PERSPEKTIVEN FÜR UMWELT & GESELLSCHAFT umweltbundesamt

NPP FENNOVOIMA

Comment to the Supplements

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Ordered by the
Federal Ministry for Agriculture, Forestry,
Environment and Water Management,
Project Management Department V/6 „Nuclear Coordination“
GZ BMLFUW-UW.1.1.2/0022-V/6/2008

lebensministerium.at

ÖSTERREICHISCHES ÖKOLOGIE INSTITUT

REPORT
REP-0242

Wien, September 2009

Project management

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For further information about the publications of the Umweltbundesamt please go to:
http://www.umweltbundesamt.at/

Imprint

Owner and Editor: Umweltbundesamt GmbH
Spittelauer Lände 5, 1090 Vienna/Austria

This publication is only available on http://www.umweltbundesamt.at/.

ISBN 978-3-99004-042-3

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INTRODUCTION

The company Fennovoima Oy (Fennovoima) plans to construct a new nuclear power plant (NPP) in Finland. Three different sites are in discussion: Hanhikivi (municipality of Pyhäjoki), Kampuslandet and Gäddbergsö (municipality of Ruotsinpyhtää near the site of the operating NPP Loviisa) or Karsikkoniemi (municipality of Simo). Alternatives for electric capacity of the new NPP shall be 1,500–1,800 MWe for one unit or 2,000–2,500 MWe for two units (with 1,000–1,250 MWe, each).

With reference to the Espoo Convention, the Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management has taken part in the international EIA procedure. The Austrian Institute of Ecology in cooperation with Dr. Helmut Hirsch and Dr. Petra Seibert (BOKU-Met) was engaged by the Austrian Federal Environmental Agency (Umweltbundesamt) to assess the Environmental Impact Assessment Report of Fennovoima. The Expert Statement (UMWELTBUNDESAMT 2008) was published at the website of the Umweltbundesamt[1].

A Bilateral consultation was held in Helsinki on January 28th, 2009. During this consultation the questions of the Austrian side were discussed with the competent Finnish authorities and the applicant Fennovoima Oy. Information presented at the Bilateral consultation was assessed in the experts' report on the consultation. As a result the following recommendations were formulated regarding the EIA procedure as well as regarding the next steps of decision making:

1. A conservative worst case release scenario should be included in the EIA, in addition to the limited release scenario according to Finnish regulations. Only results of a detailed safety assessment for the candidate reactor(s) would permit to exclude a larger source term – in case it can be proven beyond doubt that such a larger source term cannot occur.
   Such results, however, are not yet available. Therefore, a source term for e.g. an early containment failure or containment bypass scenario should be analyzed as part of the EIA – in particular because of its relevance for impacts at greater distances.
2. The potential differences between the reactor types under consideration should be duly considered in preparing the Decision in Principle, as far as they can be relevant for safety. In particular, this should include differences which can influence the source term for severe accidents, as well as the basic safety philosophy (active/passive safety concept) and the experiences available for the reactor types under consideration.
3. In the framework of the Decision in Principle as well as during later stages of the decision making and licensing, information concerning accident analyses, severe accidents and PSA results should be made available to the Austrian side.

The supplements received in summer 2009 by the Austrian Ministry are discussed in the following chapter of this report.

[1] http://www.umweltbundesamt.at

Conclusion

The main point of discussion concerned PSA results and the worst case scenario to be assumed for transboundary impacts. According to the Finnish regulation a release of 100 TBq of Cs-137 is an appropriate assumption; the probability for a higher release has to be smaller than 5E-7/yr.

For a release larger by two orders of magnitude (10,000 Bq), Fennovoima arbitrarily assumes a probability which is lower by two orders of magnitude. This assumption is not substantiated; at best, it can be taken as a declaration of intent.

Furthermore, Fennovoima interprets PSA results as actually stating event frequencies of the type “every 10 billion years”. In fact, no PSA can provide this. There are factors which cannot be incorporated into PSAs; others are beset with considerable uncertainties. Thus, PSA results merely are risk indicators of limited scope.

This has to be kept in mind even if it is duly assumed that Finnish regulations are fulfilled.

However, from the Austrian point of view, the compliance of the envisaged reactors with the Finnish regulation cannot per se be taken as granted.

All in all, substantial technical information is required, in order to be able to exclude significant impacts in Austria from new NPPs in Finland.

In this context Austria highly appreciates the announcement of the Finnish Ministry of Employment and the Economy (MEE) that the following documents would be made available to the Austrian side as an important contribution to keeping the Austrian side well-informed:

- Decision in Principle (DiP) application by Fennovoima Oy;
- Decision in Principle including the STUK report on the feasibility study of the reactor types (for all Decision in Principle applications).

1 SAFETY AND ACCIDENTS

1.1 Conclusion of Expert Statement to the EIA Report (December 2008)

Accidents leading to the release of more than 100 TBq of Cs-137 are required to be extremely unlikely by Finnish regulations[2]. Regulations furthermore specify that the probability of a release exceeding this value must be smaller than 5E-7/yr (YVL Regulation 2.8).

However, severe accidents with releases considerably higher than this value cannot be excluded for the reactor types under consideration. Such accidents should be included in the assessment in the EIA Report since their effects can be widespread and long-lasting. Countries not directly bordering Finland, like Austria, can be affected.

The analysis of a severe accident scenario, with a cesium release considerably higher than 100 TBq, would close an important gap in the EIA Report and allow a discussion of potential transboundary impacts.

1.2 Conclusion from the Bilateral Consultation in January 2009

A conservative worst case release scenario should be included in the EIA, in addition to the limited release scenario according to Finnish regulations. Only the results of a detailed safety assessment for the candidate reactor(s) would permit to exclude a larger source term – in case it can be proven beyond doubt that such a larger source term cannot occur.

Such results, however, are not yet available. Therefore, a source term for e.g. an early containment failure or containment bypass scenario should be analyzed as part of the EIA – in particular because of its relevance for impacts at greater distances.

Regarding the fulfillment of the probabilistic goal quoted above (5E-7/yr) – this could, in theory, be demonstrated by probabilistic safety analyses (PSA). In practice, however, such a demonstration is by no means straightforward.

There can be no doubt that PSA results are of considerable value for the orientation of NPP designers and regulators (for example, to identify weak points in a reactor design). On the other hand, the inherent limitations of PSA should not be forgotten – such analyses are beset with considerable uncertainties, and some risk factors are difficult to include in a PSA, or cannot included at all. Therefore, for rare events the probability of occurrence as calculated by a PSA should not be taken at face value, but as an indicative number only. Hence, it is problematic in practice to reliably demonstrate the fulfillment of a probabilistic goal by PSA.

[2] Originally: Decision of the Council of State on the general regulations for the safety of nuclear power plants (395/91), 14 February 1991. This requirement remained unchanged in the new Decision of the Council of State 733/2008.

1.3 Treatment of the issue in the Supplementary Information

In the **Statement of the Ministry of Employment and the Economy** (MEE 2009), the Austrian recommendation to consider a worst case release scenario for severe accidents is mentioned, but not discussed. MEE requires, however, that Fennovoima Oy submit a response to this Austrian recommendation (as well as to questions posed by other countries).

MEE reports that the Finnish nuclear regulatory authority STUK regards it as appropriate that Fennovoyma did not consider an accidental release of more than 100 TBq Cs-137. STUK considers it necessary, however, that the dose assessment for a severe accident is to be supplemented (in a supplement to the EIA report) by a scenario in which the emission of noble gases constitutes a significant share of the noble gases contained in the nuclear fuel. Radiation dose results should also be presented for unfavorable weather conditions.

This comment by STUK has been adopted by MEE as a requirement to be fulfilled by Fennovoima, among others, in a supplementary report.

The **response provided by Fennovoima Oy** (FENNOVOIMA 2009a) begins by quoting the Finnish regulatory requirements as mentioned above (probability of exceeding a release of 100 TBq Cs-137 must be below 5E-7/yr). Then, Fennovoima argues as follows:

- In modern reactor designs as Fennovoima has presented, the release of 100 TBq even in the worst conceivable severe accident scenarios is a significant overestimation, due to safety oriented characteristics of the reactors.
- The probability of a 100 TBq release of Cs-137 is, by design, below 5E-7/yr.
- The probability of a 10,000 TBq release is 100 times less (5E-9/yr).
- The conditional probability of such a release on a Fennovoima site to cause exceedance of intervention limits in Austria is ca. 2%.
- Thus, the probability of an accident in a Fennovoima plant causing exceedance of intervention limits in Austria is 1E-10/yr; i.e. this happens every 10 billion years.
- This risk to Austrian citizens is negligible and is more than outweighed by the global environmental benefit of using nuclear as a CO_2-free source of energy.

(Items 2, 3 and 4 are not explicitly mentioned in the response; they were presented in a Fennovoima statement at the Bilateral Consultation in January 2009 (FENNOVOIMA 2009b), which is referred to in the response paper.)

1.4 Assessment of responses and discussion

1.4.1 Statement of the Ministry of Employment and Economy

Regarding the scenario with increased noble gas emission, it is not stated by STUK or MEE what would constitute a “significant share”. In any case, however, it has to be pointed out that the radiological relevance of noble gases in an accident source term is relatively small, particularly in the long term (LÖFFLER & SONNENKALB 2006). The main effect of increased noble gas emission can be expected to be rather short-term and local.

1.4.2 Statement of Fennovoima

The Fennovoima response can be assessed as follows:

1. The response is contradictory in itself. If the release of Cs-137 were below 100 TBq even in the worst conceivable severe accident scenarios, the probability of a 10,000 TBq release would be zero, not 5E-9/yr.
2. The assumption that a release of 10,000 TBq is 100 times less likely than one of 100 TBq is completely arbitrary. No substantiation is provided. There is no technical principle or scientific law stating that the probability of a release is inversely proportionate to its size. At best, this can be taken as declaration of intent. Whether Fennovoima will indeed achieve this intent appears completely open today. In any case, it would require comprehensive substantiation.
3. The conditional probability of a 10,000 TBq-release causing exceedance of intervention limits in Austria, as quoted by Fennovoima, is in rough agreement with the corresponding values provided in the Austrian Expert Statement of December 2008. The value of a 2% climatological risk is taken from the Austrian statement, which refers to a study made in Austria, assessing the probability of weather conditions, which could result in significant contamination in Austria in case of a large release of radioactive substances from a Fennovoima site.
   In the EIA Report no details of the dispersion calculations concerning the different sites are presented. It is explained that a Gaussian model is used for dispersion calculation and that the German regulatory model is applied. The EIA Report presents only one set of results of the dispersion calculation for all three proposed sites. The result of the dispersion presented in the EIA Report is that the Cs-137 deposition at the distance of 1,000 km is 0.28 kBq/m in case of a 100 TBq release at the plant. The result depends mainly on the assumed release at the site. (Results at different weather conditions are not presented in distances beyond 50 km.)
4. It is not admissible to interpret PSA results as actually stating event frequencies of the type “every 10 billion years”. There are factors which cannot be incorporated in PSAs, in principle; furthermore, even many factors which are taken into account are beset with considerable uncertainties (details see below). Thus, PSA results do not actually provide event frequencies. They merely are risk indicators of limited scope. As such, they can be useful for checking a plant design for likely accident contributors, and for comparisons between plants.
5. It is not correct that nuclear energy is a CO_2-free source of energy, if the whole life cycle is taken into account. Furthermore, Fennovoima’s comparison of risks and benefits is not further substantiated, and is founded on their assumptions regarding accident probabilities.

1.4.3 Further discussion of the significance of PSA results

Examples for factors which cannot be incorporated in PSAs are:

- unexpected plant defects
- unforeseen physical or chemical processes
- Malevolent human behavior (sabotage, terror attacks, acts of war) is explicitly excluded from PSAs.
- Ageing phenomena can only be incorporated in PRAs in retrospect.
- Complex forms of human error are extremely difficult to model.
- Due to the complexity of an NPP, some accident initiators or sequences are simply bound to be overlooked or omitted.

Factors which are included, but exhibit particularly high uncertainties are, for example:

- external events like earthquakes
- prediction of the containment behavior
- modeling of dependent failures
- measures of „accident management“.

To some extent, the uncertainties of the input data for a PSA can be quantified. The input data are usually, wherever applicable, specified as random variables rather than point values (for example, the probability of an earthquake of a certain intensity, or the containment failure probability given a certain load). Hence, PSA results like probability of core damage or probability of large release are also not point values, but random variables with a certain distribution. Those distributions can be described, for example, by providing not only the mean value of the probability in question, but also the median and some fractiles. 5%- and 95%-fractiles are usually given to illustrate the range of uncertainty; they can differ by several orders of magnitude.

The Finnish YVL Regulation 2.8 specifies the probabilistic objectives (e.g. concerning a release exceeding 100 TBq Cs-137) for the mean values of the probabilities. Furthermore, it is stated in the regulation that uncertainties have to be taken into account and that phenomena whose frequency of occurrence and consequences include large uncertainties shall be carefully examined. Uncertainties of probabilities are to be estimated. Fennovoima, however, does not at all discuss the uncertainties of the accident probabilities mentioned in their response and their statement and provides no indications as to their extent.

The YVL Regulation mentioned above does not specify the manner in which uncertainties have to be presented as part of PSA results. It is interesting to note that the German PSA Guideline (for the PSA which is part of the periodic safety review of an NPP) requires that as results of the PSA level 2 5%-fractiles, medians and 95%-fractiles are to be provided besides the mean values (BMU 2005). The same requirement is specified in the Swiss PSA Guidelines (ENSI 2009).

PSA results should always include quantitative indicators for the uncertainty; without such indicators, their significance and informative value is rather low. It should not be forgotten, however, that even with such indicators for uncertainty, PSA results cannot take all relevant factors into account.

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APPENDIX:
CONTENT OF THE SUPPLEMENTARY DOCUMENTS

This Appendix provides a summary overview of the content of the supplementary documents. Items which are of particular interest from the Austrian point of view are briefly elaborated.

Covering letter from the Finnish Ministry of the Environment, 03.07.2009

This is the covering letter for the other three documents.

It is stated that the EIA procedure for Fennovoima's NPP project has now ended.

The Contact Authority, the Ministry of Employment and Economy, has determined in their statement (see below) that certain issues need more precise information in a supplementary report. This report is needed for processing for an application for a decision-in-principle. Possible comments on it will be included in this processing.

Statement by the Contact Authority, Ministry of Economy and the Employment (MEE), 20.02.2009

Chapter 1 deals with general information and procedural questions.

Chapter 2 gives an account of the communication of the EIA report and the related hearings.

Chapter 3 provides a summary of the comments and opinions submitted.

At first, it deals with Finnish institutions – Ministries involved, various regional authorities, the Radiation and Nuclear Safety Authority (STUK) and various municipalities, professional and environmental associations and others. The following statements are of particular interest from the Austrian point of view:

The **Ministry of the Environment (ME)** states that the EIA Report does not contain sufficient information to facilitate the balanced and reliable comparison of the alternatives involved in the project (including the zero option). Supplementary information, for example regarding the effects on aquatic ecology, is required.

Moreover, in the view of ME the report takes insufficient consideration of the differences of the reactor alternatives as concerns nuclear safety, and of the arrangements of nuclear waste management.

Consideration of the application for a decision-in-principle should only begin after all additions to the report have been made.

The **Radiation and Nuclear Safety Authority (STUK)** considers it necessary that the radiation dose assessments presented for severe accidents be supplemented by an emission of radioactive substances whereby the emission of noble gases comprises a significant share of the reactor inventory (see also section of “Safety and Accidents”). Furthermore, the selection of weather conditions should be revised, and radiation doses results presented also for unfavorable weather conditions.

In addition, STUK presents a number of observations which do not, however, require any supplement to the EIA Report. In several cases, it is pointed out that the assessments will have to be updated and more detailed in connection with the application for a decision-in-principle, and/or at the construction license stage (e.g. regarding geological and seismological conditions). Those observations concern the following topics:

- Planned power plant areas
- Population in the surrounding area
- Commercial and industrial activities and traffic (e.g. flight restrictions)
- Natural conditions
- Weather conditions
- Sea water levels and elevations of prospective sites
- Cooling water quality
- Ice conditions
- Geological and seismological conditions
- Radioactive emissions during normal operation
- Radiation impacts and control in the environment
- Accident conditions (supplementation of the dose assessment for a severe accident is required, see above)
- Emergency response arrangements and rescue operations
- Intake and discharge of cooling water
- Nuclear waste management (STUK points out that no consideration is given in the EIA Report to the issue of the final disposal location for Fennovoima’s spent fuel)

Posiva Oy and **Teollisuuden Voima Oyj (TVO)** criticize that the EIA Report creates the wrong impression that Posivy Oy would be responsible for managing the final disposal of spent fuel generated by Fennovoima, when in fact Poiva’s final disposal project does not cover the needs of Fennovoima’s NPP.

Fortum Power and Heat Oy states that it is regrettable that Fennovoima does not mention Fortum’s and TVO’s nuclear power projects in their EIA Report.

Furthermore, **international statements** received from Sweden, Norway, Lithuania, the German state of Mecklenburg-Vorpommern, Poland, Estonia and Austria are briefly presented (will be briefly discussed in the context of Fennovoima’s responses, see below).

Chapter 4 contains the actual Statement by the Contact Authority

This statement discusses the following topics:

- General remarks
- The project and the processing of its alternatives in the EIA Report: MEE maintains that the EIA Report examines the zero alternative and resulting impacts sufficiently. Furthermore, MEE states that the EIA Report is adequate without the comparison of reactor types which ME found lacking.
- Land use
- Nuclear waste management, sourcing of nuclear fuel and final disposal: MEE maintains that Fennovoima has shown no conclusive evidence on the feasibility of the plans for the final disposal of spent fuel. However, it regards the EIA Report as sufficient at this stage of the project. Regarding transport of spent fuel, the Ministry will require a more specific account than the current one. Also, a supplementary report concerning the final disposal facility for low and intermediate level waste will be required.
- Assessments concerning radiation impacts and nuclear safety: MEE takes up STUK's consideration to supplement the radiation dose assessment with an accident scenario involving high noble gas releases, and addresses it to Fennovoima as a requirement.
- Cooling towers and wastewaters
- Flora, fauna and ecological values
- Social and financial environmental impacts
- Comparison of alternatives and viability of the project: MEE finds that the EIA Report includes a sufficiently comprehensive and detailed comparison of project alternatives, and the project's viability. However, a specification of the EIA concerning the cogeneration option is still required.
- Other environmental impacts presented in the EIA Report
- Interaction and participation arrangements in the EIA process
- Mitigation and monitoring of detrimental environmental impacts

In summary, MEE requires a number of further clarifications to be provided by Fennovoima further to the application for a decision-in-principle.

There are 19 clarifications in all. They concern:

- Water quality, current status of aquatic ecosystem, cooling water and waste water (5 clarifications)
- Birdlife, fish spawning and other aspects of nature, flora and fauna (4 clarifications)
- Fulfillment of land use guidelines (1)
- Assessment of estimated rise in water temperature due to climate change (1)
- Assessment of key impacts of heat and power cogeneration (1)
- More specific account of the risks and environmental impacts of spent fuel transportation (1)
- Environmental impacts during construction and operation of a final disposal facility for radioactive wastes, and account of the basis on which Fennovoima finds the proposed emplacement in bedrock safe (1)

- Supplementary assessment of radiation doses for severe accidents, with a scenario with high noble gas emissions, and inclusion of unfavorable weather conditions (1)
- Account of how the clarifications mentioned above will influence the comparison of alternatives (1)
- Misprints and minor procedural matters (3)

The clarifications are to be provided by April 09, 2009.

Furthermore, MEE requires that Fennovoima submit responses to the questions related to the statements of various countries (see above) by April 09, 2009.

Further Clarifications Required by the Ministry of Employment and the Energy (sic!) in the Statement on the EIA Report of a New Nuclear Power Plant – Responses to the Questions of Some Foreign Countries Concerning Environmental Impact Assessment and Summary of Further Clarifications, Fennovoima Ltd., 27.04.2009.

Responses to questions of foreign countries

This section deals with questions from Estonia, Sweden and Germany (Mecklenburg-Vorpommern).

The **Estonian** questions concern algae blooms due to cooling water, maritime transport EIA, information of neighboring countries in case of an accident and nuclear liability arrangements.

The questions from **Sweden** concern salmon migration and the ecological and chemical state of the Bothnian Bay and the Tornionjoki river.

The questions from **Germany** deal with the following topics:

Impacts of a serious accident, including crash of a large commercial airliner: Fennovoima replies by describing the licensing procedure for an NPP, in particular the role of STUK, as well as the supervision practice during operation (in particular the periodic safety review). They maintain that no plant which could not withstand a serious accident or the crash of a large commercial airliner could be licensed, and that safety will be continuously improved during operation.

Storage of spent nuclear fuel: Fennovoima has not yet selected the storage facility for the dry interim storage. In any case, resistance against the crash of a large commercial passenger aircraft has to be guaranteed.

Further clarifications – topics of national interest

This section deals very briefly with issues of water quality, cooling water, flora and fauna, land use and other questions mostly of minor significance from the Austrian point of view. Three topics are of some interest to Austria, however.

A summary only of the clarifications is provided. The more detailed report on the further clarifications is available in Finnish and Swedish only.

Risk and environmental impacts of transportation of spent fuel: According to Fennovoima, the risks of transportation are extremely small and do not differ between alternative sites. The environmental impact of transportation is negligible.

Environmental impacts of repository facility for operating wastes containing radioactive substances of low and intermediate levels: The environmental impacts during construction and operation are minor and confirmed to the power plant area. After the operation phase, the environmental impacts are negligible.

Additional analysis on nuclear accidents: The analysis includes a case where all noble gases in the nuclear fuel are released. Also the effects of additional weather situations on the doses are assessed. (No results are presented in the document.)

Answer to Austrian Government Regarding Worst Case Severe Accident Scenario in a New Finnish Power Plant, Fennovoima, 15.06.2009

The argumentation in this response as well as an assessment and discussion are presented in the section of “Safety and Accidents”.