


Figure.10.6-2 Forecast of the surface soil contamination with ^{137}Cs in the KNPP SA during normal operation of the power units during 45 years

During BDBA the density of the additional contamination of the territory with ^{137}Cs within the CA can exceed by a factor of a hundred the existing levels of contamination. Outside this zone at the distance up to 15 km the maximum additional contamination can exceed the background values by a factor of ten. Density of the additional contamination with ^{90}Sr within the CA can reach dozens of $\text{kBq}\cdot\text{m}^2$, outside the CA is comparable with the background. Total contamination with the radionuclides of iodine in the first weeks after the accident within the CA can reach several hundreds of MBq/m^2 ; outside it – several MBq/m^2 . Similar to the BDBA, several months after the MDBA the main contribution into the total density of the contamination will be made by the long-lived radionuclides ^{137}Cs , ^{90}Sr .

10.7 Impact assessment on flora and fauna

10.7.1 Operation of the two additional power units within KNPP in whole will not have an impact on the structure and dynamics of the vegetation communities, as well as will not cause changes of the number of the population of rare cultures and the ones, included into the Red Book.

Radiation situation in the KNPP SA at present is defined by mainly the radionuclides of the natural origin. As bioindicators of the radioactive contamination mushrooms, as well as pine-trees, blueberry, mosses and lichens are used, for which

there is a sufficient data base and are set appropriate dependencies. In whole, there was no radiation impact on the flora within the CA of the more than 20 years of the KNPP operation.

It is established, that commissioning and operation in the normal mode of the power units 3,4 will not have negative impact on the fauna within the KNPP CA. Violations of the food reserve, shelters, nesting and migration routes are not expected.

Additional positive factor in the environment protection is the establishment of the National Park “Male Polisia” in the Khmelnytska oblast. Borders of the National Park (area around 25905 ga) symbolically go along the borders of the rivers and RC. In the north – river Horyn and RC; in the east - river Horyn; in the north-west – river Viliya; in the south – feeders of the river Horyn and of the river Viliya. The biggest part of the southern and south-eastern sectors of the CA will be included into the National Park. Establishment of the park will contribute to the protection of the unique natural resources of the region.

10.7.2 According to the results of the calculations and assessments for the emergency situations, made in the OVOS, as the main dose-forming radionuclides for the biocenosis the short-lived radionuclides can be studied.

During MDBA the conservative assessment of the maximum absorbed dose during the first year after the discharge (at the distance of 2.7 km along the axis of the discharge trace, under the worst weather conditions) for plants and farm animals makes around 20 and 4 mGy/year (external irradiation), appropriately. Received assessments of the levels of the absorbed doses showed that the changes in the flora and fauna at the species level are highly unlikely. Respectively, the changes of the biocenosis under the influence of the radiation factors will not occur.

During BDBA the conservative assessment of the maximum absorbed dose during the first year after the discharge (at the distance of 4 km along the axis of the discharge trace, under the worst weather conditions) for plants makes around 1Gy/year, which for the more radiosensitive conifers exceeds the threshold of at present established bottom limit for the detection of weak radiation effects. Herewith the limit of the medium and high severity of the radiation effects, as well as the limit of doses of even acute exposure, which results in 100% death I different taxonomic groups, outside the CA will not be reached.

Conservative assessment of the maximum external dose under the same conditions for farm animals is about 0.04 Gy/year which does not exceed the threshold of at present established bottom limit for the detection of weak radiation effects for mammals.

Received assessments of the levels of the absorbed doses showed that the changes in the flora and fauna at the species level are highly unlikely though along the axis of the discharge trace one can observe radiobiological effects by the conifers during BDBA. Respectively, the structural changes of the biocenosis under the influence of the radiation factors outside the CA will not occur.

Within the CA, on the limited territory, there is the probability of the acute irradiation dose excess for the representatives of the most adiosensitive organisms (conifers, mammals (rodents)), where the development of small impacts of the ionizing irradiations are possible (damage of chromosomes, of the reproduction function and physiology). The dose of the acute irradiation (5 days) on the pine-tree at the distance of 1 km from the source of irradiation (a cloud axis, conservative assessment) can make 1 Gy.

10.8 Impact assessment on the social environment

10.8.1 On the population health formation a range of natural & climate, social & economic, medical & biological, anthropological and other factors

One of the most important indicators of the population health is the sickness rate, continuous analysis whereof enables planning and optimizing present and future activity of the local authorities as well as of the bodies of the sanitary and epidemiological supervision. The made researches didn't detect any negative changes in the health of the SA population due to the impact of the KNPP discharge and, consequently, risk of sickness rate increase for local population is not higher than the average in the whole country.

Upon commissioning of the power units 3,4 possible impacts during NOC on condition of the air basin, geological environment, surface and underground waters, soils, flora and fauna, social and anthropogenic environment will not exceed the admissible impacts, which indirectly ensures the absence of additional negative impacts on health of the population.

10.8.2 Assessment of the individual effective dose of the population, made in the OVOS, which is formed through gas-aerosol discharge from KNPP during normal operation of the four power units, for conservative conditions (the 45th year of the plant operation, maximum ratios of the transition) showed that on the border of the CA the effective annual dose, taking into account all ways of exposure for the critical group of population will make 0.6 μSv (Figure 10.8-1). At the distance of 25 km the effective dose decreases up to hundredth parts of μSv .

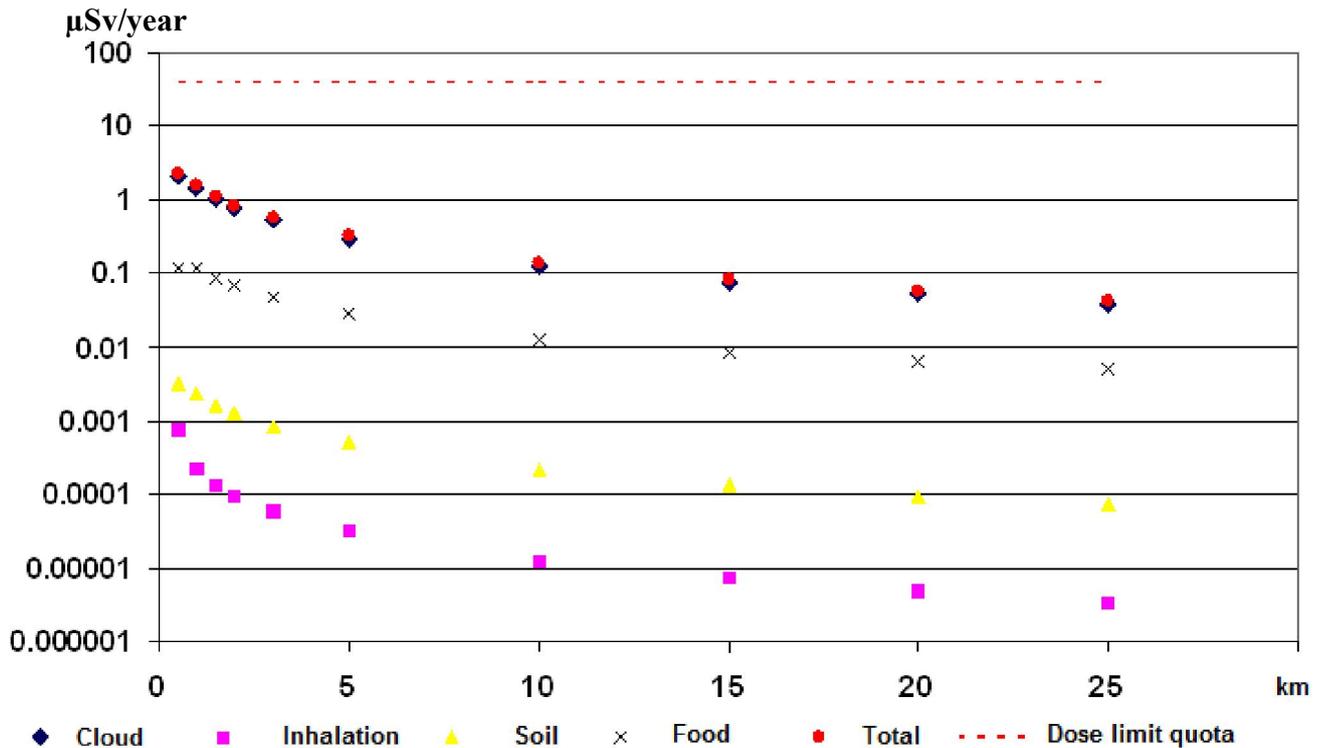


Figure.10.8-1 Effective annual dose for the population (referent group “adults”, rural population) for the 45th year of the KNPP operation comprised of 4 power units.

The main contribution into the annual dose of irradiation from the cloud of the gas-aerosol discharge from KNPP, in the first place due to the volume activity of ICG (⁴¹Ar, ⁸⁵Kr, ¹³³Xe). The next in importance is the entering of the radioactivity through food chains (Figure 10.8-1).

Assessments, made in the OVOS, confirmed the expedience of the use of milk and mushrooms as indicators of the anthropogenic radioactive contamination of the territory.

Milk is considered a critical product of entering of the ¹³⁷Cs into the human ration, taking into account the transition ratio of this radionuclide in the chains “soil-animal-milk”. Maximum levels of additional milk contamination with ¹³⁷Cs due to gas-aerosol discharge from KNPP during normal operation of the four power units in the 45th year of operation (Figure 10.8-2) are significantly less than the admissible level (100 Bq/l) and are negligible comparing to the existing levels of milk contamination (several Bq/l).

Mushrooms – even though they do not comprise the main ration, are not hyper accumulator of ¹³⁷Cs and in the forest areas can make significant contribution into the total effective dose.

Maximum levels of additional contamination of mushrooms with ¹³⁷Cs due to gas-aerosol discharge from KNPP during normal operation of the four power units in the 45th year of operation, made in the OVOS, are given in the Figure 10.8-

3. Similar to milk, these values are significantly less than the admissible level and are negligible comparing to the existing levels of mushrooms contamination.

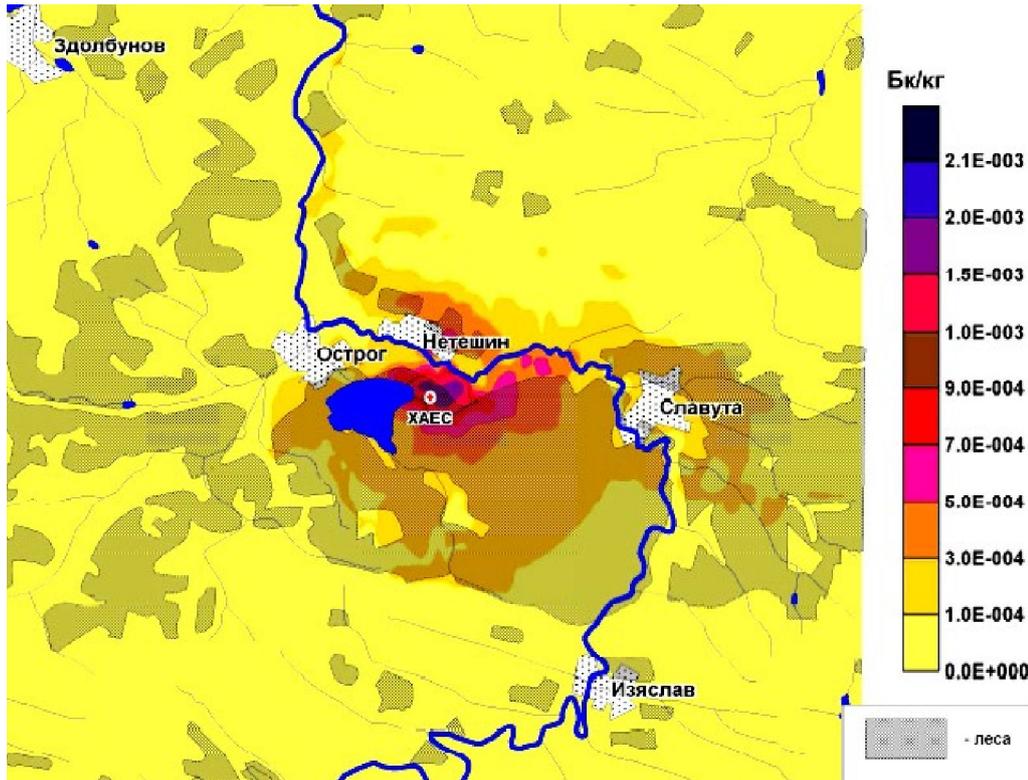


Figure.10.8-2 Maximum levels of additional contamination of milk with ^{137}Cs due to gas-aerosol discharge from KNPP during normal operation of the four power units in the 45th year of operation.

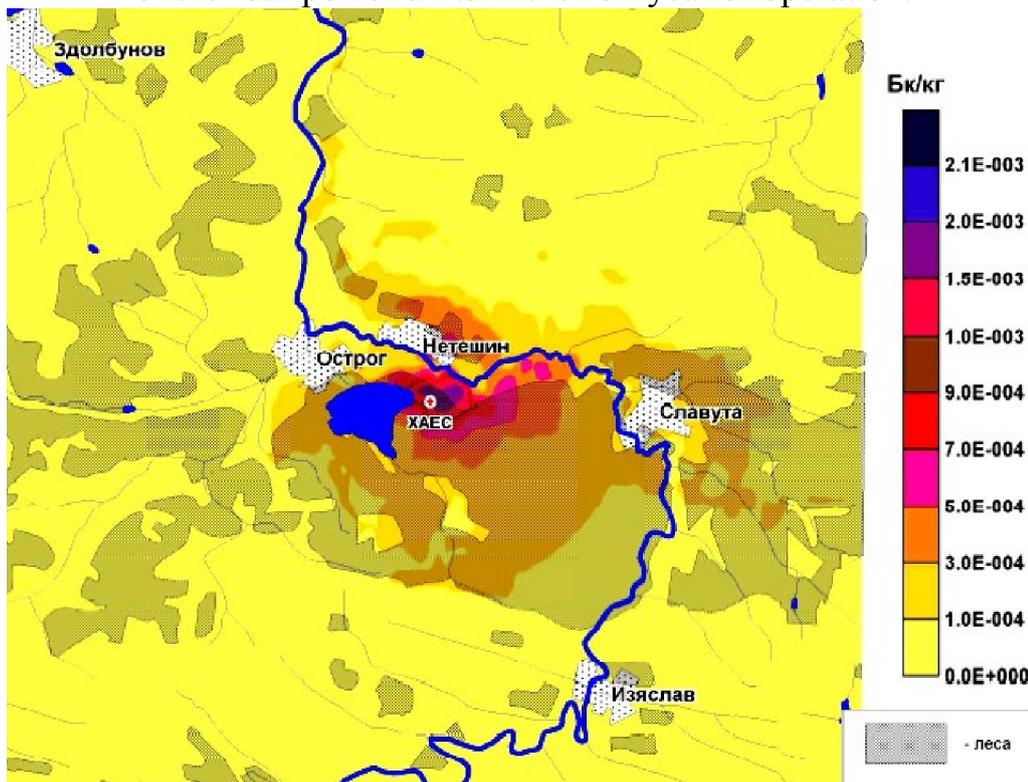


Figure.10.8-3 Maximum levels of additional contamination of mushrooms with ^{137}Cs due to gas-aerosol discharge from KNPP during normal operation of the four power units in the 45th year of operation.

^{137}Cs due to gas-aerosol discharge from KNPP during normal operation of the four power units in the 45th year of operation.

10.8.3 Individual effective doses for population as the result of MDBA are evaluated in the OVOS. Conservative assessments of the dose radiation on the population, taking into account all routes of exposure, except for entering of the radionuclides with food, showed that during MDBA no emergency or urgent countermeasures (including iodine prophylaxis) are required.

Radioactive contamination of the agricultural products as the result of MDBA can exceed the levels, established in [12,65], that is there is a probability of long-term countermeasures implementation.

The biggest probability of the necessity to take decision on withdrawal, replacement or restrictions of consumption of local agricultural products outside the CA in the immediate closeness with its border exists for leaf vegetables and milk. Outside the CA a prohibition to consume leaf vegetables and milk for the period from 1 up to 3 months is possible. For leaf vegetables this prohibition can be imposed almost up to the SA border and for milk – up to 15 km from KNPP. Imposition of these countermeasures is mainly related to the contamination of the territory with the isotopes of iodine and short-lived radionuclides. There is also a probability of the prohibition to consume grain products and meat, grown and bred in the immediate closeness to the SA (up to 6 km). According to the received conservative assessments, the duration of the prohibition to consume grain products and meat, grown and bred on this territory, can reach 2 years.

Dependence of the expected lifetime effective dose from the distance with the consideration of the radionuclide entering with food (without any countermeasures and with the prohibition to consume products in line with the criteria [12]) is shown in the Figure 10.8-4.

Evaluated individual effective doses for the population do not reach the threshold of the occurrence of deterministic effects. Individual risks of occurrence of stochastic effects for population are on the negligibly low level (Figure 10.8-5).

10.8.4 In OVOS the individual effective doses for population due to BDBA have been evaluated. Based on the maximum assessments of the maximum dose, restriction of the population presence in the open air shall be limited at the distance up to 4 km from the source of discharge. The mentioned countermeasure is defined by the avoidable dose for the whole body. The calculated dose on the thyroid gland does not exceed the bottom level of the justification for performance of the iodine prophylaxis. Nevertheless the radioisotopes of iodine, in whole, form more than 80% of the effective dose of the acute period of accident, besides on the CA border the total, effective dose is mainly formed due to inhalation. On this basis the use of the iodine prophylaxis for the population, living in the SA will be apparently justified at the earliest stage of an accident.

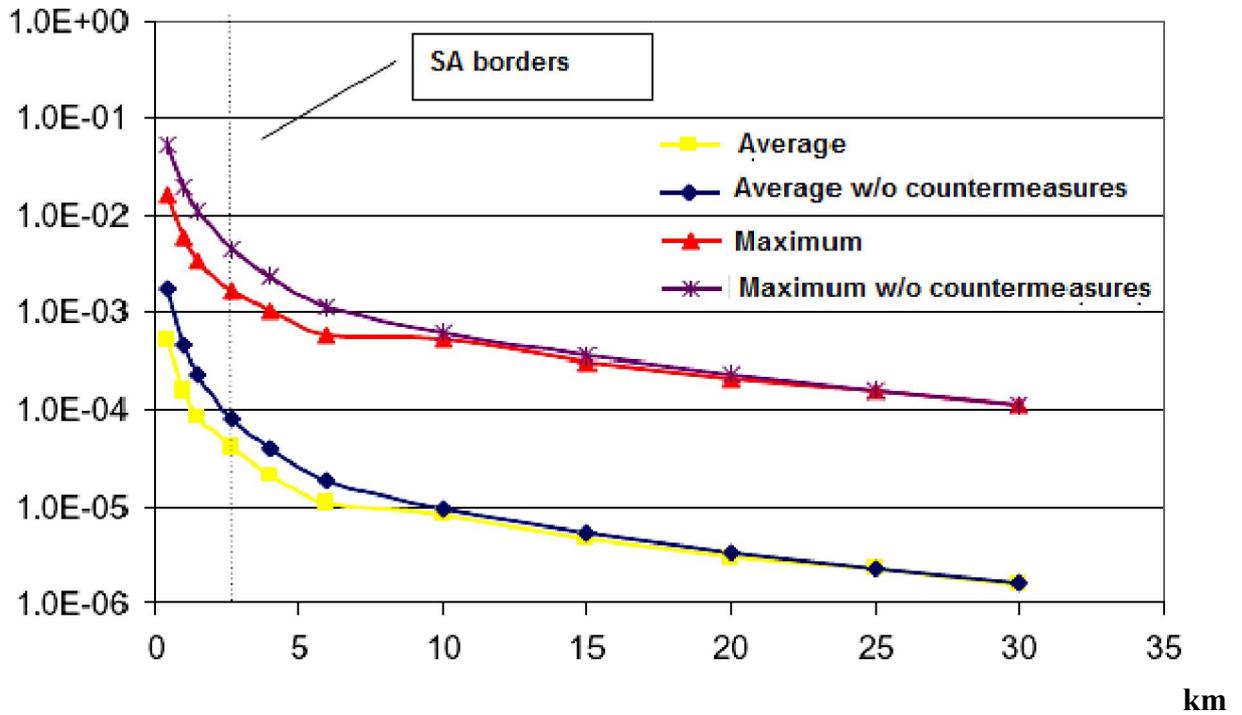


Figure.10.8-4 Expected lifetime effective dose for the population during MDBA.

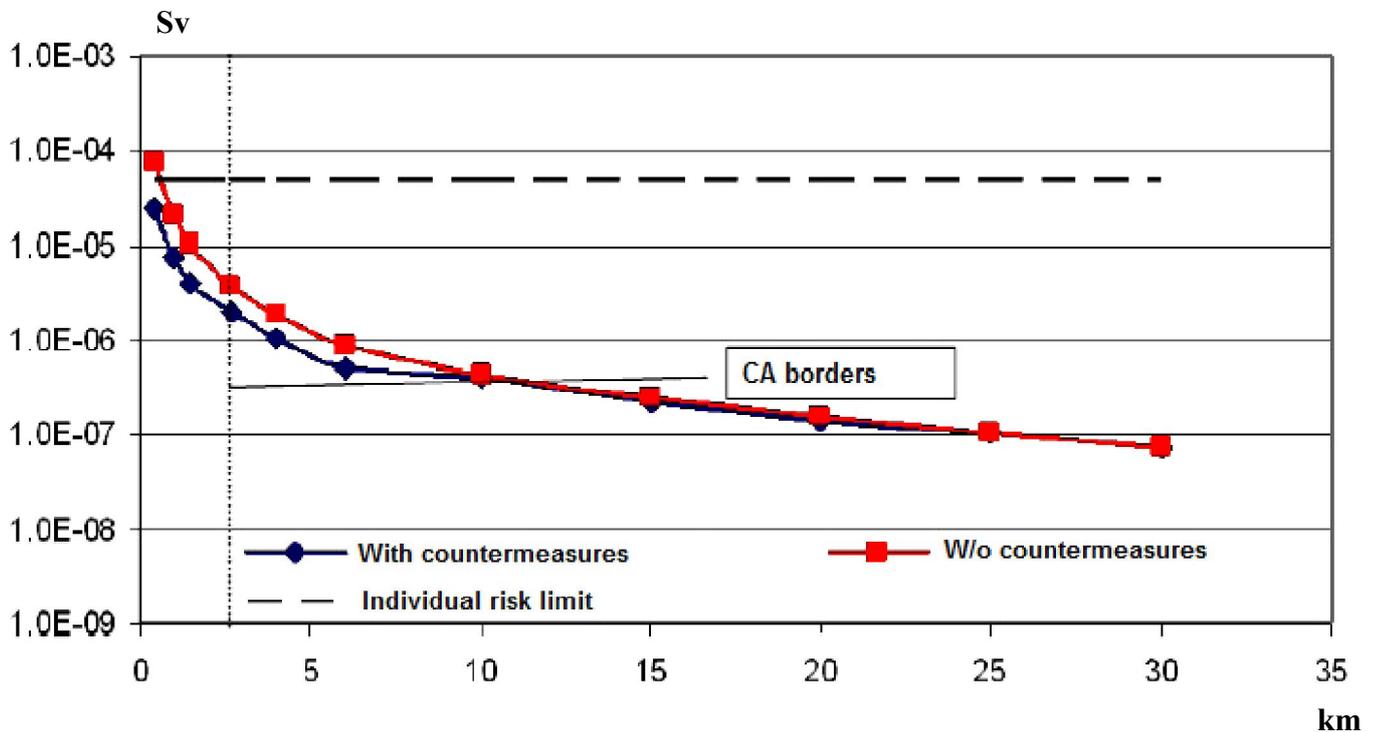


Figure.10.8-5 General risks of occurrence of stochastic effects during MDBA.

Radioactive contamination of the agricultural products in the CA during MDBA can exceed the established criteria of the decision making about withdRwAl, replacement or restrictions of such products consumption. Along the trace axis the exceed of the admissible levels of the ^{137}Cs [65] content in milk, cattle meat, bread grain and leaf vegetables can be expected at the distance of 25 km and more from

KNPP, in the cabbage – up to 20 km, in the fruit – up to 10 km away from KNPP. Content of ^{90}Sr along the trace axis can exceed the admissible levels in the bread grain and leaf vegetables at the distance of 30 km from KNPP, in milk – up to 10 km, in meat, vegetables and fruit – up to 4-6 km. According to the conservative evaluations, made in the OVOS, the duration of the prohibition to consume grain products and meat, grown and bred on this territory can reach 2 years. Excess of the admissible levels of the ^{131}I content in milk can be expected at the distance up to 40 km from KNPP, which also gives rise to impose restrictions of its consumption. Herewith, on the CA border such restrictions can continue long period of time (up to 2 months after the accident for milk and baby food).

The specified restrictions of consumption of local food are received based on the bottom bounds of the justification in line with the Norms of Radiation Safety of Ukraine 1997 (NRBU-97) [12]. When using the certainly justified levels of intervention [12] for the decisions making on withdrawal, replacement or restrictions of the radioactively contaminated food consumption, the parameters of the restrictions (prohibition period, farmland areas etc,) will be significantly lower.

Dependence of the expected lifetime effective dose from the distance with the consideration of all routes of radionuclides entering (with and without countermeasures) is shown in the Figure 10.8-6.

Individual risks of occurrence of stochastic effects for population in case of the failure to perform countermeasures (restrictions of the population presence in the open air) exceed the limit of the individual risk at the distances up to 4 km from the source of discharge (Figure 10.8-7). In case of the specified countermeasure, the individual risks of occurrence of stochastic effects do not exceed the limit of the individual risk for population.

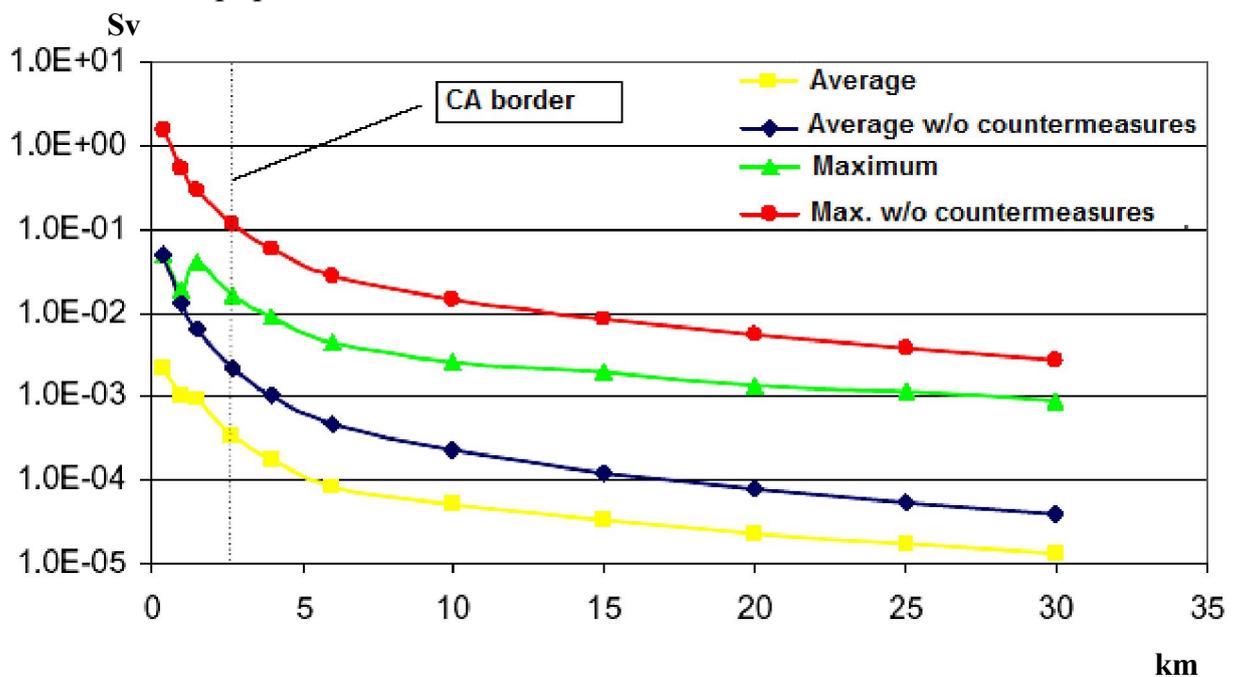


Figure.10.8-6 Expected lifetime effective dose for the population during BDBA.

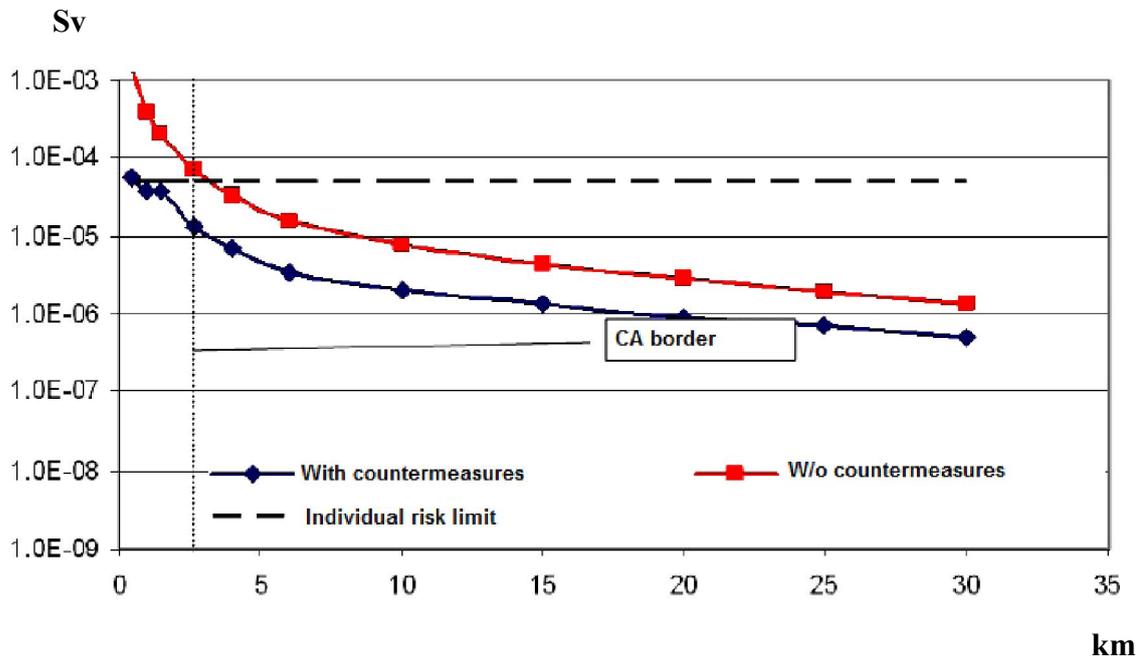


Figure.10.8-7 General risks of occurrence of stochastic effects during BDBA.

10.9 Impact assessment on the anthropogenic environment

10.9.1 Buildings and systems of the existing part of KNPP were designed and constructed with the consideration of the possible impacts of extreme phenomena. Similar designs were approved in the FS of the power units 3,4.

10.9.2 Conditions of the NPP site location exclude the possibility of the external anthropogenic impacts from other facilities of economic activity (fire, blast wave, flood, volley emission of harmful gases), which can result in the malfunction of the KNPP normal operation mode. It means that additional sources of the plant’s impacts on the anthropogenic environment will also not be created.

10.9.3 According to the estimates, additional contribution into the contamination with the long-lived radionuclides of the anthropogenic environment due to gas-aerosol discharge is dozens of thousands times lower than the fixed admissible levels. Consequently, during commissioning of the two new power units, special land treatment of the change of structure of agricultural land use, restructuring of branches of the agricultural sector and changes in the technological processing of products are inexpedient.

10.9.4 In whole, negative impact during construction, commissioning and operation of KNPP-3,4 on the objects of the anthropogenic environment, located within the CA, are not forecasted in the OVOS.

10.10 Impact assessment of the technological waste on the environment

10.10.1 Main types of waste, which will be formed during KNPP-3,4 construction are as follows:

- Unsorted iron-and-steel scrap;

- Concrete waste in lumps;
- Concrete products scrap;
- Cleaning material, contaminated with petroleum products;
- Metal containers, dirty with paint;
- Steel welding electrodes remains and stubs;
- Cardboard packaging from electrodes;
- Welding slag;
- Everyday waste.

Total forecasted number of construction waste makes about 9.1 thousand tons.

10.10.2 During operation of KNPP-3,4 gaseous, liquid and solid technological waste will be formed. Technical solutions for management of such waste and reduction of their amount, suggested in the FS, are described in the Section 8.

10.10.3 In line with the conclusions of OVOS, due to the complex of appropriate protective and security measures (See Par.10.13), negative impact of waste on the environment is not forecasted.

10.11 Impact assessment on the environment in the transboundary context

10.11.1 For the assessment of the radiological importance of the transboundary movement of the radioactive contamination during NOC, the results of the dispersion of the gas-aerosol emissions are used in the FS, made with the consideration of the actual meteorological data in the KNPP location area.

In proportion to the moving away from the source of emissions, the density of the contamination of the territory with the radionuclides decreases rapidly and, consequently, the radiation doses for population decrease too. At the border with the KNPP SA already the radiation dose during NOC is significantly lower than the dose limit quota (Figure 10.8-1). This means that the dose limit quota for the population of the neighboring countries will not be exceeded. Herewith, in the most European countries the value of the dose limit quota is much higher than in Ukraine and is 200 $\mu\text{Sv}/\text{year}$.

Thus, radiation impact during KNPP normal operation on the neighboring countries will be significantly lower than the established dose quotas and all the more so, than the limit of the individual effective annual dose of 1 μSv .

10.11.2 General risk of occurrence of stochastic effects during MDBA and BDBA, even without the countermeasures, already on the KNPP SA border is significantly lower than the established in [14] limit of the individual risk $5 \times 10^{-5} \text{ year}^{-1}$ (Figure 10.8-5, Figure 10.8-7). This means that during MDBA and BDBA at KNPP the risk of the occurrence of stochastic effects for the population of the neighboring countries is significantly lower than the acceptable limit of the individual risk.

10.12 Establishment of the control and supervised areas

10.12.1 The size of the CA for four KNPP power units (enveloping the circles with the radius of 2.7 km around the points of the organized emissions from the power units ventilation pipes) was established by the USSR Ministry of Energy Decree №150 of 28.11.1979 “Conclusion of the state sanitary and epidemiological expertise” №05.03.02-07/17573 of 27.03.2008, the Ministry of Health of Ukraine confirmed the size of the KNPP CA, established earlier.

10.12.2 Borders of the KNPP SA with the radius of 30 km are shown in the Figure 3.1-1.

10.12.3 In line with the conclusions of OVOS, commissioning and operation of the power units 3,4 do not require the changes of the sizes of KNPP SA and CA.

10.13 Measures, assuring regulatory condition of the environment

10.13.1 FS design solutions in assurance of the regulatory condition of the environment provide for the following groups of measures:

- Resource-saving;
- Protective;
- Recovery;
- Compensative;
- Safeguarding.

10.13.2 Resource-saving measures cover the issues of the rational use of ground, water and fuel & energy resources.

When locating the power units 3,4 and the complex of auxiliary buildings the territory, which is in the continuous use of KNPP, was used maximally.

For technical water saving the reverse system of the technical water supply with the use of the reservoir of the river Hniloy Rog is foreseen as the artificial water cooler of the critical and auxiliary equipment of the turbine house as well as for cooling of the equipment of the group “B” services. For the reactor compartment equipment cooling and of the group “A” services the reverse independent system of the circulation water supply is foreseen with the use of SP as the cooler.

In order to save energy resources for the main circulation water supply system, the double-speed motors and pumps with the mechanism of the vanes swing, which enable increasing their performance index, are used.

10.13.3 Protective measures, specified in the FS, include appropriate architectural and design solutions as well as measures in reduction of radiation and non-radiation impacts on the environment.

One of the most significant measures, specified in the design, is assurance of the leak tightness of buildings and constructions, where radioactive materials and mediums are handled or stored. The design provides for the containment around the equipment of the primary circuit in order to contain the released activity by equipment leaks and ruptures as well as for protection from external extreme impacts.

The base for the design of production buildings and premises is the main hygienic principle – their division into zones depending on the nature of the

technological processes, placed equipment, nature and possible degree of contamination of premises with the radioactive substances.

Environmental protection from the impact of ionizing irradiations during PP operation is ensured by the following measures:

- Organize barriers for containment according to the principle of the defense in depth;
- Create closed circuits with the radioactive mediums;
- Arrange primary circuit systems under pressure within the containment;
- Create intermediate circuits of the cooling water;
- Divide production premises into zones of the contamination control area and normally occupied area;
- Divide ventilation zones of the contamination control area and normally occupied area;
- Arrange organized collection and treatment of radioactive leakages;
- Arrange organized collection of liquid and solid radioactive waste;
- Waste storage and processing in a separate building;
- Maintain radiation and climate conditions in production premises by the ventilation systems;
- Have systems of localization of the reactor compartment accidents.\

The main source of air contamination with harmful chemical substances is the start-up standby boiler house, which upon commissioning of the power units 3,4 will be on only in several emergencies, related to the simultaneous shut-down of all power units. All other sources of chemical discharge into the air belong to periodically operating ones and do not lead to violation of the regulatory condition of the air surface layer.

Technical solutions in reduction of the non-radiation impact on the environment during management with the common industrial waste are described in the Par.8.3.

10.13.4 Measures, related to the reclamation of lands were fully completed by the commissioning of the KNPP-1. Any special land treatment of the change of structure of agricultural land use, restructuring of branches of the agricultural sector and changes in the technological processing of products are not required.

10.13.5 Safeguarding measures, specified in the FS, include:

- Functioning of the radiation situation monitoring system at the KNPP site and adjacent territory;
- Functioning of the observation system of surface and underground waters;
- Hydro biological monitoring;
- Functioning of the observation system for geological processes and soil conditions;
- Functioning of the observation system for buildings and constructions foundations;
- Functioning of the warning system in the KNPP SA;
- Implementation of the system of measures in safety of the anthropogenic

environment;

- Implementation of complex plan of the organizational and technical measures in the sphere “Environment protection and rational use of natural resources”.

10.14 A consolidated list of residual impacts and the environmental risk assessment

10.14.1 A consolidated list of residual impacts is given in the Table 10.14-1.

10.14.2 In whole, in line with the conclusions of OVOS, there is no environmental risk in factors of external impacts during construction, commissioning and operating of KNPP-3,4. Environmental risk in the factors of chemical (non-radiation) contamination of the environment will be minimal. Environmental risk in the factors of radiation impacts:

- During NOC will be significantly lower than the admissible (forecasted values of indicators of radiation condition of the environment and safety for the life of population are significantly lower than the admissible values);

Table.10.14-1 A consolidated list of residual impacts

Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
1 Radiation impact					
1.1 Gas-aerosol radiation impact from ventilation pipes of the reactor compartment, special buildings of the 4 power plants and of the sanitary inspection rooms					
Power of the emission of main radionuclides, Bq/day: argon-41 - 3,85E+10; caesium-137 - 4,97E+05; krypton-85 - 3,15E+09; xenon-133 - 1,21E+13; tritium - 2,85E+10; strontium-90 - 1,34E+01.					
<p>Average annual maximum rated concentrations of the Radioactive Noble Gases (RNG) in the air are received eastwards at the distance of about 1 km away from the NPP, Bq/m³</p> <ul style="list-style-type: none"> • ⁴¹Ar - n10⁻². • ⁸⁵Kr - n10⁻³; • ¹³³Xe - 2,0, <p>Which is 10³-10⁵ less than the maximum admissible</p>	-	-	<p>Contamination of the territory with ¹³⁷Cs is practically at the level of the global contamination – around 3 kBq/m². NPP operation within 4 power units will actually have no affect on the values of the natural radioactivity of soils</p>	<p>Bioindicators of the radiation contamination can be mushrooms, blueberry, pine-trees, mosses, lichens, for which there is the data base and respective dependences are fixed.</p> <p>Commissioning and normal operation of the power units 3,4 will have no negative impact on the SA fauna: malfunctions of the food supply, shelters, nesting places and migration routes are not forecasted.</p>	<p>Maximum rated effective individual dose 0.34 μSv/year are received at the distance of 1 km away from the NPP. Estimated radiation doses outside the CA are by a factor of a hundred lower than the fixed limits. During several hours of the natural background radiation (due to ⁴⁰K, ²³⁹U, ²³²T and the products of their decay) a person receives approximately the same dose, as from the discharge of KNPP</p>
1.2 Assessment of the radiological importance of the transboundary movement.					
As moving away from the source of discharge the contamination of the territory with radionuclides decreases rapidly, so the radiation doses for the population decrease as well. Even at the CA border the radiation doses do not exceed the dose limits for population. It means that the dose limit quota for population of the neighboring countries will not be exceeded (for most European countries it is higher than for Ukraine and is 200 μSv/year). One can assert that the radiation impact of the NPP normal operation on the neighboring countries will be significantly lower than the established dose quotas and the more than the limit of the individual effective annual dose of 1 μSv/year.					

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Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
1.3 Discharge of the neutralized regeneration waters of the chemical water treatment into RC with the activity lower than the value of PC_B^{ingest} regulated by NRBU-97. Technogenic infiltration.					
Slow hydrogeomigration of the anthropogenic contaminants, including the radionuclides, conditioned by the insignificant vertical gradients between water-bearing complexes. Wind entrainment of moisture to the distance of more than 12.5m (outside the waterproof blind area).					
	Reservoirs contamination level (RC, river Horyn, river Viliya) at ^{137}Cs and ^{90}Sr from the standard PC_B^{ingest} according to NRBU-97 is, in %: <ul style="list-style-type: none"> • ^{137}Cs - from 0,04 to 0,13; • ^{90}Sr - from 0,1 to 0,14, which fully meets the requirements of the specified standard	According to forecasts, the subject of the contamination with ^{90}Sr can be only the quaternary aquifer with the contamination level less than 5% from the realizable 100% contamination on top. Estimated concentration of ^{137}Cs is by a factor of ten lower than ^{90}Sr and will have no practical significance. Water-bearing complex, used for the water intake is characterized by the protection from the surface chemical and radiation contamination, i.e. it belongs to the environmentally stable sources of the utility and drinking water system.			
1.4 Periodical blow-down of the system from SP into RC.					

Total amount of capacities of the Liquid Waste Storage-800 m³(designed for four power units). Periodical blow-down of the system from SP into RC is performed under the condition of keeping to the level of the admissible water activity in the SP, established by the standards, in particular:

- Admissible tritium activity in the water $D^T V < 6.0 \cdot 10^{-6} \text{ Cu/dm}^3$
- Admissible total water activity $D^{\Sigma} V < 2.0 \cdot 10^{-10} \text{ Cu/dm}^3$

Maximum admissible amount of water escape is 200 m³/year. During operation of two power units the average annual water escape of the neutralized waters is 83.85 thousands m³/year.

Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
1.5 Solid Radioactive Waste					
<p>Two storages for SRW are provided for:</p> <ul style="list-style-type: none"> • In the special building; • In a separate building of SRW storage and processing. <p>There are 29 cells with the total size of 6.123 thousands m³ (for waste of the 1st, 2nd and 3rd groups) in the SRW storage. The total size of the cells of the unit of the SRW storage to store SRW of the 1st, 2nd groups is 8.004 thousands m³. Choice of equipment, assembly, access for maintenance, activities with the SRW in closed premises prevent the escape and discharge of the radioactive substances into the atmosphere during operation.</p>					<p>Radiation protection of cells for SRW ensures non-excess of the fixed radiation doses for personnel</p>
2 Chemical impact					
<p>2.1 Discharge of contaminants into the air from the sources of the NPP site, operating in the periodical mode (SUB, SWPDG, SDPP etc.), as well as ventilation emissions from the store-houses of the chemical reagents, where supply-and-exhaust ventilation with the tenfold air-exchange are specified.</p> <p>According to the report data, the average annual (2003-2008) discharge is 128.381 tons/year. Upon commissioning of the power units 3,4 the quantitative and qualitative characteristics of the discharge of contaminants will not change and their parameters will stay at the same level with the tendency to reduction, since the period of the SUB, if there are 4 power units, will be minimized.</p>					

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<p>Surface concentrations of contaminants due to NPP discharge according to all ingredients and groups of summation will not exceed the MPV for settlements. Within CA they will make from 0.2 to 0.6 of the MPV and in the zone of the nearest settlements from 0.02 to 0.12 MPV; taking into account the concentration background, they shall not exceed 0.5 MPV outside the CA. Tenfold air exchange of the rooms of the chemical agent store-houses ensures the concentration level of the contaminants in the ventilation emissions lower than the standard one, which indicates the permissible impact on the environment.</p>			<p>Content of copper, zinc and cadmium in the soils of the territory, adjacent to the KNPP, is at the background level. Slight additional contamination with lead of the farmland soils, adjacent to the roads, is possible, which will not lead to MPV excess in the agricultural products. Landscapes of the nearest KNPP zone have significant buffer resistance to the anthropogenic loads and are the reliable geochemical barrier.</p>	<p>Significant impacts of chemical factors are not expected since the relatively high proportion of rare fauna species of the territory is the indicator of the natural ecosystem preservation.</p>	<p>Assessment of the negative impact of harmful chemical compounds on the health of the CA population was made for toxic and carcinogenic compounds separately – the so called non-concentrated and carcinogenic risk. The studies established that the risk of the morbidity increase of the CA population of KNPP does not exceed the average level in the country.</p>
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Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
<p>2.2 Production water infiltration.</p>					
<p>RC blow-down (due to filtration leakages and through controlled water escape), as well as the “forced” water overflows across the automatic spillway during excess of the normal banked-up water horizon in RC during spring and rainwater floods, stipulated by the design. The rated value of the filtration leakages is 9.53 million m³/year (i.e 0.3 m³/sec). In the period of high water alone the water escape into the river Horyn can exceed the rate of flow in the amount of 0.317 m³/sec.</p>					
	<p>Filtration leakages are distributed equally along the front of the earth dam 7 m long practically at the same distance flow into the river, thus the temperate and salt regimes in the river Horyn do not have any significant impact. By timely controlled RC blow-downs in the high-water period the chemical impact on the surface waters is minimized to the environmentally acceptable level.</p>	<p>Local water temperature increase, its mineralization or insignificant level increase are possible. It will have no impact on the utility and drinking water system water-intake.</p>			
<p>2.3 Liquid non-radioactive waste</p>					
<p>(Waste oil, including the turbine TP-22S, sludge, petroleum products, domestic waste water). Average annual movement of waste, tons:</p> <ul style="list-style-type: none"> • Limit for formation – 70; • Formation a year – 33.6; • Removal, use a year – 32.3; • Balance as of 01.01 of the next year -1.5. <p>Total consumption of the utility waste water of Neteshyn and the site of the power units 1-4 makes 6.252 million m³/year. Within the water treatment constructions there are aerobic stabilizers for sediment treatment, sludge beds for drying and storage, composting beds with forced aeration and waterproof surface.</p>					

Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
	<p>A part of waste is removed; another part is treated at the assembly “Kristal”. Collected oils get burned in the SUB. Content of oils in the treated water is 1 mg/dm³. Water treatment constructions of the utility and drinking drains are designed for a full biological treatment of flows with the additional treatment in the biological ponds. Treated flows are moved into the RC, not violating the values of its water quality.</p>		<p>Composted sludge can be used in the agriculture as fertilizers. Productivity of the compost beds is from 7 to 9 m³ of compost a day.</p>		

2.4 Solid non-radioactive waste

At NPP hazardous waste of various classes of risk are formed. Average annual formation of waste according to classes of risk makes, in tons:
 1st class of risk (used mercury-containing fluorescent lamps) -3.7;
 2nd class of risk (storage batteries, spent oils (petrochemical products)) – 17.8;
 3rd class of risk – 0.0;
 4th class of risk (waste from heat insulation, wood processing, under burnt lime as well as domestic and construction garbage etc.) – 2127.6.
 Activity in hazardous waste management at KNPP is performed based on the permits for formation, collection, storage, utilization, disposal and removal of hazardous waste, as well as standards of formation and limits of placement of hazardous waste. Waste neutralization and disposal is implemented in specialized technical constructions – fields of hazardous production waste disposal.
 Waste of the 1st class of risk are full removed for demercuration. Part of waste of the 2nd and 4th classes of risk get utilized and are removed for disposal (about 75%) to specialized technical constructions; and the their remaining part is sent for storage to special containers and storages, sludge collector in line with the effective instructions. Chemical monitoring of the soil condition of the places of the waste location, CA and SA is implemented by a specialized environmental & chemical laboratory in line with the procedures and monitor volumes, approved by KNPP. On the annual basis the plant reports before the state statistics authorities according to the form № 1 (before 2006 “Toxic waste”, from 01.06.2006 “Hazardous waste”). No cases of the unauthorized disposal of waste into the environment have been registered.

Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
Environmental protection during hazardous waste management is implemented in line with the effective environmental law of Ukraine. Thus, the level of impact of solid non-radiation waste on the environment is within the established standards.					
3 Physical factors impact					
3.1 Thermal impact					
Increase of the thermal load of RC and SP by the operation of the four power units up to 8460 Gcal/h. Total rated values of the water losses due to additional evaporation and droplet entrainment with the wind from RC and SP by the operation of the four power units can reach 0.0068 million m ³ /h. Maximum permissible temperature of the cooling water is 33 °C.					
<p>One can expect the increase of the days with fog and glaze (at the distance of about 1 km from the coastal line). The air temperature will not change significantly. Possible changes of the microclimate are evaluated as environmentally permissible.</p>	<p>Model hydrothermal calculations of the RC showed that during the operation of the four power units the water temperature in it can exceed the natural water temperature of the river Horyn at 13 °C.</p> <p>Compliance with the temperature regimes in the control station is achieved by bleed water dilution.</p>			<p>Water temperature increase in RC will lead to the quantitative redistribution in the water entomological complex towards increasing the proportion of thermophilic and eurybiotic species. A number of migratory species, which stay for winter in the RC area, will increase. A number of mute swan (<i>Cygnus olor</i>), water hen (<i>Fulica</i>), mallard duck (<i>Anas platyrhynchos</i>), teals, seagulls and other species will increase. Impact on the biota is quite diverse and can have positive as well as negative effect on it.</p>	

Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
3.2 Impact of noise, ultrasound, vibration and electromagnetic irradiation					
Impact assessment of noise, vibration and ultrasound was made for premises, buildings and constructions, where there are permanent jobs of the personnel. Single short-term local ultrasound impact is possible during maintenance under ultrasound monitoring of the welded joints quality. At the Outdoor Switchgear (OS) the measuring of the Electricity Transmission (ET) intensity is performed in all places of the personnel presence. Air transmission lines from the OS of 330 and 750 kW are made according to the requirements of sanitary norms.					
<p>According to the type, purpose and characteristic of the production premises, for the reduction of the level of the sound pressure the heat and sound isolation is made, sound isolating booths are assembled and the use of headphones is specified. The permissible level of vibration on-sites is ensured by the compliance with the requirements GOST 12.1.012-78. Ultrasound impacts from mechanical and electrical equipment during operation of the power units 3,4 are not anticipated.</p>				<p>High-voltage lines laying through forest areas increases the number of shelters of several species, which serves as a pre-condition for the future increase of their quantity and extension of the population areas.</p>	<p>Due to significant remoteness of the residential construction from KNPP (approx. 3 km) the levels of noise, ultrasound, vibration and electromagnetic impacts for the SA population are anticipated at the negligibly low level. Protection of the population from the impact of the electric field of the high-voltage lines with the power 220 kv and less, which are in compliance with the requirements of sanitary norms, are not required.</p> <p>For protection of the personnel from the impact of the electric field at the OS, including the roundabout ways, the stand-by safety guards are specified (screens, shields etc.)</p>
4 Impact of demographic factors					
Population growth in Neteshyn, related to KNPP extension					

Information and analytical survey of the materials “Khmelnyska NPP.
Feasibility Study of the power units 3, 4 construction”

Air	Surface waters	Underground waters	Soil	Flora and fauna	Social environment
		<p>According to the Production Activity of the Enterprise, in line with the forecasted number of the population the need for drinking water will make, thousands m³/day: In 2010 – 16.6, in the period of the rated period of development (2020-2025) – 18.4. The approved reserve is 18 thousands m³/day. The used water-bearing horizons are protected.</p>		<p>One can expect decrease of the population of several species of the pratal entomological complex and the growth of the population of insect-pests; increase of the recreational pressure</p>	<p>Assignments in the amount up to 10% from the construction cost are forecasted for SA infrastructure development. New production development in the region is forecasted.</p>
Final assessments of the residual impacts					
Impacts do not exceed permissible limits	Impacts do not exceed permissible limits	Impacts do not exceed permissible limits	Impacts do not exceed permissible limits	Impacts do not exceed permissible limits	Impacts do not exceed permissible limits

- During MBDA is forecasted acceptable according to all constituents (permissible values of the indicators of the radiation condition of the environment and current hygienic standards will not be exceeded);
- During BDBA, taking into account low probability of such accident, the environmental risk is acceptable and individual risks of irradiation through gas-aerosol discharge for population outside the CA will not exceed the acceptable level of the individual risk during appropriate protective measures (countermeasures).

11 SOCIAL AND ECONOMICAL ASPECTS OF THE PROJECT IMPLEMENTATION

Information, given in the Section 10 of IAS, is detailed in the FS materials [22,33,39,41].

11.1 Attitude of the population of the KNPP location area to its extension

11.1.1 Measures in the public information about the planned activity prior to completion of the FS elaboration included:

- Prompt public information;
- Interaction with the authorities, state institutions, labor communities;
- Cooperation with regional and central media;
- Organization of field public meetings of the Energoatom and KNPP leading specialists;
- Vocational guidance work with students;
- Excursion and lecture work etc.

Due to completion of the FS elaboration a new cycle of public consultations is anticipated.

11.1.2 Detail social study with the objective to study the attitude of the population of the KNPP SA to the construction of KNPP-3,4 was made beginning 2009 by the Research Institute of the National University “Ostrog Academy”. During public hearing the following tasks were set:

- Learn the respondents’ attitude to nuclear energy sector;
- Define the respondents’ attitude to the KNPP extension;
- Study the basic reasons of the expedience of the construction completion, if they are available;
- Define the level of the “Post-Chernobyl” syndrome;
- Set conditions, under which the respondents with the negative attitude to the KNPP extension are ready to change their mind for positive;
- Define the most acute problem of the population according to their priorities;
- Learn which benefits the population counts for in case of the KNPP extension;
- Define, what can the KNPP extension have impact on in the social and economic sphere etc.

11.1.3 Sociological study covered 3200 respondents. According to its results, the attitude of the respondents to the KNPP extension was distributed as follows:

- Totally support the KNPP extension – 18.3%;
- Are more likely to agree than to disagree – 22.5%;
- Are more likely to disagree than to agree – 18.9%;
- Are against the KNPP extension – 26.7%;
- Hesitate in the answer – 13.6%.

11.1.4 According to the conclusions of the sociological study, in whole the attitude of the population to the KNPP extension can be characterized as potentially positive, however the education of the population shall continue and activate.

11.2 National and regional impact of the KNPP extension

11.2.1 In line with the Strategy [44] during construction of new nuclear capacities in Ukraine the maximum attraction of national enterprises is forecasted, including:

- Scientific & technical and design enterprises;
- Industrial enterprises;
- Construction and installation enterprises.
- Educational institutions.

In particular, the main Ukrainian manufacturers of equipment and energy facility systems, which are anticipated to be involved in production for KNPP-3,4 construction, are as follows:

- OAO "Turboatom", Kharkov;
- ZAO "KTsKBA", Kyiv;
- ZAO "Zaporizhzhya transformer", Zaporizhzhya;
- ZAO "Impuls", Severodonetsk;
- ZAO "Rady", Kirovograd;
- NPO "Monolit", Kharkov;
- OAO "Sumy plant "Nasosenergomash", Sumy;
- KhGPZ named after Shevchenko, Kharkov;
- OOO «Vestron», Kharkov;
- OAO “Sumy mashynostroitelnoye NPO named after Frunze”, Sumy;
- OAO “Melitopol compressor”, Melitopol etc.

11.2.2 In the regional respect significant extension of KNPP as the main employer of the region, will provide new jobs, influx of skilled workers and will lead to population growth in Neteshyn. It will result in the improvement of the general level of education and qualification of the population of the region and, as the result, development of new businesses.

11.3 Development of the social infrastructure of the KNPP SA and of Neteshyn

11.3.1 Costs for development of the social infrastructure in the KNPP SA, stipulated by the FS, make about 10% of the construction costs. The list of specific facilities of the social and domestic purposes will be defined at the stage “design” according to the suggestions of the local authorities according to the procedure, specified in the law.

11.3.2 Construction of a rehabilitation preventive clinic and sports and recreation clinic is forecasted in Neteshyn. These facilities will give a possibility to provide good health improvement of the employees and their families, to remove the social tension involving children and the youth in sport activities, as well as will contribute to future development of the public health base of the region in whole.

12 CONCLUSION

12.1 According to the FS conclusions, the suggested constructions of KNPP-3,4 is based on the perspective scientific and technical decisions, technologies and equipment and is in compliance with the requirements of laws.

12.2 Admissibility of the KNPP-3,4 construction according to environmental and sanitary & epidemiological factors is confirmed In FS.

12.3 Economic necessity, technical practicability, social and economic expedience of the planned KNPP extension are given In FS.

12.4 Requirements and conclusions concerning the next stages of the KNPP-3,4 design are formulated In FS.

12.5 Based on the results of the analysis and evaluations, made in FS, the “Statement on environmental consequences of KNPP-3,4 construction and operation” is prepared, complete text whereof is given in Annex A.

LIST OF REFERENCES

1. Law of Ukraine ”On ratification of the joint convention about safe management of spent nuclear fuel and safe management of radioactive waste”, №1688-III of 20.04.2000.
2. Law of Ukraine “On ratification of the convention about nuclear safety”, №736/97-BP of 17.12.1997.
3. Law of Ukraine “On ratification of the convention about access to information, public participation in the process of decisions making and access to justice in the issues, which are related to the environment”, №832-XIV of 06.07.1999.
4. Law of Ukraine “On ratification of the convention about impact assessment on the environment in the transboundary context”, №534-XIV of 19.03.1999.
5. Law of Ukraine “On environmental protection”, №1264-XII of 25.07.1991.
6. Law of Ukraine “On the use of nuclear energy and radiation safety”, №39/95-BP of 08.02.1995.
7. Law of Ukraine “On radioactive waste management” №255/95-BP of 30.07.1995.
8. Law of Ukraine “On permissible activity in the sector of nuclear energy use” №1370-XIV of 11.01.2000.
9. Law of Ukraine “On human protection from the ionizing irradiation impact” №15/98-BP of 14.01.1998.
10. Law of Ukraine “On environmental expertise” №45/95-BP of 09.02.1995.
11. Law of Ukraine “On the procedure of decisions making on location, design, construction of nuclear facilities and objects, designed for radioactive waste management, which are of a state importance” № 2861-IV of 08.09.2005.
12. НРБУ–97 (NRBU-97). Norms of Radiation Safety of Ukraine. State hygienic standards. Ministry of Health of Ukraine, 1997.
13. ГСП 6.177-2005-09-02 (GSP 6.177-2005-09-02). Basic sanitary regulations to ensure radiation safety of Ukraine. State sanitary regulations. Ministry of Health of Ukraine, 2005.
14. НРБУ–97/Д-2000 (NRBU-97/D-2000) Norms of Radiation Safety of Ukraine. Addendum: Radiation protection from the sources of potential irradiation. Ministry of Health of Ukraine, 2000.
15. ДБН А.2.2-3-2004 (DBN A.2.2-3-2004) Compound, procedure of elaboration, endorsement and validation of the design documentation for construction. State Committee for Construction of Ukraine, 2004.
16. ДБН А.2.2-1-2003 (DBN A.2.2-1-2003) Compound and content of the materials of the Environmental Impact Assessment (OVOS) during design and construction of enterprises, buildings and constructions. State Committee for Construction and Architecture of Ukraine, 2004.
17. СП АС-88, ПНАЭ (SP AS-88, PNAE) Sanitary regulations of design and operation of nuclear power units.
18. НП 306.2.141-2008 (NP 306.2.141-2008) General provisions of nuclear power plants safety (OPB-2008), SNRIU, 2008.
19. НП 306.2.144-2008 (NP 306.2.141-2008) Requirements to safety during selection of the site of the nuclear power plant location. SNRIU, 2008.
20. IAEA document №50–С –S. Safety Guides. Nuclear Power Plants Safety – selection of sites for NPPs.
21. 43-814.203.004.OE.01 Basic reference provisions
22. 43-814.203.004.OE.02 Necessity and expedience to construct power units 3,4. NPP capacity. Unit capacity of a power unit.

23. 43-814.203.004.OE.03 NPP provision with fuel, materials, water and with other resources
24. 43-814.203.004.OE.04 Confirmation of the NPP site applicability for construction of power units 3,4 in line with the requirements of effective norms.
25. 43-814.203.004.OE.05 Configuration of the power units 3,4 and NPP in whole taking into account extension with the power units 3,4.
26. 43-814.203.004.OE.06 General schedule and transportation
27. 43-814.203.004.OE.07 Principle technological decisions
28. 43-814.203.004.OE.08 Assurance of nuclear and radiation safety
29. 43-814.203.004.OE.09 Principle design and construction decisions
30. 43-814.203.004.OE.10 Operation
31. 43-814.203.004.OE.11 Decommissioning
32. 43-814.203.004.OE.12 Quality assurance at all stages of NPP service cycle
33. 43-814.203.004.OE.13 Environmental Impact Assessment (OVOS)
34. 43-814.203.004.OE.14 Organization of project control
35. 43-814.203.004.OE.15 Principle provisions for organization of construction, construction period.
36. 43-814.203.004.OE.16 Principle decisions in preparation of the territory and protection of the facilities from hazardous natural and/or anthropogenic factors
37. 43-814.203.004.OE.17 Principle decisions in sanitary and domestic service
38. 43-814.203.004.OE.18 Principle decisions in fire safety and labor protection
39. 43-814.203.004.OE.19 Social aspects of the project implementation
40. 43-814.203.004.OЭ.20 Cost estimates documents
41. 43-814.203.004.OЭ.21 Substantiation of the economic efficiency of the NPP extension
42. 43-814.203.004.OЭ.22 Technical and economic indicators
43. 43-814.203.004.OЭ.23 Conclusions and suggestions
44. CoM Order “On approval of the Energy Strategy of Ukraine for the period up to 2030” №145-p of 15.03.2006.
45. CoM Order “On preparatory activities for construction of new KNPP power units” № 281-p of 21.07.2005.
46. Ministry of Fuel and Energy of Ukraine Decree “On preparatory activities for construction of KNPP-3,4” № 425 of 22.08.2005 r.
47. CoM Order “On approval of the Action Plan for 2006-2010 in implementation of the Energy Strategy of Ukraine for the period up to 2030” № 436-p of 27.07.2006.
48. CoM Order “On the primary measures in construction of KNPP-3,4” № 118 of 18.02.2009.
49. Development of the variants of schemes of the power delivery by KNPP under commissioning of the power units 3,4. Report of the Institute “UkrEnergoSet’Proekt”, № 6357-T1, Kharkov, 2009.
50. Khmelnyska NPP. Power units 3,4. Inspection and assessment of the technical condition of the reservoir-cooler for preparation of the power units’ construction. 43-613.216.001.OT00, KIEP Report, №42486-B, K.: KIEP – 2008.
51. Inspection and assessment of the technical condition of the reservoir-cooler for preparation of KNPP-3,4 construction. Water system balances of the river Horyn. Report of “UkrVodProekt”, № 3465, K: “UkrVodProekt” 2007.
52. IAEA document № 50-SG-S1. Safety Guides. Consideration of earthquakes and related phenomena when selecting the sites for nuclear power plants, Vienna: IAEA, 1994.

53. СНиП 2.04.02-84 (SNiP 2.04.02-84) Water system. Outdoor networks and constructions.
54. Resolution of the Ministry of Fuel and Energy Board “Approval of the decision on the selection of the reactor facility type for construction of KNPP-3,4” №4.1 of 13.10.2008.
55. НП (NP) 306.5.02/3.017-99. Requirements to the quality assurance program at all stages of the service life of nuclear facilities.
56. НП (NP) 306.5.02/2.069-2003. Safety requirements and conditions (license conditions) during design of the nuclear facility or of the storage for radioactive waste disposal.
57. ДСТУ (DSTU) ISO 10005:2007. Quality control systems. Quality programs guide.
58. Law of Ukraine “On Fire Safety” № 3745 of 17.12.1993.
59. Law of Ukraine “On Labor Protection” of 21.11.2002.
60. Law of Ukraine “On physical protection of nuclear facilities, nuclear materials, radioactive waste, other sources of ionizing irradiation” № 2064-III of 19.10.2000.
61. Law of Ukraine “On regulation of issues, related to nuclear safety assurance” №1868-IV of 24.06.2004.
62. НД 306.2.02/1.004-98. General provisions of safety assurance during decommissioning of nuclear power plants and research nuclear reactors. Ministry of Environmental Safety. 1998.
63. Concept of decommissioning of operating nuclear power units of Ukraine, approved by the Ministry of Fuel and Energy Decree №249 of 12.05.2004.
64. 0.ОБ.5797.ПН-08 Concept of decommissioning of power units VVER-1000 of KNPP. К.: NAEK Energoatom, 2008.
65. ГН 6.6.1.1-130-2006 Permissible levels of content of radionuclides ^{137}Cs and ^{90}Sr in food and water. Hygienic standard.

ANNEX A. STATEMENT ON ENVIRONMENTAL CONSEQUENCES OF KNPP-3,4 CONSTRUCTION

Nuclear energy sector takes one of the leading places in the economy of Ukraine. Four operating nuclear power plants (NPP) with 15 power units with the nuclear reactors of VVER type, which share is 26.6% of general installed capacities of the country, generate almost the half of the electric power in Ukraine.

State enterprise “National Nuclear Energy Generating Company Energoatom” (Energoatom) is the operating organization, which is in charge of safety of the operating NPPs of the country in line with the Law of Ukraine “On Use of Nuclear Power and Radiation Safety”

Main task of Energoatom was and is the generation of electric power at NPPs, as well as creation of new capacities under the mandatory condition of assurance of the safety level in line with the current requirements.

DATA ON THE PLANNED ACTIVITY, OBJECTIVES AND WAYS OF THEIR IMPLEMENTATION

Construction of KNPP-3,4 is one of the priorities of energy sector development in Ukraine. Creation of additional nuclear capacities will ensure strengthening of the energy safety of the country and will satisfy demands in electric power in conditions of future economy growth of the country.

Construction, commissioning and operation of new power units is forecasted at the site of the existing Khmelnytska NPP (KNPP), which was selected and approved for the NPP with the capacity 4000 MWt. KNPP site with the operating power units 1,2 with the total capacity 2000 MWt is located in the west of the Slavuta rayon Khmelnytska oblast.

Necessity to construct KNPP-3,4 is defined by the following documents:

- CoM Order “On preparatory activities for construction of new KNPP power units” № 281-p of 21.07.2005;
- Ministry of Fuel and Energy “On preparatory activities for construction of new KNPP power units” № 425 of 22.08.2005;
- “Energy Strategy of Ukraine for the period up to 2030”, approved by the CoM Resolution № 145-p of 15.03.2006;
- CoM Order “On assurance of Action Plan for 2006-2010 in implementation of the Energy Strategy of Ukraine for the period up to 2030” №436-p of 27.07.2006;
- CoM Order “On the primary measures in construction of KNPP-3,4” № 118 of 18.02.2009”.

In line with the provisions of the specified documents, the first stage of the activity in construction of KNPP-3,4 is elaboration of the feasibility study (FS), including Environmental Impact Assessment (OVOS). FS is incorporated in the set of documents, necessary for decision making on the construction in accordance with the Law of Ukraine “On procedure of decisions making about location, design, construction of nuclear facilities and objects, designed for radioactive waste management which are of a state importance” r. №2861-IV of 08.09.2005.

FS of the KNPP-3,4 construction was elaborated by Kyiv Scientific & Research and Design Institute “Energoproekt” (KIEP) on request by Energoatom

In FS of the KNPP-3,4 construction:

- Admissibility of the KNPP site in line with the requirements of the effective Ukrainian regulatory documents was confirmed;
- principle technical decisions and technical and economic indicators of the power units were defined;
- safety justification was made (nuclear, radiation and environmental);
- OVOS was made.

KNPP-3,4 construction is forecasted with the use of the existing constructing structures of the main building and other facilities, which are in the state the uncompleted construction now.

SIGNIFICANT FACTORS WHICH HAVE OR CAN HAVE IMPACT ON THE CONDITION OF THE ENVIRONMENT TAKING INTO ACCOUNT POSSIBILITIES OF THE ENVIRONMENTAL EMERGENCIES.

During assessment of the impacts of the planned activity on the environment:

- Current condition of the environment at the site of the facility construction and adjacent territories has been studied;
- All sources of possible impacts of the facility on the environment were defined;
- Assessments of the impact on all the environmental components were made.

Impacts on the environmental components which result in excess of the regulated levels, were not detected by the assessment.

Made assessment showed that the main types of impacts of the KNPP-3,4 on the environmental components are radiation, thermal and chemical impacts.

Possible impacts for normal conditions and accidents on the following environmental components are analyzed in FS:

- Geological environment;
- Air;
- Water;
- Soils;
- Flora and fauna;
- Anthropogenic environment;
- Social environment.

Possible impacts were assessed for normal conditions and accidents – design basis as well beyond design-basis ones. The criteria of the assessment are the requirements of the Ukrainian regulatory documents.

The following accidents at of the new power plants were chosen for the analysis of accidents:

- Maximum Design-Basis Accident (MDBA), conditioned by the guillotine rupture of the main circulation pipeline with the two-sided leak;
- Beyond Design-Basis Accident (BDBA), conditioned by the guillotine rupture of the main circulation circuit with the failure of the active systems of the emergency cooling of the zone and operating sprinkler system (probability of such BDBA is 10^{-8} year⁻¹).

QUANTITATIVE AND QUALITATIVE INDICATORS OF THE EVALUATION OF THE LEVELS OF ENVIRONMENTAL RISK AND SAFETY OF THE PLANNED ACTIVITY FOR LIFE OF THE POPULATION

Construction and operation of the power units 3,4 is planned on the existing and initially meant for these purposes industrial site of the KNPP. The landscape of the site is industrial and is characterized positively for the location of an NPP, including the infrastructure.

During construction and operation of the power units 3,4 any anthropogenic changes of the geological state under the impact of the KNPP facilities are not forecasted. Any negative impacts of the power units on the objects of the anthropogenic environment, situated within the SA, are not forecasted as well.

Impact of noise, vibration and electromagnetic fields are limited by the KNPP site and do not exceed the admissible limits.

Assessment of the radiation impact on the air during Normal Operating Conditions (NOC) showed that the main contribution into the dose from the gas-aerosol discharge of the KNPP-3,4 will give the Inert Radioactive Gases (IRG) concentration whereof is forecasted to be significantly less than the maximum permissible levels.

Upon commissioning of the power units 3,4 the quantitative and qualitative characteristics of the non-radioactive discharge of KNPP will not change significantly; the conditioned by them surface concentrations of the contaminants according to all ingredients as well as according to groups of summation will not exceed the maximum permissible values for settlements. Due to commissioning of the power units 3,4 the necessity to use start-up standby boiler – of the main source of the present emissions of chemical contaminants - will practically dissolve.

Operation of KNPP-3,4 will lead to increase of the thermal discharge into the reservoir-cooler (RC), which will to some extent change the conditions of the water exchange in the RC upper layer and heat exchange in the adjacent level of the atmosphere. The zone of the impact on the local microclimate (changes of air temperature and humidity, frequency of fogs and glaze) will not exceed 1 km from the line of the RC watershed. Taking into account the admissible impact of the cooling systems on the local climate parameters, special measures in restriction of these impacts during operation of the four KNPP power units are not required.

Impact on the hydro geological environment from KNPP-3,4 operation can occur as a local temperature increase of the underground waters, their mineralization or insignificant increase of the level on the limited area, which will have no impact on the water intake of the utility and domestic water system. Water supply complex is characterized by protection from the surface chemical and radiation contamination.

Needs for technical water supply during operation of KNPP four power units will be ensured through the river Horyn without violating the inviolable sanitary consumptions. Covering the low-water period deficit is planned through the partial actuation of the RC conservation zone with its future replenishment with the flow of the rivers Hnyloy Rog and Horyn during the spring high-water.

The assessment shows that the regulatory performance of the blow-downs of the RC during the high-water periods minimizes the chemical and thermal impacts on the surface waters, which excludes the possibility of the violation of the requirements of the sanitary norms regarding their hydro chemical indicators and temperature modes.

Radiological condition of soils in the KNPP location area as of today is mainly defined by the radionuclides of the natural origin which is forecasted in future for NOC.

Content of copper, zinc and cadmium in the soils of the territories adjacent to KNPP is and is forecasted in future at the background level.

Degradation processes in the soils, related to the KNPP construction, are common only within the site bounds. Their presence in the SA is not related to the NPP operation.

Operation of the two additional power units within KNPP will not result in the direct impact on the structure and dynamics of flora and fauna as well as will not cause changes in the population of rare species of plants and animals, included into the Red Book of Ukraine.

According to the results of the carried out studies, the negative changes in the health of the population, living within the SA (due to KNPP impact) are not detected; the risk of morbidity for local population will not exceed the average level in the country. During operation of the two additional power units no excess of such risk is forecasted.

Carried out conservative assessment of the impact of gas-aerosol discharge from KNPP comprised of four power units during NOC demonstrates that at the border of the CA the effective annual dose taking into account all ways of impacts for the critical group of the population will not exceed 6% of the dose limit.

Positive impact on the social environment from KNPP-3,4 construction in the first place will be defined by additional development of the social infrastructure, in which respect the appropriate assignments in the amount of 10% from the construction cost are specified in FS.

Conditions of the KNPP site location exclude the possibility of external anthropogenic impacts from other facilities of the economic activity (fire, blast wave, flood, volley emission of harmful gases etc.) which can result in the malfunction of NOC of KNPP facilities. On the other hand, construction, commissioning and operation of KNPP-3,4 will have no impact on the anthropogenic environment. Any special agricultural measures in the change of the structure of the agricultural land use, restructuring of the agricultural complex sectors or change in the technological processing of the products are not required.

In whole, according to the OVOS conclusions, there is no environmental risk in the factors of external impacts during construction, commissioning and operation of KNPP-3,4. Environmental risk in the factors of chemical (non-radiation) contamination of the environment will be minimal. Environmental risk in the factors of the radiation impacts:

- Under NOC will be significantly lower than the permissible level (forecasted values of the indicators of the radiation condition of the environment and safety for life of the population are significantly lower than the permissible values);
- Under MDBA is forecasted acceptable according to all components (permissible values of the indicators of the radiation condition of the environment and current hygienic standards will not be exceeded);
- Under BDBA, taking into account probability of such accident, the environmental risk is acceptable and individual risks from irradiations as the result of gas-aerosol emissions for population outside the CA will not exceed the limits of acceptable level of the individual risk during appropriate protective measures (countermeasures).

According to the results of accident consequences assessments, the existing as of today KNPP CA and SA do not need to be extended during commissioning of power units 3,4. Outside the CA the individual risks of the occurrence of the stochastic effects at the population due to the radiation impact of the aerosol discharge from KNPP, will not exceed the acceptable level, defined in the NRBU-97. There are no risks of the deterministic effects.

Findings of the assessment of the transboundary impact indicate that during none of the studied accidents the level of the individual annual effective dose for the individuals of the critical group in the neighboring countries will be exceeded.

ACTIVITIES WHICH GUARANTEE IMPLEMENTATION OF THE ACTIVITY IN ACCORDANCE WITH THE ENVIRONMENTAL STANDARDS AND REGULATIONS

Complex of project decisions in assurance of the regulated conditions of the environment during construction and operation of KNPP-3,4 contains a group of activities in different spheres, in particular:

- Resource-saving – preservation and rational consumption of resources;
- Protective – creation of protective constructions etc;
- Recovery – reclamation, normalization of the condition of individual components of the environment etc.;
- Compensative;
- Safeguarding – environmental monitoring

Implementation of the project decisions, provided for in FS, will ensure normative condition of the environment.

LIST OF RESIDUAL IMPACTS

During construction, commissioning and operation of KNPP-3,4 the residual impact on the air, water, soils, flora and fauna, anthropogenic and social environment is minimal.

Consequences during MDBA of KNPP-3,4 do not exceed the indicators, established by the effective hygienic standards.

Consequences during BDBA of KNPP-3,4 in case if protection measures (countermeasures) will not exceed the limits of the acceptable individual risk level.

ACCEPTED MEASURES IN PUBLIC INFORMATION ON THE PLANNED ACTIVITY, OBJECTIVES AND WAYS OF THEIR IMPLEMENTATION

At the beginning of the FS elaboration “Statement on the intentions to construct power units 3,4 at the KNPP site” was prepared and distributed in the regional media.

In order to ensure prompt information of the public, authorities and media on the KNPP operation, perspectives of KNPP-3,4 construction, events which occur at it, Energoatom carries out the following activities:

- On a daily basis there is an automatic telephone service of information of the population on the operation of the power units 1,2, capacity level, electric power generation per day, from the beginning of a month, on the ongoing outages, information on malfunctions in the power units operation, radiation condition at the industrial site and in the SA;
- On a weekly basis information is prepared and distributed about the events, which occurred at KNPP: measures in safety improvement, radiation condition at the industrial site, meetings, press-conferences, seminars, visits, sessions, cooperation with international specialists etc.
- On a monthly basis the summarized information on the technical and economic indicators of the power units operation, water chemical condition of the RC is sent to state authorities, environmental inspections, Civil Defense Headquarters, oblast and regional media;
- Site public meetings with leading specialists of Energoatom;
- Vocational guidance work with students;
- Excursion and lecture work etc.

Findings of the sociological studies, carried out in 2009 by the Institute of Researches of National University “Ostrog Academy”, showed in general positive attitude of the population to

KNPP-3,4 construction.

In line with the completion of FS elaboration, a new cycle of Public Consultations (PC) is planned, which will include:

- Consultations, mutual endorsement of the planned measures and interaction during public activities with local authorities during the whole process of public discussions of the project;
- Public information about the initiation and planned activities of the PC process (through media, regular and electronic mail, fax-letters);
- Organization and conduct of briefing for representatives of central and local media about the initiation and planned activities of the PC process;
- Preparation and distribution of the information set of document for representatives of public organizations, media and individuals, which will show their interest in the PC process, including: press-release about the PC process, Action Plan in public consultations on the KNPP-3,4 construction (Action Plan), information and analytical review of the FS materials of the KNPP-3,4 constructions; form for registration of the application for participation in the PC process; form for submission of questions, remarks, comments and recommendations;
- Organization and assurance of functioning of office for work with the public (registration of applications for participation in PC), collection of questions, remarks, comments and recommendations from representatives of public organizations and individuals etc.);
- Information of the neighboring countries about possible impact in the transboundary context according to the legislation;
- Organization and conduct of roundtable discussions with the participation of representatives of central and local authorities, public organizations and interested persons, representatives of media in line with the Action Plan, collection of the questions, remarks, comments and recommendations received during roundtable discussions;
- Information provision and organizational & technical assistance of PC in case when local authorities take a decision about their conduct, collection of the questions, remarks, comments and recommendations received during received during PC;
- Preparation and distribution of press-release according to the result of roundtable consultations and PC;
- Preparation of the report on PC about KNPP-3,4 construction, including the book of questions-answers (annex to the report);
- Preparation of the report on activities in information of the neighboring countries about the possible impact in the transboundary context;
- FS finalization taking into account the PC results.

**CLIENT’S OBLIGATIONS IN IMPLEMENTATION OF THE PROJECT
DECISIONS IN LINE WITH THE NORMS AND REGULATIONS OF THE
ENVIRONMENTAL PROTECTION AND REQUIREMENTS OF THE
ENVIRONMENTAL SAFETY AT ALL STAGES OF THE CONSTRUCTION
AND OPERATION OF THE FACILITY OF THE PLANNED ACTIVITY**

Energoatom, as the operating organization, realizing in full the importance of the performed activity, putting above all the human safety and preservation of the environment, is obliged to:

- Fulfill requirements of the environmental legislation of Ukraine, international agreements of Ukraine, standards and regulations in the sphere of use of nuclear energy, environmental management and environmental protection;
- Create and implement systems of environmental protection which, in particular, includes consideration of quantitative and qualitative indicators of discharge of contaminants into the air, discharge into the water objects, management of all types of waste, rational consumption of natural resources etc.;
- Implement monitoring of the environment in the CA and SA through organization of supervision of radiation, hydro geological, hydro chemical condition of the environment objects;
- Provide to the population transparent and reliable information on the environmental condition in the KNPP location area;
- Constructively interact with supervision authorities, public organizations and media in the issues of environmental safety.

Energoatom commits itself to implement in full all technical, organizational, financial and other decisions, stipulated by the project as well as along the whole period of power units 3,4 operation to follow technological procedure, bear commodity and material costs to ensure their safe operation and, thereby, guarantee fulfillment of environmental requirements.

On behalf of the Client:
President of NAEK Energoatom

(SIGNATURE, STAMP)

_____ Yu.A. Nedashkovsky

«__»_____2011.

On behalf of the General Designer:
KIEP Chairman of the Board

(SIGNATURE, STAMP)

_____ Yu.V. Malakhov

«__»_____2011.