ANNEX E. Description of potential impact

1 ENVIRONMENTAL COMPONENTS AND TYPES OF IMPACTS, REVIEWED IN OVOS

In this document only these types of impacts are under review, which can have direct or indirect impact on the transboundary transfer.

2 IMPACT ASSESSMENT ON THE AIR

Radiation exposure

Radiological situation in the area of the plant location is mainly defined at present by the radionuclides of the natural origin. Long-lived anthropogenic isotopes have not been detected. Territory contamination with ^{137}Cs is at the level, close to the levels of global contamination (about 3 kBq/m^2).

During the calculation of estimates of the contamination of the territory, adjacent to NPP, with gas-aerosol discharge for the normal operation mode of all power units, it was assumed that there is one source of continuous discharge with the height of 100m and with total power, equal to discharge from the ventilation pipes of the rector compartments of the four power units and special buildings.

The specified discharge comprise 89 radionuclides with different periods of half-decay, discharge activity and, respectively, with the different contribution into the radiation exposure. As the result of the made calculations, the estimates were received of the contamination densities of the NPP close area with ^{3}H, ^{137}Cs and ^{90}Sr and volume concentrations of ^{41}Ar, ^{85}Kr и ^{133}Xe in the surface atmosphere layer of the NPP close area during continuous normal operation of the four power units during 45 years (chart 2.1).

Chart 2.1 – **Total discharge of radionuclides during KNPP normal operation**

Radionuclides	Half-decay period	Discharge power, Bq/day
^{41}Ar	1,82 ч	3,85E+10
^{137}Cs	30,20 год	4,97E+05
^{85}Kr	10,72 года	3,15E+09
^{133}Xe	5,23 сут	1,21E+13
^{3}H	12,33 года	2,85E+10
^{90}Sr	29,2 года	1,34E+01

Made assessments showed that the main contribution to the dose from gas-aerosol discharge during the power plant operation will be made by Radioactive Noble Gases (RNG) through exposure from the cloud (chart 2.2)

Chart 2.2 – **Rated concentrations of RNG in the air surface layer of KNPP Supervised Area (SA)**

Title	RNG concentrations in the air surface layer, Bq/m^3		
	^{41}Ar	^{85}Kr	^{133}Xe
Maximum average annual concentrations, received in the eastern direction at the distance of about 1 km from NPP	n·10^{-2}	n·10^{-3}	2,0

Given rated RNG concentrations indicate that during NO of the power units they are significantly lower than the admissible ones and thereby guarantee the non-excess of quota of the radiation exposure limit of 40 μSv /year for the population of the category B.

Thus, gas-aerosol radioactive discharge into the air is admissible.

Chemical, thermal and humidity impacts and influence of physical factors

Chemical, thermal and humidity impacts as well as the influence of physical factors of KNPP-3,4 on the environment are of the local nature and respectively their review in the transboundary context is not required.

3 IMPACT ASSESSMENT ON THE SURFACE AND UNDERGROUND WATER, SOILS, FLORA AND FAUNA

Impacts on the surface and underground water, soils, flora and fauna of KNPP-3,4 on the environment are of the local nature and respectively their review in the transboundary context is not required.

4 IMPACT ASSESSMENT ON THE SOCIAL ENVIRONMENT

Radiation exposure

Radiation exposure on the population, inhabiting the SA KNPP, is mainly formed through natural radionuclides, contained in the soils and undersoils.

The average total radiation exposure of the Ukrainian population due to natural sources is 3,5 μSv ·year^{-1}, at that its main part is formed through exposure from radon.

The main contribution into the expected effective radiation exposure (from NPPs) at all distances is made by RNG ^{133}Xe, ^{135}Xe from the exposure from the cloud. The other routes of the impact on the dose formation make a significantly smaller contribution (figure 6.1).

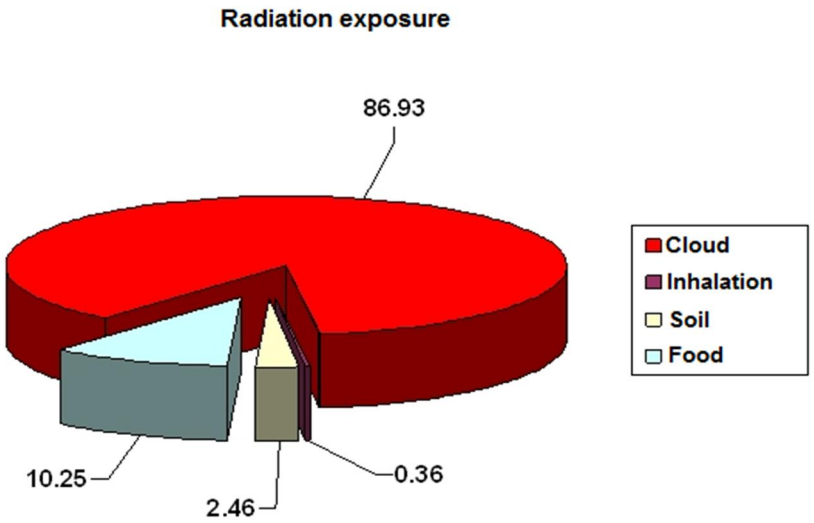

Figure 4.1 – Structure of formation (in %) of the expected effective radiation exposure on the population (referent group "adult", rural population) during the 30th year of KNPP operation consiting of four power units according to the routes of impact. Azimuth 0°, distance 3 km

Maximum rated effective radiation exposure 0,34 μSv /year is received at the distance of 1 km to the east from the NPP. At the distance of 25 km the total effective radiation exposure is decreased to hundredth parts of μSv .

The main contribution into formation of the radiation exposure on a human body will be made by natural radionuclides: ^{40}K, ^{238}U, ^{232}Th and the products of their decay (within 1-3 μSv /year). During several hours of the natural background irradiation a person receives the same dose as through KNPP discharge for a year.

Population, living close to NPP, can get the radiation exposure through gas-aerosol discharge from NPP, not exceeding 4% of the limit dose, i.e. <40 μSv /year. In the case with KNPP the estimated radiation exposure on the population outside the Control Area (CA) will be by a factor of a hundred lower than the established limits (figure 6.2).

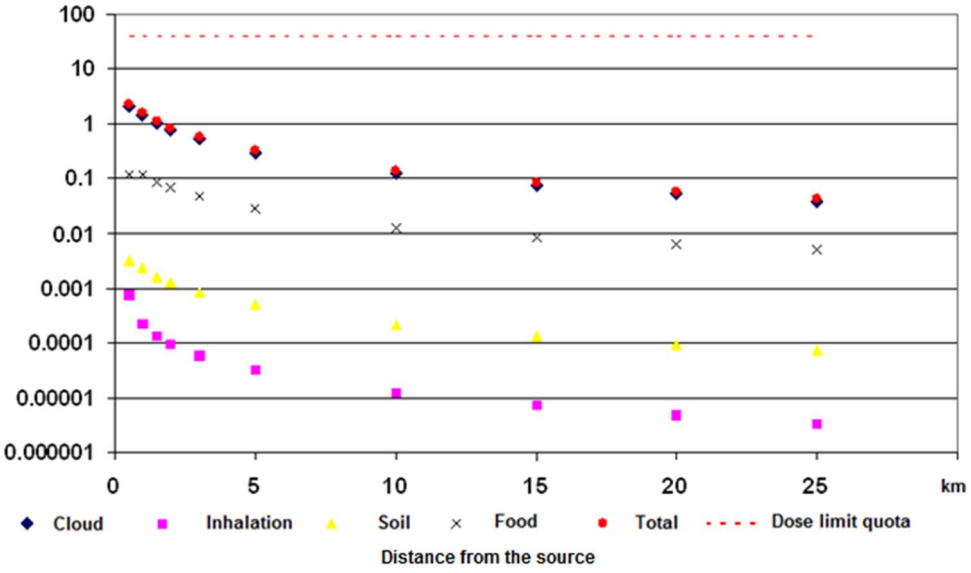

Figure 4.2 – **Dependance of the expected effective radiation exposure on the population (referent group "adult", rural population) during the 30th year of KNPP operation consiting of four power units according to the routes of impact. Azimuth 0°**

Transboundary transfer of radioactive materials

According to the removal from the source of discharge, the contamination of the territory with the radionuclides decreases rapidly, consequently, the radiation exposure for the population decreases as well (figure 6.2). Even if the plant is located directly on the border, in this case as well the limit quota of the radiation doze for population of the neighboring countries will not be exceeded (for most European countries it is higher, than for Ukraine and makes 200 μSv per hour -1)

Radioactive contamination due to gas and aerosol discharge at long distances outside the CA of KNPP cannot exceed such at the CA border due to a number of physical reasons.

Thus, one may state that the radiation exposure of the normal operation of KNPP on the neighboring countries will be significantly lower than the established dose quotas and, respectively, of the individual annual radiation exposure limit of 1 μSv.

General conclusions on the radiation exposure

Assessment made for the 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 routes of exposure for the critical group of population, was 0.6 μSv. The maximum rated individual effective dose of 2,8 μSv is received at the distance of 0,5 km to the east from the plant. At the distance of 25 km the total effective dose decreases up to hundredth parts of μSv, which indicates the absence of the additional negative impacts on the health of the population.

5 IMPACT ASSESSMENT ON THE ENVIRONMENT IN THE TRANSBOUDARY CONTEXT

For the assessment of the radiological significance of the transboundary transfer during normal operation of the power plant it is suggested to use the results of the calculation of the dispersion of the gas and aerosol discharge for the Supervised Area (SA) of KNPP. These calculations are made taking into account the actual meteorological data in the area of the NPP location with the actual reserve of persistence. As far as the distance from the source of discharge, the contamination of the territory with radionuclides decreases rapidly, which leads to the reduction of the radiation doze for population. Besides, even in the CA the radiation dose does not exceed the limits of the radiation doze for population. It means that even if the plant is located directly on the border, in this case as well the limit quota of the radiation exposure for population of the neighboring countries will not be exceeded (for most European countries it is higher, than for Ukraine and makes 200 μSv per hour -1).

Radiation exposure of the NO of KNPP on the neighboring countries will be significantly lower than the established dose quotas, and, respectively, of the individual annual radiation exposure limit of 1 μSv.

6 IMPACT ASSESSMENT ON THE ENVIRONMENT DURING ACCIDENTS

Non-radiation exposure assessment

Impact of the non-radiation exposure is of the local nature and respectively their review in the transboundary context is not required.

Radiation exposure assessment

For the analysis of the radiation exposure during accident MDBA and BDBA were studied.

As Maximum Design-Basis Accident (MDBA) (the most severe design-basis accident) was chosen the scenario with the rupture of the main circulation pipeline.

As Beyond Design-Basis Accident (BDBA) was chosen the scenario with the RCC guillotine rupture Du 2×850 mm with the failure of ECCS active part and operating sprinkler system.

The probability of the reviewed BDBA is $4{,}29 \cdot 10^{-7}$/reactor year, which is in the permissible range of the considered BDBA under the value of the "sifting" criteria 10^{-8} [1].

Discharge into the air during MDBA as well as during BDBA shall be defined by the leakage of the power unit containment and by the period of the increased pressure in it. Discharge into the air comprises RNG, radioisotopes of iodine, aerosols ^{137}Cs, ^{90}Sr and other radionuclides.

Impact on soils and agricultural food

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

Made analysis showed that for KNPP SA the critical source of radionuclides route in the agricultural food during probabilistic accidents will be meadows and pastures, located in the valley of the river Horyn. Consequently, the route of the radionuclides migration at the early stage of the accident as well as at further stages will be the chain pastures-animals-livestock products-person.

The assessments of the agricultural products contamination during MDBA and BDBA showed that as the result of the aerial contamination at the early stages of accident, the excess of the permissible levels of the radionuclides is possible. At the distances up to 30 km from the source of discharge, the radioactive contamination of the agricultural products can exceed the lower levels of

justification of intervention and of the actions in restrictions of the local agricultural products, established by NRBU-97 [2].

Impact on flora and fauna

According to the results of the calculations during emergency situations, the short-lived radionuclides can be studied as the main dose-forming radionuclides for the biocenosis.

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.

Impact on the population

Individual radiation exposure on the population due to MDBA has been evaluated. Made conservative estimates of the radiation exposure on the population taking into account all routes of exposure, except for routes of radionuclides with food, showed that during MDBA no emergency or urgent countermeasures (including iodine prophylaxis) are required. 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.

Radioactive contamination of the agricultural products in the CA during MDBA can exceed the criteria of the decision making about withdrawal, replacement or restrictions of such products consumption at the distances up to 30 km, established in NRBU-97 and DR-2006 [2,3]. In other words there is the probability of the necessity to perform long-term countermeasures.

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.

The individual effective radiation exposure on population due to BDBA has 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.

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. 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.

As the result of the aerial contamination of crops and pasture vegetation, the radioactive contamination of the agricultural products in the CA during BDBA can exceed the criteria of the decision making about withdrawal, replacement or restrictions of such products consumption at the distances of 30 km, established by NRBU. In other words there is the probability of the necessity to perform long-term countermeasures.

During BDBA along the trace axis, one can expect the excess of the admissible levels of the ^{137}Cs content in milk, cattle meat, bread grain and leaf vegetables can be expected at the distance of 25 km and more from KNPP, in cabbage – up to 20 km, in fruit – up to 10 km away from KNPP. During BDBA the 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, established by DR-2006, in milk – up to 10 km, as well as at small distances up to 4-6 in meat km, vegetables and fruit. According to the conservative evaluations, 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 before and behind the border (up to 40 km from KNPP) gives the ground to rise the restrictions of its consumption during BDBA. Herewith, on the CA border such restrictions can continue for a 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) [2]. When using the certainly justified levels of intervention (for the decisions making on withdrawal, replacement or restrictions of the radioactively contaminated food consumption) in line with NRBU-97 [2], the parameters of the restrictions (prohibition period, farmland areas etc,) will be significantly lower.

So, as the countermeasures during accidents, probably the restriction to consume local agricultural products at a certain territory will be required.

Assessment of the accident consequences at the territory of the neighboring countries

Taking into account, that KNPP is located at the distance of 160 km from the border with Belorussia and of about 190 km from the border with Poland, for the solution of the transboundary movement of the radioactive discharge from KNPP the mesogrid Lagrangian-Eulerian diffusion model of the atmospheric transfer (LEDI) was chosen.

According to the findings of the assessment of the transboundary transfer consequences for the reviewed accidents – MDBA and BDBA, the following can be concluded:

- Calculations, made with the help of the mesogrid model of the atmospheric transfer LEDI, showed that under no studied accident the level of the individual annual effective dose [4] for the members of the reference group in the neighboring countries will be exceeded;
- The children's age group (1-2 years) remains critical. The critical meteorological scenario is scenario 3A, according to which the fallouts happen during vegetation of plants. For this meteorological scenario the main way of the dose formation (for all studied accidents) is the food chain. About 99% of the dose is formed according to it;
- The main dose-forming radionuclide under hypothetical accidents for all studied meteorological scenarios is 131I.

Conclusions

Impacts of the accident non-radiation exposure and discharge on the environment are excluded.

Assessment of the radiation exposure during MDBA and BDBA are as follows:

- Radioactive contamination during MDBA and BDBA will not lead to any changes of the physicochemical and water physical peculiarities of the soil;
- Changes in flora and fauna at the species level are unlikely (though radiobiological effects by conifers during BDBA can be observed at the restricted territory along the trace axis); structural changes of the biocenoses under the influence of radiation factors outside the CA will not occur;
- Reviewed accidents (MDBA, BDBA) do not pose radiation hazards for the Ukrainian population, since according to all criteria of the regulatory documents of Ukraine, Russia, Great Britain, European Community outside the CA there is no need for evacuation, shelter, iodine prophylaxis, constant relocation, but there can be necessity for restriction in food consumption. Risks of deterministic effects are zero. Risks of individual stochastic effects (severe hereditary effects and cancer fatalities) during MDBA are lower than the acceptable level of 10-5, during BDBA in case of failure to carry out countermeasures they exceed the limit of the acceptable individual risk at the distance of 4 km from the source of discharge; in case of countermeasures the individual risks of the stochastic effects do not exceed the limit of the acceptable individual risk for population;
- Under none of the reviewed accidents the level of the individual annual radiation exposure on the members of the referent group in the neighboring countries will not be exceeded.

REFERENCE LITERATURE

1 Proceedings of the IAEA Regional Workshop on "Evaluation of Specific Preventive and Mitigative Accident Strategies". Russia, Volgodonsk, September 2004.

2 DGN 6.6.1.-6.5.001-98 (NRBU-97) Radiation Safety Norms of Ukraine. State Sanitary Norms.

3 Hygienic standards ГН 6.6.1.1-130-2006. Admissible levels of the radionuclides ^{137}Cs and ^{90}Sr in food and in water (DR-2006).–Kyiv, 2006.

4 Council Directive 96/29 EUROATOM of 13 May 1996.

5 DGN 6.6.1.-6.5.061-2000 (НРБУ-97/Д-2000)) Radiation Safety Norms of Ukraine. Supplement: Radiaction protection from the sources of potential exposure. State Sanitary Norms of the Ministry of Health of Ukraine.. GDSLU Resolution № 116 of 12.07.2000.