



ENVIRONMENTAL IMPACT ASSESSMENT KHMELNITSKY 2/ROVNO 4

Markus GRAGGABER
Beatrix PFANZAGL
Antonia WENISCH
Petra SEIBERT
Roman LAHODYNSKY

Report to the
Austrian Government

Vienna, October 1998

Contents

	Page
4 ENVIRONMENTAL IMPACT ASSESSMENT KHMELNITSKY 2/ROVNO 4	5
4.1 Executive Summary	5
4.1.1 Energy Policy and Alternatives to Nuclear Power	5
4.1.2 Accident Analysis	6
4.1.2.1 Consequences of a Severe Accident	6
4.1.3 The Plant and its Surroundings.....	6
4.1.4 Radioactive Emissions and Monitoring.....	7
4.1.5 Impact of the Fuel Cycle and Nuclear Waste.....	8
4.1.6 Environmental Action Plan.....	9
4.1.7 Conclusion	9
4.2 Introduction	10
4.3 The description of the proposed activity	10
4.3.1 The Reactor	10
4.4 The analysis of alternatives	11
4.5 Safety and accidents analysis	12
4.5.1.1 Radiological impact of accidents.....	13
4.6 Description of a „worst case“ scenario, modeling of transboundary emissions and consequences for Austria	14
4.6.1 Dispersion Calculation	16
4.6.1.1 The model.....	16
4.6.1.2 The input data	16
4.6.1.3 Calculation domain and evaluation grid.....	16
4.6.1.4 Selection of the accident date and time.....	17
4.6.1.5 Meteorological situation	17
4.6.1.6 Deposition pattern	17
4.7 Radiation monitoring and radiation protection	19
4.7.1 Monitoring system	19
4.7.2 Protection of the public.....	19
4.7.3 Emergency planning.....	20
4.7.4 Environmental action plan	20
4.8 Terms of Reference	21
4.8.1 Definitions.....	21
4.8.2 Activities which require an EIA	22
4.8.3 Content of an EIA	22
4.8.3.1 Description of the project.....	23
4.8.3.2 The surroundings of the project	23
4.8.3.3 Assessment of the environmental impact.....	24
4.8.4 Fundamentals to the procedures of an EIA.....	24

4.9	Khmelnitsky NPP – description of the site and the region	24
4.9.1	Seismicity	25
4.9.2	Geology and Hydrogeology	25
4.9.3	Meteorology	25
4.9.4	Existing contamination	26
4.10	Environmental impact of Khmelnitsky-2	26
4.10.1	Airborne radioactive emissions	26
4.10.2	Liquid radioactive emissions	27
4.10.3	Non radioactive release	29
4.10.4	Radiological impact of normal operation	30
4.10.5	Environmental Impact of the nuclear fuel cycle	30
4.10.5.1	Low and intermediate waste	30
4.10.5.2	Spent fuel management	31
4.11	Rovno NPP – the description of the site and the region	32
4.11.1	Seismicity	33
4.11.2	Geology and Hydrogeology	34
4.11.3	Meteorology	35
4.11.4	Existing contamination	35
4.12	Environmental impact of Rovno-4 NPP	36
4.12.1	Airborne radioactive emissions	36
4.12.2	Liquid radioactive releases	38
4.12.3	Release of non-radioactive substances and heat in liquid emissions	40
4.12.4	Radiological impact of normal operation	41
4.12.5	Environmental impact of the nuclear fuel cycle	41
4.12.5.1	Low and intermediate active waste	42
4.12.5.2	Spent fuel management	42
4.13	References	43
4.13.1.1	Annex	44
4.13.1.2	General References	44
4.13.1.3	Khmelnitsky NPP	45
4.13.1.4	Rovno NPP	45
4.13.1.5	Data and information required	45

4 ENVIRONMENTAL IMPACT ASSESSMENT KHMELNITSKY 2/ROVNO 4

4.1 Executive Summary

The Environmental Impact Assessment (EIA) of Khmel'nitsky-2/Rovno-4 (K2/R4) refers to Western standards. In order to determine whether the provided documents comply with these standards concerning the content and scale of details of an EIA we compared them with European guide-lines and laws, in particular with the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo-Convention).

4.1.1 Energy Policy and Alternatives to Nuclear Power

For any EIA the analysis of alternatives (the non-action alternative included) is a requirement. The EIA for K2/R4 presents continuation of operation at Chernobyl NPP as an alternative, even mentioning the possibility of a restart of unit 2, which has been shut down after a severe fire in the turbine hall. Continuation of electricity generation at Chernobyl unit 3 could be called a non-action alternative and would result in 10 times higher routine emissions of radioactivity to the atmosphere than expected from K2/R4 and probably a higher accident risk, as is asserted in the EIA. The fact that this assertion is not backed by results of probabilistic safety analyses (PSA) for the K2/R4 VVER 1000 reactors and for the Chernobyl-3 RBMK reactor does not allow to judge its credibility.

Existing PSA results for VVER 1000 reactors and for RBMK indicate that both types will not meet the IAEA's probabilistic safety target of a likelihood of occurrence of severe core damage below 10^{-4} events per reactor and year.

Every EIA has to include an overview of the most important alternatives examined and specification of the essential criteria for the selection. As a base case alternative for an EIA the project causing the lowest environmental impact with comparable costs should be chosen.

Continuation of energy production from Chernobyl 3 cannot be accepted as the base case alternative to completion of K2/R4. The second alternative considered, namely an increase in electricity generation by existing fossil-fuel plants in their current state of inadequate air pollution control equipment, is also not acceptable as a base case alternative, because this is also a low cost option compared to the completion of K2/R4. Improvement of air pollution control measures for existing fossil fuel plants – like the modernization of Starobeshevo fossil fuel plant financed by EBRD – is required anyway.

The likely environmental impact of the construction of efficient new plants like CCGTs (closed cycle gas turbines) or measures to improve energy efficiency are not mentioned in the EIA.

The EIA provides neither data on the demand of electricity nor a discussion of future needs and possibilities to meet the predicted demand. The provided data on electricity generation show that in 1995 the total electricity generation was only 70 % of that in 1991. **The production of the coal/oil/gas fired plants in 1995 was approximately half of the production in 1991. This indicates that there is a considerable surplus of installed capacities.**

With respect to the protection of the environment the final closure of the Chernobyl NPP would be an important step forward, but the arguments for a nuclear alternative are not convincing, because this implies an accident risk and a nuclear waste problem, and causes considerable radioactive emissions (radon and radioactive dust) by uranium mining. The existing fossil fired plants currently are not adequately equipped with air pollution control systems, but at some plants upgrading has started already (and new investments should be channeled into this direction or into the construction of CCGTs, which are considered to be the best al-

ternative in Western Europe. Alternatively, comparable investments could be used for energy saving measures, which would be preferable with respect to management of resources and greenhouse gas emissions.

4.1.2 Accident Analysis

For the identification of adverse transboundary impacts and its significance the Espoo-secretariat recommends several criteria including the characteristics of the impact, the affected area, the number of potentially affected people, its duration and frequency. If significant impacts are expected only in the event of an accident, Espoo requires the presentation of the worst case scenario. Compared to these requirements of the Espoo Convention it is a serious deficiency of the EIA that potential consequences of severe accidents at K2/R4 are not considered.

Instead of a worst case scenario the EIA discusses the radiological impact of two design basis accidents: a big loss of coolant accident and a leak in the steam generator collector. The latter is said to be a beyond design basis accident. But during the accident sequence, as it is outlined in the EIA, the operators do not lose control over the reactor and all safety systems function as designed. This sequence does not lead to any damage of the fuel and therefore the emissions for the BDBA do not exceed the source term of the large break loss of coolant accident. As long as the operators act appropriately within a very short time, the so called BDBA is not beyond the design basis. But every operator error could exacerbate the accident seriously. It seems that without functioning of accident management measures the break of steam generator header is a main contributing factor to the core damage frequency.

4.1.2.1 Consequences of a Severe Accident

As the EIA does not investigate the possible consequences of severe accidents, we have performed ourselves a study of such an event. We concentrate on the consequences in other countries, especially Austria, but this does not mean that the effects in the surroundings are not important.

In order to investigate the possible impact following a severe accident at Rovno 4 or Khmel'nitsky-2 a release of 20 % of the total core inventory of cesium-137 was assumed. For this study, a meteorological situation has been selected that did occur in reality. As meteorological input fields were already available for the year 1995 from another study, that year has been taken as the reservoir from which the worst situation for Austria was selected. It turned out that for both sites an accident on December 3 would have had the worst impact on Austria.

The results of this calculation show that a severe accident at K2 or R4 could lead to a contamination of distant regions in Europe with contamination maxima even higher than those caused by the Chernobyl accident in 1986. For the Eastern part of Austria the calculation resulted in a maximal radioactive fallout of 1000 kBq/m² Cs-137, which would result in a contamination about 5 times as severe as observed in Austria in 1986.

4.1.3 The Plant and its Surroundings

Any environmental impact assessment requires a description of the proposed activity and its purpose. This has to include information about the most important characteristics of the processes of production and manipulation concerning the type and quantity of the used materials and resources, the type, quantity and quality of the estimated residues and emissions to water, air and land (including light, heat and radiation) which arise during construction and operation of the proposed project.

The K2/R4 project presentation does not contain any detailed information about the planned work which is described as completion and modernization of a construction which is 80 % to 90 % completed. After an interruption of construction work for 5 years the degradation of materials could be a major problem. A documentation of the quality assurance program for the existing buildings and components is missing.

An overview of the NPP as a whole (including all auxiliary buildings and facilities at the site) with respect to the risk of explosion and fire is missing. No technical data of the reactors and their safety systems are presented.

Information about the surroundings of the plants is scarce. Geological cross sections and clear maps indicating terrestrial transport routes and flight corridors are missing.

For Khmel'nitsky NPP, which is located in the highlands, a map showing the location of weather stations and radiological monitoring stations with respect to the relief would have been absolutely required.

Concerning the risk posed by earthquakes the EIA states that the design of both NPPs has been based on an intensity of MSK7 corresponding to a ground acceleration of 0,1 g, which is the absolute minimum level for NPPs recommended by IAEA. It is noted in the EIA that further studies are required to ensure that the plant design is in accordance with current seismic requirements.

With respect to radioactive contamination of the environment the provided data are scarce. Especially in the case of Rovno NPP, where in spite of the fact that environmental radiation monitoring has been conducted at a number of sites for several years, including monitoring of air, precipitation, soil, foodstuffs, open water and groundwater, algae, and sediments, very few useful data are presented. Sampling sites are in most cases not adequately specified or results averaged over several sampling sites are presented. Although a high percentage of land is used for production of feed for domestic animals, meat is not sampled at all. No adequate data are presented for radioactive contamination of fish either, although there are commercial fish farms in the 30 km zones of both NPPs, in the case of Khmel'nitsky NPP even in the vicinity of the NPP outlet of radioactive liquid emissions into the cooling reservoir. It should be stressed that especially in the case of Khmel'nitsky NPP cooling reservoir the scarce and inadequate presentation of data from environmental radiation monitoring leaves the impression that existing contamination might be purposefully concealed. The same might apply to groundwater and atmospheric precipitation in the surroundings of Rovno NPP, for which no data are provided. Although it is stated that groundwater is not protected from pollution and has been monitored in the surroundings of both NPPs, no results are provided. Possible contamination of agricultural products by irrigation and flooding with river water receiving liquid radioactive emissions is also not considered in the EIA, in spite of the fact that this could be an important contribution to individual doses.

4.1.4 Radioactive Emissions and Monitoring

- The EIA has to inform about the anticipated increase of the immission load caused by the proposed project compared with the status quo, the lifecycle of the proposed project, the environmental impact of construction, operation and decommissioning.

Mean annual emissions of long-lived nuclides, noble gases and I-131 are presented for Khmel'nitsky unit 1 (also a VVER 1000) for the years 1988-1996 and for Rovno NPP as a whole for 1987-1996. These data show that annual emissions were variable (about 5 to 10-fold differences in the amount of activity released in the groups of radionuclides considered). **Compared with reactors in Germany airborne radioactive emissions of VVER 1000 reactors are high, a longer retention in the filtering systems would be required.** The facilities for retention of radioactive emissions via the stack are discussed only superficially, without giving

any technical details. Data about the retention capacity for different radioactive substances and the related delay times are also missing.

It is promised in the EIA that the commissioning of the planned units will be dependant on the completion on the construction of an on-line system (called ASKRO) for monitoring of releases and immissions. This is an absolute requirement with respect to the installation of an adequate alarm system, as currently emissions are only measured on a weekly schedule in the ventilation stacks of the NPPs already in operation.

Concerning the radiological impact of normal operation, no NPP would be licensed on the basis of such scarce information in western countries. It is not explained which methods are used for the calculation, neither for the dispersion model nor for the dose calculation. The source term used for the impact assessment is a list of selected nuclides with deliberately reduced annual emission (compared to the predicted values as well as to the actual average emissions from Khmel'nitsky-1).

Currently the Ukraine has no radiation monitoring and warning system comparable with Western standards. Although the Ukraine has 14 working reactor units (at 5 sites) the only state of the art monitoring system for radiation protection operated by the Ukrainian Ministry of Environmental Protection of the Ukraine is only partially in operation in the surroundings of Rovno NPP and Zaporozhe NPP. The nationwide early warning system in the Ukraine is not automated. The communication between the NPP and the responsible authorities is based on the public telephone network. Currently the Ukraine has no appropriate computer system which can be used for an automated calculation of accident consequences based on radiological and meteorological data. A project for the installation of such a system was delayed due to lack of financial resources.

With respect to protection of the public it is irresponsible to use nuclear power plants, as long as the Ukraine does not have a reliable state of the art monitoring and warning system. Completion of a countrywide monitoring and warning system working with independent data lines should be subject of the Western financial and technical assistance, irrespective of funding for K2/R4.

4.1.5 Impact of the Fuel Cycle and Nuclear Waste

No clearly organized management system for radioactive waste is presented in the EIA. No adequate description of the amount, the origin, the chemical and radiological characteristics of wastes arising is provided. According to the usual requirements for an EIA a detailed waste management plan is absolutely necessary.

New waste treatment facilities are planned at both NPPs. Current treatment facilities and storage capacities for low and intermediate active waste in Khmel'nitsky NPP are insufficient. The planning of a final repository for low and intermediate active waste is part of the State program on radioactive waste management. Storing capacities for spent nuclear fuel are sufficient for 6 years. It is planned to build an interim storage in the surroundings of both NPP sites. **There is no program presented for the handling of all nuclear wastes arising from the NPP and it is not clear which institution is responsible for which part of the nuclear waste management program. It is also not explained, how these necessary activities will be funded.**

Concerning the fuel cycle as a whole, the EIA is incomplete. The impact from the production and transports of nuclear fuel is not considered at all. This is a crucial point because, besides accidents in NPPs, uranium mining is the most important contribution to radioactive contamination. Even if transports of fresh fuel assemblies are relatively harmless, the radiation caused by transports of spent fuel is subject of a legal debate in Western Europe, which will probably lead to obstacles for transports and a minimization of the amount of fuel which can be shipped at all.

4.1.6 Environmental Action Plan

According to European standards and the Espoo Convention, EIA documents are supposed to present an environmental action plan (EAP). This plan should describe measures which are able to mitigate potential hazards as well as the predicted pollution. Important problems like the impact of water abstraction on hydrogeology and rivers, water pollution and heat discharges to rivers or possible consequences of earthquakes and the related mitigation measures are planned to be addressed by the EAP. The environmental action plan for K2/R4 is only schematically outlined. Although it is admitted that the problems awaiting to be addressed in the EAP are important, the plan has still not been prepared.

4.1.7 Conclusion

With respect to international requirements for environmental impact assessment procedures the presented documentation for the K2/R4 completion project is not satisfactory. This refers especially to the Espoo Convention, which requires information about the risks of an adverse transboundary impact also for projects, for which transboundary impacts are expected only in case of an accident.

In Western countries a project of this scale would not be licensed based on such insufficient information.

Airborne and liquid radioactive emissions will be higher than from French and German reactors. The impact of heat discharge with liquid effluents can be expected to be high, at least in the case of Rovno NPP. The consequences of additional water abstraction from artesian sources and rivers have not been fully investigated. A management plan for all radioactive wastes arising from NPP operation does not exist.

The accident risk and the environmental impact of routine operation of K2/R4 does not allow the conclusion that this project will be environmentally sound.

4.2 Introduction

The EIA documentation for the public participation process for the completion of K2/R4 NPP consists of two parts, one for Khmelnitsky-2 and one for Rovno-4. Since several chapters of the two EIAs are identical, our comment presents generic parts valid for both plants as well as site specific comments on the EIA.

4.3 The description of the proposed activity

In the project presentation submitted with the EIA documents the project scope is explained as:

- Completion of the units according to the original design
- Repair and replacement of deteriorated equipment
- Improvement of the safety, quality of operation and the availability of the unit.

Even the Annex to the project presentation does not contain any detailed information about the planned work. In the EIA the description of the proposed activity is arranged in a confusing manner.

In the project presentation as well as in chapter 4 of the EIA there is no overview of the NPP as a whole including all auxiliary buildings and facilities at the site, with respect to the risk of explosion and fire:

- nitrogen and oxygen station
- reserve diesel fuel-fired power stations
- start-up and reserve boiler house
- oil and lubricant handling facilities
- laboratory and auxiliary facilities
- radioactive waste handling complex.

Complete maps of all buildings including vertical sections are missing. There is no comprehensive information about systems common to both units and about interconnections between systems.

4.3.1 The Reactor

Chapter 4 of the EIA – entitled “Proposed Project” – contains a very general overview of the VVER-1000 reactor type. It does not include technical data of the reactor and its safety systems. The reactor protection system is outlined without any details.

There is only general information about the design of safety and essential systems, and no information about the capacities, redundancies and spatial separation of backup systems for all the safety relevant systems. There is no detailed discussion of the status quo of the plant, which is 80 % to 90 % completed according to chapter 8 of the EIA.

Neither the quality nor the quality assurance program of the existing buildings and components are discussed in detail. After a five year long interruption of construction work the degradation of materials could be a major problem. Therefore, we would have expected to find at least some information about the moth-balling of components and the maintenance at the construction site in the EIA documentation.

Based on the provided data it is not possible to evaluate the effect of the planned modernization program.

The pre-stressed concrete containment „is designed to withstand an overpressure of 0.5 MPa“,“maximum leak rate shall not exceed 0.1 % per day“. These are design values. It is not explained if these values are met by existing VVER 1000 units, in particular Rovno-3 or Khmelniisky-1. Results of pressure and leak tests of the twin unit's containment would be useful for the prediction of the containment behavior in case of accidents.

Facilities for retention of radioactive emissions via the stack are discussed in general, without giving technical details. Data about the retention capacity for radioactive substances and the delay time of the retention system are incomplete.

There is also no information provided about the capability of the retention system in case of an accident. A schematic outline of airborne emissions treatment and monitoring is presented only in Fig. 4.11 and not adequately described in the text.

4.4 The analysis of alternatives

For any EIA the analysis of alternatives (the non-action alternative included) is a requirement. Every EIA has to include an overview of the most important alternatives examined and specification of the essential criteria for the selection. As a base case alternative for an EIA the project causing the lowest environmental impact with comparable costs should be chosen.

Chapter 10 of the EIA presents a base case alternative, As far as the current situation of power generation in the Ukraine is concerned continuation of operation at Chernobyl unit-3 could be called a non-action alternative, but the restart of Chernobyl unit-2, which was shutdown after a severe fire in the turbine hall cannot be part of a non-action alternative. This is no continuation of the status quo !

Since RBMK reactors have considerably higher radioactive emissions than VVER 1000 reactors, the environmental impact of Chernobyl-3 operation would be higher. The main adverse effect of these emissions will result in contamination of the vicinity of the plant, which in case of Chernobyl-3 is the exclusion zone.

The safety standards of Chernobyl unit-2 and unit-3 are hardly comparable: unit 2 is an RBMK of the first generation equipped only with rudimentary safety systems, unit 3 is of the later more sophisticated generation, its safety standard should be reassessed since the known design faults which resulted in the Chernobyl accident have been redesigned.

The EIA reassures that the core damage frequency (CDF) for K2/R4 reactors will be significantly lower than the CDF for a RBMK reactor, because the CDF for the upgraded K2/R4 reactors will be comparable to “recently reapproved Western PWRs. (p. 10.10.) The fact that this assertion is not backed by results of probabilistic safety analyses (PSA) for the K2/R4 VVER 1000 reactors and for the Chernobyl-3 RBMK reactor does not allow to judge its credibility.

Chapter 10 provides some data on electricity generation in the Ukraine, but there is neither information about the demand of electricity nor a discussion of future needs and possibilities to meet these demands

Table 10.1. mainly indicates that the load factors of all electricity generating plants in the Ukraine decreased heavily from 1991 to 1995. In 1995 the total electricity generation was only 70 % of the generation in 1991. The production of the coal/oil/gas fired plants in 1995 was approximately half of the production in 1991. With a load factor of a little more than 60 % the NPPs were also not operating very efficiently. Based on the provided data we cannot follow the conclusion that the Ukraine needs new generation capacities. In fact the data show that the existing capacities are more than enough.

The existing fossil fired plants currently are not adequately equipped with air pollution control system as the Addendum to the EIA explains. At some plants upgrading has started already. One of this projects is the modernization of Starobeshevo – financed by the EBRD. Minimization of emissions from the fossil fuel plants is required anyway and can be achieved either by changes in the fuel or by upgrading of the retention systems.

The existing fossil fuel plants currently are not adequately equipped with air pollution control systems, but at some plants upgrading has started already and new investments should be channeled into this direction or into the construction of CCGTs, which are considered to be the best alternative in Western Europe. Alternatively, comparable investments could be used for energy saving measures, which would be preferable with respect to management of resources and greenhouse gas emissions.

Since the EIA provides no prediction of the future electricity demand and there is no serious comparison of the environmental impact of the alternatives in Ukraine, it is not possible to decide which option will be the most appropriate.

4.5 Safety and accidents analysis

Chapter 8 of the EIA, entitled “Safety analysis”, provides an overview of the general safety principles and explains, that in general the “design of (VVER 1000) model 320 is consistent with international safety practice”.

Chapter 8 also addresses safety problems and the recommended solutions.

In the project presentation a probabilistic safety assessment (PSA) is announced for some time after the beginning of commercial operation of the NPP. This is a serious deficiency in the process of completion and upgrading of the plant, because the PSA is a valuable instrument to determine the weak points of the plant. The PSA could be used to define the most significant initiating events which contribute to the core melt frequency of the plant. The improvement program should be based on this analysis.

In section 8.6.1. it is said that no full scope study of beyond design basis accidents (BDBA) has been performed for VVER 1000 reactors. But in the same section one specific BDBA is presented as “the most representative accident”. The explanation in chapter 8 that this accident is chosen on the basis of preliminary analyses which were used to implement accident management measures for VVER 1000 reactors, is no proof for the statement. The EIA contains no discussion of all accidents which could lead to a radiological impact. German nuclear regulations require the analyses of a specific spectrum of accidents, which includes not only loss of coolant accidents but also the following

- double sided break of main coolant pipe
- leak in a primary circuit measuring pipe outside of the containment
- insoluble leak in main steam pipe connected with damages of steam generator tubes
- long term loss of ultimate heat sink connected with operational leakage of steam generator tubes
- leak in the ventilation system
- damage of fuel element during handling
- leak of a tank containing radioactive water
- leak of a tank containing radioactive water due to an earthquake.

(BMI 1983, GRS 1993)

The EIA discusses only the radiological impact of two accidents: a big loss of coolant accident and a leak in the steam generator collector. There is no discussion of other accidents and it is not explained whether more accidents have been addressed during the licensing procedure.

The EIA does not assess the impact of an accident with release of radioactive water to the environment, which obviously also does not conform with Western standards.

In Chapter 8 of the EIA two DBA are analyzed. The first is a double ended break of the main primary coolant pipe, which in principle is in compliance with the international regulation practice. The second accident which is called a “beyond design basis accident” in fact is an accident with a primary to secondary side leak in the steam generator. According to German regulations this type of accident has to be analyzed to verify that the radiological impact does not exceed the limits. In case of the VVER 1000 reactor the horizontal steam generators require an analysis of the specific potential of failure of the steam generator collector and its consequences. At no time during the accident sequence, as it is outlined in the EIA, the operators do lose control over the reactor and all safety systems function as designed. This sequence does not lead to any damage of the fuel and therefore the emissions for the BDBA do not exceed the source term of the design basis accident. As long as the operators act appropriately within a very short time (10 minutes), this accident is not beyond the design basis. Every operator error could exacerbate the accident seriously. It seems that without accident management measures the break of the steam generator header is a main contributing factor to the core damage frequency.

According to the Espoo convention it is required to analyze the impact and the potential for emissions not only in the surrounding of the plant, but also the risk of emissions with a trans-boundary impact. For a NPP this should include the risk of BDBA. Because plant specific PSAs have not been carried out yet, it is not possible to draw any meaningful conclusions regarding the risk for severe accidents at Rovno-4.

To assess the consequences outside the plant it is necessary to analyze a range of severe accidents, including those where the containment fails at early and late times with respect to the time of the core damage, and severe accidents where the containment is bypassed. Because of the lack of such analysis, the conclusion of the EIA that there will be no radiological consequences outside the boundary of the 3 km protection zone which could require protective countermeasures, is not very credible.

The assessment of the radiological consequences is not sufficiently explained. Several assumptions are not defined:

- the radioactive inventory of the core
- the radioactive inventory of the coolant
- the release rate
- the release time and duration
- the release energy and height.

4.5.1.1 Radiological impact of accidents

Criticism raised concerning the assessment of radiological impact caused by routine operation (section 7.1.4) are also valid for 8.5, except that it is stated which model was used to calculate the accident consequences, namely PC COSYMA. However, this program contains a lot of user-selectable and changeable parameters and with the exception of population and food production statistics, nothing is said about which values have been used.

The parameters used for the assessment of the radiological impact are not listed in detail. It is not clear for which parts of the dose calculations the generic database or site specific parameters were used. It is also not clear which version of PC COSYMA was used for the cal-

ulation. (The first version considered mainly habits of people living in British cities and provided few options to change these values).

For a deterministic approach of the dispersion of radionuclides after an accident it is necessary to use weather data from the site. Since the EIA provides only average data from weather stations around the plant, some of them in a distance of more than 50 km, the statement that the assumptions lead to an overestimation of the consequences (conservative or pessimistic approach) cannot be verified.

It is claimed that the worst case meteorological situation would be without precipitation (erroneously, the unit of precipitation is given as m s^{-1}). This is surprising and needs to be substantiated further, if it is really claimed to be true. It is also surprising that ingestion doses were not calculated. It is really strange to read a sentence like "Nevertheless, it is recommended that a complete deterministic evaluation of the radiological consequences of the DBA, including the ingestion pathway, is completed according to the most recent ICRP recommendations". Is this the Environmental Impact Assessment, or is this a preliminary study for such an assessment ?? If it needs to be done, why has it not been done?

4.6 Description of a „worst case“ scenario, modeling of transboundary emissions and consequences for Austria

For the identification of adverse transboundary impacts and its significance the Espoo-secretariat recommends several criteria including the characteristic of the impact, the affected area, the number of potentially affected people, the duration and the frequency. If significant impacts are expected only in the event of an accident Espoo requires the presentation of the worst case scenario. Compared to these requirements of the Espoo Convention it is a serious deficiency of the EIA that potential consequences of severe accidents at K2/R4 are not considered.

As the EIA does not investigate the possible consequences of severe BDBAs, we have performed ourselves a study of one such event. We concentrate on the consequences in other countries, especially Austria, but this does not mean that the effects in the surroundings are not important.

In 1995 the IAEA organized a meeting on the comparison of PSA results with the programs of safety upgrading of VVER NPPs. Under this program for four VVER 1000 units (Balakovo-4, Kozloduy 5/6 and Temelin-1) some PSA results have been obtained. For other plants PSAs, are in various stages of progress. (IAEA, 1995)

The existing PSA results don't allow to draw optimistic conclusions, such as that VVER 1000 reactors will be able to reach the safety target set by the IAEA: "The target for existing NPP, consistent with the technical safety objective, is a likelihood of occurrence of severe core damage below about 10^{-4} events per plant operating year. Implementation of all safety principles at future plants should lead to the achievement of an improved goal of not more than about 10^{-5} such events per plant operating year." (INSAG-3, 1988)

For Kozloduy 5/6, after carrying out a number of safety improvements during 1992-1995, the reported CDF (core damage frequency) is $3.7 \cdot 10^{-4}$ per year. (Not all possible external initiating events are included in this PSA). For Temelin, a PSA, for internal initiating events only, results in a CDF of $0.76 \cdot 10^{-4}$ per year.

The modernization program for Temelin NPP is known to be the most far-reaching and comprehensive modernization presently. Based on the results of the PSA for Temelin it can be assumed that the modernization measures for VVER 1000 units have a limited scope and the safety goal achievable at Rovno-4 and Khmelnitsky-2 will not be better than that at Temelin.

The limited results obtained for VVER-1000 units exceed the safety goal of 10^{-5} per reactor year for new NPP. The Temelin PSA shows also that among all initiating events, steam generator header failures and SG tube ruptures are the most important contributions to the core damage frequency (>50 %) in VVER 1000 reactors.

In order to assess the consequences of a severe accident in Rovno NPP, results of source term calculations from Kozloduy NPP are used. At the PSAM-3 conference I.D. Iordanov from the Bulgarian Academy of Sciences and B.M. Synodinou from the Institute of Nuclear technology and Radiation Protection in Greece presented source terms for different core melt accidents at a VVER 1000 reactor.

Tab 4.1: Release parameters for severe accidents in VVER 1000 reactors.

Scenario	Core melt-down followed by steam explosion	Failure of core cooling systems, containment spray and residual heat removal	Overpressure failure of the containment heat removal	LOCA, failure of containment spray and containment isolation	Interfacing system LOCA (containment bypass according to NUREG 1150)
Time between reactor shutdown and release	2,5 hr	2,5 hr	5 hr	2 hr	2 hr
Duration of release	0,5 hr	0,5 hr	1,5 hr	3 hr	1 hr
Release energy	5 MW	49 MW	1,8 MW	29 kW	0 kW
Release fractions:					
Xe, Kr	0.9	0.9	0.8	0.6	1
I	0.7	0.7	0.2	0.09	0.1
Cs	0.4	0.5	0.2	0.04	0.1
Te	0.4	0.3	0.3	0.03	0.1
Sr, Ba	0.05	0.06	0.02	0.005	0.01
Mo, Ru	0.4	0.02	0.03	0.003	0.01
La, Ce	0.003	0.004	0.003	0.0004	0.001

IORDANOV, I. D., 1996

For the calculation of the transboundary impact following a severe accident at Rovno-4 based on the cited assessments the following parameters were chosen. Since the release fractions for cesium-137 which are related with these accidents are estimated between 10 and 40 percent of the total inventory and the release energy is also varying from 0 to 50 MW we selected the following source term:

- Release duration 1 hr
- Cs-137 released fraction: 0,2
- Release energy: 2 MW
- Containment failure and release out of the reactor building (roof height 75 m).

It is not intended to predict the exposition for the people in the affected areas, therefore only Cs-137 is considered. The modelling of the transboundary transport of the contaminated plume along a trajectory (included precipitation along the path) shows that several regions in Europe share the risk of contamination due to an accident at Khmelniisky-2 or Rovno-4.

4.6.1 Dispersion Calculation

4.6.1.1 The model

The transport and deposition of aerosol-bound radionuclides from the assumed BDBA has been simulated with the Lagrangian particle dispersion model FLEXPART which has been validated with a number of large-scale tracer studies such as ETEX and ANATEX (Stohl et al., 1998). It includes transport, diffusion (through the random turbulent velocities), dry and wet deposition. As we focus on Cs-137, radioactive decay has been neglected. The wet deposition rate is parameterized as a function of the precipitation rate. Spatial inhomogenities in convective precipitation are considered in a parameterized form. The Lagrangian approach allows to simulate advection without any numerical diffusion and problems caused in Eulerian models by the fact that puffs are smaller than the typical grid size close to the source.

Though the model is capable of calculating deposition fields as well as the fields of concentrations in air, only deposition was evaluated because the major contribution to the doses far from the source comes from the deposition (groundshine and ingestion).

4.6.1.2 The input data

The meteorological input to the model was taken from model output of the European Center for Medium Range Weather Forecasting (ECMWF). Analyses were used with a time resolution of 6 hours and complemented by 3 hour forecasts so that the time resolution of the fields was 3 hours. The horizontal resolution was 1 degree, and in the vertical the full resolution of the ECMWF model was utilised. FLEXPART uses the three-dimensional wind field, the temperature field and various surface parameters; the latter are used for the boundary layer parameterization. Precipitation is a crucial parameter in the case of severe nuclear accidents, however, gridded precipitation analyses are not routinely available. Therefore, the precipitation has been analyzed from SYNOP data with 6 hour resolution. ECMWF short-time precipitation forecasts have been used in data-sparse areas and to distribute the analyzed values into 3 hour intervals and between large-scale and convective precipitation. Enhanced horizontal resolution, namely 0.5° in E-W and 0.333° in N-S direction (corresponding to about 38 km) was used for precipitation fields..

The source term has already been described. To account for plume rise due to associated release of energy (heat), the source has been assumed to be equally distributed between 76 m agl (roof height) and 200 m agl.

4.6.1.3 Calculation domain and evaluation grid

The domain of the calculations comprise the area between 50°E - 100°E and 25°N – 81°N . The deposition is evaluated on two grids, a larger, coarse grid and a smaller, fine grid. Only results from the fine grid are shown here. The fine grid has the same resolution as the precipitation analysis (for areas far from the source, more resolution would not make sense). The domain covered by the fine grid is 5°E - 29.5°E and 43°N - 54.667°N , including all of Central Europe and large parts of Ukraine.

The resolution of the deposition grid means that it cannot resolve the spatial pattern of deposition close to the source. Local maxima are spread out over at least one grid cell of about 1000 km^2 . Furthermore, ECMWF fields cannot resolve details of the flow around the NPPs. This might be of some relevance for the Khmelnitsky site which is in hilly terrain whereas such influences are probably smaller at Rovno NPP.

The simulations were carried out for 7 days; however, already after about 2 days the puff had crossed Austria and most of its activity had been washed out and deposited to the ground.

4.6.1.4 Selection of the accident date and time

For this study, a meteorological situation has been selected that did occur in reality. As meteorological input fields were already available for the year 1995 due to another study, this year has been taken as the reservoir from which the worst situation for Austria was selected. For this purpose, releases were simulated twice daily for the whole year of 1995. It turned out that for both sites (Rovno and Khmel'nitsky NPP) an accident on December 3 would have the worst impact on Austria. Experiments with hourly varying release times lead to the selection of the release time 8-9 UTC for Rovno NPP and 21-22 UTC for Khmel'nitsky NPP. However, shifting these releases a few hours does not affect the results very much. This approach is sufficient to demonstrate that Austria and other countries can be severely affected by BDBA in the two plants. Statements about the frequency of meteorological situations which would lead to this or worse contamination in Austria were beyond the scope of the present study. However, common sense tells that finding such a day in a data set of one year and the additional experience of the Chernobyl accident, leading to severe contamination in several areas of Central Europe including Austria from a source in Ukraine, indicates that this is not something extremely rare.

4.6.1.5 Meteorological situation

The situation during the relevant period of time (3 and 4 December 1995) was characterized by a strong and stable high pressure system over Scandinavia and a low pressure system over the Mediterranean. At first, it was located over Greece and then moved westward. Between these two systems, a broad band of easterly air flow was able to convey the radioactive release to Austria within about 36 hours. Precipitation, amounting to about 5 mm per day in Eastern Austria, washed out the airborne contamination to the ground. The precipitation fell in form of snow.

4.6.1.6 Deposition pattern

Figure 4.1. and 4.2 show the resulting deposition pattern. The track of the contaminated air is clearly visible. In addition to the main maximum in Austria, there are secondary maxima in southern Poland and close to the NPP. As already mentioned, the size of the grid does not allow for a realistic resolution of the maximum near the site. In reality, it will be smaller but with higher values.

The results of this calculation indicate that there is the possibility that an accident at Rovno or Khmel'nitsky NPP would contaminate not only regions in Ukraine but also several regions in Europe, as it happened in May 1986 after the Chernobyl accident. The contamination maxima could be even higher as 1986. For the Eastern part of Austria the calculation resulted in values up to approx. 1000 kBq/m²contamination with Cs-137 (which is about 5 times the highest values measured in Austria in 1986).

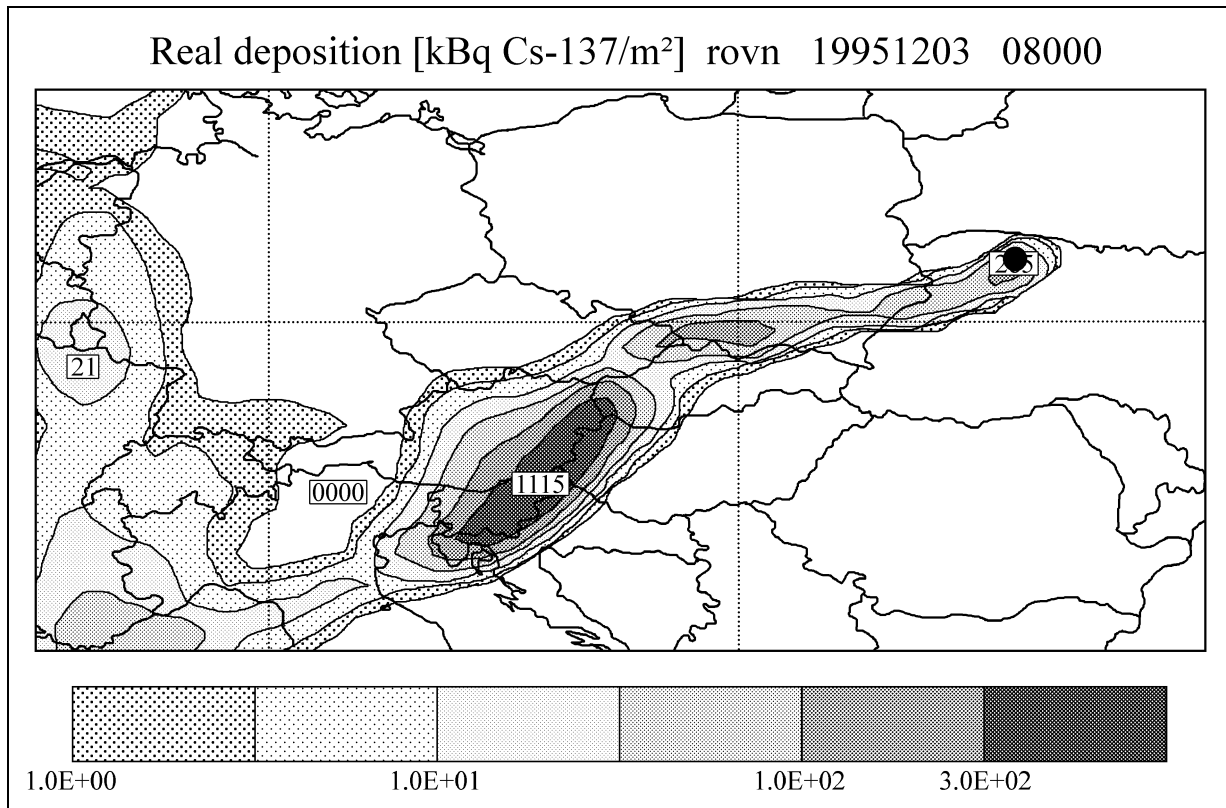


Figure 4.1: Deposition of Cs-137 [kBq m⁻² from a hypothetical BDBA in Rovno NPP. A geographical grid with 10° resolution and state boundaries are plotted for orientation

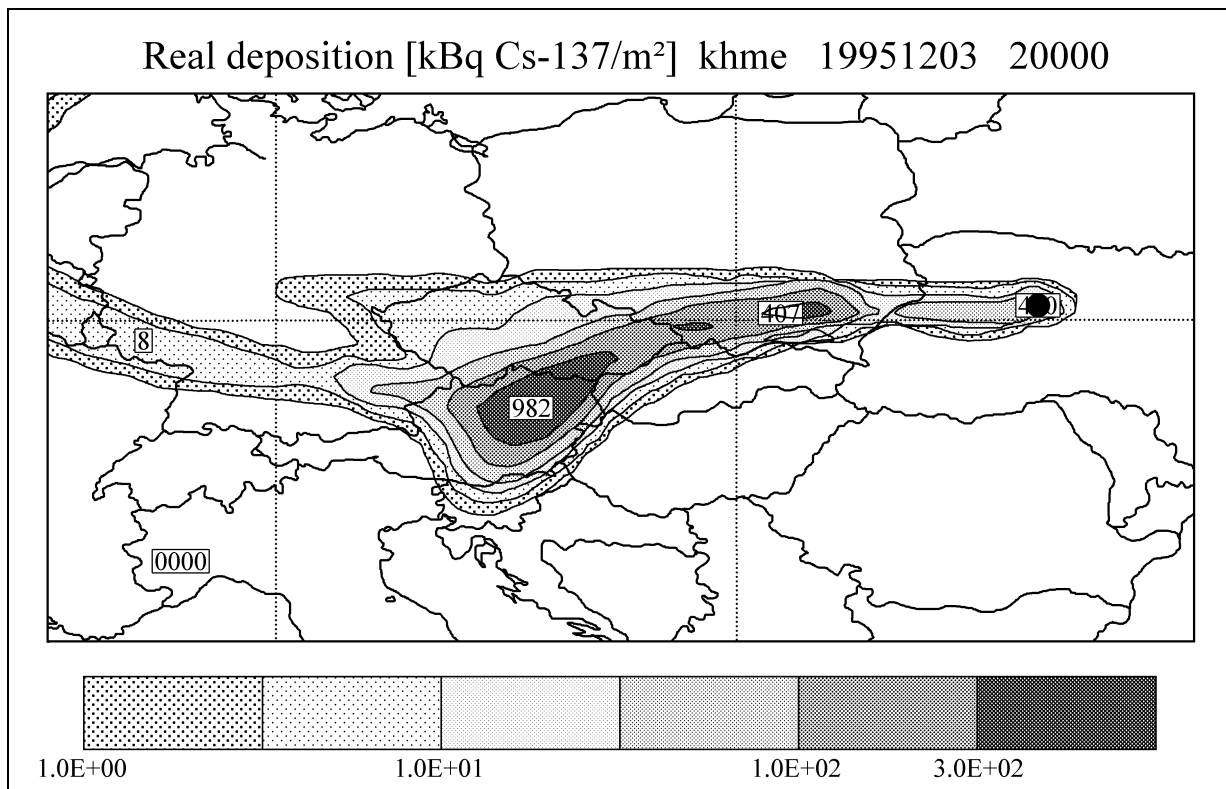


Figure 4.2: Deposition of Cs-137 [kBq m⁻² from a hypothetical BDBA in Khmel'nitsky NPP. A geographical grid with 10° resolution and state boundaries are plotted for orientation.

4.7 Radiation monitoring and radiation protection

4.7.1 Monitoring system

Instead of a clearly organized description of environmental monitoring systems, we found different and inconsistent explanations about systems and methods without clear distinction between existing and planned systems. In detail, the description of following items is missing:

- Continuous measuring methods (technical data, limits of detection) and the location of the related devices, (air, water)
- Continuous sampling methods and the location of related devices, chemical preparation in laboratory and measuring methods.
- Dose rate measuring system and the location of its devices
- The program of sampling of fallout, vegetation, agricultural products
- The warning system.

Section 5.5. about the environmental monitoring provides a list of media which are monitored, but without specifications of the technical measuring equipment. It is interesting to learn that the laboratory at Rovno processes 2,000 samples by year and has six semiconductor spectrometers, but this a worthless information since the results are largely not referred to in the EIA. A laboratory at Khmelnytsky is not mentioned.

Section 5.5.2 assures that an automated system for the control of radiation at the site and in the surroundings is in a developing stage – at Rovno since 1989 (!). We can only hope that the system (ASKRO) will be subject to modernization, since its completion is said to be connected with the completion of the NPP.

The only state of the art monitoring system for radiation protection is operated by the Ukrainian Ministry of Environmental Protection of the Ukraine. Even this systems seems to be incomplete, it is “partially in operation in the Rovno NPP and Zaporzhe NPP 30 km zone and consists of 47 gamma dose rate stations, and one aerosol measuring station (p.5.31). But the nationwide early warning system in the Ukraine is not automated, but “operated on the basis of **manual** measurements in a daily working mode”!!

4.7.2 Protection of the public

The exposure limits are set according to ICRP 26, but they will be based on ICRP 60 by the time Khmelnytsky-2 begins operation. The exposure limit set for the public is said to be lower than the value recommended by the IAEA. We cannot compare this with the IAEA recommendation since the statement comes without a reference. The limit for individuals for external exposure is set with 0,25 mSv/year [Table 5.6.] and the limit due to other sources of exposure (gaseous releases and liquid discharges) is also set to 0,25 mSv/year. It is not defined which pathways are considered in the calculation of this dose limit and therefore a comparison with the Euratom Council Directive (EURATOM 96/29) and ICRP 60 is impossible.

The setting of limits for radioactive airborne emissions and liquid effluent discharges is not clearly explained. Table 5.8 refers to the results of a calculation of average permissible emissions. A daily value is given for radioactive noble gases, I-131, short lived nuclides mixture and long-lived nuclides mixture (Table 5.8a)”. In the case of long-lived nuclides, a more restrictive monthly value is also given which should be presented in Table 5.8b. Compared to the limits indicated in chapter 6 (p. 6.4), the values given in Table 5.8. appear to be annual limits rather than monthly limits presented in Bq/d.

The habit to calculate new limits every year seems unusual to us. According to the EIA the calculation for liquid discharges is carried out each year “taking into account the amount of

water **used** by each NPP”, p.5.10.. Why can the water need of an NPP for the coming year be better deduced from the year before than from the annual average? Or is this just a retrospective calculation and limit setting?

4.7.3 Emergency planning

Since there is no information about the monitoring system based on which the public will be alarmed, it is not astonishing that we are informed by the EIA only about the regulations which have to be considered in an emergency situation and the organizations responsible for declaring an emergency.

The emergency planning, as it is described in chapter 5, takes severe accidents into account to an extent, where not only an emergency control center on site and one offsite could be necessary, but sheltering is provided for almost the complete staff of the NPP

The implementation of countermeasures for the public in case of an accident requires the information of several national and local authorities, which are responsible for this decision (based on Intervention levels according to the Ukrainian legislation Table 5.13, 5.14).

Settlements inside the 30 km zone around the plant are equipped with sirens, which can be used for alarming the population as well as radio information by the responsible authority.

Unfortunately the communication between the NPP and the bodies mentioned above is based on the public telephone network, “whose reliability and availability is not satisfactory in comparison with West-European standards”.

Currently the Ukraine has no appropriate computer system which can be used for an automated calculation of accident consequences based on radiological and meteorological data. A project for the installation of such a system was delayed due to lack of financial resources.

Currently the Ukraine has no radiation monitoring and warning system comparable with Western standards. Although the Ukraine has 14 working reactor units (at 5 sites) the only state of the art monitoring system for radiation protection operated by the Ukrainian Ministry of Environmental Protection of the Ukraine is only partially in operation in the surroundings of Rovno NPP and Zaporozhe NPP. The nationwide early warning system in the Ukraine is not automated. The communication between the NPP and the responsible authorities is based on the public telephone network. Currently the Ukraine has no appropriate computer system which can be used for an automated calculation of accident consequences based on radiological and meteorological data. A project for the installation of such a system was delayed due to lack of financial resources.

With respect to protection of the public it is irresponsible to use nuclear power plants, as long as the Ukraine does not have a reliable state of the art monitoring and warning system. Completion of a countrywide monitoring and warning system working with independent data lines should be subject of the Western financial and technical assistance, irrespective of funding for K2/R4.

4.7.4 Environmental action plan

According to European standards as well as according to the Espoo Convention EIA documents are supposed to present an environmental action plan (EAP). This plan should describe measures which are able to mitigate potential hazards as well as the predicted pollution. The environmental action plan for K2/R4 is only schematically outlined. Although it is admitted that the problems awaiting to be addressed in the EAP are important, the plan has still not been prepared.

According to the standards mentioned above, measures for monitoring and prevention of potential adverse effects to the environment are supposed to be prepared before licensing of

the plant. Chapter 9 of the EIA contains only a list of topics, which should be addressed, but no solutions:

- The local geological conditions are planned to be studied
- Earthquake risk: A verification of the design basis of the plants is recommended, but it is not seen as an urgent task which should be a condition for the completion of the plant
- The evaluation of the possible effects of other external hazards as extreme weather conditions (tornados, heavy snowfall) has to be part of the EIA itself and cannot be postponed.
- Impacts, control and regulation of water abstraction from artesian sources and rivers and consequences of heat discharges to water bodies.

The environmental action plan (EAP) itself is outlined without any details besides the main topics which are supposed to be solved by this plan. According to an European standard for an EIA this is absolutely not sufficient.

4.8 Terms of Reference

The project of completion and modernization of the Ukrainian NPP Rovno-4 is described as a project which will result in the commissioning of a NPP with a safety standard comparable with the standards required for NPPs in Western Europe. The Ukraine also will be a party to the Convention on Environmental Impact Assessment in a Transboundary Context. This Convention is the basis on which citizens and authorities from other countries have the right to be fully informed and participate in the EIA process for a NPP.

The Environmental Impact Assessment of Rovno-4 refers in several chapters to Western standards. In order to determine whether the provided documents comply with these standards concerning the content and scale of details of an EIA we compared them with European guide-lines and laws. For this comparison the following references are used.

- Convention on Environmental Impact Assessment in a Transboundary Context [Espoo-Convention]
- Austrian law of Environmental Impact Assessment (UVP-Gesetz Österreich BGBl 1993/697; BGBl 1996/773)
- Guide to an EIA – Austria (UVE Leitfaden, Eine Information zur Umweltverträglichkeit, Österreich)
- Guide to an EIA – Switzerland (Handbuch UVP)
- Council Directive on the Assessment of the Effects of Certain Public and Private Projects on the environment. (Richtlinie 97/11/EG des Rates zur Änderung der Richtlinie 85/337/EWG über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten).

4.8.1 Definitions

The Espoo Convention implies (among others) the following definitions:

- **“Proposed activity”** means any activity or any major change to an activity subject to a decision of a competent authority in accordance with an applicable national procedure.
- **“Environmental impact assessment”** means a national procedure for evaluating the likely impact of a proposed activity on the environment.
- **“Impact”** means any effect caused by a proposed activity on the environment including human health and safety, flora, fauna, soil, air, water, climate, landscape and historical mo-

numents or other physical structures or the interaction among these factors; it also includes effects on cultural heritage or socioeconomic conditions resulting from alterations to those factors.

- The definitions of “impact” gives a short overview of all aspects which have to be discussed in the EIA.
- **“Transboundary impact”** means any impact, not exclusively of the global nature, within an area under the jurisdiction of a party caused by a proposed activity the physical origin of which is situated wholly or partly within the area under the jurisdiction of another party.

4.8.2 Activities which require an EIA

All used references demand an EIA for a nuclear power station. To underline this fact the relevant text of the Espoo-Convention (Appendix I and III) is quoted:

- Nuclear power stations
- Installations for the storage, disposal and processing of radioactive waste
- Activities with particularly complex and potentially adverse effects, including those giving rise to serious effects on humans or valued species or organisms, those which threaten the potential use of an affected area and those causing additional loading which cannot be sustained by carrying capacity of the environment.

For the identification of adverse transboundary impacts and its significance the Espoo-secretariat recommends several criteria including the characteristic of the impact, the affected area, the number of potentially affected people, the duration and the frequency of these events. If significant impacts are expected only in the event of an accident Espoo requires the presentation of the worst case scenario. Compared to these requirement of the Espoo Convention it is a serious deficiency of the EIA that potential consequences of severe accidents at K2/R4 are not considered at all. [UN/ECE 1996]

4.8.3 Content of an EIA

In general there is a consensus according to the topics which have to be discussed in the EIA. A difference is given concerning the required standard and precision of an EIA.

The Espoo Convention demands the following content of the EIA documentation:

- A description of the proposed activity and its purpose.
- A description, where appropriate, of reasonable alternatives (for example, site or technology) to the proposed activity and also the no-action alternative.
- A description of the environment likely to be significantly affected by the proposed activity and its alternatives.
- A description of the potential environmental impact of the proposed activity and its alternatives and an estimation of its significance.
- A description of mitigation measures to keep adverse environmental impact to a minimum.
- An explicit indication of predictive methods and underlying assumptions as well as the relevant environmental data used.
- An identification of gaps in knowledge and uncertainties encountered in compiling the required information.
- Where appropriate, an outline for monitoring and management programs and any plans for the post-project analysis.
- A non-technical summary including a visual presentation as appropriate (maps, graphs, etc.).

All the required topics of an EIA remarked in the Espoo Convention are specified in more detail in the European, Austrian and Swiss legislation or in the guides to an EIA. The following requirements are defined for an EIA.

4.8.3.1 Description of the project

A detailed description of the proposed project as a whole with respect to the location, type and dimension, including the following:

- Description of the proposed project, including information about the demand on infrastructure and space during construction and operation, and also the possible impact to other facilities.
- Description of the most important characteristics of the processes of production and manipulation especially concerning the type and quantity of the used materials and resources
- The type, quantity and quality of the estimated residues and emissions to water, air and land (including light, heat, radiation) which arise during construction and operation of the proposed project
- The anticipated increase of the immission load caused by the proposed project compared with the status quo
- Energy needs on (demand from different sources)
- Lifecycle of the proposed project, environmental impact of construction, operation and decommissioning,
- Monitoring of pollution before the start of operation as well as monitoring of emissions during operation
- Overview of the most important alternatives examined and specification of the essential criteria for the selection.

4.8.3.2 The surroundings of the project

A description of the environment likely to be affected by the proposed project especially referring to impacts on humans, fauna and flora, land, soil, water, air, climate, biotopes and ecosystems, the landscape, natural reserves and cultural monuments. The discussion has to cover the following topics:

- Quantity, quality and possibility of regeneration of the natural resources of the surrounding area.
- Loading capacity of the nature with respect to the following regions:
 - Humid regions
 - Coastal areas
 - Mountains and woodland
 - Nature Reserves and Wildlife Parks
 - Regions with high density population
 - Places of historical, cultural or archeological heritage.

4.8.3.3 Assessment of the environmental impact

This part of the documentation has to provide an overview about the expected negative and positive impacts of the proposed project (including the interaction of the particular impacts) caused by

- The existence of the proposed project
- The use of the natural resources
- The impact of emissions to air and water,
- The impact of waste arising from the project
- The impact of heat transfer to atmosphere and natural waters.

The EIA documentation has to deal with the following issues:

- The accident risk according to the materials and techniques used
- Heaviness and complexity of the impacts
- Period, frequency and reversibility of the impacts
- Description of measures which avoid, restrict or compensate essential negative impacts to the environment by the proposed project as well as measures for the reduction of emissions, savings of resources and energy, waste treatment and the disposal of residues
- An estimation of transboundary impacts
- Detailed Information about the methods used for assessment and an analysis of the sensitivity
- Explanations on difficulties (encountered e.g. to technical problems or missing data) during the compilation of the required information.
- The EIA should also propose a plan for mitigation of environmental impacts.

4.8.4 Fundamentals to the procedures of an EIA

In the mentioned references some requirements on the public participation procedure can also be found:

- The project team should provide the necessary information on the proposed activity, including any available information on the possible transboundary impact for everyone who can be affected by the proposed project
- A reasonable time schedule within which a response is required has to be announced.
- In Article 3.6 of the Espoo-Convention it is mentioned that an affected party shall, at the request of the party of origin, provide the latter with reasonably obtainable information relating to the potentially affected environment under the jurisdiction of the affected Party, where such information is necessary for the preparation of the environmental impact assessment documentation. The information shall be finished promptly and as appropriate.

4.9 Khmelnitsky NPP – description of the site and the region

The maps included in the EIA are not clearly copied, big signs cover locations, the relief is not visible, almost all the maps have no scale and no contour lines!

We miss a description of the landform at the site, as well as of the relief, geological cross sections, a drainage map and a map where the location of weather stations and radiological monitoring stations is shown.

Data about concentration of algae in the Goryn have obviously been copied from the Rovno EIA or *vice versa*, as the values are the same as those given for Goryn river for all seasons.

Information about the environment is scarce, even with respect to facilities and transport routes which could be a hazard for the NPP.

On page 3.13 it is mentioned that there are 85 industrial enterprises within the 30 km zone around Khmelnitsky NPP. The danger of explosion at these sites has to be discussed in connection with the distance from KNPP because an accident with an explosion or a fire can have a severe impact on the NPP. On the presented maps there are no factories marked and there is no further information to the type of production in the surrounding of the plant. The lack of information is just the same as transport is concerned. The EIA does not inform about any influence by traffic or flight corridors.

4.9.1 Seismicity

Chapter 3.2.2. of the Environmental Impact Assessment for Khmelnitsky 2 NPP is identical to the same chapter in the EIA for Rovno NPP. Both EIA's have a fundamental error in common: they assign earthquake magnitudes to the MSK scale. There is no simple correlation between intensity and maximum ground acceleration as presented in that chapter. Some additional information is provided in chapter 9.3.1.1., for example the information that the design in the 70ies was based on an earthquake with intensity 7 (MSK) and that foundations of the buildings are built 1m into the bedrock, 6m below ground level – but a detailed geological profile is missing. Besides, what is the bedrock?

In a recent geophysical study on Bayesian seismic hazard assessment an upgrading was suggested for the Khmelnitskyj site by VAN GELDER & VARPASUO (ESREL'98).

There are severe contradictions in the assessments of Riskaudit: On one hand the experts suggest seismic hazard studies (including the local geological conditions) to confirm the value of the design basis earthquake and the gaining of appropriate response spectra, on the other hand they considered that there was no immediate urgency for these tasks. In Riskaudit No. 120 the experts again recommended exhaustive geophysical studies in order to identify possible needed improvements.

4.9.2 Geology and Hydrogeology

On page 3.23 the EIA describes the location of the NPP as within the eastern borders of the Volhynian-Podolian artesian basin with a widely developed system of ground waters related to Proterozoic and Cainozoic strata – but forgets about the Mesozoic strata.

The bullets on page 3.24 on protection of aquifers need some additional explanation: On the one hand ground waters are not protected against pollution on the other hand the Upper Proterozoic aquifer is protected (why?). This water is used for water supply of the towns of Netishin and Slavuta – but there is no information on the water supply of the town of Ostrog, situated immediately downstream of the NPP.

4.9.3 Meteorology

There are a number of shortcomings in the description of the meteorological situation which are discussed in the following.

The report states that the discussion of the meteorological conditions is based on 3 different weather stations at distances between 20 and 40 km. It is not clear how these 3 stations were

used as most data quoted seem to stem from the on-site station, except some wind data cited to be from Shepetivka. We miss the height above sea level and the geographical co-ordinates of all the stations as well as of the NPP itself.

In contrast to Rovno, there seems to be an on-site meteorological station. However, it is not indicated where exactly this station is situated, how much it can be influenced by topography, NPP buildings etc. Furthermore, it is not said how long the record at this station is. Was it set up only in the beginning of 1996? Or what is the reason that later on only data from 1996 and 1997 are quoted? In any case, two years are not sufficient for climatological considerations.

4.9.4 Existing contamination

An environmental impact assessment requires a detailed description of the surroundings of the planned project allowing an evaluation of the environmental burden already existing before the start of the project. On this basis the contributions of the new source of emissions can be evaluated prospectively and the predictions can be verified after commencement of operation. From a NPP which has already been almost completed – thus making the impact of construction work negligible – the most important sorts of emissions are airborne and liquid radioactive discharges and residual heat transferred into the environment via cooling towers and liquid discharges.

At the planned site for the construction of Khmel'nitsky unit 2 one VVER 1000 unit is already operating. This unit was put into operation in 1987, an information not given in the EIA, although it could be important with respect to immission data. In the following the completeness of the presented data on existing and prospected environmental impacts of Khmel'nitsky NPP units 1 and 2 will be examined.

4.10 Environmental impact of Khmel'nitsky-2

4.10.1 Airborne radioactive emissions

Khmel'nitsky NPP is located outside the 37 kBq/m² contamination zone of the 1986 Chernobyl accident (fallout on Austria: 15-60 kBq/m²). Air is sampled at 8 sites, most of them in the 10 km zone. Data for total β activity are provided for the years 1990-1995 for 8 sites defined only by numbers. The activity in air in the years 1993-1995 was some 40 % higher than in 1990-1992. Differences between sites were small. Sr-90 has been determined, but the results are not presented. Radionuclides in precipitation are monitored at 24 sites, but data are only given for total β activity within 6 subsequent radial zones around the NPP. Total β activity in precipitation has been higher in 1990-1992 than in 1993-1995. In connection with the cited data about activity in air samples this points to higher precipitation in the years 1993-1995. Due to averaging of precipitation data within radial zones it cannot be judged, if contamination in the preferred wind directions (NE and SE) of the NPP has been higher than average.

Not nearer specified vegetation samples have been taken at 25 sites, defined only by numbers. At one site high Cs-137 concentrations (about 10 times the average) were measured in 1993 and 1994. It is stated that I-131 was not detected in any vegetation sample. Surface activity of Cs-137, Cs-134 and Sr-90 were also determined for soils with no clear downward trend discernible in the data given for 1990-1995. Agricultural products were obtained from 3 farms in the 10 km zone (SE, SW and NW of the NPP), but activity values are not presented separately for the three locations. Cs-137 in milk is declining and I-131 has not been detected in milk according to the EIA. Measurement results for Cs-137 and Sr-90 in fish are given without any indication of species, sampling points and number of samples taken. Although about

25 % of the land are used as pastures or for production of hay, meat is not sampled. Data from the time before the 1986 Chernobyl accident are not presented and it is not mentioned when environmental radiation monitoring was started. The Euratom treaty requires information about the foodstuffs distribution system and about exports to other member states of agricultural products, fish or game, which is also not provided.

At present (e.g. in unit 1) gamma-activity of inert radioactive gases, beta- and gamma-activity of iodine and of long-lived nuclides in aerosols are measured only weekly in the ventilation stacks of the three units in operation. An on-line system (called ASCRO) for monitoring of releases and immissions is under construction, however, hopefully for both units. Limits for atmospheric discharges will be set annually for the two NPP units together. There are limits for J-131, the total of long-lived nuclides, the total of short-lived nuclides, noble gases, as well as separate limits for special long-lived nuclides, but no limits for tritium and C-14 airborne emissions.

Mean annual emissions of long-lived nuclides, noble gases and I-131 are presented for Khmel'nitsky unit 1 (also a VVER 1000) for the years 1988-1996. These data show that annual emissions were variable (about 5 to 10-fold differences in the amount of activity released in the groups of radionuclides considered). Calculated predicted emissions for Khmel'nitsky unit 2 are also provided, but the basic assumptions underlying these calculation are not defined.

Compared with other European Reactors the emissions of the VVER 1000 reactor are high, in order to meet the safety level of French and German reactors a modernization of the ventilation system is required.

Table 4.2: Comparison of annual emissions of reactors in Ukraine, Germany and France.

	annual emission in Bq			
	Khmel'nitsky 1	Rovno 3	Germany ¹⁾	France
long-lived nuclides	$8,7 \times 10^7$	$1,7 \times 10^8$	3×10^7	$2,2 \times 10^8$
I-131	$5,5 \times 10^8$	$6,7 \times 10^8$	2×10^7	-
noble gases	5×10^{13}	$9,7 \times 10^{13}$	2×10^{12}	7×10^{12}

EIA R4 and EIA K2; Unscear 1993.

¹⁾ average over 5 years from NPP Grafenrheinfeld, Grohnde, Biblis

Emissions of long-lived nuclides from the waste solidification facility, which are quite high, are presented in a way leaving the exact location of their production and their treatment before release into the atmosphere obscure.

Epidemiological data of the region are missing. Other topics which are not mentioned at all include the history of the one already operating unit (time of putting into operation, shut down periods, accidental releases of radioactivity into the environment) and the alarm system (points of installation, levels for and consequences of alarm).

4.10.2 Liquid radioactive emissions

Liquid radioactive discharges from all units of the NPP apparently are treated together in special purification units. This treatment includes ion exchange and evaporation. The effluent of the purification units is recycled. Used filter material and stillage residues are collected in tanks. After decay of short lived nuclides stillage residue is solidified in a UGU-1-500 evaporator, the fate of the used filtering material is not further explained. Plans for the future include installation of an integrated facility for concentration, cementation and combustion of liquid radioactive waste, whatever this may mean. Estimations of the resulting release of radioactivity (including tritium) into the atmosphere are missing.

The main radioactive liquid discharge reaching the Goryn river is imbalance water from the special purification unit for waste waters from special laundry and showers. Emergency limits for discharge of this waste water into the spraying pond (having an outlet to the cooling reservoir) are specified for I-131 (74 Bq/l), Cs-134 (320 Bq/l), Cs-137 (555 Bq/l) and Sr-90 (15 Bq/l). About 9,000 liters of imbalance water are released to the 40 to 120 million m³ reservoir annually. Further effluents indicated in chapter 6 as possible sources of radioactive emissions into the river (but mentioned in chapter 4 in the subchapter "domestic and other non-radioactive effluents") are water from the circulation channel and site domestic water, probably of the fenced-off area. This sanitary sewage is discharged into the spraying ponds after biological treatment on the site. Dried sewage sludge is disposed at the solid radioactive waste storage facility, indicating radioactive contamination.

For a number of nuclides (tritium not included) activity limits for liquid radioactive discharges will be set annually for the 2 units of the NPP together. Although it is stated that the activity of liquid discharges has been monitored twice a week since 1991, actual measurements are provided only for 1995 (total annual discharge of Co-60, Sr-90, Cs-134 and Cs-137). In contrast to the other mentioned nuclides, Cs-134 release in 1995 was as high as the discharge limit, a result "requiring substantiation", according to the EIA. If this substantiation has taken place in the two years gone by since 1995, is not mentioned. The actual emission of long-lived nuclides in 1995 was 2.9×10^9 Bq. Tritium activity in liquid discharges was neither measured, nor estimated. It is indicated that the activity of liquid discharges is monitored twice a week in circulation channels and domestic water and in intervals not specified also in service water, waste water (source not specified) and industrial and rainfall effluent. A description of methods and results of these measurements is completely missing.

Water was sampled at different locations including 4 river sites upstream and 2 river sites downstream of the NPP, 3 sites of the cooling reservoir (2 in the vicinity of the NPP and one at the other end, probably some 6 km away) the drainage channel of the cooling reservoir, drinking water and some other locations (including a lake) which are ill defined with respect to location and type of water. Only some of the sampling points can be localized relative to the NPP with the information provided in the EIA. For the cooling reservoir only one data set is provided, e.g. the results are either averaged or presented only for one of the sampling sites (which one?). Open waters were sampled twice a year, other waters monthly. Algae and sediments were sampled once a year at some of the sampling points. Methods of sample preparation and measurement are not adequately defined.

Results are given for total β activity for 1990-1995 (for the cooling reservoir until 1997), for Cs-137, Sr-90 in water, sediments and algae and for total radioactivity in sediments and algae. Concerning Cs-137, Sr-90 and total β activity (presumably not including tritium) in water no obvious differences can be discerned between the different sampling sites, with the exception of drinking water (stemming from a protected aquifer) with a 2-fold higher total β activity and of water of the Viliya river in 1990 and 1991 at the downstream sampling point. If this 100-fold augmentation in β activity could somehow have been caused by NPP emissions is not commented and remains unclear because of the lack of a detailed map and information about the exact sampling point. Data about radioactivity in sediments are presented for 7 sites, but only one of the sites – the drainage channel of the cooling reservoir – can be unequivocally identified as a site influenced by NPP emissions from the information provided in the EIA. In the sediments of this drainage channel Sr-90 concentration and total radioactivity are about 10-fold higher than in river sediments of a measuring point upstream of the NPP and higher than at all other sampling sites. Data about radioactivity in sediments are not presented for the cooling reservoir and for the Goryn river sampling sites downstream of the NPP. Sr-90 and total radioactivity in algae is generally high. The highest Sr-90 values (551 Bq/kg) have been found in the lake of unknown location in 1994 (data of subsequent years not presented) and in Goryn river downstream from the NPP (up to 39.6 Bq/kg). In sum data about radioactivity in algae are too incomplete to draw any conclusions.

Although there is a fish farm in the cooling reservoir in the immediate vicinity of the NPP, results of measurements of radioactivity in fish are not provided. For the calculation of the individual dose it is assumed that the annual liquid discharge of Co-60, Sr-90, Cs-134 and Cs-137 gets equally distributed throughout the reservoir (which is assumed to be filled to the highest level). Concentrations in fish are derived from the calculated concentrations in water by the application of not clearly defined concentration factors. The underlying assumption of equal distribution throughout the reservoir does not seem appropriate, especially with respect to fish reared in the fish farm situated close to the NPP.

A survey of tritium in waters around the NPP during 1986 is cited, in the course of which an increase in tritium concentration with time in the cooling reservoir has been noted. It is stated that ground waters (not protected, according to the information provided in chapter 3) are monitored for total β activity and tritium contents every month, but no results are presented.

It is indicated in chapter 3 that the river plain is periodically flooded and that river water is used for irrigation in the 30 km zone from the NPP. Nevertheless the possible impact of radionuclides from the NPP on soil contamination is not considered in the EIA. Data given for radioactivity of soils and crops are not valuable for judging a potential impact of flooding or irrigation with river water, because no adequate details about the samples are provided.

The Euratom Treaty also requires information regarding radioactive discharges into the same waters by other installations where there may be an additive effect, a topic not mentioned in the EIA.

4.10.3 Non radioactive release

Non-radioactive waste water finally discharged into the Styr include sanitary/household water of the non fenced-off area (after biological treatment), effluent of oily water purification (probably after biological treatment), storm and drain water, water from the circulation channel and clarified effluent from process water treatment and from biological treatment of sanitary waste water of the fenced-off area.

The design capacity of the biological treatment plant for sanitary sewage of the fenced-off area on the NPP site is 400 m³/d for two units. It is stated that the flow from 2 units is 148 m³/d. Sanitary/household sewage of the non fenced-off area are treated at the municipal treatment facility with a design capacity of 20,000 m³/d and a flow rate from two power units of 540 m³/d. It is not clear, how much is contributed to the sewage treatment facility from municipal sources, but the capacity seems sufficient. Data about the effectiveness of the purification are not provided, however. Water quality data are presented for the cooling reservoir and for the Goryn (sampling points not indicated in any case), showing periods with very high ammonia concentrations in the river (up to 1.6 mg/ml NH₄(-N?)).

The question whether the temperature of the Goryn will rise because of drainage of water from the cooling reservoir to the river is not directly addressed in the EIA. In chapter 7 it is mentioned that bleed water from the NPP heat sink, probably meaning the cooling reservoir, is only allowed once a year by special authorization. In chapter 3, however, it is said that the flow rate through the dam of the cooling reservoir will be given in Table 3.14. This may be true, although it is in contradiction with the heading of this table. The resulting confusion and the lack of information on the temperature of the cooling reservoir and the location of the temperature measuring point in the Goryn river make any predictions about the change in river temperature after start-up of unit 2 impossible. River temperature already reaches a maximal temperature of 26°C in summer at the measurement point of unknown location with respect to the drainage channel of the reservoir.

4.10.4 Radiological impact of normal operation

The EIA does not state at all which Gaussian plume dispersion model has been used for the dose calculations and which parameterizations have been used in the model. Furthermore, it says that “The windrose was established using data provided by Kyievenergoproekt”. However, a wind rose is not the kind of input needed to derive the annual doses. Rather, a four-dimensional frequency distribution of wind speed, wind direction, stability category, and precipitation rate is needed. Instead of this information Table 6.4. presents annual average dilution coefficients for most probable wind directions at different release heights, these data are also provided by Kievenergoproekt. It is not at all clear from which meteorological measurements (site, length of time series, etc.) the input to the dispersion has been derived. This means that there is no basis to judge whether the calculations were made properly and results are reliable. In western countries, a NPP would never be licensed on the basis of such scarce information.

The dose calculation is clearly not conservative because the source term used is neither the calculated predicted annual release rate, nor the annual emission of Khmelnitsky-1 in 1995 cited as a more “realistic” basis for the calculation (1995 was a year with only average emissions of all groups of nuclides!), but a list assumed emissions of selected nuclides. While Cs-137 emissions have been lowered by a factor 15 with respect to predictions, possibly based on actual emissions of Khmelnitsky 1 in 1995, I-131 emissions have been lowered by a factor 3 to 5 when compared to actual emissions of Khmelnitsky 1 in 1995 or 1996, as is stated in the footnote to table 7.2 without any explanation

It is not explained on which food consumption data the dose calculation is based, but table 7.6 (EIA p.11) provides data about annual agricultural production in the 30 km zone around the NPP. The production data are meaningless because they come without any units and important products are not listed (e.g. fish, which is a significant contribution to the nutrition of the local population and not unlikely to be contaminated when caught near the outlet or downstream from the NPP).

The lack of information about the dose calculation model hinders a meaningful comparison with the dose limits, which are set according to ICRP 26 as it is explained in chapter 5.

Because of the lack of information about the calculation model and data, we cannot follow the conclusion that the exposition will be very small.

4.10.5 Environmental Impact of the nuclear fuel cycle

Concerning the fuel cycle as a whole, the EIA is incomplete. The impact from the production and transports of nuclear fuel is not considered at all. This is a crucial point because – besides accidents in NPPs – uranium mining is the most important contribution to radioactive contamination. Even if transports of fresh fuel assemblies are relatively harmless, the radiation caused by transports of spent fuel is subject of a legal debate in Western Europe, which will probable lead to obstacles for transports and a minimization of the amount of fuel which can be shipped at all. There is no program presented for the handling of all nuclear waste arising from the NPP and it is not clear which institution is responsible for which part of a the nuclear waste management program. It is also not explained, how these necessary activities will be funded.

4.10.5.1 Low and intermediate waste

In the EIA no clearly organized management system for radioactive waste is presented. An exhaustive description of the amount, the origin and the chemical and radiological characteristics of waste is not given. According to the usual requirements for an EIA a detailed description of the waste arising and a waste management plan are absolutely necessary.

Concepts for the low and intermediate radioactive waste generated by the NPP (including waste from decommissioning) foresee only **interim** storage facilities at the site. The planning of a final repository is part of the state program on radioactive waste management.

At the moment Group I wastes (low radioactive) from normal operation of Khmel'nitsky unit-1 is stored at the site without prior packaging or conditioning, since a waste treatment facility is only in the stage of planning. The EIA is mentioning that at the end of 1996 100 % of the cells designed for Group I wastes were full and now Group I wastes are now disposed in cells for Group II. (page 4.31)

It remains also unclear how the processing of liquid radioactive waste is performed (page 4.33). The planned project which should be carried out in cooperation with NUKEM is not explained sufficiently and potential emissions and effluents are not discussed.

Whereas solidified liquid radioactive wastes (page 4.33) is considered, it is not outlined how the module-type storage facility for salt fusion cake containers which is under construction is designed.

Concepts for low and intermediate radioactive waste generated by the NPP (including waste from decommissioning) foresee only interim storage facilities at the site. The planning for further storage is part of the State program on radioactive waste management.

It is a serious deficiency of the EIA that potential radioactive emissions and effluents caused by the future waste handling facility are not discussed sufficiently. Construction and operation of a nuclear waste handling complex would require a EIA as part of an licensing procedure, because of the "complex and potentially adverse effects, including those giving rise to serious effects on humans or valued species or organisms, ..." (Espoo-Convention)

4.10.5.2 Spent fuel management

There is no detailed plan for management and storage of spent fuel from Khmel'nitsky-2.

Spent nuclear fuel has to stay for 3 years in the reactors spent fuel pool. The capacity of the cooling pond is enough for more than 10 years of operation. After a first hold-up time spent fuel will be shipped from the spent fuel pool either to:

- a reprocessing plant, which is the principle design scheme, or
- to the spent nuclear fuel storage facility (still to be built) for intermediate storage where it will stay for at least five more years. The site for the interim storage is not defined but it is planned to be inside the sanitary protection zone of the NPP. The facility is planned as a cask storage hall cooled by natural convection of ambient air. Capacity of the interim storage will be 30 „TK-13“ containers. Every TK-13 can be loaded with 12 WWER-1000 fuel assemblies. Spent fuel generated by one year's operation requires 5 casks, a complete core 14. The planned storage capacity will be exhausted after 6 years but an enlargement of the storage building is possible.
- after interim storage the spent fuel shall be shipped away from the plant
- handling, packaging, and transport of failed fuel elements after storage in the pool is not discussed!

As far as the reprocessing of fuel is concerned, there apparently exists no definite agreement with a commercial reprocessing facility outside of the Ukraine.

Concepts for the final repository for High active waste are not outlined in the EIA.

Since the planned cask storage for spent fuel is not item of this EIA, the licensing of the interim storage near the plant will require a further EIA.

4.11 Rovno NPP – the description of the site and the region

The maps included in the EIA are not clearly copied, big signs cover locations, the relief is not visible, the maps have no scale and no contour lines!

We miss a description of the landform at the site, as well as of the relief, geological cross sections, a drainage map and a map where the location of weather stations and radiological monitoring stations is shown.

Data about concentration of algae in the Styr have obviously been copied from the Khmelnitsky EIA or *vice versa*, as the values are the same as those given for Goryn river for all seasons.

Information about the environment is scarce, even with respect to facilities and transport routes which could be a hazard for the NPP.

On page 3.12 it is mentioned that there are various industrial enterprises within the 30 km zone around Rovno NPP. According to information received from the regional administrations there were no facilities within the 30 km zone with a probable hazard of fire and explosions. On the presented maps there are no factories marked and there is no further information about the type of production in the surrounding of the plant presented in the EIA. The lack of information is the same where transport is concerned. The EIA does not inform about any influence by traffic, since neither transports of hazardous materials on the railway near the Rovno NPP, nor the regular flight corridor which is located in the immediate vicinity are considered (distance to the NPP 10 km, minimum flight height 1100 m). This is an important deficiency of the EIA.

UK-P-3 Рівне Rivne РОВНО ԵԲԲԻՅ ՔԻՒ L'viv FIR ԵԲՅՕՅ ՔԻՒ	րադիուս 5 կմ շ ճԵՆԻՐՈՄ: radius 5 km, centre: րադիուս 5 կմ Տ ճԵՆԻՐՈՄ: N5120 E02555	$\frac{6000}{\text{GND}}$	AEC Atomic power-station AԶC	H24
UK-P-4 ԽՄԵԹՆԻՏՅԻՅԻ Khmel'nyts'kyi ԽՄԵԹՆԻՏՅԻՅԻ	րադիուս 5 կմ շ ճԵՆԻՐՈՄ: radius 5 km, centre: րադիուս 5 կմ Տ ճԵՆԻՐՈՄ: N5020 E02640	$\frac{6000}{\text{GND}}$	AEC Atomic power-station AԶC	H24

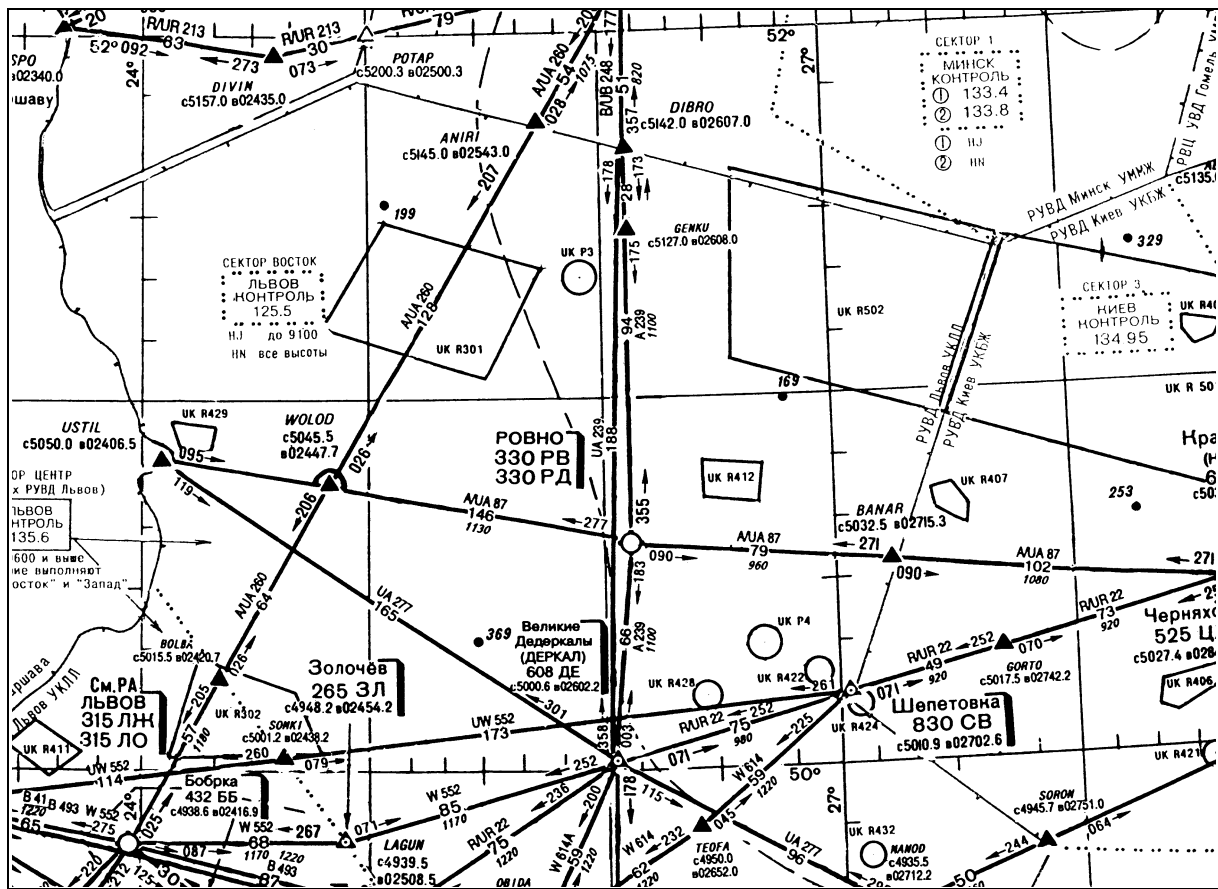


Figure 4.3: Flight corridors in the Ukraine

Austro control GmbH, Flugsicherungsstelle Wien and Aeronautical Information Circular of Ukraine, August 1997.

4.11.1 Seismicity

Chapter 3.2.2. of the Environmental Impact Assessment of Rovno 4 NPP is exactly the same as in the EIA of Khmelniysky 2 NPP although Rovno-NPP is situated in the Polesje-Lowlands (marshland and lake district) whereas Khmelniysky NPP is situated in the area of the Volhynian Heights about 130 km towards Southeast and therefore closer to the Carpathian Mountains and the area of strong earthquakes in Romania (Vrancea).

Both studies contain the same fundamental errors in chapter 3.2.2. and are explained and corrected as follows:

Magnitudes of earthquakes are shown on different magnitude scales that rely upon different seismic waves. The recorded magnitudes are not classified on the macroseismic intensity scale (MSK)! Therefore the magnitudes 5 and 6 do not correspond to maximum ground accelerations of 0.02 g and 0.05 g as written in these chapters.

Chapter 9.3.1.1. of Rovno NPP adds some corrections to chapter 3.2.2. but there is no documentation of seismic observations and geophysical studies in that area.

The statement therein that the design of Rovno units 3 and 4 has been based on an intensity of 7(MSK) corresponding to a maximum ground acceleration of 0.1 g is accepted at face value from the designer. It is hard to believe, however, because the cited assessment was carried out by Atomenergoprojekt in Russia who designed NPP's within stronger seismic areas at lower levels. Besides a g value of 0.1 g is the absolute minimum level for NPP's recommended by IAEA.

Although some papers on tectonics, neotectonics and karst phenomena in western Ukraine have been published, these are not mentioned or their results are not discussed in this EIA. A much greater attention should be paid to neotectonic and recent movements of blocks into which the Eastern European Platform is subdivided. These movements seem to be the far field expressions of movements along faults and thrusts running oblique and along the Carpathian Mountains.

In earlier and recent seismotectonic studies the importance of these zones of weakness for seismotectonics and for economic geology and hydrogeology has been recognized. There may be a link between these block boundaries and historical earthquakes in the Carpathian foreland.

Rejuvenation of fault zones and renewed seismic activity of Carpathians and East European platform was discovered by several ukrainian earth scientists: "It is necessary to take into consideration that high seismic and geodynamic activity coincide with such zones to prevent the destruction of large objects by disastrous phenomena".

4.11.2 Geology and Hydrogeology

The authors of the EIA do not present geological maps of the region or demonstrate the geological situation with the help of geological cross sections. Despite the fact that Rovno NPP is situated within a Karst area of broad extension and that safety related structures (reactor building, diesel generator building and essential service water pump house) have deep pile foundations and that karstified limestones are underlying the NPP, no detailed engineering geological and hydrogeological maps, profiles or borehole documentation is presented in this environmental study.

The very important information on pile foundation of the buildings down to basaltic bedrock at a depth of 33-35 m is only a short note within the chapter on seismicity and not discussed in the geological chapter. Apart from the missing scientific documentation the special subsoil conditions (karstified limestones, chalk layers, fissured basalts, tuffs) would have demanded an intensive geotechnical documentation of the construction works (especially grouting) and their effects on hydrogeological conditions. The distribution of faults, joints, karstic features and their injection with different agents (suspensions, pastes) as well as the control of the results requires documentation.

Concerning environmental impacts during operation, an assessment of the effects of further artesian abstraction on hydrogeological conditions of the area would have been a requirement for the EIA. Environmental impacts during the completion of construction are considered, but not the environmental impact on the hydrogeological situation due to foundations and grouting in the karstic and crystalline fissured rocks.

There is no hydrobiological study of the Karst environment.

Finally, the EIA neither includes the evaluation of Karst occurrence in Cretaceous rocks nor the recent activity of karst processes under natural and technically influenced conditions. Previous scientific research proved a rather high activity of karst processes within the Rovno operating site. Therefore a complex Karst monitoring and preventional measures against an impact on existing buildings and foundations are strongly recommended.

Because fissured hard rocks have a very low sorption capacity a risk assessment for groundwater contamination with radionuclides in case of emergency is necessary.

The ongoing active karst development should be taken into account as an additional hazard to the storage of radioactive wastes on the NPP sites.

4.11.3 Meteorology

There are a number of shortcomings in the description of the meteorological situation which are discussed in the following.

The report states that the discussion of the meteorological conditions is based on 5 different weather stations at distances between 25 and 150 km. It is not clear how these 5 stations were used. Are the data quoted taken as averages and extremes of these stations if not specified otherwise?

We miss the height above sea level and the geographical co-ordinates of all the stations as well as of the NPP itself.

It is also surprising that obviously there are no on-site meteorological data though the nuclear power plant is operating since 1980. Western standards would require continuous operation of a meteorological station at a NPP site.

What is the data period that has been used? Is it long enough to justify climatological conclusions?

What is the environment of the stations and can the measurements at these stations also be assumed valid for the NPP site? This would depend on land use, topography and distance and it cannot be concluded from the material presented. Distances of more than 100 km are probably too large for reliable on-site data.

Though this does not constitute a problem, it is surprising to find the vapor pressure expressed in millibar instead of hectopascal which is the official unit since many years.

The report appears to have been prepared and/or translated without involvement of qualified specialists. For example, it states a lowest height of the snow cover which makes absolutely no sense. Then, solid precipitation is called "rigid precipitation".

A frequency distribution of atmospheric stability according to Pasquill is given in Table 3.12. These stability categories are important for the calculation of radiological impact in the surroundings. It is not stated how these values were derived (from which station(s), which kind of measurements, how long is the underlying time series?).

4.11.4 Existing contamination

An environmental impact assessment requires a detailed description of the surroundings of the planned project allowing an evaluation of the environmental burden already existing before the start of the project. On this basis the contributions of the new source of emissions can be evaluated prospectively and the predictions can be verified after commencement of operation. From a NPP which has already been almost completed – thus making the impact of construction work negligible – the most important sorts of emissions are airborne and liquid radioactive discharges and residual heat transferred into the environment via cooling towers and liquid discharges.

At the site for the construction of Rovno unit 4 three units are already operating (two VVER 440 and one VVER 1000). Rovno1/2 started commercial operation in 1980/81, Rovno-3 in 1986 (information not provided in the EIA). Presented emission data only include the years 1987-1996, those about environmental radioactivity are with one exception provided only from 1990 onwards. Earlier data could have been interesting for the evaluation of the contribution of the different units to the actual contamination of the environment. In the following chapter the completeness of the presented data on existing and prospected environmental impacts of Rovno NPP units 1-4 will be examined.

4.12 Environmental impact of Rovno-4 NPP

4.12.1 Airborne radioactive emissions

Concerning airborne radioactive emissions from the three units already operating it is reported that no radionuclides of technical origin (including I-131) could be detected in near-ground surface air sampled at 7 different locations in the 10 km zone and one location at a distance of 25.5 km from Rovno NPP and that it was impossible to single out the contribution of Rovno NPP emissions against Chernobyl-induced and natural background radiation.

The only data shown are mean annual averages (1990-1995) over all locations of the measured near-ground surface air activity of Be-7, Cs-134 and Cs-137. A map showing surface contamination by Cs-137 following the Chernobyl accident in 1986 is presented, but the Rovno NPP site lies beyond the boundaries of the map. It can only be guessed that the site might have fallen into the 37-185 kBq/m² zone. (comparable with the contamination in Austria reached values from 10 to 180 kBq/m²)

It is reported that radionuclides in wet and dry deposition have been monitored at a height of 2 m above ground at 17 points in the 10 km zone and one point at 25,5 km from the NPP, but absolutely no data are provided about the results of these measurements. In chapter 5 a monitoring system named Gamma-1 (sponsored by the EU Commission and under control of the Ukrainian Ministry of Environmental Protection) is mentioned to be partially in operation in the 30 km zone, but again no data are provided. Radionuclides in the upper 5 cm of soil have been determined annually at the same 18 locations and annual averages over all locations are given for Sr-90, Cs-134 and Cs-137. In contrast to Cs-134 in near-ground surface air, concentrations of Cs-134 in the upper 5 cm of soil are declining, which needs to be explained.

Grass samples were taken once a year and mean annual averages are presented for the activity of Sr-90, Cs-134 and Cs-137 without indicating at which locations the samples have been collected. It is mentioned, however, that vegetation contamination prior to the start of Rovno NPP has been 2.5-9.5 Bq/kg for Cs-137 (mean value 1996 22 Bq/kg, declining) and 2.2-10.2 Bq/kg for Sr-90 (mean value 1996 approximately 9 Bq/kg). Cs-134 in grass samples is not declining. At the onset, of the pasturing period milk samples are annually taken at 10 locations showing declining concentrations of Cs-134 and Cs-137 (0.68 Bq/l and 7.4 Bq/l, respectively, in 1995). Potatoes and cereals sampled at the same locations show no corresponding decline. Other vegetables are not considered. Although a high percentage of the land is used as pastures or for production of hay, meat samples are not taken.

Contamination by the 1986 Chernobyl accident probably is the main contribution to radioactive contamination of foodstuffs produced in this region but seems to be declining steadily. The omission of data about wet and dry deposition gives the impression that the contribution of Rovno NPP to radioactive contamination of its surroundings is intentionally concealed. Activity in water, sediments and algae of fish ponds is not measured or at least not mentioned, as is radioactive contamination of fish and game, although there are a number of lakes and fish ponds in the region and locally produced fish accounts for about 10 % of consumption. The Euratom treaty also requires information about the foodstuffs distribution system and about exports to other member states of agricultural products, fish or game, which is not provided. Although the Laboratory of External Radiation Monitoring was already created in 1978, the sparse data provided about results of radiation monitoring in the 30 km zone all stem from after 1990 and almost no pre-Chernobyl data are included.

It is admitted that there is no monitoring of tritium at the NPP site because of lack of corresponding devices and the absence of relevant regulations. Gamma-activity of inert radioactive gases, beta- and gamma-activity of iodine and of long-lived nuclides in aerosols are measured only weekly in the ventilation stacks of the three units in operation. An on-line system

(called ASKRO) for monitoring of releases and ambient concentration is under construction, however. It is not clear if continuous monitoring (including tritium) will be installed in the central stacks of all units, but it can be hoped from indications in the EIA that it will be at least installed for unit 4. Limits for atmospheric discharges are set annually for the four Rovno NPP units together. The politic of limit setting is not entirely clear. There are limits for I-131, the total of long-lived nuclides, the total of short-lived nuclides, noble gases and at least in some years separate limits for special long-lived nuclides, but no limits for tritium and C-14 airborne emissions.

According to the data presented, which are very scarce, the legal limits for airborne radioactive discharges are set much higher than the actual emissions and thus seem to be of minor importance for the actual radioactive burden to the environment. Actual emissions are given for long-lived nuclides, I-131 and noble gases for Rovno NPP as a whole (units 1+2+3) for the years 1987-1996 and for unit 3 alone (the only VVER 1000) for the years 1994-1996 (see Table). Average emission values for unit 3 are also provided without an indication of their origin. These data show that annual emissions were highly variable (about tenfold differences in the amount of activity released in the groups of radionuclides considered). As deduced from emissions of Khmel'nitsky unit 1, unit 3 appears to be responsible for about half of the activity released, implying that one more VVER 1000-unit would roughly increase total Rovno NPP airborne radioactive routine emissions by a factor of 1.5. The planned concentration of liquid radioactive waste by evaporation (see subchapter about liquid radioactive emissions) might additionally contribute to airborne radioactive emissions, a point not addressed in the EIA. From these assumptions about the amount of radioactivity to be released no further direct conclusions can be drawn because of the lack of data provided on the environmental impact of the existing 3 units. Epidemiological data concerning the years of operation of Rovno NPP before the Chernobyl accident are missing. Other topics which are not mentioned at all include the history of the three operating units (time of putting into operation, shut down periods, accidental releases of radioactivity into the environment) and the alarm system (points of installation, levels for and consequences of alarm).

Relevant data are scarce (annual emission data are provided only for one VVER 1000 and 3 years) and the presentation is chaotic. For example, the emission data of the VVER 1000 Rovno unit 3 are presented only in chapter 10 ("Alternatives") and not in chapter 6 ("Routine discharges and waste arising"). This probably is due to the fact that the presented data for the Rovno VVER 1000 unit are in reality derived from Khmel'nitsky unit 1, because for this unit exactly the same emissions are presented for 1994-1996. Airborne radioactive emissions are presented in Bq/d, Ci/d (an outdated unit!) or Bq/a for a varying number of NPP units making comparisons time-consuming.

Future radioactive emissions caused by the planned waste treatment facility, are not discussed at all.

The annual emissions of VVER 1000 reactors in operation are important for the EIA, because they are used as source term for continuous airborne radioactive release in the calculations of individual and collective doses for the surrounding population on the grounds that the release predicted from calculations was "sometimes pessimistic" when compared to Khmel'nitsky NPP (one VVER 1000). The value for I-131 was lowered without explanation to one third or one fifth of the actual emissions, as is mentioned in a footnote. With this source term the dispersion and deposition is calculated using a Gaussian plume model and the wind rose of the site. It is not entirely clear if precipitation data were also considered for the dispersion calculations, as they are not mentioned in the corresponding subchapter (7.1.4.2. "Dispersion and deposition").

Tab 4.3: Annual emissions of VVER reactors in operation:

	long-lived nuclides		I-131		noble gases	
	units 1,2+3	unit 3*	units 1,2+3	unit 3*	units 1,2+3	unit 3*
1994	1.71x10 ⁸	7.6x10 ⁷	4.96x10 ⁸	1.3x10 ⁸	1.10x10 ¹⁴	1.4x10 ¹³
1995	3.92x10 ⁸	8.0x10 ⁷	1.39x10 ⁹	3.0x10 ⁸	9.99x10 ¹³	5.7x10 ¹³
1996	1.29x10 ⁸	9.9x10 ⁷	1.61x10 ⁹	5.7x10 ⁸	9.29x10 ¹³	7.4x10 ¹³
Averages*	2.99x10 ⁸	1.7x10 ⁸	1.25x10 ⁹	6.7x10 ⁸	1.11x10 ¹⁴	9.7x10 ¹³

* Values probably derived not from Rovno unit 3, but from Khmelnitsky unit 1

Average radioactive emissions of the years 1987-1996 for units 1,2+3 calculated from the data presented in the EIA, and average values given for radioactive emissions of unit 3 in chapter 10 of the EIA (years not indicated).

For a comparison we present average emissions data of Rovno unit 1/2 in the years 1981-1985:

- noble gases 6,5x10¹³ Bq/year
- I-131 6x10⁸ Bq/year.

Average calculated from the annual emission data according to [UNSCEAR 1988]

The fact that the UN Scientific Committee on Radiation got these data from the Ukraine shows that these data are available. It is a serious deficiency of the EIA that relevant emission as well as immission data are not presented. Also not mentioned are measurements of tritium release undertaken at Rovno NPP by Markelova and Maziukevich (1990). The authors claim that 70 % of tritium are emitted by the cooling towers and the remaining quantity is discharged into the Styr.

Compared with other European Reactors the emissions of the VVER 1000 reactor are high, in order to meet the safety level of French and German reactors a modernization of the ventilation system is required.

Table 4.4: Comparison of annual emissions of reactors in Ukraine, Germany and France.

	annual emission in Bq			
	Khmelnitsky 1	Rovno 3	Germany ¹⁾	France
long-lived nuclides	8,7x10 ⁷	1,7x10 ⁸	3x10 ⁷	2,2x10 ⁸
I-131	5,5x10 ⁸	6,7x10 ⁸	2x10 ⁷	-
noble gases	5x10 ¹³	9.7x10 ¹³	2x10 ¹²	7x10 ¹²

EIA R4 and EIA K2; Unscear 1993.

¹⁾ average over 5 years from NPP Grafenrheinfeld, Grohnde, Biblis

4.12.2 Liquid radioactive releases

Liquid radioactive discharges from all units of the NPP apparently are treated together in special purification units. This treatment includes ion exchange and evaporation. The effluent of the purification units is recycled. Used filter material and stillage residues are collected in tanks and bitumenified. Plans for the future foresee solidification by evaporation instead of bitumenification. This probably will lead to higher airborne radioactive emissions, including emissions of tritium. Estimations of the foreseeable augmentation of the amount of radioactivity released into the atmosphere are missing.

The main radioactive liquid discharge reaching the Styr river is imbalance water from the special purification unit for waste waters from special laundry and showers. Activity limits for discharge of this waste water into a spraying pond having an outlet to the Styr river are said to exist, but are not specified. Further effluents indicated in chapter 6 as possible sources of radioactive emissions into the river (but mentioned in chapter 4 in the subchapter „domestic and other non-radioactive effluents“) are blow-off water from the circulation channel and site domestic water, probably of fenced-off area. This sanitary sewage is discharged into the spraying ponds after biological treatment on the site. Dried sewage sludge is disposed at the solid radioactive waste storage facility, indicating radioactive contamination.

For a number of nuclides (tritium not included) activity limits for liquid radioactive discharges are set annually for all units of the NPP together. Although it is stated that the activity of liquid discharges has been monitored twice a week since 1991, actual measurements are provided only for 1995 (total annual discharge of Co-60, Sr-90, Cs-134 and Cs-137). The actual emission of these nuclides in 1995 was 4.1×10^{10} Bq. An estimation of the supposed contribution of unit 4 to these emissions is not provided. Tritium activity in liquid discharges has been neither measured nor estimated. It is indicated that the activity of liquid discharges is monitored twice a week in circulation channels and domestic water and in intervals not specified also in service water, waste water (source not specified) and industrial and rainfall effluent. A description of methods and results of these measurements is completely missing.

The Laboratory of Environmental Radiation Monitoring is said to have monitored radioactivity in water, sediments and algae of the Styr and in groundwater for several years. The applied methods are not or inadequately specified. Where the samples were taken is only indicated for water-monitoring of the Styr, namely 10 km upstream and 10 km downstream of the NPP, as well as at the discharge site. Sampling procedure and extent of mixing of radioactive effluent and river water at the sampling points are not properly defined. Concerning the results, the only data provided are annual averages of Cs-137 activity from 1981 to 1996 for the three sampling points, where total β -activity (presumably without tritium) has been determined every 10 days from 4l of river water. These data show a great variability in activity and no attempt is made to explain this fact. It is not clear if waterflow of the river at the sampling time has been taken into account to make the data of different years comparable. The data are presented in the form of one table (3.25, years 1990, 1991, 1993-1995) and one figure (7.4, years 1981-1985, 1988-1993, 1996, values for upstream discharge point omitted for 1995, 1988 and 1989). Although in most years Cs-137 activity is higher at and downstream from the discharge point than upstream, it is concluded (without mentioning the results of the indicated activity measurements in sediments and algae) that it is difficult to identify any impact of the NPP on radioactive contamination of the Styr.

It is indicated in chapter 3 that river water is used for irrigation in the 3 km zone, not specifying if this is also the case for the part downstream from the NPP, and that the river plain is periodically flooded. Nevertheless the possible impact of radionuclides from the NPP on soil contamination is not considered in the EIA. Data given for radioactivity of soils and crops are not useful for judging a potential impact of flooding or irrigation with river water, because no adequate details about the samples are provided.

The Euratom Treaty also requires information about radioactive discharges into the same waters by other installations where there might be an additive effect, a topic which is not mentioned in the EIA.

4.12.3 Release of non-radioactive substances and heat in liquid emissions

Non-radioactive waste water finally discharged into the Styr include sanitary household water of the non fenced-off area (after biological treatment), effluent of oily water purification (probably after biological treatment), storm and drain water, blow-off water from the closed circulation system of the turbogenerator condensers, and clarified effluent from process water treatment and from biological treatment of sanitary waste water of the fenced-off area.

The design capacity of the biological treatment plant for sanitary sewage of the fenced-off area on the NPP site is 4630 cm³/s for two units. It is stated that the flow from 2 units is 2616 cm³/s. If there is only this one purification unit (a possibility which cannot be excluded based on the information given in the EIA), it will be overloaded leading to discharge of not adequately purified water into the Styr. The same applies for sanitary/household sewage of the non fenced-off area with a design capacity of 0.016 m³/s and a flow of 0.012 m³/s from two units. The fate of this kind of waste water is not at all clear from the contradictory descriptions in the EIA. While some sentences give the impression that it is treated in the municipal sewage treatment plant, the design capacity and the mentioning of „site treatment facilities“ (plural!) give the impression that there might be even two such treatment plants on the NPP territory, one for units 1+2 and one for units 3+4. The same might apply to sewage treatment in the fenced-off area. But this has to remain mere speculation.

Water quality data are presented for „above“ and „below“ the town of Kuznetsovsk (at a distance of 3 km from the NPP) without any indication of how the dimensionless values presented for the different parameters and chemical substances have been obtained. No great differences can be seen between the data given for the two sites (values for nitrate seem much too low compared to the other substances). The significance of this is unclear however, because it is not even indicated where the measurement points are situated with respect to the outlets of the NPP and the municipal sewage treatment plant. Results of measurements undertaken 10 km upstream and 10 km downstream of the NPP are also presented, this time indicating the dimensions, but nothing else. Even the upstream values are higher than the ones given for Kuznetsovsk, although no tributary can be seen on the map between the two locations, indicating that the values given are at best comparable within the same table and not between the two different tables presented. According to table 7.8 sulphate, iron, nitrate, ammonia and nitrite concentrations are 20 to 50 % higher downstream than upstream of the NPP. It is not clear at all, however, over which time the values presented have been averaged and if they refer to a distinct waterflow. Maximum concentrations reached at times of minimum water flow should have been indicated, especially for ammonia, where the concentrations indicated are very high (0.44 mg/l at the downstream site). The phosphate load of the Styr is also quite high (0.5 mg/l). It is admitted in the EIA that legal limits for discharges from the municipal sewage treatment plant (which probably include discharges from biological treatment of NPP waste waters) are already exceeded for ammonia and phosphate (although it is set at the high value of 5 mg/l) and that this question has to be addressed in the environmental action plan.

Current NPP heat release in water discharge is stated to lead to a temperature rise of 2.7-3°C 500m downstream of the NPP water outlet. It is not indicated for which waterflow this rise has been measured. The figure presented in connection with this topic shows a rise of 3°C for a discharge water temperature of 40°C, but, according to the text, discharge water temperature can on hot days reach 42°C. It can be inferred from the figure that this could cause a total temperature rise of at least 4°C. Temperature rise after the start-up of unit 4 thus can be expected to be higher than 4°C in hot periods. Legally admissible in Ukraine are a temperature rise of 5°C and a maximal water temperature of 28°C. Mean monthly water temperature is stated to be 21°C in July and 20°C in June and August. As usual, the number of years from which these averages have been derived is not indicated and the exact point of temperature measurement is only defined as „in the vicinity of the NPP“, hopefully meaning downstream from the NPP water outlet. In any case these average values are not very in-

dicative of the maximum temperature reached at the minimum waterflow, which appears to be sometimes as high as 28°C according to some values given under the heading „highest annual 10-day period water temperature”. In sum, and taking into account also the reduction in waterflow which will be caused by unit 4, it appears that the limit of 28°C will be periodically reached or exceeded after start up of unit 4. It is hard to believe that this would have no impact on the biology of the Styr downstream of the NPP.

4.12.4 Radiological impact of normal operation

The EIA does not state at all which Gaussian plume dispersion model has been used for the dose calculations and which parameterizations have been used in the model. Furthermore, it says that “The windrose was established using data provided by Kyievenergoproekt”. However, a wind rose is not the kind of input needed to derive the annual doses. Rather, a four-dimensional frequency distribution of wind speed, wind direction, stability category, and precipitation rate is needed. Instead of this information Table 6.4. presents annual average dilution coefficients for most probable wind directions at different release heights, these data are also provided by Kievenergoproekt. How were these dilution coefficients derived and used in the dose calculation for routine operation? It is not at all clear from which meteorological measurements (site, length of time series, etc.) the input to the dispersion calculation has been derived. This means that there is no basis to judge whether the calculations were made properly and results are reliable. In western countries, a NPP would never be licensed on the basis of such scarce information.

The dose calculation is clearly not conservative because the source term used is neither the calculated predicted annual release rate nor the annual emission of Khmelnitsky-1 in 1995 cited as a more “realistic” basis for the calculation (1995 was a year with only average emissions of all groups of nuclides!), but a list of selected nuclides. While Cs-137 emissions have been lowered by a factor 15 with respect to predictions, possibly based on actual emissions of Khmelnitsky 1 in 1995, I-131 emissions have been lowered by a factor 3 to 5 when compared to actual emissions of Khmelnitsky 1 in 1995 or 1996, as is stated in the footnote to table 7.2 without any explanation. C-14 has not even been included in the source term.

It is not explained on which food consumption data the dose calculation is based, but table 7.6 (EIA p.11) provides data about annual agricultural production in the 30 km zone around the NPP. The production data are meaningless because they come without any units and important products are not listed (e.g. fish which is a significant contribution to the nutrition of the local population).

The lack of information about the dose calculation model hinders a meaningful comparison with the dose limits, which are set according to ICRP 26 as it is explained in chapter 5.

Because of the lack of useful information about the calculation model and data, we cannot follow the conclusion that the exposition will be very small.

4.12.5 Environmental impact of the nuclear fuel cycle

Concerning the fuel cycle as a whole, the EIA is incomplete. The impact from the production and transports of nuclear fuel is not considered at all. This is a crucial point because besides accidents in NPPs uranium mining is the most important contribution to radioactive contamination. Even if transport of fresh fuel assemblies are relatively harmless, the radiation caused by transports of spent fuel is the subject of a legal debate in Western Europe, which will probably lead to obstacles for transport and a minimization of the amount of fuel which can be shipped at all. There is no program presented for the handling of all the nuclear waste arising from the NPP and it is not clear which institution is responsible for which part of a the nuclear waste management program. It is also not explained, how these necessary activities will be funded.

4.12.5.1 Low and intermediate active waste

In the EIA no clearly organized management system for radioactive waste is presented in the EIA. An exhaustive description of the amount, the origin, the chemical and radiological characteristics of waste is not given. According to the usual requirements for an EIA a detailed description of the waste arising and a waste management plan is absolutely necessary.

Concepts for the low and intermediate radioactive waste generated by the NPP (including waste from decommissioning) foresee only **interim** storage facilities at the site. The planning of a final repository is part of the state program on radioactive waste management.

Low active solid waste arising from normal operation and maintenance at Rovno NPP is collected, sorted and stored in concrete bays at the storage facility which is designed to hold the waste from 10 years operation. Nonflammable and flammable (!!) waste is stored in plastic bags. At this time a bituminisation facility for LAW is in use. Approximately 400 containers with a volume of 200l have been filled with bitumen salts compound.

Intermediate active waste, e.g. parts from control assemblies, is stored in a burial which is designed to suffice for 30 years.

Although Rovno NPP is already operating more than 15 years, the installation of a waste handling complex is still in progress:

- Two lines of evaporators are under construction to replace the bitumenisation procedure.

The following facilities are planned:

- Waste sorting and fragmentation
- Drying and compacting
- A temporary storage
- Handling and transportation of solid waste at the site.

According to the EIA these facilities are determined only for packaging and interim storage of radwaste at the Rovno NPP site, because of the planned establishment of a national solid radwaste handling center.

Liquid radioactive waste (LRW, e.g. used filter material and stillage residue from the treatment of liquid radioactive discharges) currently is stored in tanks to allow the decay of short-lived nuclides. After that, the liquid is solidified by bituminisation, and the drums are stored.

It is a serious deficiency of the EIA that potential radioactive emissions and effluents caused by the future waste handling facility are not discussed sufficiently. Construction and operation of a nuclear waste handling complex would require an EIA as part of a licensing procedure, because of the “complex and potentially adverse effects, including those giving rise to serious effects on humans or valued species or organisms, ...” (Espoo-Convention).

4.12.5.2 Spent fuel management

There is no detailed plan for management and storage of spent fuel from Rovno-4.

Spent nuclear fuel has to stay three years in the reactor's spent fuel pool. The capacity of this pond is enough for more than 10 years of operation. After a first hold-up time, spent fuel will be shipped from the spent fuel pool either to:

- a reprocessing plant, which is the principle design scheme,
- or to the spent nuclear fuel storage facility for intermediate storage (still to be built), where it will be left for at least five more years. The site for the interim storage is not defined but it is determined to be inside the sanitary protection zone of the NPP. The facility is planned as a cask storage hall cooled by natural convection of ambient air. Capacity of the interim

storage will be 30 „TK-13“ containers. Every TK-13 can be loaded with 12 WWER-1000 fuel assemblies. Spent fuel generated by one year's operation requires 5 casks, a complete core 14. The planned storage capacity will be exhausted after 6 years but an enlargement of the storage building is possible.

- after interim storage the spent fuel shall be shipped away from the plant
- Handling, packaging, and transport of failed fuel elements after storage in the pool is not discussed!

As far as the reprocessing of fuel is concerned, there is no definite agreement with a commercial reprocessing facility outside of the Ukraine.

Concepts for the final repository of highly active waste are not outlined in the EIA.

Since the planned cask storage for spent fuel is not an item of this EIA, the licensing of the interim storage near the plant will require a further EIA.

4.13 References

- Änderung der Richtlinie über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten, Brüssel: Europäische Gemeinschaft – EG, 1997. – (Amtsblatt; L 73/5)
- Änderung des Umweltverträglichkeitsprüfungsgesetzes, Wien: Republik Österreich, 1996. – (Bundesgesetzblatt ; 96/773)
- Austrian Law of Environmental Impact Assessment (UVP-Gesetz Österreich BGBl 1993/697; BGBl 1996/773)
- BMI 1983: Störfallberechnungsgrundlagen für die Leitlinien des BMI zur Beurteilung der Auslegung von Kernkraftwerken mit DWR gemäß §28 Abs. 3 StrlSchV, BRD 1983
- CHEBANENKO, I. I. et al., 1998: The net of global fracturing of the Carpathian-Balkan-Dinaric orogenic system. Geol. Journal 1998, No. 1-2, 9-13, National Academy of Sciences of Ukraine, Kyiv
- Council Directive (97/11/EG): Council Directive on the Assessment of the Effects of Certain Public and Private Projects on the Environment. (Richtlinie 97/11/EG des Rates zur Änderung der Richtlinie 85/337/EWG über die Umweltverträglichkeitsprüfung bei bestimmten öffentlichen und privaten Projekten)
- Council Directive (96/29 EURATOM): Richtlinie 96/29- Euratom des Rates vom 13-5-1996 zur Festlegung der grundlegenden Sicherheitsnormen für den Schutz der Gesundheit der Arbeitskräfte und der Bevölkerung gegen die Gefahren durch ionisierende Strahlungen
- DOLENKO, G. N. et al., 1989: Razlomnaja tektonika i neftegazonosnost' ukrainy. Akademija nauk ukraïnskoy SSR, 116p, Naukova dumka, Kyiv (in Russian)
- Espoo-Convention: Convention on Environmental Impact Assessment in a Transboundary Context, UN/ECE, 1996
- GALETSKIY, L. S. & Shevchenko, T. P. 1998: Planetarium geodynamic system of throughout ore concentrating zones of activation (exemplified by the east european platform and carpathian-balkan region). Geol. Journal 1998, No. 1-2, 54-65, National Academy of Sciences of Ukraine, Kyiv
- GELDER, van P. & VARPASUO, P. 1998: Bayesian seismic hazard assessment for a nuclear power plant. in: Lydersen, S. (ed.), proc. Europ. conf. on safety & reliability, Trondheim, Vol. 2, 1437-1443, Balkema, Rotterdam
- GRS, 1993: Sicherheitstechnische Bewertung des Kernkraftwerkes Stendal, Block A vom Typ WWER-1000/W320, GRS 1993, GRS-99, OSBN 3-923875-49-5
- Guide to an EIA – Austria (UVE Leitfaden, Eine Information zur Umweltverträglichkeit, Umweltbundesamt Österreich, 1994; Hrg: Bundesministerium für Umwelt, Jugend und Familie)

- Guide to an EIA – Switzerland (Handbuch UVP, Bundesamt für Umwelt, Wald und Landschaft, Schweiz, 1990)
- GUTDEUTSCH, R. & Aric, K. 1988: Seismicity and neotectonics of the East-Alpine-Carpathian and Pannonian area. in: Royden & Horvath (eds.). The Pannonian Basin. AAPG memoir 45, 183-194, Tulsa
- Handbuch Umweltverträglichkeitsprüfung – UVP; Bern: Bundesamt für Umwelt, Wald und Landschaft
- IAEA 1995: Comparison of PSA results with the programs of safety upgrading of WWER NPPs, Vienna 1995
- IORDANOV, I. D., Bulgarian Academy of Sciences, Institute for Nuclear Research and Nuclear Energy, Sofia: Analysis for the Kozloduy Nuclear Power Plant (unit 5) in: Conference Proceedings: Probabilistic Safety Assessment and Management – 96; ESREL-96-PSAM-3 June 1996, Kreta/Greece
- LAHODYNSKY, R. (ed.) 1998: Seismotectonic seminar. Risk research report 21d, Vienna
- MARKELOVA-VF, Maziukevich-NP (1990). Monitoring the tritium content in waste waters and objects in the surroundings of Soviet nuclear power plants. Gigenia-i-Sanitariia 2: 42-45.
- MAROSI, S. & MESKO, A. (ed.) 1997: Seismic safety of the Paks nuclear power plant. Akademiai Kiado, 193p, Budapest
- PALIENKO, V. P., 1998: The structure geomorphical features for the neotectonic rejuvenation zones in the Eastern Carpatians. Geol. Journal 1998, No. 1-2, 14-20, National Academy of Sciences of Ukraine, Kyiv
- SHESTOPALOV, V. M., 1970: The Cretaceous Karst of Volyn and hydrogeological conditions of its development. Fizichna geografija ta geomorphologija 65-70, Kyiv (in Ukrainian)
- SHESTOPALOVA, O. V., 1998: Future of geological formations usage for hazardous waste isolation in Carpathian region. Geol. Journal 1998. No. 1-2, 47-53, Nat. Acad. Sci. Ukraine, Kyiv
- STOHL, A., M. HITTEBERGER and G. WOTAWA (1998): Validation of the Lagrangian particle dispersion model FLEXPART against large scale tracer experiments. Atmospheric Environment, in print. (Special issue on ETEX).
- SYNODINOU, B. M. Institute of Nuclear Technology and Radiation Protection, Attiki, Conference Proceedings: Probabilistic Safety Assessment and Management – 96; ESREL-96-PSAM-3 June 1996, Kreta/Greece
- UN/ECE 1996: Specific methodologies and criteria to determine the significance of adverse trans-boundary impact; Report by the Espoo secretariat, UN 1996
- UNSCEAR 1988: United Nations Scientific Committee on the effects of Atomic radiation, UNSCEAR Report 1988, Report to the general Assembly, New York 1993
- UNSCEAR 1993: United Nations Scientific Committee on the effects of Atomic radiation, UNSCEAR Report 1993, Report to the general Assembly, New York 1993

4.13.1.1 Annex

K2/R4 documentation requested in the Frame of the PPP

(Austrian Institute for Applied Ecology 1. October 1998)

4.13.1.2 General References

„The Resolution On the Procedure Of EIA development of Khmelnitsky and Rovno NPPs“ agreed upon with the Ministry of Environment, Ministry of Health, NRA and approved by Goskomatom of Ukraine, 28.1.1994

DBN A2.2-1-95 The structure and contents of the materials for the EIA in the course of designing and constructing enterprises, buildings and structures, Derzhkomatom and Ministry of Environmental Safety, 1.7.95

Ukraine Ministry for Environmental Protection and Nuclear Safety. Status of radiation safety in Ukraine, 1995

Law on nuclear energy use and radiation safety N 39/95, 8.2.1995

Law on radioactive waste management N 255/95 30.6.1995

State programme on radioactive waste management up to 2005. Cabinet of Ministers of Ukraine, Decree N 480 29.4.1996

Requirements for siting nuclear power plants, 1987

RSS-76/87 Radiation Safety Standards

High density fuel rack VVER 1000, Radiation protection calculations. Kh.NPP N 4101-6-940163. EGP Prague 1995

Containers utilised for disposal of radioactive waste classes I and II (normative document)

4.13.1.3 Khmelniisky NPP

Khmelniisky NPP – Data for Environmental Impact Assessment – UKKE00001, Kyivenergo-proekt 1996.

Information for updating of EIA for KhNPP (Parts 1, 2, 5 and 6), SSEC CSER, November 1997

Koval H.N., Svarichevska Y. et.al; The results of environmental studies of tritium content in areas affected by Ukrainian NPPs In: Proceedings of an Academic Workshop on ecology of the NPP 4- 8.10., Odessa 1993

Assessment of the KhNPP reservoir on the surface and ground water – Romas NI, Shumav Y.A. Kyiv State University, KhNPP

4.13.1.4 Rovno NPP

15 years of Rovno NPP operation- Rovno NPP 1995

Data for Environmental Impact Assessment, Kyivenergo-proekt, UKKE00001R, 1996.

Information for updating of EIA for Rovno NPP (Parts 1 and 2), SSEC CSER, November 1997.

Review of the seismological information available at the Kyivenergo-proekt Institute on the Khmelnitzky NPP and Rovno NPP sites, which forms the basis for taking decisions on the seismicity of the sites, Kyivenergo-proekt 1996.

Environmental Impact Assessment for Rovno 4 and Khmelniisky 2 SRTI System P2S/29112/1218/BBO/C April 1997

4.13.1.5 Data and information required

- Information about severe accidents investigations for K2/R4 and Chernobyl, especially analysis of beyond DBA
- Information about the assessment of the presented DBA and BDBA impact: release rate and energy release time, radionuclide inventory of the core
- Technical documentation of the radiation monitoring systems (existing and planned): location of control and sampling devices, description of measuring devices, minimum detectable activity, sampling procedures
- Results of environmental monitoring (ERM + Gamma-1 system) for every control posts (yearly averages and minimum and maximum monthly averages, for wet and dry deposition, vegetation and different crops, milk)

- Data on atmospheric radioactive emissions from Rovno 3 and separately Rovno-1/2 yearly averages and minimum and maximum monthly averages
- Data on radioactive effluents from Khmelnitsky-1 for several years (yearly averages and minimum and maximum monthly averages)
- Data on radioactive effluents from Rovno 3 and separately Rovno-1/2 yearly averages and minimum and maximum monthly averages
- Technical data on retention capacity of filter systems in stack (for normal operation and in case of accident)
- Information about usage of ground water.
- Technical description of ground water monitoring system
- Minimum and maximum daily averages of the flux of water of Styr river.
- Location of the temperature measurement device in Styr river
- Which data were used as input data in PC Cosyma dispersion and deposition calculation for normal operation?

Authors:

Markus Graggaber,

Beatrix Pfanzagl,

Antonia Wenisch

Österreichisches Ökologie-Institut/Austrian Institute for applied Ecology

A-1070 Seidengasse 13 Vienna, Austria

phone 523 61 05 fax: 523 58 43

email: oekoinstitut@ecology.at

Petra Seibert, Institut für Meteorologie und Geophysik, Universität für Bodenkultur

Roman Lahodynsky, Institut für Risikoforschung