



commission for environmental impact assessment

Review advice on the proposed completion of the
Khmelnitsky 2 (K2) and Rivne 4 (R4) nuclear
power plants in Ukraine

27 April 1999

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commission for environmental impact assessment

His Excellency Mr. J.P. Pronk
Minister for Housing, Spatial Planning and the
Environment
P.O. Box 30945
2500 GX Den Haag

your reference
DGM/B/BMB Mbb 99147207

your letter
March 11, 1999

our reference
U99/Vh/bt/1013-47

subject
Review advice on the environmental and
safety studies for the completion of the
Khmelnitsky 2 and Rivne 4 nuclear
power stations in Ukraine.

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Utrecht (the Netherlands),
April 27, 1999

Excellency,

By your letter dated 11 March 1999, the Commission for Environmental Impact Assessment (EIA) was requested to carry out an advisory review of the environmental and safety studies for the completion of the Khmelnitsky 2 and Rivne 4 nuclear power stations in Ukraine.

According to article 7.38g of the Environmental Management Act I herewith submit the advice prepared by a working group of the Commission for EIA.

With this advice the Commission hopes to contribute in a constructive way to the consultation under the Espoo Convention and the adoption of a Netherlands standpoint on any possible investment by the EBRD in the completion of the two power plants. The Commission appreciates to be informed about the use that is made of this advice.

Yours Sincerely

ir. N.G. Ketting,
chairman of the working group
of the Commission for EIA.

enclosure

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1. INTRODUCTION

In his letters of 11 March 1999 and 15 April 1999 the minister for housing, spatial planning and the environment, referring to article 7.38g clause 2 of the Environmental Management Act, requested the Commission for EIA to advise on the quality and completeness of the safety and environmental studies for the proposed completion of the Khmel'nitski 2 (K2) and Rivne 4 (R4¹) nuclear power plants in Ukraine.^{2]}

The advice was prepared by a working group of the Commission for EIA.^{3]} The working group represents the Commission for EIA and in the rest of this report is referred to as 'the Commission'.

According to these letters, the framework for the Commission's advice is determined both by the Espoo Convention on transboundary environmental impact assessment and by the request for finance from the government of Ukraine to the European Bank for Reconstruction and Development (EBRD). Under the Espoo Convention the Netherlands is in the position to evaluate the assessment of possible environmental impacts in the Netherlands made in the environmental and safety studies. Regarding the request for financing, the Netherlands must adopt a standpoint on the safety and environmental aspects of the proposal to be able to form an opinion on any possible investment by the EBRD in the completion of the two power plants.

From this framework the Commission has derived the following four criteria for evaluating the quality of the studies:

- Are the studies complete?
- Is the information of sufficient quality to be able to assess whether, after completion, the power plants will comply with internationally accepted environmental and safety standards for design, operation and quality assurance?^{4]}
- Do the studies provide sufficient insight into the probability of occurrence of large off-site release of radioactive material as a result of a severe accident and into the potential risks and environmental impacts of such severe accidents in the Netherlands?

1 Sometimes also referred to as Rovno 4 in the documents.

2 The Commission's evaluation is based on the contents of the following documents:

- Completion of Rovno Unit 4 and Khmel'nitsky Unit 2 Project Presentation - Energoatom, August 1998
- Final Assessment Report For the Loan Approval Procedure - Riskaudit report nr. 120, December 1997
- EIA for Completion of Rivne Unit 4 Nuclear Power Station - Mouchel Consulting Ltd, June 1998
- EIA for Completion of Khmel'nitsky Unit 2 Nuclear Power Station - Mouchel Consulting Ltd, June 1998
- EIA for Completion of Rivne Unit 4 and Khmel'nitsky Unit 2 Nuclear Power Stations. Addendum. Environmental Impact of the Non-Nuclear Alternative - Mouchel Consulting Ltd, September 1998

3 See Appendix 1 for the composition of the working group and other project information.

4 This question is important for determining whether the completion of the power plants is justified in the light of the potential consequences, both when operating normally and in the event of a severe accident, for the people of Ukraine.

- Have more environmentally friendly alternatives for achieving the intended objectives of the proposal – meeting the expected demand for electricity in Ukraine – been adequately described?

2. EVALUATION OF THE STUDIES AND RECOMMENDATIONS

2.1 Evaluation

1 Are the studies complete?

The studies exhibit important omissions. In particular, inadequate attention is given to the probability of occurrence of 'beyond-design basis' accidents and to the subsequent impacts. These are the types of severe accidents most likely to involve the largest releases of radioactive material.

2 Will the completed power plants meet internationally accepted environmental and safety standards?

The nuclear power plants will comply with internationally accepted standards after described follow-up studies and upgrading measures have been completed and under the condition that a sound safety culture will be established. However, the documents do not indicate in which way such compliance will be ensured.

3 What is the probability of occurrence of a severe accident with large off-site releases and what is the potential risk and environmental impact of such an event in the Netherlands?

The previously mentioned omissions mean that the studies provide no insight into potential impact in the Netherlands. If the nuclear power plants comply with the Western safety standards, environmental impacts requiring specific protective measures in the Netherlands are not to be expected, even in the unlikely event of a major severe accident.

4 Have environmentally friendlier or safer alternatives for achieving the intended objective of the proposal been adequately discussed?

There is too little discussion of alternatives: the option of burning fossil fuels to generate electricity is insufficiently addressed; other realistic alternatives are not examined in any detail, such as upgrading existing nuclear power plants, building a new nuclear power plant, greater efficiency in the use of electricity and importing electricity.

2.2 Recommendations

The above evaluation leads the Commission to make the following recommendations:

- **Mandatory verification:** The implementation of the declared forthcoming studies and measures is essential for achieving compliance with international standards as well as for reducing potential consequences in the Netherlands.

The Commission recommends that a decision to grant financing be accompanied by an obligation to obtain independent verification, according to internationally accepted environmental and safety standards. Such a verification concerns the successful completion and startup of the nuclear power plants. Evaluation of the management of the plants is also recommended and could be undertaken, for example, by the IAEA Assessment of Safety Culture in Organizations Team (ASCOT).

- **Bring forward the PSA:** One of the studies yet to be carried out is a probabilistic safety analysis (PSA), scheduled to take place after the plants are brought into service. As this analysis is important for defining and prioritizing the measures to be taken, the Commission recommends performing this study as soon as possible – preferably before the plants are started up.
- **Further substantiation of impacts:** The Commission recommends further examination of its preliminary conclusion on expected impacts in the Netherlands (see 3 above) by a scoping analysis of the dispersion and exposure models to assess potential consequences of a severe accident with a major off-site release. To this end existing information on source terms can be derived from severe accident analyses in Western nuclear power plants.
- **Assessment of a broad range of alternatives:** The Commission recommends considering possible options not discussed in the studies when coming to an investment decision.

3. EXPLANATORY NOTES ON THE EVALUATION AND RECOMMENDATIONS

3.1 Completeness of the studies

Description of accidents

In the description of possible accidents the studies focus mainly on *design basis* accidents.^{5]} Analyses of a few of these types of accidents show that the mitigating measures effectively limit emissions. The Commission notes, though, that the estimates of expected emissions from these types of accidents are lower than in Dutch studies of similar cases. Moreover, there is no consideration of the ingestion pathway in the discussion of the impacts resulting from these emissions. It is likely that this route in particular could be responsible for impacts on the local population.

5 'Design basis' accidents are serious disruptions to the operation of the plant, accidents (e.g. pipe break) and external events such as earthquakes and floods, which are taken into account in the design and operation of the plant. Accurate and detailed analyses should show that the reactor can be safely shut down in these circumstances and adequately cooled according to stringent radiological standards. The studies mention the following design basis accidents: loss of coolant, pipe break, loss of external electricity supply, reactivity accidents, earthquakes and an aeroplane crashing on the plant.

The studies give little information on expected *beyond-design basis* accidents.^{6]} Although the probability of such accidents is much smaller, the potential impacts are much larger and could possibly result in an environmental impact in the Netherlands. The largest impacts are to be expected from 'beyond-design basis' accidents that include severe damage to the nuclear fuel. Examples of such accidents are mentioned in the studies,^{7]} but no analysis is presented of the course of these accidents under conditions in which no mitigating measures are taken and a considerable amount of radioactive material is released to the environment.

The EISs discuss the failure of a header in a steam generator as the '*most representative beyond-design basis accident*'.^{8]} In the opinion of the Commission this accident – which does not involve any damage to the core, and therefore has limited impact – cannot be considered representative of 'beyond-design basis' accidents in this type of nuclear power plant.

Description of measures to be implemented

The studies give a good overview of more than 170 necessary environmental and safety measures. However, a major part of these measures still need further definition depending on additional studies yet to be carried out, or concern measures planned to be carried out after the plants are in operation (about one third of the measures). The studies examined by the Commission do not clearly show the procedure to ensure that these measures will actually be carried out.

This criticism also applies to a number of the announced safety studies. The analysis carried out by Riskaudit is primarily *deterministic*: based on clearly defined assumptions the modernization programme is evaluated against firm internationally accepted safety standards and compared with Western nuclear power engineering practice. However, a *probabilistic* safety analysis (PSA)^{9]} is needed to determine the completeness and effectiveness of the proposed measures and to compare the risks with those for similar Western reactors.

The proposal makes provision for this type of analysis (i.e. the PSA) *after* the power plant is operational. However, the proposal does not outline how the completion of this analysis is being ensured. Also, due to the execution of the PSA at a late stage in the project, it is likely that the then revealed shortcomings or vulnerabilities cannot be included in the scope of the modernisation project

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- 6 'Beyond-design basis' accidents are a class of accidents that can lead to serious damage to the reactor core and emission of radioactive material to the environment. In these accidents the complete failure of safety systems and absence of corrective action by the operators are considered in relation to the probability of its occurrence. These types of accidents have a very small probability of occurring, but emissions of radioactive substances can cause impacts great distances away. High emissions of radioactive material can be expected in a non-design basis accident if a large proportion of the nuclear fuel is damaged, the containment fails at the beginning of the accident, a more or less direct pathway to the environment is established *and* no preventive or mitigating action is taken.
- 7 In the summary of the EISs a few beyond-design basis accidents – such as transients without rapid shutdown of the reactor, total loss of feedwater and total loss of a.c. power – are mentioned but not discussed to any extent in the main report.
- 8 For this accident a description is given of effective accident management to limit emissions.
- 9 In a PSA all possible accident scenarios are worked out and any omissions in the modernization programme are identified and prioritized.

or in the estimate of costs. It is also possible that appropriate additional measures might be identified at a time when it is too late to implement them.

Finally, the Commission notes that the probability of a major accident and any resulting impacts will largely be determined by the established 'safety culture'^{10]} in the operation of the nuclear power plants. The information provided does not elaborate on this issue and it is not clarified in which way an adequate safety culture will be ensured.

3.2 Compliance with internationally accepted standards

Assuming that the announced measures will be implemented and that an adequate safety culture is being established, the Commission notes that:

- the completed studies are based on safety measures for this type of reactor^{11]} as drawn up by the IAEA^{12]} and supplemented by the Ukrainian government;
- the adopted concept of safety barriers meets internationally accepted principles^{13]};
- after modernization the nuclear power plants will meet internationally accepted safety standards as described in the IAEA (INSAG-3) Basic Safety Principles.

As mentioned earlier the available studies do not indicate in which way it is ensured that the necessary measures and studies will be implemented. In the Commission's opinion an effective way of doing this is to organize an independent verification of the completion and startup of the power plants and an evaluation of operational practice (see the recommendation on this point in section 2.2 of this advice). Special attention is needed for the verification of measures which will be implemented after the plants are taken into operation.

The estimates given in the studies on the time required to complete the modernization programme and the associated costs highlight the importance of ensuring the implementation of necessary measures. In the Commission's opinion these estimates are on the low side and are subject to a high degree of uncertainty. It is important to make sure that crucial measures are not being postponed nor cancelled if at a later stage the costs turn out to be higher than expected.

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- 10 The safety culture comprises all individual and organizational qualities that afford the highest priority to guaranteeing safety and due attention to questions relevant to safety issues. A good safety culture is of the utmost importance for maintaining the condition of equipment and ensuring the expertise and capabilities of the operators and management are effectively employed. Guidelines can be found in INSAG-3 and INSAG-4 (INSAG = International Nuclear Safety Advisory Group of the IAEA).
- 11 The K2 and R4 nuclear power plants are based on the VVER concept (VVER-1000 model 320); the nuclear power plants in Chernobyl are based on the RMBK concept. It is difficult to compare these two concepts.
- 12 Safety Issues and their Ranking for VVER-1000 Model 320 Nuclear Power Plants - IAEA (1996).
- 13 Particularly because of the presence of a containment, which is lacking at the Chernobyl power plants.

3.3 Expected impacts and risks in the Netherlands

Owing to the previously mentioned omissions in the studies it is not possible to derive an indication of the potential risks and environmental impacts in the Netherlands. We can conclude, however, that if the announced measures are implemented and with an adequate safety culture for the operation and maintenance of the plants in place, impacts requiring specific measures in the Netherlands are not to be expected in the Netherlands from this type of reactor – even in the event of a major accident.^{14]}

However, it is recommended that this assessment be substantiated by an analysis of the expected impacts from selected severe accidents with a major release. This could, for example, be based on existing knowledge on source terms for assessing the environmental impact at similar Western power plants. Using these data, and assuming adverse weather conditions, a scoping analysis of the dispersion and exposure can be performed, providing insight into the expected consequences of a worst case scenario. The studies under review do not provide such insight.

3.4 Discussion of alternatives

The objective of the proposal is to ensure adequate generating capacity to meet the electricity needs of Ukraine after the remaining Chernobyl power plants are finally withdrawn from service. Two alternative ways to achieve this objective are discussed in the studies:

- The EISs compare the proposal with the situation in which the Chernobyl reactors remain operational. The studies conclude that this is not a good alternative, in particular because these plants have no containments, which are required by internationally accepted safety standards.
- In the document 'Environmental Impact of the Non-nuclear Alternative' the proposal is compared with the generation of electricity using fossil fuels. It states that this alternative would lead to fewer environmental impacts from major accidents but higher emissions during normal operation.

The Commission endorses the conclusion on the 'Chernobyl alternative'. Concerning the non-nuclear alternative, the Commission is of the opinion that the emissions expected during normal operation have been adequately described, but that there is too little information about equally relevant environmental aspects of this alternative, such as fuel transport and waste. As a result, there is insufficient information to make a proper comparison between this alternative and the project proposal.

The Commission also notes that a number of realistic alternatives for achieving the objectives are not mentioned at all. These alternatives include the following options, either separate or in combination:

14 Concerning the local population, impacts are not to be expected from normal plant operation. In the event of a major accident protective measures will most likely be needed in the Ukraine.

- making the existing VVER nuclear power plants in the Ukraine safer and more efficient;
- building a completely new nuclear power plant, making use of the latest advances in environmental protection and safety;
- electricity-conservation measures, for example making the transmission grid and electrical equipment more efficient;
- importing electricity.

APPENDICES

with the Review advice on the
proposed completion of the
Khmelnitsky 2 (K2) and Rivne 4
(R4) nuclear power plants in
Ukraine

(appendix 1)

APPENDIX 1

Project information

Proponent: Minister of Housing, Spatial Planning and the Environment

Competent authority: Minister of Housing, Spatial Planning and the Environment

Decision: Consultation under the Espoo Convention on transboundary environmental impact assessment & Request for finance from the government of Ukraine to the European Bank for Reconstruction and Development (EBRD). Under the Espoo Convention the Netherlands is in the position to evaluate the assessment of possible environmental impacts in the Netherlands made in the environmental and safety studies. Regarding the request for financing, the Netherlands must adopt a standpoint on the safety and environmental aspects of the proposal to be able to form an opinion on any possible investment by the EBRD in the completion of the two power plants.

Activity: Proposed completion of the Khmel'nitski 2 (K2) and Rivne 4 (R4¹) nuclear power plants in Ukraine.

Procedural information:

request for reviewing advice: 11 March 1999

reviewing advice published: 27 April 1999

Members of the expert committee:

ing. J.C. Abrahamse

dr. R.O. Blaauboer

ir. J.N.T. Jehee

ir. N.G. Ketting (chairman)

ir. R.J. Swanenburg de Veye

Secretary of the expert committee: drs. R.A.A. Verheem.

1 Also referred to as Rovno 4 in the reviewed documents.