

Evaluation of relevant aspects of the Environmental Impact Assessments for Completion of the Nuclear Power Stations Rivne Unit 4 and Khmel'nitsky Unit 2

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1 Environmental Impact Assessment according to EU provisions required

The EBRD commissioned Mouchel Consulting Ltd to conduct an Environmental Impact Assessment (EIA) for two Nuclear Power Plants (NPPs) in the Ukraine: The completion of Rivne Unit 4 and Khmelnytsky Unit 2.

It is stated in Sections 1.1 of both reports that the radiological EIA for these NPP shall be based on data corresponding to that listed in Commission Recommendation 91/4/Euratom and that the EIA with reference to non-radiological aspects would have to be made in accordance with Articles 3 and 5 of Directive 85/337/EEC (EIA-Directive).

The latter Directive has been amended by Council Directive 97/11/EEC of 3 March 1997. The new requirements for national EIA set by Directive 97/11/EEC came into force in April 1997, some time before the two EIA on the NPP in question have been conducted by Mouchel Consultant in 1998. If EBRD and its consultant regarded the old provisions of the original EIA-Directive to be the yardstick they would miss the European legal requirements for EIA of 1998. It means that both Rivne 4 and Khmelnytsky 2 assessments need to comply with the amended Article 3 and 5 of the EIA-Directive 85/337/EEC. In other words, the EIAs conducted by Mouchel Consulting Ltd. have to match those principals that set the minimum¹ procedural EIA standards in the EU.

2 Information and assessment obligations in EIA Directive

According to Article 5.1 the developer has to supply in an appropriate form information specified in Annex IV if the information is relevant to a given state of the consent procedure and to the specific characteristics of a particular project or type of project and of the environmental features likely to be affected (Article 5.1 a).

Pursuant to Article 5.3 required is at least

- a description of the project, comprising information on the site, design and size of the project,
- a description of measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects,
- the data required to identify and assess the main effects which the project is likely to have on the environment,

¹ EU-Member-States may lay down stricter rules to protect the environment (consideration (3) of Directive 97/11/EEC).

- an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects,
- a non-technical summary of the information mentioned in the previous indents.

Pursuant to Article 3 the purpose of an EIA is to identify, describe and assess in an appropriate manner, in the light of each individual case and in accordance with Article 4-11 the direct and indirect effects of a project. The direct and indirect effects of Rivne 4 and Khmelnitsky 2 on the following factors need to be examined to comply with Article 3:

- human beings, fauna and flora
- soil, water, air, climate and the landscape
- material assets and the cultural heritage
- the interaction between the factors mentioned in the first , second and third indents.

3 Deficits of data basis and/or assessment of effects in EIAs

However, a whole range of relevant information and data is either not or inadequately compiled and/or evaluated in the EIA reports for Rivne 4 and Khmelnitsky 2. This chapter presents some important examples in order to illustrate these deficits.

3.1 Infrastructure

3.1.1 Major roads

Explosive substances could be carried along the sites of the NPPs by trucks. Traffic accidents with such trucks can cause explosions. A gas cloud could drift towards an NPP and explode nearby. This is a kind of accident that is investigated in international safety studies as a design-basis accident. Therefore it is necessary to investigate distances of roads, traffic on the roads, i.e. importance for transit or delivery of explosive substances. Such an investigation has not been made in both EIAs; consequently it is impossible to assess the possible impact of such an accident.

Traffic must also be investigated in connection with the amount of truck movements necessary during the completion of the NPPs. To evaluate the environmental impact by noise and other emissions it is necessary to compare the additional traffic with the existing traffic and the conditions of the roads. Such an assessment and an evaluation is not possible due to the missing information in the EIA reports.

3.1.2 Railways

For the same reasons as mentioned above for roads it is necessary to investigate distance and traffic of railways nearby the NPP sites. A major railway, connecting Kiev and Brest, passes the site of Rivne NPP in a very small distance (some 100 meters). Another major railway passes the Khmelnytsky NPP site in a distance of about 8 km.

Nearby the Rivne NPP site two railways can be identified by maps, that seem to connect industrial complexes to the national railway net. Normally transports to and from industrial complexes include transports of explosive or burnable materials.

No information is given by the EIAs about railways and their traffic so that the possible impact cannot be evaluated.

3.1.3 Pipelines

Explosive or burnable substances are often transported by pipelines. Broken pipelines can also cause an emission of a gas cloud that can drift toward an NPP and explode nearby. No information is given by the EIAs about pipelines so that it is impossible to evaluate the possible impact.

3.2 Socio-economic data

The given socio-economic data are not detailed enough for a EIA. Information is mainly given about the percentage of people employed in material production and industrial enterprises in a 30 km zone around the sites. There is no information about distances of industrial facilities, the kind of facilities, numbers of employees etc.

The EIAs state that there should be no negative impact to the NPPs by industry, but the reasons for this conclusion are missing. On the other hand there is no information about possible negative impacts on the other industrial facilities and the people working there by the NPPs.

Therefore it is impossible to evaluate the impact of the NPPs regarding the socio-economic framework and even health effects.

In the EIA for Khmelnytsky 2 land use is described on the basis of the Netishin District and the area of 30 km radius around the NPP. Information about the percentage of ploughed land, land used for production of hay, pastures and as gardens etc. is given, also information about the number of farming enterprises and numbers of cattle, pigs and sheep etc. The EIA for Rivne 4 gives also information about soil qualities and two tables with numbers of farmland enterprises and sums of used hectares by districts and about used hectares for special purposes in the 30 km zone around the site.

Nevertheless, in both EIAs the given information is totally insufficient to evaluate potential impacts. The impacts strongly depend on the distance to the NPPs so that detailed information about the distances of enterprises, farmlands etc. must be known to evaluate the consequences. This is especially important because in the EIAs possible impacts by airborne releases are only assessed as a radiological dose for people outside the 3 km zone around the NPPs. From this assessment the conclusion is drawn in the EIAs that no relevant impacts to animals, plants etc. are expected <see sections 7.1.6>. Obviously it would be necessary to calculate the dose to men at the point with the highest impact to use it in the described comparison, because no information about potential doses is given for distances closer than 3 km to the NPPs in the EIAs.

The EIAs also ignore the fact that food produced in a nearer distance to the NPPs than 3 km can contribute to the dose to men. Therefore detailed information about the use of land in a distance up to 3 km around the NPPs is necessary for the evaluation.

3.3 Meteorological data

Knowledge of the site-specific meteorology is necessary to calculate potential doses to the population by emissions of radioactive substances. This includes long-term statistics of wind speed, wind direction, atmospheric stability and precipitation. Commonly „long-term“ means a statistic over ten or more years because of major differences between short-term statistics (for example over 2 years) and long-term statistics. A meteorological statistic varies by location if there are influences by land shape, hydrological situation etc. Therefore the meteorological stations that are used for the impact assessment should be located at the site, especially when there are NPPs in operation over some years.

The meteorological data used in the EIA for Khmelnitsky 2 are derived from stations situated 20 to 40 km from the NPP site. Information about air temperature, humidity, cloud cover, precipitation and snow covers only two years (1996 and 1997). No information is given about the covered time by the average wind and atmospheric stability data. The maximum daily precipitation mentioned in the text of the EIA is 112 mm, but the tabulated maximum value for the year 1996 is 20.7 mm.

In the EIA for Rivne 4 the meteorological data are based on observations at stations in a distance of at least 30 km. There is no information about the observation time that is the basis of the given average values for air temperature, humidity, cloud cover, precipitation, snow, wind and atmospheric stability.

Thus the meteorological data base remains quite unclear for both NPPs. From experience it can be stated that the uncertainties cause a low reliability of the calculated dose for the

population from normal operation and accidents. A better data base could result in calculated doses that are a factor of two or more higher than the doses presented in the EIAs.

3.4 Fauna, Flora, Landscape (Nature reserves)

In the EIA reports numbers of nature sanctuaries, parks, monuments of nature etc. are presented for districts and the 30 km zones. Detailed information about the distances of the protected areas and monuments is missing. Only the EIA for Khmel'nitsky 2 NPP presents a map (figure 3.7) which shows the nearby surroundings of the NPP site with locations of endangered or rare species. Those are mainly located nearby the reservoir (in its south).

Detailed information about nature reserves and protected species are necessary to evaluate possible impacts. Such impacts are not covered by the dose calculations for the public, because for example, also noise, traffic and steam production caused by construction and operation of the NPPs can cause damage do species. Therefore the information given in the EIAs provides no sufficient basis for an appropriate evaluation of impacts.

3.5 Hydrological situation

3.5.1 Hydrological situation at Khmel'nitsky NPP

At the Khmel'nitsky NPP site a water reservoir is used for cooling of „Group B and C“ consumers. These consumers are defined as „non-critical users“ in the safety sense. The cooling water supply for „Group A“ consumers, defined as „critical users due to safety considerations“ is by the Goryn River. Radioactive wastewater from the Khmel'nitsky NPP is discharged into the reservoir.

The reservoir collects water in an area of 195 km² and, at capacity has an area itself of 20.2 km². The maximum capacity of the reservoir is 120 million m³. The reservoir can be filled with water from the Goryn River. According to the EIA this is only allowed from October to May. Also water from the reservoir can be discharged to the Goryn River.

The average water flow of the Goryn River is stated to be 15.6 m³/s. In winter the minimal flow rate is more than 4.21 m³/s (probability 50%), more than 3.20 m³/s (probability 75%), more than 2.14 m³/s (probability 95%) and more than 1.94 m³/s (probability 97%). It is stated that the river water is used for angling, watering of cattle, irrigation, economic and domestic purposes and for industrial water supply. The daily maximum and minimum water temperatures during 1996 were 26 °C (June; more than

20 °C in May to September) and 0 °C (December and January). Data for other years than 1996 are not given in the EIA for the Khmelnsky NPP. This means that the given maximum and minimum data are of very poor statistical value.

The needed cooling water supply is described in the EIA for the Khmelnsky NPP as follows:

- The design rate of maximum water intake from the Goryn river for group A consumers is 1.2 million m³/yr for unit 2. The other source of replenishment water is from artesian wells and providing 0.01 million m³/yr.
- The design water consumption for the main cooling system and group B consumers is 16 million m³/yr.

The balance of water for the two units of the Khmelnsky NPP on the basis of revised data is, according to figure 4.8b in the EIA report:

- water intake from Goryn river: 23.86 million m³/yr,
- influx and precipitation: 28.46 million m³/yr,
- water consumption in the NPP: 42.79 million m³/yr,
- discharge to Goryn river: 10.44 million m³/yr.

This means a loss of 13.42 million m³/yr of evaporated water from the Goryn river. The average water flow of the Goryn river is 15.6 m³/s, respectively 490 million m³/yr. In winter the average flow rate for one month is less than 4.00 m³/s, respectively 10.7 million m³/month with a probability of 25%. The 28.46 million m³/yr water from influx and precipitation are also consumed so that the equilibrium of water supply ist disturbed.

The Khmelnsky NPP site can be regarded as very disadvantageous for the operation of NPPs from the view of cooling water supply. Probably the site is one of the sites in Europe with the lowest water supply. The mentioned figures must also be seen in connection with freezing river in winter. This fact is not adequately investigated in the EIA. There are a lot of relations that were not assessed or evaluated:

- need to enhance the water capacity in the reservoir,
- flooding of rare species nearby the reservoir,
- extreme raise of temperature in the Goryn river,
- loss of water in the region with possible consequences for other consumers,
- need to shut down the NPP in times with insufficient cooling water supply (this means that no real substitution of Chernobyl NPPs ist possible).

3.5.2 Hydrological situation at Rivne NPP

The Styr river serves as the source of cooling water for the Rivne NPP. The catchment area of the Styr river is 10,400 km². The average water flow at the NPP intake site is stated to be 39.4 m³/s in the EIA report. The observed minimum flux (observation time-span unclear) is stated to be 9.33 m³/s in August. The maximum water temperature is stated to be 21.5 °C (July and August). According to the EIA report the river freezes from a date between 17 November and 24 December with the date of melting varying between 12 March and 13 April.

Fish is produced, in the main, by local pond farms. River fishing is, according to the EIA report, of an exclusively amateur nature. The rivers water is not used as source of drinking water but used for watering kitchen gardens, cattle and other agricultural needs.

In the Executive Summary of the EIA report the following numbers are given: „R4 alone will require in the order of 19 million m³ of water from the Styr per annum. It will also require an increased water requirement from artesian sources. This increase represents approximately 50% of the current abstraction of 7.5 million m³ per annum.“

The water balance for Rivne Unit 4 is described as follows in the EIA report for the Rivne NPP:

- The water intake from the Styr river for the main cooling system and group A and B consumers is 20.54 million m³/yr.
- The designed bleed-off to Styr river is 1.80 million m³/yr.
- Losses from the cooling tower are 18.34 million m³/yr.

The balance of water for the four units of the Rivne NPP are described in figure 4.8 in the EIA report:

- water intake from Styr river: 67.56 million m³/yr,
- water intake from artesian wells: 10.99 million m³/yr,
- water losses (mainly steam) from the NPP: 67.17 million m³/yr,
- water drain to Styr river: 11.38 million m³/yr.

The intake from artesian wells is a major problem. At the NPP site the ground water level is 1.69 to 1.81 m. The issue is also mentioned in the Executive Summary of the EIA report: „Recent safety studies have indicated that ground water levels at the NPP site must be maintained in order to ensure adequate protection against design-basis earthquakes.“ A system for monitoring groundwater levels is therefore recommended in section 3.2.8 of the EIA report. A reduced ground water levels has or can have a lot of consequences:

- problems with protection against design-basis earthquakes,

- damage to plants and animals,
- missing water supply for other purposes, for example in industry and agriculture.

According to the EIA, the forests and marshes provide a natural setting for a wide range of flora and fauna including several species that are listed in the Red Data Book of the Ukraine. This fact is mentioned but the obviously possible impacts are not investigated.

The EIA does not investigate these possible consequences. Therefore the EIA is insufficient to give an adequate evaluation of consequences from the project.

3.6 Geological situation at Rivne NPP

The geological situation at Rivne NPP site is described in section 3.2.8 „Geology and hydrology“ of the EIA report. The section mainly deals with the hydrological situation. Major problems that are caused by the water consumption of the NPP are described here above in section 2.2.4.2: The protection of the NPP against earthquakes is influenced by the water consumption.

This is the result of the very disadvantageous geological situation at the site which is characterised by porosity of the ground. Therefore even the sufficient stability (without respect to earthquakes) of the facilities at the site is questionable. Major problems with the ground during construction at the NPP site were reported but are not mentioned in the EIA report.

3.7 Emission of pollutants - radiological consequences during normal operation

3.7.1 Emissions and dose to members of the public

In Ukraine, the permissible releases depend on the effective power of the NPP unit. Calculation of average permissible liquid discharges depends on the particular conditions, such as water utilisation which are specific to each NPP. As a consequence the calculation is carried out each year taking into account the amount of water used by each NPP.

The calculated maximum permissible releases of radioactive substances for Khmelnytsky Unit 1 and Rivne NPP in 1995 are given in table 2.1, below. There is a difference in this table to the corresponding tables in the EIA reports because in these tables of the EIA reports the so-called „permissible“ liquid releases were results of measurements instead of permissible releases. This could be proved by comparison with the number in section

6.3.5.1 of the report. The EIA for Rivne 4 NPP gives also different numbers for the liquid discharges in chapter 6.3.5.1. Those numbers are implemented here in table 2.1.

Table 3.1: Calculated permissible emissions for Khmelnytsky NPP and Rivne NPP in 1995 (in Bq/year)

Radionuclide (group)	Khmelnytsky	Rivne
Airborne releases		
Noble gases	6,67E+15	9,40E+15
Long-lived nuclides	2,03E+11	2,81E+11
I-131	1,35E+11	1,89E+11
Cr-51	6,67E+09	9,36E+09
Mn-54	6,67E+09	9,36E+09
Co-60	6,67E+09	9,36E+09
Sr-90	6,67E+08	9,36E+08
Cs-134	6,67E+08	9,36E+09
Cs-137	6,67E+09	9,36E+09
Liquid discharges		
Co-60	1,07E+10	1,40E+11
Sr-90	2,15E+08	2,08E+11
Cs-134	2,22E+09	7,63E+10
Cs-137	1,11E+09	4,34E+11

The releases were compared to releases of French PWRs in the EIA reports. The conclusion in <EC 1998a, chapter 6.4> is: „It is apparent that, even if French limits for atmospheric discharges are lower than Ukrainian ones, the released activity of KHNPP in 1995 was well below both Ukrainian and French limits.“ The comparison in the two EIA reports is summarised here in table 2.2, below.

Table 3.2: Comparison of radioactive releases at KNPP, RNPP and French NPPs in 1995 (in Bq/year)

Radionuclide group	Khmelnytsky NPP		Rivne NPP		French NPPs	
	Released	Limit	Released	Limit	Released	Limit
Airborne releases						
Long-lived nuclides	8,06E+07	2,03E+11	3,90E+08	2,81E+11	2,20E+08	1,88E+10
Noble gases	5,70E+13	6,67E+15	1,00E+14	9,40E+15	7,30E+12	5,75E+14
Liquid discharges						
Long-lived nuclides	2,30E+09	1,40E+10	4,10E+10	8,60E+11	2,20E+09	5,50E+11

The liquid discharges from the Khmelnytsky and Rivne NPPs are higher than the discharges of French NPPs, according to table 2.2. For the Rivne NPP the discharges are

a factor of about 20 over the French data. Additionally it must be regarded that in other EU-states than France the liquid discharges are even more lower. German NPPs have discharges in the order of 10^8 Bq/year, related to long-lived radionuclides (without tritium) as average value for all German NPPs. In some other countries NPPs discharge more radioactivity, especially in the United Kingdom, where the NPP sites are situated at the sea. For the Ukrainian situation - sites at rivers with low water flow - discharges should generally be minimised. Such a minimisation is obviously not planned in the Ukrainian reactors.

According to the EIA reports there is currently a lack of requirements concerning the release of tritium into the environment. A new regulation is in preparation that is expected to cover this issue. Routine releases of tritium normally are in the order of 10^{12} Bq/year. Therefore it is very important to set limits for the airborne and liquid releases.

The source term used for the calculation of the dose caused by routine releases to the atmosphere is the same for Rivne unit 4 and Khmelnytsky unit 2 in the EIAs. The source term is different from the calculated limits of releases for 1995 (see above). For example, the limits for releases of Iodine-131 to the atmosphere are by a factor of 1000 to 1500 higher than the source term. For Strontium-90 the factor is 6200 to 8600, for Cesium-137 it is 2200 to 3000. Therefore the dose calculations in chapter 7 of the EIA reports are based on a wrong source term, because it is quite useful and necessary to take the authorised limits as source term for the evaluation.

The EIA for Rivne 4 NPP even states that the Iodine-131 in the source term is a factor of 3 lower than the actual discharge in 1995 and a factor of 5 lower than the actual discharge in 1996. The same statement is written in the EIA for Khmelnytsky 2 NPP. Table 7.4 of the EIA reports gives a breakdown of the dose between pathways and radionuclide. Contributions by iodine or aerosols are far below 1%. The EIAs' conclusion is: „Given the contribution of noble gases and cloud exposure to total estimated doses, the uncertainties in the source term for radionuclides such as I-131, Sr-90 and Cs-137 ... cannot be expected to have any significant on the overall conclusion.“ <EC 1998a and EC 1998b, section 7.1.4.3>.

But this conclusion depends on the wrong definition of the source term. With the allowed limits of releases the contribution of Iodine-131, Cesium-137 etc. would be significant.

In general, the assessment of environmental impacts has to consider the releases that are allowed or planned to be authorised. This is quite usual and necessary because the operator can make use of the authorised limits without further investigation. Therefore

the EIA reports do not investigate the consequences of normal operation in the common sense.

In a lot of other countries the dose limits have to be respected not only in a distance of 3 km from a NPP, but at its fence, for example. According to the EIA reports, there are no villages nearer to the NPPs than 3 km. But it is also necessary to consider isolated houses and people outside their houses, spending their free time or working. To consider food consumption, agriculture and private collection of wild foodstuff must be included in the dose calculations. In <EC 1998b, section 3.2.4.3> it is stated: „Forest products, such as mushrooms, berries and nuts, represent a small addition to the population’s diet in terms of quantity.“ It is commonly known since the Chernobyl accident that mushrooms, berries and nuts can accumulate much more radioactivity compared to „normal“ agricultural products. Therefore the argument that only „a small addition to the population’s diet in terms of quantity“ is represented by mushrooms, berries and nuts does not exclude significant contributions to dose by this pathway.

In section 7.1.5 of <EC 1998b> the dose by liquid discharges is calculated on the basis of a river water consumption rate of 2 litres per day. The monitoring at the discharge point gives concentrations of about 10 to 100 Bq/m³ Cesium-137 in the Styr river (figure 7.4 in <EC 1998b>). The dose is calculated for the value of 100 Bq/m³ Cesium-137; the result is about 0,001 mSv/year respectively a factor 50 below the corresponding Ukrainian dose limit of 0,05 mSv/year.

The calculation model ignores that the consumption of fish results in a higher dose than the drinking water pathway. Cesium is concentrated by a factor 1500 l/kg in fish, according to the German regulations. This means that the concentration of Cesium in fish can be 150 Bq/kg. The consumption of 40 kg fish/year then results in a dose that is higher than the Ukrainian dose limit.

Furthermore the dose must be calculated on the basis of the limits of liquid discharges, this means $4,34 \cdot 10^{11}$ Bq/year. Even a total dilution with the average water flow over the year, 39,4 m³/s for the Styr river, results in an average concentration of 350 Bq/m³ over the year. This is a factor 3.5 more than the concentration used for the dose calculations in <EC 1998b>. This shows the insufficiency of modelling and source term for routine releases in the EIA report again.

At the Khmelnytsky NPP site the radioactive wastewater is discharged to the reservoir. In <EC 1998a> the dose is calculated with the assumption of equally dispersion throughout the volume of the reservoir (120 million m³). The calculated concentrations for Cs-134 and Cs-137 are 18 and 0.74 Bq/m³. But with the discharge limits the concentrations would be 18,5 Bq/m³ (Cs-134) and 9,25 Bq/m³ (Cs-137). With the concentration factor

of 1500 l/kg for fish (the factor 100-1000 mentioned in <EC 1998a> is not conservative) the calculated concentration in fish is about 14 Bq/kg Cs-134 and 28 Bq/kg Cs-137. The fish consumption rate of the modelling in <EC 1998a> is 0.2 kg/day resp. 73 kg/year. The dose then is about 90% of the corresponding Ukrainian dose limit. This means that with respect to other radionuclides and the accumulation in the reservoir over years the dose limit will be violated.

Even the EIA for Khmel'nitsky NPP mentions some radioecological problems with the reservoir: „The situation regarding aquatic discharges to the cooling reservoir requires further investigation given the fact that the reservoir is already used for fish farming and that this practice could be extended. Preliminary but cautious calculations indicate that the individual annual dose to a member of a reference group consuming fish produced in the cooling reservoir and drinking water from the reservoir might approach 0.027 mSv/yr. This figure is 54% of the corresponding limit applied in Ukraine. ... The calculations will be refined as part of the Environmental Action Plan for the project.“ <EC 1998a, Executive Summary>

The radioecological impact on the reservoir is a very important point. Probably further NPPs can not be operated at the site without significant damage. Therefore it cannot be accepted that further investigation is postponed to an EAP. It is the purpose of an EIA to investigate and finally evaluate the consequences.

3.7.2 Consequences for other species than human beings

In the summarising section 7.2 of the EIA reports it is stated: „It is part of the basic philosophy of radiation protection that, if man is adequately protected then so will other species.“

From this thesis the conclusion is drawn that there will be no effects on other environmental factors. This „investigation“ is absolutely insufficient. At least a calculation of dose at the point nearby the NPPs with the maximum expected dose per year would be necessary. It is impossible to evaluate effects on other environmental factors than man, when the dose to man is only calculated for distances of 3 km and more.

3.7.3 Occupational collective dose

The collective dose for the workers in Khmel'nitsky NPP in 1996 is stated to be 3.21 man-mSv/MWe <EC 1998a, table 5.10>. In <EC 1998b, table 5.10> a value of 2.65 man-mSv/MWe is given for Rivne NPP.

The EIA reports state: „The average annual dose and station collective doses are not very different from those for Western PWRs. For example, the average annual dose for all EDF PWRs during 1995 was 4.34 mSv for external workers and 1.55 for EDF workers. The collective dose for all EDF PWRs was 1.6 man-mSv/MWe.“

The comparison with the average collective dose of French reactors is insufficient for the evaluation. The collective dose is much higher for older reactors than for those that started operation in the 1980s. For example, the collective dose for the last three German NPPs is about 0.15 man-mSv/MWe <Hock 1998>. For the three oldest German reactors the collective dose is more than one order of magnitude higher.

To evaluate the collective dose of Rivne 4 NPP and Khmelnytsky 2 NPP the expected collective dose has to be compared to the standard of new western NPPs. This comparison shows a level of collective dose in the Ukrainian NPPs that is about one order of magnitude above the standard in the last generation of German reactors.

Moreover, the tables 5.10 in the EIA reports show an inexplicable inconsistency. Whilst the average individual exposure dose for Ukraine NPPs in the report on Rivne is 2.00 mSv/year, it is said to be 2.22 mSv/year in the Khmelnytsky report. The collective dose differs similarly between 2.65 man.mSv/MWe (Rivne EIA report) and 3.21 man.mSv/MWe (Khmelnytsky EIA report).

3.8 Nuclear Safety

3.8.1 Safety design

The EIA reports do not give much information about the planned safety design of the NPPs. The purpose of an EIA related to the safety issues is mainly to investigate the consequences of incidents and accidents. But even the given information shows that internationally accepted and implemented rules were violated:

- According to figure 4.5 in the EIA for Rivne 4 NPP the cooling water supply is not redundant. There is only one make-up water pump room and one pipe. The water supply of the three group A consumers spray ponds are not separated, also not the group A backup spray pond. The normal standard would consist of four absolutely separated cooling systems.
- The cooling system for group A consumers for Rivne Unit 4 is not separated from the system for Unit 3.
- According to figure 4.5 in the EIA for Khmelnytsky 2 NPP the cooling water supply is also not redundant. The water supply of the three group A consumers from the Goryn river is not redundant.

For some safety aspects it is stated, that they are similar to western PWRs. The EIA reports say that the scram signals were „quite commensurate to those of western PWRs“. This statement is only „proved“ by a list of five criteria for scram (for example „neutron flux“, „primary coolant system“). The safety standard strongly depends on the limits (e.g. height of neutron flux), the measurements (measured parameters, redundancy of measurements) and the management of the results to produce the signal „scram“. Therefore the information in the reports is not sufficient to give any prove to the stated standards.

Nevertheless, information about safety design and reconstruction concepts are available and were evaluated by several organisations. Some of these studies raised a lot of safety problems, for example:

- insufficient qualification of equipment,
- problems with control rod insertion,
- insufficient redundancy and separation of cooling systems and other safety-related systems and components,
- deficits in the design of electrical power supply and emergency power supply.

Therefore the completion of the NPPs by the planned standard would mean that the safety of the NPPs will be far below the standard in western European countries.

3.8.2 Consequences of accidents

For the assessment of the consequences of accidents in the NPPs the EIAs define a „worst-case design-basis accident“. Radiological consequences are calculated and compared with the „lower threshold for internationally accepted criteria for the implementation of emergency countermeasures“. In principal, this method does not fulfil the demands in a lot of other countries, because there are also special defined dose limits for incidents (far below thresholds for the implementation of emergency countermeasures), for example in Germany, Switzerland and the United Kingdom. In some cases the dose limits are combined with the expected probability of incidents.

Concerning the assessment of radiological consequences of accidents the EIA reports promise further investigations: „The assessment will be repeated once the safety analysis has been completed and submitted to the nuclear regulatory authority and prior to the unit being put into operation.“ <EC 1998a, Executive Summary>.

The defined „worst-case design-basis accident“ in the EIA reports is a rupture of a main cooling pipe. This accident was seen as a worst-case accident up to the 1960s in deed. Nowadays it is commonly known that it is much more difficult to handle other kinds of accidents that do not cause loss of primary cooling water, for example station black out

or failure of the secondary cooling cycle. The probability of those accidents can be much higher than the probability of a rupture of a main cooling pipe.

For example, in Germany the following design-basis accidents must be investigated in their consequences and resulting releases of radioactive nuclides to the environment:

- large leakage of a main cooling pipe,
- small leakage of a main cooling pipe,
- leakage in a steam generator,
- several kinds of loss of cooling water from the secondary cooling cycle, also combined with a leakage in the steam generators,
- loss of primary coolant outside the containment,
- incidents in the off-gas system, ventilation system and waste water system,
- earthquake,
- reactivity incidents and incidents concerning the power distribution in the reactor core,
- long-term loss of power supply,
- leakage in the emergency cooling systems,
- internal flooding,
- drop of fuel elements, drop of heavy weights into the cooling pond for spent fuel, loss of water from the cooling pond for spent fuel,
- internal fire,
- internal explosions,
- turbine rupture,
- over-speed of a main cooling pump combined with a loss of primary coolant accident,
- impacts from outside: fire, flood, flash and other natural impacts.

Obviously, the reduction of the assessments in the EIA reports to the rupture of a main cooling pipe means that a lot important accidents were not considered. Therefore the analysis is absolutely insufficient.

A further insufficiency is the choice of pathways and other parameters in the dose calculation in the EIA reports. Little information is given about the model parameters, but, for example the missing of the ingestion pathway (food consumption) is obvious. Also the distance from release point of 3 km is not in accordance with the models in other countries. An own calculation based on the German regulations resulted in about 300 mSv dose to the thyroid in a distance of 3 km for the released I-131 alone. The dose

in a closer distance, for example 500 m to the NPP is even more than 10 times higher. The effective dose, caused by the Cs-137 alone, is about 4.5 mSv in a distance of 3 km. The German dose limits for design-basis accidents are therefore violated by the source terms derived in the EIA reports.

A comparison with the own calculation and the results given in the EIA reports (there table 8.3) shows the obvious deficits in the used models. The doses calculated according to German regulations are more than two orders of magnitude higher than the doses calculated in the EIA reports. Additionally, it must be kept in mind that the source terms include more radionuclides than I-131 and Cs-137 and that closer distances would have to be regarded in the German regulations. Therefore the conclusion in chapter 8.5 of the EIAs is not correct. There is stated: „accumulated doses are well within the requirements applied to DBA elsewhere in Europe“.

A second accident is investigated in the EIA reports, a „beyond design basis accident“. The chosen scenario concerns a primary to secondary leak with an open dump valve on a damaged steam generator. The resulting doses, given in the EIA reports, are higher than doses of the „design-basis accident“ by about one order of magnitude.

Commonly „beyond design basis accidents“ cover accidents with core damage. This means that the accidents cause a partial or complete meltdown of the core. Such accidents can occur in the NPPs of WWER-1000 design and in western style reactors as well. Investigations of such accidents are internationally done to estimate the probability of special kinds of accidents and to calculate the consequences. Furthermore special weak systems etc. can be identified.

In connection with an EIA the investigation of „beyond design basis accidents“ should give information about the following aspects, for example:

- area with need of off-site emergency countermeasures,
- transboundary impacts (commonly major impacts cover distances of up to several hundred kilometres, so that an impacts even in foreign countries has to be expected),
- impacts on industrial zones, infrastructure etc. by the „loss of land“ after an accident.

To cover such aspects the „beyond design basis accident“ investigated in the EIA reports is the wrong choice. Other „beyond design basis accidents“ can obviously have much more serious consequences, especially accidents with damage to the core, containment bypass or core meltdown. A sufficient analyses of „beyond design basis accidents“ is missing in the EIA reports.

3.9 Radioactive waste management

3.9.1 Intermediate storage of radioactive wastes of groups I, II and III

In the EIA reports, radioactive waste is classified into three groups:

- Group I (low): cleaning and insulating material, industrial clothing and footwear, individual radiation protection means, flexible PVC, construction waste, implements and tools.
- Group II (average): pipework, reinforcement, parts of pumps and drives of control and protection systems, filters of ventilation systems, waste metal, heat insulation material, detachable detectors.
- Group III (high): scramcontrol/shim assembly tops, ionisation chambers with communication lines, heat and energy release detectors with communication lines.

At both sites the group I and II radwaste will be stored in the concrete bays at the storage facilities. Flammable waste will be stored in plastic bags. Ventilation filters will be stored without prior processing. It is planned to store the waste over 10 years.

This waste management does not fulfil common western standards. The interim storage of radioactive waste over lots of years should be performed as solid and conditioned waste. This is necessary to minimise potential releases of radioactive substances in the case incidents, e.g. fire impact. For the Rivne 4 NPP group I waste will be processed with bitumen. In this case the conditioned waste is inflammable and a fire can cause major radioactive releases.

Group III radwaste will be stored in the burials at the NPP units. Their capacity is determined to suffice for 30 years of unit's operation. No information about conditioning of group III waste is given in the EIA reports.

3.9.2 Spent fuel

At the Rivne 4 NPP spent fuel will be stored in the unit's cooling pond. At Rivne NPP site a spent nuclear fuel storage facility is planned. After start of operation the spent fuel will be transported to this storage facility and will stay there for intermediate storage over at least five years. Also at the Khmelnytsky NPP a spent nuclear fuel storage facility is planned inside the 3 km zone.

In the past, spent fuel from the Rivne and Khmelnytsky NPP has been shipped to Russia for reprocessing. „Although this practice is continuing, the project includes plans for the development of long-term storage of spent fuel on site based on dry-storage methods which meet international safety and environmental standards.“<EC 1998b and EC 1998a, Executive Summary>

An alternative is mentioned in the EIA reports: Due to financial aspects of reprocessing it is envisaged that a temporary long-term storage facility will be constructed at each Ukrainian VVER NPP. The concept consists of special dry storage containers.

3.9.3 Final disposal of radioactive wastes

The final disposal of radioactive waste is not addressed adequately in neither EIA. This is a major deficit of the assessments because the waste management is not completely described and evaluated.

Countries with NPPs normally have programs for final disposal of two categories of waste: for waste with heat production (especially spent fuel or high active waste from the reprocessing of spent fuel) and for waste without heat production. Usually two different projects in different geological formations are planned.

A concept for final disposal is absolutely necessary when the operation of NPPs is planned. Therefore this aspect had to be investigated in the EIAs.

Both EIA only state that spent nuclear fuel „is intended to be shipped to a reprocessing plant or for intermediate storage“ (sections 4.9.3 and 4.10) and that „it is envisaged that a temporary long term storage facility will be constructed at each Ukrainian VVER NPP <sections 4.10.3>.

If Ukraine wants to plan a final disposal project together with another country, at least a bilateral agreement would be necessary. It is obvious that such an agreement is impossible with Russia, because according to article 50 (3) of the RFSFR law about the protection of the natural environment the import of radioactive waste or materials from other countries with the aim of intermediate or final storage of the waste or materials is forbidden.

The disposal of the nuclear waste in the Chernobyl exclusion zone is regarded to be the only other potential option <section 4.10.3>. However, it is more than doubtful that the geological situation of Chernobyl is suitable as a final disposal.

Besides, it is unclear how far countries that finance the completion of foreign reactors get responsible for the resulting radioactive waste.

3.9.4 Non-radioactive wastes

Whilst solid household wastes for Khmelnytsky are specified in terms of waste material composition, a similar specification is missing for Rivne. Sewage sludges are also not being addressed in the Rivne EIA.

3.10 Preventive and reduction measures

The developer shall provide a description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment (Annex IV.5 EIA-Directive)

Almost no concrete mitigation measures, which are a crucial element of an EIA have been addressed in any of the EIA reports. Instead, the required mitigation measures „will be taken into account during development of an Environmental Action Plan (EAP)“ <section 9>.

As long as the final EAP does not exist it is impossible to evaluate or even show a final approval on the EIA submitted. To a large extent very crucial elements of an EIA procedure are subject to the announced EAP. Particularly mitigation measures on a range of activities and impacts mentioned in section 9 need to be known before assessing the impact of the proposed projects. The present EIAs are incomplete if they do not take into account the results on most of those topics that are listed in section 9. To outline the content of an EAP without exactly describing each relevant measure envisaged to mitigate significant adverse effects does not comply with the requirements of the EIA-Directive.

Besides, it is stated that impact during construction works associated with noise, effects of transportation, emissions to air discharges to water and disposal of solid wastes „can be mitigated by good working practice“ <executive summary>. However, good working practice should be mandatory in any case - it is not adequate to be called a mitigation measure.

3.11 Alternatives, Reasons for choice

Pursuant to Article 5.3 and Annex IV.2 EIA-Directive the developer shall provide an outline of the main alternatives studied by him and an indication of the main reasons for his choice taking into account the environmental effects. These alternatives and reasons have to be considered in the EIA-procedure.

According to the project documents <section 10> only one alternative situation, the current situation with Chernobyl Unit 3 in operation and the possibility of both Units 2 and 3 operating has been discussed. Obviously, the developer did not provide information on alternative energy supply options such as the construction of new thermal power stations based on oil, gas or coal and the implementation of energy conservation measures to reduce Ukraine's energy demands.

Accordingly the EIA is lacking a required comparative analysis of the environmental impacts of the proposed project in relation to other alternatives. Instead, the main reasons for the choice to complete Rivne Unit 4 and Khmelnytsky Unit 2 have only been put in relation to the base case alternative with Chernobyl in operation but not to any other scenario.

A more detailed assessment of different scenarios was undertaken by Stone & Webster in May 1998. Their report is attached to the documents on Rivne Unit 4 and Khmelnytsky Unit 2. It is not clear if this report actually is a part of the EIA. However, even if so, the Stone & Webster comparative assessment is limited to pure economic criteria determining a least cost option for electric power systems. Their evaluation did not take into account any environmental-related criteria. Thus it would not fulfil the criteria of the EIA-Directive in any case.

4 Procedural requirements

4.1 Authorities involved

Due to Article 6.1 authorities likely to be concerned must be given the opportunity to express their opinion on the project. Although the EIA describes an organisation chart of the relevant authorities in the Ukrainian <section 2.2.1> it gives no indication that so far there was any room for any specific authority to express their opinion on Rivne 4 and Khmelnytsky 2.

Interviews during the drawing up of the EIA reports have only been made with the Department for Nuclear Power, Nuclear Regulatory Administration, Nuclear safety Inspectorate and the Management of the plant <section 1.4.2> but not to any governmental branch in charge of environmental protection or health protection issues.

4.2 Public participation

According to the results of the reports public consultation has so far been undertaken at two stages during the EIA process.

However, the public meeting during the more relevant second stage was held in Kiev, some distance away from the planned NPPs. It is doubtful if the local population in the projected regions thus have been able to express their concerns as it is required by Article 6.2 EIA-Directive.

The reports state that „the results of that meeting in Kiev were recorded and the comments received along with those submitted in writing subsequent to or following the

meeting, were taken into account in preparing the present version [of the EIA]“ <summary section 9>. However, the authors of this review could not find any indication for this assertion.

The results of consultations and the information gathered pursuant to Article 5, 6, and 7 must be taken into consideration in the development consent procedure (Article 8 EIA Directive). The results of the public consultations must easily be identified as such - separated from other findings and information sources within an EIA. However, it remains unclear from the present EIA reports which are the public comments and how they influenced the drafting of these EIAs.

4.3 Information of other states

Where a project is likely to have significant effects on the environment in another State the State in whose territory the project is intended to be carried out shall send the State concerned as soon as possible but at least at the same time as it informs the public in its own country a description of the project including all accessible information on potential transboundary effects and considerations on the art of the final decision (Article 7.1). The other State shall have the option to participate in the EIA procedure (Art. 7.1 and 2).

The EIA documents do not mention any information or involvement of neighbouring states (Belorus, Poland, Romania, Moldavia). All these states are in a relatively close distance to the projected NPP. It should be questioned if those states (and their population) were given the opportunity to express their views on the planned NPPs.

5 Summary

The most important deficits of the EIA reports on the projects Rivne 4 and Khmelnitsky 2 are summarised below.

1. The description of infrastructure is insufficient. There is no assessment of possible impacts to the NPPs by explosive or burnable materials that are transported nearby. The information given about socio-economic data, meteorological data, fauna, flora and landscape is not detailed enough. The data are given on the basis of 30 km zones respectively districts so that the distance to the NPP of relevant parts of the local situation is unknown. Meteorological data are of poor statistical value and not site specific though these data are very important for the calculation of radiation doses.
2. The Khmelnitsky NPP site can be regarded as very disadvantageous for the operation of NPPs from the view of cooling water supply. The EIA reports do not investigate possible consequences of the water consumption sufficiently. The geological and

- hydrological situation at the Rivne NPP is so disadvantageous that sufficient stability especially in the case of an earthquake is questionable.
3. Doses to members of the public are underestimated. The dose calculation is done for much lower emissions than the „permissible releases“. A lot of factors that can contribute to the dose significantly were neglected, for example consumption of food from an area less than 3 km to the NPPs and consumption of forest products. Own calculations show that the Ukrainian dose limits for the liquid release pathway will be violated by fish consumption. Consequences for other species than men were investigated in an absolutely insufficient way.
 4. The collective dose for the workers in the NPPs will be about one order of magnitude above the standard in the last generation of German reactors. Therefore also the radiation protection of workers does not fulfil international standards.
 5. The safety design of the NPPs are of a low standard. Therefore the completion of the NPPs by the planned standard would mean that the safety of the NPPs will be far below the standard in western European countries. Major safety problems are, for example insufficient qualification of equipment, problems with control rod insertion, insufficient redundancy and separation of safety-related systems and components, deficits in the design of electrical power supply and emergency power supply.
 6. The consequences of a lot of nuclear incidences that must be investigated in other countries were not regarded. The dose calculation for investigated incidents underestimates the possible consequences. For example, German dose limits for design-basis accidents would be violated. Furthermore the defined „worst-case design-basis accident“ in the EIA reports does not represent the international standard which includes much more and other incidents. The deficits of the safety design cannot be identified by the investigation method in the EIA reports.
 7. The „beyond design basis accident“ that is investigated in the EIA reports is a more or less harmless accident. Commonly investigations of „beyond design basis accidents“ cover accidents with core damage. Therefore the EIAs are cannot give information about the need of off-site emergency countermeasures, transboundary impacts and impacts on industrial zones, infrastructure etc. by the „loss of land“ after an accident. Such consequences will be the result of a lot of possible accidents.
 8. The information given about radioactive waste management is poor. Nevertheless, some deficits are evident concerning waste storage and waste processing. Furthermore any information about the final storage of radioactive waste is missing.

9. Relevant elements of an EIA procedure are not included but shall instead be subject to an announced EAP. The present EIAs are incomplete if they do not exactly describe each relevant measure envisaged to mitigate significant adverse effects of the projects.
10. The EIAs are lacking a comparative analysis of the environmental impacts of the proposed project in relation to other alternatives as required by the EIA-Directive. A present comparative assessment is limited to pure economic criteria without taking into account any environmental-related criteria.
11. The results of the public consultations must easily be identified as such. However, it remains unclear from the present EIA reports which were the public comments and how they influenced the drafting of the reports.
12. The reports do not mention any information or involvement of neighbouring states. Belarus, Poland, Romania, Moldavia are in a relatively close distance to the projected NPP so they would have to be given the opportunity to express their views on the planned NPPs.

6 Conclusion

The EIAs on Rivne 4 and Khmelnytsky 2 do not comply with the provisions of Directive 85/337/EEC amended by Directive 97/11/EEC. A broad range of relevant information and data is either not or inadequately compiled and/or evaluated in both reports. Therefore the requirements of Article 3 and Article 5.3 EIA-Directive are not being kept. Besides, the reports do not show how public comments have been taken into account and if (and how) neighbouring states have been involved in the EIA procedure in order to satisfy Article 7 EIA-Directive in analogy.

The presented EIAs thus do not (yet) provide with a sufficient assessment of the extent to which environmental and radiological impacts associated with the proposed project have been addressed to date, or will be addressed during further development of the project. In fact, the EIAs have so many deficits that it is impossible to assess the environmental impacts of the proposed completion of Rivne 4 and Khmelnytsky 2 properly. They would need a substantial upgrading in order to fulfil the provisions of the EIA-Directive and to provide for a serious scientific basis.

The sites of the Rivne and Khmelnytsky NPPs are very disadvantageous in respect to cooling water supply and for Rivne also for geological reasons. Own calculations had the result that the Ukrainian dose limit for the public would be violated by the proposed liquid discharges of radionuclides. Another deficit is the safety standard of the NPPs which does not fulfil the standard in other western European countries.

References

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