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# NPP Fennovoima

## Expert Statement to the EIA Report

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ÖSTERREICHISCHES ÖKOLOGIE INSTITUT

BOKU

Met

**University of Natural Resources and Applied Life Sciences, Vienna**
Department of Water, Atmosphere and Environment
**Institute of Meteorology (BOKU-Met)**

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Ordered by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, Project Management Department V/6 “Nuclear Coordination”

REPORT
REP-0196

Vienna, 2008

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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

*Printed on recycling paper.*


ISBN 3-85457-994-2

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# 1 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).

According to the Finnish law the construction of a new nuclear power plant is subject to a Decision-in-Principle issued by the Government and ratified by the Parliament.

With reference to the Espoo Convention the Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management, has expressed its interest to take part in the transboundary EIA. The Austrian Institute of Ecology was assigned by the Austrian Ministry of Agriculture and Forestry, Environment and Water Management to elaborate an Expert Statement on the EIA Program for the Fennovoima NPP. In the second stage of the EIA process 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 to assess the Environmental Impact Assessment Report of Fennovoima.

The findings of this evaluation are presented in this Expert Statement, which is structured as follows:

After a short introduction in chapter 1, in chapter 2 the summary of the expert statement is given (in chapter 3 in German). The planned project and the EIA procedure are described in chapter 4. In chapter 5 the reactor types considered for Fennovoima are discussed in detail. Safety and accident analysis with focus on possible transboundary consequences are assessed in chapter 6 and 7. In chapter 8 management of radioactive waste is discussed. Questions are summarized in chapter 9.

# 2 SUMMARY

## 2.1 Description of the Project and Procedure

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).

According to Finnish law the construction of a new nuclear power plant is subject to a Decision-in-Principle which has to be issued by the Government and ratified by the Parliament. The EIA process has to be completed before issuing the Decision-in-Principle.

The **first stage of the EIA** process (assessment program) was completed with the issuing of the Statement of the Ministry of Employment and the Economy in May 2008. This Statement included the summarized comments of all organizations on the EIA Program.

The **second stage of the EIA** procedure started with the preparation of the EIA Report which was submitted in October 2008. This part of the procedure including the Espoo procedure is still under way. It will be concluded with another Statement of the Ministry of Employment and the Economy.

Not only Fennovoima is planning a new NPP, but also Teollisuuden Voima Oy (TVO) and Fortum Oy. Even if the Finnish demand for electricity will probably grow, construction of three new big nuclear power plants will not be needed. The Finnish Government approved a new **Climate and Energy Strategy for Finland** on 6th November 2008. This strategy indicates that the electricity demand will not grow as fast as was assumed by Fennovoima's EIA Report. Besides, the Government stated in the strategy that "nuclear power will not be constructed in this country for the purpose of permanent export of electricity." (MINISTRY OF EMPLOYMENT AND THE ECONOMY 2008).

The government will decide about all three applications for the Decisions-in-Principle for new NPPs together. The outcome is open, concerning the number of plants as well as the operator(s).

The Finnish procedure allows the applicant to deal with the different reactor projects as a "black box". As was also the case with the EIA procedures of Olkiluoto-4 and Loviisa-3, Fennovoima does not present **detailed information about reactor types** and their technical specifications. During the consultations concerning Olkiluoto-4 and Loviisa-3 the Austrian side has proposed considering changes in the licensing process (concerning the chronological order). The **Finnish regulations** are regarded as very strict but beside limited emission targets there are no detailed safety requirements for Generation III reactors available in English until now. From representatives of the Finnish nuclear regulation authority STUK the Austrian experts have been informed that the general requirements are outlined in the YVL guides that are currently in revision and were announced to be newly issued in autumn 2008[1]. Together with these new YVL safety guides for design basis and safety analysis, a background paper will be issued which will compare the Finnish regulations with European Utility Requirements (EUR) and WENRA reference levels.

**Nonetheless, without any description of the NPP's features it is not possible to assess the feasibility of realization of the radiation protection targets. Therefore it is of high relevance for Austria to be able to follow the still ongoing procedures. Establishing an exchange of information between the competent authorities of Austria and Finland covering the results of feasibility studies and safety assessments is recommended.**

## 2.2 Reactor Types

The EIA Report provides only a very general basic technical description of the reactor project.

Following a preliminary assessment of all light water reactor types on the market, Fennovoima has chosen three reactor alternatives for closer analysis – the Toshiba ABWR, the EPR and the SWR 1000.

**Fennovoima's EIA Report is complete according to the minimum requirements** of the Espoo Convention. However, considering possible transboundary impacts, there is some general lack of information. For this expert statement the authors have compiled some additional information on the reactor types chosen by Fennovoima.

As of yet, only the ABWR type units are in operation; however, those belong to earlier ABWR designs. The Toshiba AB1600 so far is only in the planning stage.

Two EPR units are in different stages of construction, but none is operating today.

The SWR-1000 is, in a sense, the most advanced of the reactor types considered here since it relies most extensively on passive safety systems. However, there are no concrete projects for this reactor type today; it exists on paper only.

**It is apparent that there is little operational experience with the reactor types chosen by Fennovoima. Only one of those types (ABWR) has been in operation so far.**

It is the general practice in Finland, as laid down in the corresponding regulations, that specific and detailed technical information concerning the reactor types under consideration is not provided in the EIA Report.

It is understood that several overlapping procedures are ongoing, beside the EIA procedure. Preparation for the Decision-in-Principle includes feasibility studies, which have to be provided by the company. Based on these documents the regulatory authority STUK has to assess whether there are safety issues to be foreseen which could prevent the plant meeting the Finnish requirements.

[1] Until Dec 10th, 2008, only Finnish versions of several new YVL-Guides were published on http://www.stuk.fi.

After the Decision-in-Principle and the definitive selection of a reactor type, a much more detailed assessment of the NPP project will be performed by STUK, in the course of the nuclear licensing procedure.

However, this does not exclude the possibility to go into somewhat more technical detail already during the course of the EIA procedure. In particular, it would be desirable that information which indicates that there could be significant and clear-cut differences between the reactor types under consideration would already be provided, discussed and evaluated in some detail in the EIA Report. **In concluding, it has to be stated that the information contained in the EIA Report does not permit a reliable assessment of the possible influence of the reactor type selection on accident consequences for Austrian territory.**

## 2.3 Accident Analysis

The EIA Report provides a very basic introduction to nuclear safety issues. Concerning accident situations it is stated that in order to assess impacts caused by a nuclear power plant accident, two accidents (INES 6 and INES 4) have been assessed.

The caesium-137 emission caused by an **INES 6 accident** is assumed to be 100 TBq. This corresponds to the limit set by the Government Decision 395/1991. The source term for the INES 4 accident is not provided in the EIA Report. According to the YVL Guide 2.8, the probability for core damage shall be less than 1E-5/a. The probability for a core damage accident exceeding the limit of 100 TBq Cs-137 shall be less than 5E-7/a.

**The INES 6 accident which is the most severe accident assessed in the EIA Report does not constitute a worst-case scenario.**

**Severe accidents** with releases considerably higher than 100 TBq of Cs-137 cannot be excluded for the reactor types under consideration, even if their probability is required to be below 5E-7/a. There is no convincing reason why such accidents should not be addressed in the EIA Report; quite to the contrary, it would appear rather evident that they should be included in the assessment since their effects can be widespread and long-lasting and even countries not directly bordering Finland, like Austria, can be affected.

**The analysis of a severe accident scenario with a caesium-137 release considerably higher than 100 TBq, would close an important gap in the EIA Report and allow a discussion of potential transboundary impacts and, in particular, the effects on Austrian territory.**

In the EIA Report it is explained that a Gaussian model is used for dispersion calculation and that the German regulatory model is applied. Moreover, the EIA Report presents only one set of results of the dispersion calculation for all three proposed sites. Furthermore, no values are presented for the unfavourable weather conditions at distances beyond 50 km.

The EIA seems to have adopted some kind of “worst-case” method to assess the possible impact of severe accidents. 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 $kBq/m^2$.

The use of a Gaussian model for assessment of transboundary impacts with unfavourable weather conditions as a worst-case is an acceptable approach, but in the EIA it suffers from the fact that the “worst-case” with respect to the emission is rather arbitrarily taken as 100 TBq Cs-137. **In summary, it is not easy to infer the consequences in Austria of possible severe accidents from the EIA Report.**

If one upscales the result of the EIA according to the more realistic accident source term of 25,000 TBq which is 250 times larger than the 100 TBq considered in the EIA, 70 $kBq/m^2$ would result. This result is approximately the same as presented by the Austrian assessment below.

## 2.4 Austrian Analysis of Transboundary Accident Impacts

For the estimation of possible transboundary impacts, a worst-case scenario for the release is assumed. The determination of a complete source term, including all important nuclides, is by far beyond the scope of this report. Only the source term for Cs-137, as a characteristic nuclide, is considered. With a core inventory of 510,000 TBq (EPR) and a release fraction of 5%, a source term of 25,500 TBq Cs-137 results, which was used in the evaluation of possible transboundary consequences of accidents at the proposed sites. Transport, diffusion and deposition were calculated with the Lagrangian particle dispersion model FLEXPART.

The output is evaluated on a latitude-longitude grid. For the domain covering the whole of Europe, the grid cells have 1° length (111 km in N-S) and width (approx. 70 km in E-W). Features smaller than one grid cell cannot be resolved, especially local maxima near NPP sites.

With the assumed Cs-137 source term for all proposed sites among the 88 cases calculated for the weather situations of the year 1995 examples were found where Austria would be affected by contamination, in some cases up to an extent where protection measures could be required in Austria.

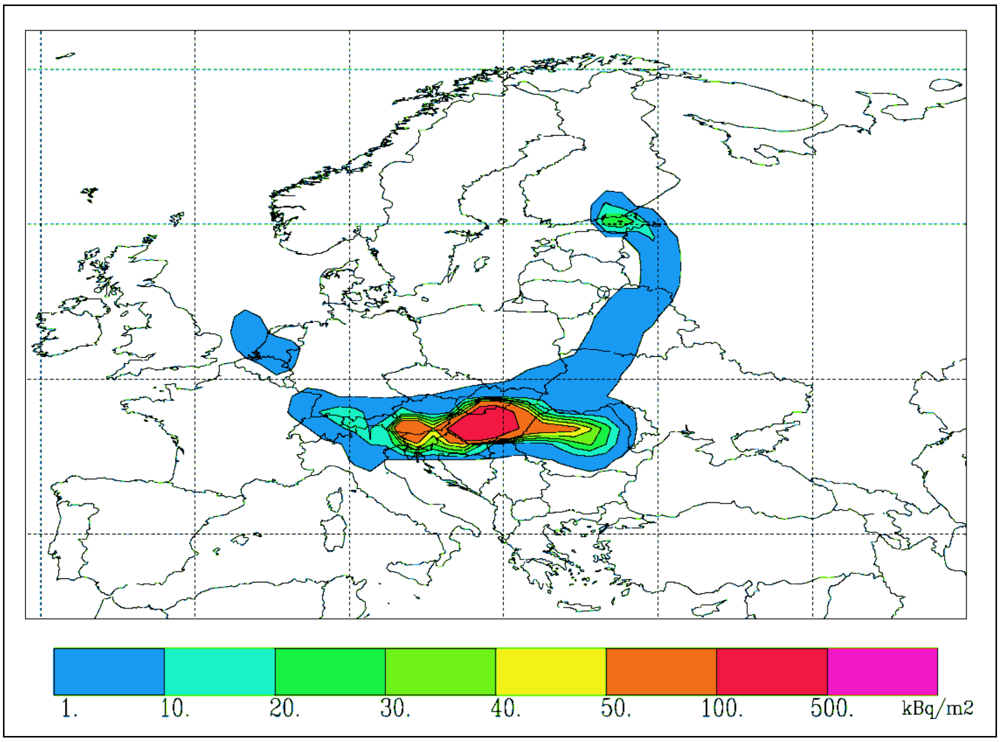


*Figure 1: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP at Kampuslandet (near Loviisa), assuming a release of 25,500 TBq in the hour after 1995-07-28 06:00. Output grid size is 1°.*

The figure shows a worst-case scenario for Austria and Hungary, where the south of Austria would receive a deposition above 50 kBq Cs-137/m$^2$ on a larger area, and almost all of Hungary would be contaminated higher than 100 kBq/m$^2$ Cs-137. During spring and summer food bans and restriction in stock farming would be necessary if such a situation were to become reality.

If a deposition of 50 kBq/m$^2$ is exceeded in Austria as it is indicated in figure 1, during spring and summer food bans and restriction in livestock farming would be necessary if such a situation were to become reality. 50 kBq/m$^2$ correspond to an effective dose of 2.5 mSv for the first year, which implies the Austrian warning scale level 2 requiring protection measures for children, expectant and breast-feeding mothers (RAHMENEMPFEHLUNGEN 1992). The new order for intervention in radiological emergencies (INTV 2007) recommends sheltering for risk groups if an effective dose of 1 mSv in seven days could be exceeded. Because the largest part of the dose will be received in the first week after an accident it cannot be excluded that the intervention limit for seven days could also be exceeded.

The difference between the proposed sites, with respect to potential impact on Austria, would strongly depend on the magnitude of the source term considered. For source terms on the order of 1E16 Bq Cs-137, the risk from the northern sites is much smaller than from the southern side, while for a catastrophic source term on the order of 1E17 Bq even the northerly sites can produce impact on Austria at the warning scale level 2 (requiring protection measures for children, expectant and breast-feeding mothers) at a relevant climatological frequency.

**The presentation of the results of the Austrian analysis of transboundary impacts of a potential severe accident in a NPP at one of the sites proposed by Fennovoima proves that an impact on southern central and even south European regions cannot be excluded. Moreover, the results emphasize the importance of a serious evaluation and discussion of the severe accident scenarios for Generation III reactors in the framework of the transboundary EIA.**

**As discussed above, if one upscales the assumed source term to a more realistic value and takes into account effects of precipitation, the results in the report would at least suggest relevant consequences also in Austria, while with the 100 TBq source term such consequences would not be expected.**

## 2.5 Radioactive waste management

Radioactive waste management is presented in the EIA report in a very general manner. Different technological options for interim storage, final disposal of spent fuel and high and intermediate level radioactive waste are described but without concrete decisions on technology and location of the facilities. It appears that Fennovoima has not yet developed a comprehensive nuclear waste management strategy. Fennovoima Oy should clarify whether they intend to store the spent fuel in Olkiluoto like the other NPPs of Finland. The needed capacity has to be stated along with a feasibility study of the possible expansion.

In case it is intended to construct a separate final storage facility, a schedule of the completion as well as information on the site should be provided in order to be able to estimate the required duration of interim storage and the subsequent security aspects, and to assess whether the planned site fulfils the geological requirements.

# 3 ZUSAMMENFASSUNG

## 3.1 Beschreibung von Projekt und Verfahren

Die Firma Fennovoima Oy (Fennovoima) plant, in Finnland ein neues Kernkraftwerk (KKW) zu bauen. Drei verschiedene Standorte werden diskutiert: Hanhikivi (Gemeinde Pyhäjoki), Kampuslandet und Gäddbergsö (Gemeinde Ruotsinpyhtää in der Nähe des bereits in Betrieb befindlichen KKW Loviisa) oder Karsikkoniemi (Gemeinde Simo). Angeführte Alternativen für die elektrische Kapazität des neuen KKW bewegen sich zwischen 1.500–1.800 MWe für einen Block oder 2.000–2.500 MWe für zwei Blöcke (mit jeweils 1.000–1.250 MWe).

Gemäß finnischer Gesetzgebung unterliegt der Bau eines neuen Kernkraftwerkes einer „Decision-in-Principle“ (Grundsatzentscheidung), welche von der Regierung erlassen und vom Parlament ratifiziert werden muss. Das UVP-Verfahren muss vor dem Erlass der „Decision-in-Principle“ abgeschlossen sein.

Die **erste Stufe des UVP-Verfahrens** (Vorverfahren) wurde mit einem Standpunkt des Ministeriums für Beschäftigung und Wirtschaft abgeschlossen. Dieser Standpunkt beinhaltete die zusammengefassten Kommentare aller Organisationen zu dem UVP-Vorverfahrens.

Die **zweite Stufe des UVP-Verfahrens** begann mit der Erstellung des UVP-Berichtes, welcher im Oktober 2008 eingereicht wurde. Dieser Teil des Verfahrens, der auch das Espoo-Verfahren beinhaltet, ist noch im Gange. Er wird mit einem weiteren Standpunkt des Ministeriums für Beschäftigung und Wirtschaft abgeschlossen werden.

Nicht nur Fennovoima plant ein neues KKW, sondern auch Teollisuuden Voima Oy (TVO) und Fortum Oy. Auch wenn der finnische Elektrizitätsbedarf wahrscheinlich steigen wird, ist der Bau von drei neuen großen KKWs nicht nötig. Die finnische Regierung genehmigte am 6. November 2008 eine neue **Klima- und Energiestrategie für Finnland**. In dieser Strategie wird angeführt, dass der Elektrizitätsbedarf nicht so schnell steigen wird, wie in Fennovoimas UVP-Bericht angenommen wurde. Überdies führt die Regierung in der Strategie an, dass „Kernkraftwerke in diesem Land nicht für den Zweck von permanentem Stromexport errichtet werden.“ (MINISTRY OF EMPLOYMENT AND THE ECONOMY 2008).

Die Regierung wird über alle drei Anträge für eine „Decision-in-Principle“ über neue KKWs zusammen entscheiden. Das Ergebnis, betreffend sowohl die Anzahl an Kraftwerken als auch an Betreibern, ist offen.

Das finnische Verfahren erlaubt dem Antragsteller die verschiedenen Reaktortypen als eine „black box“. Wie es schon bei den UVP-Verfahren von Olkiluoto-4 und Loviisa-3 der Fall war, führt auch Fennovoima keine **detaillierten Informationen über die Reaktortypen** und ihre technische Spezifikationen an. Im Laufe der Konsultationen zu Olkiluoto-4 und Loviisa-3 schlug die österreichische Seite Veränderungen im Bewilligungsprozess vor (betreffend die zeitliche Abfolge). Das **finnische Atomrecht** wird als sehr streng angesehen – allerdings sind abgesehen von beschränkten Emissionswerten keine detaillierten Sicherheitsanforderungen für Generation-III-Reaktoren in Englisch verfügbar. Die österreichischen ExpertInnen wurden von Vertretern der finnischen Atomaufsichtsbehörde STUK darüber informiert, dass allgemeingültige Anforderungen in den YVL-Richtlinien dargelegt werden, welche sich zum Zeitpunkt in Überarbeitung befinden, sie sollten bis Herbst 2008 neu herausgegeben worden sein[2]. Zusammen mit diesen neuen YVL Sicherheitsrichtlinien über Auslegung und Sicherheitsanalyse wird ein Hintergrund-Dokument herausgegeben werden, das die finnischen Rechtsvorschriften mit den „European Utility Requirements“ (EUR) und den WENRA-Richtwerten vergleichen wird.

**Nichtsdestoweniger ist es ohne Beschreibung der Hauptmerkmale des KKWs nicht möglich, die Möglichkeit der Einhaltung der Strahlungsschutzziele zu beurteilen. Deshalb ist es für Österreich von großer Bedeutung, dem noch laufenden Verfahren weiter folgen zu können. Die Einführung eines Informationsaustausches zwischen den zuständigen Behörden in Österreich und Finnland, der die Ergebnisse der Machbarkeitsstudien und Sicherheitsbewertungen abdeckt, wird empfohlen.**

## 3.2 Reaktortypen

Der UVP-Bericht stellt nur sehr allgemeine technische Basisbeschreibungen über das Reaktorvorhaben zur Verfügung.

Anhand einer vorausgehenden Einschätzung aller auf dem Markt befindlichen Leichtwasserreaktoren, wählte Fennovoima drei Reaktortypen zur genaueren Analyse aus – den Toshiba ABWR, den EPR und den SWR 1000.

**Fennovoimas UVP-Bericht erfüllt die Mindestanforderungen der Espoo-Konvention**. Allerdings herrscht in Bezug auf grenzüberschreitende Auswirkungen ein genereller Mangel an Informationen. Aus diesem Grund stellt diese Fachstellungnahme zusätzliche Informationen über die von Fennovoima ausgewählten Reaktortypen zur Verfügung.

Bislang befinden sich lediglich Einheiten des ABWR-Typs in Betrieb, allerdings gehören diese Blöcke einer früheren ABWR Bauart an. Der Toshiba AB1600 befindet sich derzeit noch im Planungsstadium.

Zwei EPR-Einheiten befinden sich in verschiedenen Bauphasen, aber keine ist bisher in Betrieb.

Der SWR-1000 ist in gewisser Hinsicht der fortgeschrittenste der in Betracht gezogenen Reaktortypen, da er sehr stark auf passiven Sicherheitssystemen aufbaut. Allerdings gibt es im jetzigen Moment keine konkreten Vorhaben für diesen Reaktortyp – er existiert bis jetzt nur auf dem Papier.

**Es ist offensichtlich, dass nur wenig praktische Erfahrung mit den von Fennovoima gewählten Reaktortypen besteht. Nur einer dieser Reaktortypen (ABWR) ist derzeit in Betrieb.**

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[2] Bis zum 10. Dezember 2008 wurden nur finnische Versionen neuer YVL-Richtlinien auf http://www.stuk.fi publiziert.

Offenbar finden neben dem UVP-Prozess verschiedene sich überlappende Prozesse statt. Die Vorbereitungen für die Grundsatzentscheidung („Decision-in-Principle“) inkludieren Machbarkeitsstudien, die von der Firma erstellt werden müssen. Aufbauend auf diesen Studien muss die Aufsichtsbehörde STUK beurteilen, ob es absehbare Sicherheitsaspekte gibt, die verhindern könnten, dass das KKW die finnischen Anforderungen erfüllt.

Nach der „Decision-in-Principle“ und der endgültigen Entscheidung für einen Reaktortyp wird von der STUK im Zuge des atomrechtlichen Bewilligungsverfahrens eine viel stärker ins Detail gehende Beurteilung des KKW-Projekts durchgeführt.

Allerdings schließt das nicht die Möglichkeit aus, bereits während des UVP-Prozesses mehr ins technische Detail zu gehen. Es wäre besonders wünschenswert, dass Angaben darüber, dass es erhebliche klar umrissene Unterschiede zwischen den in Betracht gezogenen Reaktortypen geben könnte, bereits im UVP-Bericht bereitgestellt, diskutiert und bewertet werden. **Abschließend muss festgestellt werden, dass die Angaben im UVP-Bericht keine zuverlässige Einschätzung des möglichen Einflusses der Reaktortyp-Auswahl auf die Unfallfolgen für österreichisches Gebiet zulassen.**

## 3.3 Unfallanalyse

Der UVP-Bericht enthält eine sehr elementare Einleitung über nukleare Sicherheitsaspekte. Bezüglich Unfallsituationen wird angegeben, dass zur Abschätzung von durch einen KKW-Unfall hervorgerufenen Auswirkungen zwei Unfälle (INES 6 und INES 4) bewertet wurden.

Die Cäsium-137-Emission durch einen INES 6-Unfall wird auf 100 TBq geschätzt. Dies entspricht dem von der Regierung in der Entscheidung 395/1991 gesetzten Limit. Der Quellterm für den INES 4-Unfall ist nicht im UVP-Bericht enthalten. Dem YVL-Leitfaden 2.8 zufolge liegt die Wahrscheinlichkeit einer Kernschmelze unter 1E-5/a. Die Wahrscheinlichkeit eines Unfalls mit Kernschmelze, der den Grenzwert von 100 TBq Cs-137 überschreitet, soll weniger als 5E-7/a sein.

**Der schwerste im UVP-Bericht untersuchte Unfall (INES 6) stellt nicht das Worst-case-Szenario dar.**

**Schwere Unfälle** mit einer Freisetzung von weitaus mehr als 100 TBq Cs-137 können für die in Frage kommenden Reaktortypen nicht ausgeschlossen werden, auch wenn deren Wahrscheinlichkeit unter 5E-7/a liegt. Es gibt keinen überzeugenden Grund, solche Unfälle nicht im UVP-Bericht zu behandeln; ganz im Gegenteil erscheint es einleuchtend, dass sie in die Betrachtungen mit einbezogen werden, da ihre Auswirkungen weit reichend und lang anhaltend sein können, und sogar Länder wie Österreich, die nicht direkt an Finnland grenzen, können betroffen sein.

**Die Analyse eines schweren Unfallszenarios mit einer Cäsium-137-Freisetzung von wesentlich mehr als 100 TBq würde eine entscheidende Lücke im UVP-Bericht schließen und eine Diskussion über mögliche grenzüberschreitende Auswirkungen, und insbesondere Auswirkungen auf Österreich, ermöglichen.**

Im UVP-Bericht wird erklärt, dass ein Gauss-Modell für die Ausbreitungsrechnungen verwendet wurde, und dass die deutschen Störfallberechnungsgrundlagen angewandt wurden. Darüber hinaus stellt der UVP-Bericht lediglich einen Ergebnissatz der Ausbreitungsrechnung der drei vorgeschlagenen Standorte vor. Weiters werden keine Werte für ungünstige Wettersituationen in Entfernung von über 50 km präsentiert.

In der UVP scheint eine Art Worst-case-Methode angewendet worden zu sein, um die möglichen Auswirkungen eines schweren Unfalls abzuschätzen. Die Cs-137 Deposition beträgt in einer Entfernung von 1.000 km laut UVP-Bericht 0,28 kBq/m$^2$.

Die Verwendung eines Gauss-Modells für die Abschätzung grenzüberschreitender Auswirkungen unter ungünstigen Wetterbedingungen als Worst-case ist eine akzeptable Herangehensweise, in der UVP jedoch leidet sie unter der Tatsache, dass der Worst-case bezüglich der Emissionen ziemlich willkürlich mit 100 TBq Cs-137 angesetzt wurde. **Zusammengefasst ist es nicht einfach, die Konsequenzen eines möglichen schweren Unfalls auf Österreich aus dem UVP-Bericht abzuleiten.**

Wenn dieses Ergebnis auf einen realistischeren Quellterm mit 25.000 TBq, der 250-mal größer ist als die 100 TBq, die im UVP-Bericht berücksichtigt werden, umgelegt wird, würden 70 kBq/m$^2$ resultieren. Dieses Ergebnis entspricht in etwa demjenigen, das in der österreichischen Abschätzung (siehe unten) vorgestellt wird.

## 3.4 Österreichische Analyse der grenzüberschreitenden Auswirkungen

Für die Abschätzung von möglichen grenzüberschreitenden Auswirkungen wird von einem Worst-case-Szenario ausgegangen. Die Festlegung eines vollständigen Quellterms, welcher alle wichtigen Nuklide enthält, überschreitet den Rahmen dieser Fachstellungnahme bei weitem. Lediglich der Quellterm für das charakteristische Nuklid Cs-137 wird betrachtet. Ausgehend von einem Kerninventar von 510.000 TBq (EPR) und einer Freisetzungsrate von 5 % erhält man einen Quellterm von 25.500 TBq Cs-137, welcher für die Beurteilung von möglichen grenzüberschreitenden Auswirkungen von Unfällen an den beabsichtigten Standorten verwendet wurde. Transport, Verteilung und Deposition wurden mit dem Lagrange'schen Teilchenverteilungsmodell FLEXPART berechnet.

Der Output wurde auf ein Netz aus Breiten- und Längengraden übertragen. Für den Bereich, der ganz Europa bedeckt, wurden Netzzellen mit 1° Länge (111 km in Nord-Süd) und Breite (etwa 70 km in Ost-West) gewählt. Merkmale kleiner als eine Netzzelle können nicht aufgelöst werden, besonders betrifft dies die lokalen Maxima nahe der KKW-Standorte.

Mit dem angenommenen Cs-137 Quellterm wurden für alle vorgeschlagenen Standorte unter den 88 Fällen, die für die Wettersituationen des Jahres 1995 kalkuliert wurden, Beispiele gefunden, bei denen Österreich durch die Kontamination betroffen sein könnte, in einigen Fällen könnten sogar Schutzmaßnahmen in Österreich notwendig sein.

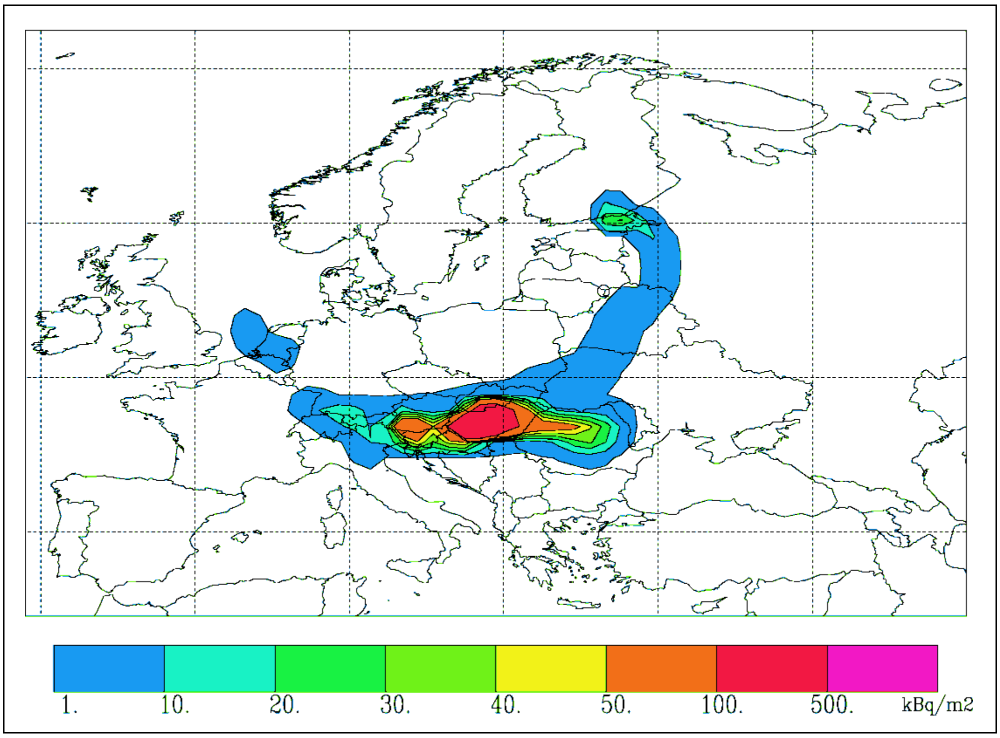


*Abbildung 1: Beispiel der Cs-137 Deposition über Europa, die aus einem hypothetischen schweren Unfall in dem neuen KKW in Kampuslandet (Nähe Loviisa) stammen, unter der Annahme einer Freisetzung von 25.000 TBq in der Stunde nach 06:00 h am 28.7.1995. Netzgröße ist 1°.*

Die Abbildung zeigt ein Worst-case-Szenario für Österreich und Ungarn, wobei der Süden Österreichs eine großflächige Deposition über 50 kBq Cs-137/m$^2$ erhalten und beinahe ganz Ungarn mit mehr als 100 kBq Cs-137/m$^2$ kontaminiert würden.

Falls eine Deposition von über 50 kBq/m$^2$ in Österreich überschritten würde wie dies in Abbildung 1 abgebildet wird, wären im Frühling und im Sommer Verbote bestimmter Lebensmittel und Einschränkungen in der Viehhaltung notwendig, falls eine solche Situation Realität werden würde. 50 kBq/m$^2$ entsprechen einer Effektivdosis von 2,5 mSv im ersten Jahr. Dies bedingt die österreichische Warnstufe II, welche Schutzmaßnahmen für Kinder, Schwangere und stillende Frauen erfordert (RAHMENEMPFEHLUNGEN 1992). In der neuen Interventionsverordnung (INTV 2007) wird das Aufsuchen geschlossener Räume für Risikogruppen an eine erwartete Effektivdosis von 1 mSv (bezogen auf sieben Tage) geknüpft. Da der Großteil der Dosis in der ersten Woche nach einem Unfall erhalten wird, kann es nicht ausgeschlossen werden, dass das Interventionslimit für sieben Tage überschritten wird.

Der Unterschied zwischen den vorgeschlagenen Standorten würde im Hinblick auf die potenziellen Auswirkungen auf Österreich stark von der Größe des Quellterms abhängen. Für Quellterme in der Größenordnung von 1E16 Bq Cs-137 ist das Risiko der nördlichen Standorte viel kleiner als das der südlichen, während für einen Katastrophen-Quellterm in der Größenordnung von 1E17 Bq Cs-137 sogar die nördlichen Standorte Auswirkungen auf Österreich haben könnten, die bei relevanten klimatologischen Frequenzen in die Erreichung der Warnstufe 2 münden könnten (erfordert Schutzmaßnahmen für Kinder, Schwangere und stillende Frauen).

**Die Präsentation der Ergebnisse der österreichischen Analyse von grenzüberschreitenden Auswirkungen eines potenziellen schweren Unfalls in einem KKW an einem der von Fennovoima vorgeschlagenen Standorte beweist, dass Auswirkungen auf südliche zentral- und sogar südeuropäische Regionen nicht ausgeschlossen werden können. Zusätzlich machen die Ergebnisse die Bedeutung einer seriösen Evaluierung und Diskussion der schweren Unfallszenarien für Generation-III-Reaktoren im Rahmen der grenzüberschreitenden UVP klar.**

Wenn, wie bereits oben diskutiert, der angenommene Quellterm auf einen realistischeren Wert erhöht wird und wenn Niederschlagseffekte berücksichtigt werden, würden die Ergebnisse des Berichts zumindest relevante Konsequenzen auch in Österreich vorstellen lassen, während mit einem 100 TBq-Quellterm solche Konsequenzen nicht erwartet werden könnten.

## 3.5 Management des radioaktiven Abfalls

Radioaktiver Abfall wird im UVP-Bericht in einer sehr allgemeinen Weise behandelt. Verschiedene technologische Optionen für Zwischen- und Endlagerung von abgebranntem Brennstoff und hoch- und mittelaktivem Müll werden beschrieben, es werden jedoch keine konkreten Entscheidungen für Technologien oder Standorte der Anlagen benannt. Es scheint, als ob Fennovoima bisher keine umfassende Strategie für das Management des radioaktiven Mülls entwickelt hat. Fennovoima Oy sollte klarlegen, ob sie beabsichtigen den abgebrannten Brennstoff in Olkiluoto endzulagern, wie dies die anderen KKW auch tun. Die dafür benötige Kapazität müsste gemeinsam mit einer Machbarkeitsstudie für eine Erweiterung angegeben werden.

Für den Fall dass es beabsichtigt ist, ein eigenes Endlager zu erreichten, sollten der Zeitplan für die Fertigstellung als auch Informationen über den Standort herausgegeben werden, damit die Möglichkeit besteht, die benötigte Zeit im Zwischenlager, die damit zusammenhängenden Sicherheitsaspekte und die Frage nach der Erfüllung geologischer Vorgaben abzuschätzen zu können.

# 4 DESCRIPTION OF THE PROJECT AND PROCEDURE

According to the Finnish law the construction of a new nuclear power plant is subject to a Decision-in-Principle issued by the Government and ratified by the Parliament. The EIA process has to be completed before the Decision-in-Principle concerning a new nuclear power plant can be issued.

The first stage of the EIA process (assessment programme) was completed with the issuing of the Statement of the Ministry of Employment and the Economy in May 2008. This Statement included the summarized comments of all organizations on the EIA programme.

The second stage of the EIA procedure started with the preparation of the EIA Report which was submitted in October 2008. This part of the procedure including the Espoo procedure is still under way. It will be concluded with another Statement of the Ministry of Employment and the Economy.

## 4.1 Treatment in the EIA Report

### 4.1.1 Alternatives and Zero-Option

The prospective new NPP will be a light water reactor; either a pressurized water reactor (PWR) or a boiling water reactor (BWR) (FENNOVOIMA 2008, p. 8). Alternatives for electric capacity of the new NPP shall be 1,500–1,800 MWe for one plant or 2,000–2,500 MWe for two plants with 1,000–1,250 MWe each (FENNOVOIMA 2008, p. 39). Construction work is planned to start in 2012. For one reactor, construction will take about six years, for two reactors about eight years (FENNOVOIMA 2008, p. 14). Therefore energy production could start in 2020. An operating phase of 60 years is envisaged (FENNOVOIMA 2008, p. 46).

Three different types of reactors are considered: EPR by Areva (PWR with 1,700 MWe), ABWR by Toshiba (BWR with 1,600 MWe) and SWR 1000 by Areva (BWR with about 1,250 MWe) (FENNOVOIMA 2008, p. 11).

The new NPP could be constructed for combined district heating production (FENNOVOIMA 2008, p. 8).

In the EIA Report it is stated that "Fennovoima was specifically established to prepare, design and implement a nuclear power plant project to cover its owners needs for electricity, and its plans do not include other alternative other plant projects." (FENNOVOIMA 2008 p. 8). The zero option is described as non-implementation of the nuclear power plant. In this case electricity demands would be covered by imports and/or by power plants of other operators (FENNOVOIMA 2008 p. 43). Fennovoima argues that the new NPP will produce energy free from $CO_2$-emissions (FENNOVOIMA 2008 p. 41).

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). During the EIA Program phase another location had been considered (Norrskogen), which is not in discussion any more (FENNOVOIMA 2008, p. 39).

### 4.1.2 Seismicity at the sites

Finnish bedrock is among the most seismically stable areas in the world. However, there is rock stress in the Finnish bedrock, and its eruption may cause mild earthquakes. The rock stress is caused by the expansion of the North Atlantic ridge; the Eurasian and North American crustal plates separate by approximately 2 cm per year. Land-up-lift may cause earthquakes in the Gulf of Bothnian area (FENNOVOIMA 2008, p. 211).

According to the EIA Report there are differences between the three regions considered for the site of the new NPP.

There are approximately 15–30 earthquakes in Finland every year, ranging between 1 and 4 on the Richter scale. The strongest recorded earthquake took place in Alajärvi in 1979 (approximately 3.8). Nearly half of all earthquakes observed in Finland took place in the Kuusamo region (UNIVERSITY OF HELSINKI 2008, cit. in FENNOVOIMA 2008).

Pyhäjoki, Hanhikivi (in the East):

The Hanhikivi headland is part of a seismically low-active area. The largest earthquake observed in the vicinity (2.7) was measured approximately 10 kilometres to the northeast of Hanhikivi (ELMINEN et al. 2007, cit. in FENNOVOIMA 2008).

Ruotsinpyhtää/Kampuslandet and Gäddbergsö (in the South):

In terms of earthquakes, Ruotsinpyhtää is located in a very stable area. The magnitude of earthquakes observed in the area has been less than 3 on the Richter scale (POHJATEKNIIKKA OY 2007, cit. in FENNOVOIMA 2008).

Simo, Karsikkoniemi (in the North at the Swedish border):

With respect to Finnish conditions, the Simo region is located in a seismically active area. There have been several earthquakes of a magnitude of more than 4 on the Richter scale in the area close to Simo, outside the borders of Finland. The magnitude of the largest observed earthquake (Bothnian Bay earthquake in 1882) is estimated as 4.9. Its centre was immediately to the west of the Simo area (HÄRMÄ et al. 2007, cit. in FENNOVOIMA 2008).

**Procedure**

In February 2009, Fennovoima will apply for the Decision-in-Principle. For this application, a “preliminary safety assessment on the basis of the application from the Radiation and Nuclear Safety Authority “[3] is needed. Also statements from the Ministry of Environment, from the municipal council of each municipality which could harbour a site for the new NPP and from the neighbouring municipalities are required (FENNOVOIMA 2008, p. 102).

[3] Radiation and Nuclear Safety Authority = STUK

The Decision-in-Principle will be issued in 2010. After that, Fennovoima will select the plant site and will apply for the other necessary permits (due to Environmental Protection Act, due to Water Act, construction licence, building permit). After construction, the operating licence will be applied for, and the plant will be commissioned.

## 4.2 Discussion

Fennovoima's EIA Report is complete according to the minimum requirements of the Espoo Convention. However, considering possible transboundary impacts, there is some general lack of information. The missing information is specified in the subsections of this expert statement. Also some topics, whose discussion has been requested in the scoping phase by Austria, are missing:

Austria has requested a comprehensive comparison of all electricity production technologies over their life-cycle. The EIA Report provides a comparison between the life-cycle $CO_2$-emissions of nuclear power and fossil fuel/natural gas but leaves out the comparison with renewables, which partly have smaller emissions than nuclear power according to the report cited by Fennovoima (WORLD ENERGY COUNCIL 2004, p. 37).

Furthermore, the possibility of higher $CO_2$-emissions due to a low-quality source of uranium should be assessed: The uranium from Russia results in life-cycle $CO_2$-emissions of 65 g per kWh (FRITSCHE 2007, p. 6) which is far more than Fennovoima's indicated limit of 40 g $CO_2$ per kWh (FENNOVOIMA 2008, p. 343).

Furthermore a comparison of the environmental and health impacts of the total nuclear fuel chain with the impacts of other power generation technologies has been required in the scoping phase. No such comparison is given, merely the $CO_2$-emissions of the zero-option are stated, where Fennovoima assumes that 70% import and 30% additional production in Finland would have substituted the electricity that would have been generated by the NPP. The needed electricity would mainly be generated by coal or natural gas (FENNOVOIMA 2008, p. 351) (Note: The $SO_2$, $NO_x$ and particle emissions are said to be in figure 8-136 which is actually missing.)

Not only Fennovoima is planning a new NPP, but also Teollisuuden Voima Oy (TVO) and Fortum Oy have started EIA procedures for new NPPs. TVO is planning a fourth unit at Olkiluoto (see also WENISCH et al. 2008a), Fortum Oy proposed a third unit in Loviisa (WENISCH et al. 2008b).

Electricity needs in Finland are discussed in all three EIA Reports for new Finnish NPPs. All applicants (TVO, Fortum and Fennovoima) argue that the Finnish demand for electricity will increase. Fennovoima assumes an increase from about 90 TWh in 2007 up to 107 TWh in 2020 and 115 TWh in 2030 (FENNOVOIMA 2008, p. 41).

The Finnish Government approved a new Climate and Energy Strategy for Finland on $6^{th}$ November 2008 (MINISTRY OF EMPLOYMENT AND THE ECONOMY 2008). In this strategy targeted electricity demands for 2020 are about 98 TWh, which is 8% less than Fennovoima’s numbers in its EIA Report. A NPP of 1,500–1,800 MW would produce about 12–14 TWh electric energy per year, a NPP with 2,000–2,500 MW 16–18 TWh (FENNOVOIMA 2008, p. 69). It is the responsibility of the Finnish Ministry of Employment and the Economy (MEE), the Government and the Parliament to decide when and what capacity will be required to serve the electricity demand, and how many NPPs shall be built and where. This is even more necessary as the Government stated that “nuclear power will not be constructed in this country for the purpose of permanent export of electricity.” (MINISTRY OF EMPLOYMENT AND THE ECONOMY 2008).

Because these three EIA procedures all deal with the same topic – the planning of new NPPs to meet Finland’s increasing electricity need – they should be dealt with together. This is also the position of the Ministry of Employment and the Economy. The MEE required that the application for the Decision-in-Principle of Fennovoima will be made only after the MEE has finished the EIA process by issuing its statement (FENNOVOIMA 2008, p. 59).

The Minister of Economic Affairs, Mauri Pekkarinen, would also have preferred the completion of the EIA process for Olkiluoto 4 before receiving the application by TVO for the Decision-in-Principle, as he told in a press release of the Ministry of Employment and the Economy of April 25th 2008[4]. Concerning the other two expected applications (Loviisa-3 and Fennovoima) for Decisions-in-Principle the Minister announced that it was “essential for all applications to be considered at the same time”. So even if TVO submitted earlier than the other operators, a joint consideration will take place.

The Finnish procedure allows the applicant to deal with the different reactor projects as a “black box”. As was also the case with the EIA procedures of Olkiluoto-4 and Loviisa-3, Fennovoima does not present detailed information about reactor types and their technical specifications. It is apparent that there is little operational experience with the reactor types listed in the EIA Report. Only one of those types (ABWR) has been in operation so far. More information about the reactor is important in order to assess the hazard of large accidental releases, which could affect Austria.

Also the MEE declared in its statement for the EIA Assessment Program: "The Ministry considers that the assessment report must include an overview of nuclear power plants currently in the market that are suitable for the inspected project. Similarly, the bases of the nuclear power plant’s safety design with regard to limiting the emissions of radioactive substances and environmental impacts must be presented, as must an estimate of the opportunities for fulfilling the current safety requirements.” (FENNOVOIMA 2008, p. 54f.).

The Finnish regulations are regarded as very strict but beside limited emission targets there are no detailed safety requirements for Generation III reactors available in English until now. From representatives of the Finnish nuclear regulatory authority STUK the Austrian experts have been informed that the general requirements are outlined in the YVL guides that are currently in revision and were announced to be newly issued in autumn 2008[5]. Generally, STUK does not issue precisely defined requirements for safety, because the vendors should have enough room for creating innovative solutions. The new safety guides will become part of first stage legislation. Together with the new issue of the YVL safety guides for design basis

[4] http://www.tem.fi/?89521_m=91497&l=en&s=2471, seen 05-09-2008

[5] Until Dec 10th, 2008, only Finnish versions of several new YVL-Guides were published on http://www.stuk.fi.

and safety analysis, a background paper will be issued which will compare the Finnish regulations with European Utility Requirements (EUR) and WENRA reference levels. (WENISCH ET AL. 2008c).

Since there is not enough detailed information about the reactors under review for Fennovoima, chapter 5 of this statement provides some additional information on this issue.

In contrast to the Finnish procedure a similar consultation process in the UK provides feasibility studies of Generation III reactors at a public website[6]. The British authorities have made comprehensive documents about the reactor types in discussion available to the public.

The EIA procedure should be in accordance with the Finnish EIA Act, the Espoo Convention and the Aarhus Regulation.

The *Finnish EIA Act* (EIA Act 2006) corresponds to the EIA-Directive of the EC (Council Directive 85/337/EEC) by including nuclear power stations into the list of projects that are subject to the EIA legislation. The notification of Member States that are possibly affected by the project has to include information on the project and on any transboundary environmental impact, information on the assessment procedure and the time period for commenting this information.

The *Espoo Convention* (Espoo Convention 1997) lists activities that should be subject to a transboundary EIA process. These activities include nuclear power stations. The Espoo Convention states in Article 6 (Final Decision): “The Parties shall ensure that, in the final decision on the proposed activity, due account is taken of the outcome of the environmental impact assessment.

The *Aarhus Convention* guarantees the right of environmental information for the public. The Aarhus Convention is an international legal Convention. The United Nations Economic Commission for Europe (UNECE) “Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters” was adopted on 25 June 1998 in the Danish city of Aarhus and entered into force on 30 October 2001. At the end of 2006 40 parties have signed the Convention, including all Member States of the European Union (HÖRMAYER et al. 2007).

In the Aarhus Regulation (EC 1367/2006) all three pillars of the Aarhus Convention are covered: access to information, public participation, access to justice. In 2003 the European Commission adopted two Directives concerning the first and second pillars of the Aarhus Convention, the right of access to environmental information and the right of public participation. The Directives are implemented into national law of the EU Member States (EC 2003/4 und EC 2003/35[7]).

*EC Directive 2003/4* on public access to environmental information (EC 2003/4) grants the right of access to environmental information. Environmental information includes according to Article 2 any information on “factors, such as substances, energy, noise, radiation or waste, including radioactive waste, emissions, discharges and other releases into the environment, affecting or likely to affect the elements of

[6] http://www.hse.gov.uk/newreactors/reactordesigns.htm, seen 05-08-2008

[7] EC Directive 2003/35 deals with the right of public participation in respect of the drawing up of certain plans and programmes relating to the environment (EC 2003/35)

the environment". If a Member State disobeys central elements of the Directives 2003/4/EC and 2003/35/EC, any natural or legal person will be allowed to lodge a complaint with the Commission against this Member State (HÖRMAYER et al. 2007).

During the bilateral consultations between Finland and Austria concerning Olkiluoto-4 and Loviisa-3, the Austrian side has proposed considering changes in the licensing process concerning the chronological order because completion of the EIA procedure before the project phase seems to be too early and only few details about the project are available. It is highly appreciated by the Austrian side that the Finnish side considers changes in the EIA process. As it is the case with Olkiluoto-4 and Loviisa-3, it is also of high relevance for Austria to be able to follow the still ongoing procedures for the NPP of Fennovoima. Therefore, establishing of an exchange of information between the competent authorities of Austria and Finland covering the results of feasibility studies and safety assessments is recommended (WENISCH et al. 2008c).

Seismicity at the sites

In general Finland has a very low seismic hazard. However, it is conspicuous that the northern location Karsikkoniemi is in the most seismically active area of the country. The magnitude of 4.9 on the Richter scale corresponds with an Intensity of 7 on the MSK scale. This should be considered in the selection of the site.

## 4.3 Conclusion

As was the case in the EIA procedures of Olkiluoto-4 and Loviisa-3, the EIA Report does not present a certain project and alternatives. In the EIA Report a list of three reactor types is presented, with an approximate output of 1,500–2,500 MWe. This is very vague because reactor type and exact output are not determined. It is not possible to properly assess transboundary impacts with this missing information.

The EIA Report presents only general information about the project. The NPP is presented as a black box. The Finnish regulations are regarded as very strict but beside limited emission targets there seem to be no detailed safety requirements published.

Without any detailed description of the NPP's features it is not possible to assess the feasibility of realization of this target. Furthermore, from our point of view the EIA Report does not fulfil the recommendation of the Ministry of Employment and the Economy sufficiently.

According to EC 2003/4 all environmental information should be made available to the public. Therefore the missing information could also be claimed with reference to the Aarhus Convention and the corresponding EC Directive 2003/4, respectively.

During the bilateral consultations between Finland and Austria concerning Olkiluoto-4 and Loviisa-3, the Austrian side has proposed considering changes in the licensing process concerning the chronological order because completion of the EIA procedure before the project phase seems to be too early and only few details about the project are available. It is highly appreciated by the Austrian side that the

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The Ministry for Employment and the Economy wants to consider all three applications for a Decision-in-Principle together (OL-4, LO-3, NPP by Fennovoima Oy). We encourage this approach of the Ministry. We also support the principle that the new Finnish Climate and Energy Strategy will not allow construction of nuclear power capacity for the purpose of electricity export (MINISTRY OF EMPLOYMENT AND THE ECONOMY 2008).

Concerning seismicity, the northern location Karsikkoniemi is in the most seismically active area of the country. This should be considered in the selection of the site.

# 5 REACTOR TYPES

## 5.1 Treatment in the EIA Report

Chapter 3 of the EIA Report provides a basic technical description of the reactor project.

The prospective new unit will either be a boiling water reactor or a pressurized water reactor, with direct water cooling. Main purpose is electricity production; the production of district heating is considered as an option.

Regarding power output, there are two alternatives: Construction of one large unit with electrical power of 1,500–1,800 MW and thermal power of about 4,500–4,900 MW; and construction of two smaller units with a total electrical power of 2,000–2,500 MW and thermal power of about 5,600–6,800 MW.

In combined operation, a reactor with a thermal output of 4,300 MW is taken as example in the EIA Report: It could either produce 1,600 MW of electricity and 2,700 of waste heat; or 1,200 MW of electricity, 2,000 MW of district heat and 1,100 MW of waste heat.

Following a preliminary assessment of all light water reactor types on the market, Fennovoima has chosen three reactor alternatives for closer analysis – the Toshiba ABWR, the EPR and the SWR 1000.

A brief table with basic information of those reactor types is provided in the EIA Report (Table 3-2):

| | **Toshiba ABWR** | **EPR** | **SWR 1000** |
|---|---|---|---|
| Manufacturer, country | Toshiba<br>Japan | Areva NP<br>France/Germany | Areva NP<br>France/Germany |
| Electric power, MW | 1,600–1,800 | 1,600–1,800 | 1,000–1,250 |
| Thermal power, MW | 4,300–4,900 | 4,300-4,900 | 2,700–3,400 |
| Reactor type | Boiling water | Pressurized water | Boiling water |
| Main type of safety systems | Active and passive | Active | Passive and active |
| Plant used as the model | Hamaoka-5 | Olkiluoto 3 | Gundremminge C |

Of the EPR or ABWR type, one reactor would be built whereas two units of SWR 1000 would be installed.

Supplementary to the table, some further information is presented in the EIA Report.

It is emphasized that the EPR combines the key elements of the German Konvoi and the French N4 plants. The safety design of this reactor type is based on active systems. There is a general mention of core melting accidents and plane crashes having been addressed at very basic stages of design.

The ABWR is described as based on the GE ABWR, further jointly developed by Toshiba and Westinghouse Sweden. The original safety design is based on active systems; however, passive safety systems have been added. Core melting accidents and aircraft crashes have been taken into consideration for the design.

Although this is not explicitly mentioned, it appears that the EIA Report actually refers to the new conceptual 1,600 MWe ABWR being developed by Toshiba, tentatively called AB1600 (MURASE et al. 2008).

The SWR 1000 is reported to be based on the latest German BWR technology as employed in the Gundremmingen B and C plants. The primary safety systems are passive. Core melting and plane crashes have been addressed at the very basic stages of the design.

No more specific information concerning the reactor types is provided in the EIA Report. Issues like thermal efficiency, plant area activities and land usage, the time schedule for the project, estimated mass quantities generated during construction are briefly discussed. A general discussion of the construction process follows. Other sub-sections of chapter 3 concern nuclear fuel procurement, chemicals used during operation, water requirements and supply, waste water, waste management, transportation and commuter traffic, radioactive emissions, atmospheric emissions and also traffic connections and power lines. None of those sub-sections contains any reactor type specific information or discussion.

### 5.1.1 Further Information on the Reactor Types Selected

In the Expert Statements to the Olkiluoto-4 and the Loviisa-3 NPPs (WENISCH et al. 2008a, 2008b), the authors already have compiled further-reaching information on the three reactor types selected by Fennovoima (as well as on some other reactor types). For reference, the corresponding tables are reproduced in this section, with updates to take into account new developments having taken place in the last 5 months.

This information was researched by the authors and taken mostly from publications of plant designers and other nuclear industry sources, as well as from IAEA.

“Units existing” includes units in operation, under construction or firmly planned with start-up of construction in the near future.

Under “special features”, the most important features which go beyond Generation II plants are listed.

*Table 1: European Pressurized Water Reactor.*

| EPR | European Pressurized Water Reactor (Evolutionary PWR) |
|---|---|
| Basic data | PWR, ca. 1,700 MWe |
| Manufacturer | AREVA (France/Germany) |
| Origin | Developed from the German KONVOI and French N4 PWR types |
| Certification | EUR certified<br>NRC certification process ongoing (WNA 2008) |
| Units existing | 2 units under construction:<br>Olkiluoto-3 (Finland); start of construction 2005, original estimate of start-up 2009. Due to problems with quality control in 2006 and further delays in 2007, the schedule slipped to about 2011 so far (NEIMAG 2007).<br>Flamanville (France); start of construction 2007, expected start-up 2012 (WNIH 2008). Schedule threatens to slip due to problems with quality control similar to those at OL-3 (NW 2008)<br>Construction of two EPR units at Taishan, China, is at present beginning; first concrete to be poured in autumn 2009 (DPA 2008). |
| Special features | Core-catcher for reactor core in case of meltdown<br>In-containment refuelling water storage tank (combines coolant storage and sump function – switchover from safety injection to sump recirculation is avoided)<br>Double containment (two concrete hulls)<br>(EDF 2006) |
| PSA results | Olkiluoto-3 CDF (external and internal initiators, operation and outages) = 1.8E-06/a<br>Frequency of exceeding release limit (100 TBq Cs-137, plus other nuclides) = 1.0E-07/a<br>(STUK 2005)<br>Flamanville CDF (ext. and int. initiators, op. and out.; seismic analysis not complete, internal explosions not included) = 1.33E-06/a<br>(EDF 2006)<br>The same value is given for the EPR applied for in the UK (UK-EPR 2008) |

*Table 2: Advanced Boiling Water Reactor.*

| ABWR | Advanced Boiling Water Reactor |
|---|---|
| Basic data | BWR, 1,400–1,600 MWe<br>(1,600 MWe for the AB1600) |
| Manufacturer | Hitachi/Toshiba/General Electric (Japan/USA) |
| Origin | Originally designed by GE, developed from older GE BWR designs |
| Certification | EUR certified<br>NRC certified (WNA 2008) |
| Units existing | 5 in operation, all in Japan (begin of commercial operation):<br>Kashiwazaki-Kariwa-6 (1996), -7 (1997)<br>Hamaoka-5 (2005)<br>Higashidori-1 (2005)<br>Shika-2 (2006)<br><br>4 under construction (2 in Japan, 2 in Taiwan):<br>Fukushima-Daiichi-7, J<br>Shimane-3 (2011), J<br>Lungmen-1, -2, T (2009, 2010)<br><br>2 “firmly planned” in Japan:<br>Kaminoseki-1, -2 (start of construction 2009/2012, operation 2014/2017) (WNIH 2008) |
| Special features | “Simplified active safety systems”. In case of LOCA, plant response has been fully automated and operator action is not required for 72 hours, the same capability as for passive plants (DNE 2008)<br><br>Some passive severe accident mitigation features (BEARD 2007)<br><br>Spreading area in lower drywell and passive drywell flooding system to guarantee coolability of core debris (IAEA 2004, BEARD 2007)<br>This feature seems to apply to the US ABWR only, not to the units existing so far. The sources above are not fully clear in this respect, but a paper on Kashiwazaki-Kariwa does not mention a capability of ex-vessel core cooling (TSUJI ET AL 1998).<br><br>More passive systems have been introduced for the AB1600. There are passive as well as active systems for core cooling and decay heat removal in case of DBAs; severe accidents are to be coped with by a fully passive system. A core catcher combined with passive containment cooling is installed (MURASE et al. 2008). |
| PSA results | Internal events CDF = 1.6E-07/a, high seismic margins claimed, LRF < 1.0E-9/a<br><br>(The contribution of mode 6 (refuelling) to CDF is reported to be 99%, so no level 2 (PSA) would be required.)<br><br>(BEARD 2007)<br><br>AB1600 is reported to have lower CDF than earlier ABWR designs; however, no PSA results are available so far (MURASE et al. 2008). |

*Table 3: Siedewasserreaktor 1000.*

| | |
|---|---|
| SWR-1000 | SWR = Siedewasserreaktor (boiling water reactor) |
| Basic data | BWR, ca. 1,000 MWe |
| Manufacturer | AREVA (Germany) |
| Origin | Developed by Siemens-KWU in the 1990s, based on the concept of the SWR-300<br>The SWR-300 was developed in the 1980s as a small, inherently safe BWR |
| Certification | EUR certified |
| Units existing | No units are in operation, under construction or firmly planned today |
| Special features | Passive safety systems – e.g. containment cooler, passive flooding and emergency condensers for core cooling, passive pulse generator for initiation of safety systems<br>(The reactor, however, does not entirely rely on passive systems for accident control; there is a combination of active and passive measures. It is claimed that passive systems and active systems each are alone sufficient to provide adequate cooling of the reactor core in case of an accident.)<br>In-vessel retention of damaged core – external cooling of RPV by flooding of the reactor shaft (passive via the containment cooler)<br>(BRETTSCHUH & SCHNEIDER 2001) |
| PSA results | CDF for internal events = 1.1E-07/a (5.0E-08/a for power operation, 6.0E-08/a for shut-down)<br>(BRETTSCHUH & MESETH 2000, BRETTSCHUH & SCHNEIDER 2001) |

It becomes apparent that there is little experience with the reactor types chosen by Fennovoima.

As of yet, only the ABWR type units are in operation; however, those belong to earlier ABWR designs. The Toshiba AB1600 so far is only in the planning stage.

Two EPR units are in different stages of construction, but none is operating today.

The SWR-1000 is, in a sense, the most advanced of the reactor types considered here since it relies most extensively on passive safety systems. However, there are no concrete projects for this reactor type today; it exists on paper only.

The reference to the Gundremmingen B and C units is not quite appropriate in the context. Whereas Hamaoko-5 and Olkiluoto-3 actually are plants of the ABWR and the EPR type, respectively, Gundremmingen B and C are of the German BWR “Mark '72” (“Baulinie '72”), a Generation II plant type relying on active safety systems. It is true that the development of the SWR-1000 was based on the older German BWR types but there are very significant differences between SWR-1000 and BWR '72.

For the three reactor types considered by Fennovoima, there are differences regarding the basic method of coping with a core melt accident. EPR and ABWR rely on ex-vessel cooling; i.e. the core is spread and cooled after it has melted through and exited the reactor pressure vessel. For the SWR-1000, on the other hand, in-vessel cooling is planned – the reactor pressure vessel is to be cooled from the outside in case of a severe accident to prevent discharge of the molten core and to keep it inside the vessel.

Ex-vessel cooling is a completely new concept and, so far, there appears to be no operating unit with provisions for this measure. In-vessel cooling has already been implemented as severe accident management measure; for example, at the Loviisa NPP in Finland (CSNI 2002).

However, in-vessel cooling is difficult to implement in larger reactors, due to the surface-to-volume ratio getting less favourable with increasing power.

Different core damage frequencies and large release frequencies are reported for the three reactor types; this also could be indicative for different safety levels.

For the EPR, CDF values of 1.33–1.8E-06/a are reported; for the ABWR, 1.6E-07/a; and for the SWR-1000, 1.1E-07/a. CDF is to be lower for the AB1600 than for earlier ABWR designs; however, no PSA results appear to have been published so far.

The LRF for the EPR is reported as 1.0E-07/a, whereas for the ABWR, a value of < 1.0E-09 is given. No published LRF value for the SWR-1000 could be found.

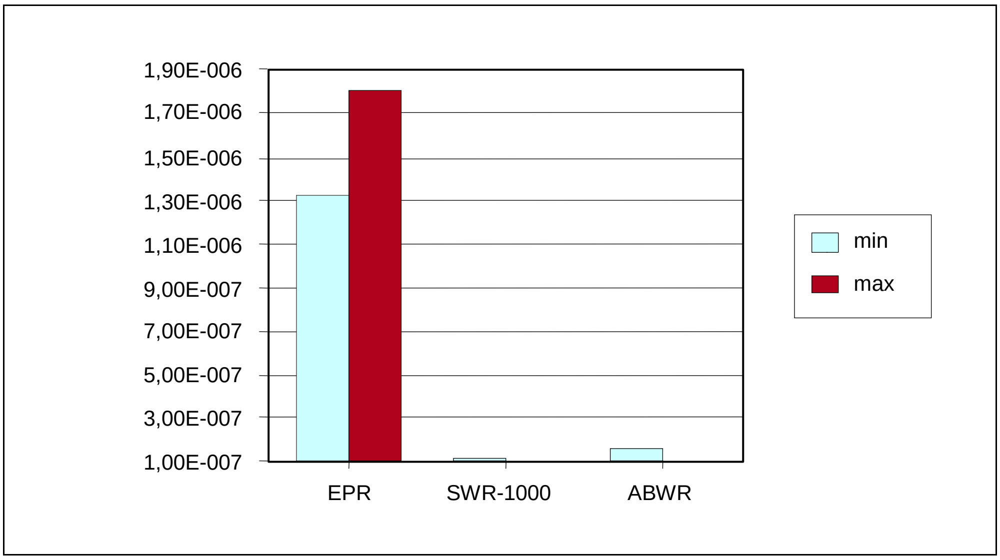


*Figure 2: Core damage frequency for the considered reactors.*

(It has to be noted that all CDF and LRF values quoted above cover operational as well as shutdown states; however, the values for ABWR and SWR-1000 refer to internal initiators only, whereas for the EPR, external initiators are also included.)

## 5.2 Discussion

It is the general practice in Finland, as laid down in the corresponding regulations, and already followed in the EIA procedures for the Olkiluoto-4 and Loviisa-3 projects, that specific and detailed technical information concerning the reactor types under consideration is not provided in the EIA Report. Rather, the new NPP is regarded as a black box with standard impacts, which has to fulfill the regulatory requirements.

This approach is also followed in the Fennovoima EIA and explicitly described in chapter 6 of the EIA Report.

It is understood that several overlapping procedures ore ongoing, beside the EIA procedure. Preparation for the Decision-in-Principle includes feasibility studies, which have to be provided by the company. Based on these documents, the regulatory authority STUK has to assess whether there are safety issues to be foreseen which could prevent the plant meeting the Finnish requirements.

After the Decision-in-Principle and the definitive selection of a reactor type, a much more detailed assessment of the NPP project will be performed by STUK, in the course of the nuclear licensing procedure.

This course of action is predetermined and has to be accepted by the Austrian side. However, this does not exclude the possibility to go into somewhat more technical detail already during the course of the EIA procedure. In particular, it would be desirable that information which indicates that there could be significant and clear-cut differences between the reactor types under consideration would already be provided, discussed and evaluated in some detail in the EIA Report.

Significantly different experiences with reactor types, basically different safety approaches (active/passive) as well as differences in PSA results spanning orders of magnitude should be regarded as indicators deserving such identification, discussion and evaluation.

In concluding, it has to be stated that the information contained in the EIA Report does not permit a reliable assessment of the possible influence of the reactor type selection on accident consequences for Austrian territory.

Such an assessment could be performed on the basis of extensive research and analyses by the authors. However, this lies outside the scope of the present statement.

As pointed out above, it does not necessarily appear to lie outside the scope of the EIA Report to follow up indications of differences between the reactor types selected in some detail. This would then provide a basis for assessing possible influences of the reactor types on accident consequences.

## 5.3 Conclusions

Information which indicates that there could be significant and clear-cut differences between the reactor types under consideration should be provided in the EIA Report, followed by a discussion and evaluation regarding possible implications for the selection of a reactor type.

For example, significantly different experiences with reactor types, basically different safety approaches as well as significant differences in PSA results should be regarded as indicators deserving such identification, discussion and evaluation.

This would then provide a basis for assessing possible influences of the reactor types on accident consequences in general, as well as on consequences for Austrian territory.

# 6 ACCIDENT ANALYSIS

## 6.1 Severe Accident Source Term

### 6.1.1 Treatment in the EIA Report

Chapter 6 of the EIA Report provides a very basic introduction to nuclear safety issues.

Safety requirements in Finland (Nuclear Energy Act, Decrees and Decisions of the Council of State and STUK YVL Guides) are briefly explained. Levels of protection, nuclear safety principles (e.g., redundancy, diversity and separation principles for safety systems) as well as technical barriers are presented. Finally, the implementation of nuclear safety requirements and principles in the design, construction and operation of an NPP is discussed in a concise a rather general manner.

Chapter 7.14 deals with accident situations. It is stated that in order to assess impacts caused by a nuclear power plant accident, two accidents (INES 6 and INES 4) have been assessed.

The caesium-137 emission caused by an INES 6 accident is assumed to be 100 TBq. This corresponds to the limit set by the Government Decision 395/1991. The emission of other nuclides has been assumed on the basis of the relationship between the inventory of the nuclides and Cs-137 in fuel, taking also into account that the release rate from the fuel varies for different nuclides.

The emissions of iodine-131 were estimated to be 1,000 TBq.

The source term for the INES 4 accident is not provided in the EIA Report.

In chapter 8.15 of the EIA Report, impacts of abnormal and accident situations are treated. The concept of postulated accident and severe accidents is briefly discussed, as well as the international nuclear event scale (INES).

According to the draft government decree which will supersede the Decision of the Council of State (395/1991), postulated accidents are divided into the following categories:

- Accidents with expected frequency of occurrence below 1E-2/a. Annual radiation dose limit for the most exposed person is 1 mSv.
- Accidents with expected frequency of occurrence below 1E-3/a. Annual radiation dose limit for the most exposed person is 5 mSv.
- Postulated accidents combining an initial event with a common cause failure of the safety systems or a complex combination of failures. In this case, the nuclear fuel in the reactor must not suffer extensive damage, and the maximum radiation dose permitted for the most exposed individual is 20 mSv.

For severe accidents, the limit for the release of Cs-137 is 100 TBq according to Government Decision 395/1991, as has already been pointed out. Furthermore, the combined fallout consisting of radioactive nuclides other than caesium-isotopes shall not cause, in the long term, a hazard greater than would arise from a caesium release at the above-mentioned limit.

According to the YVL Guide 2.8, the probability for core damage shall be less than 1E-5/a. The probability for a core damage accident exceeding the limit of 100 TBq Cs-137 shall be less than 5E-7/a.

### 6.1.2 Discussion

In the context of safety, severe accidents are the issue of foremost interest from the Austrian point of view since such accidents can potentially lead to adverse effects on Austrian territory.

The source term for the INES 6 accident appears as questionable for a PWR since the estimated release of I-131 appears to be rather small in relation to the Cs-137 release. (The situation for a BWR could be different.)

In the Expert Statement to the Loviisa-3 NPP (WENISCH et al. 2008b), it was pointed out that for German PWRs, considerably higher releases of I-131 are reported for accident scenarios with comparable Cs-137 releases (releases of I-131 higher by a factor of 55–1,400 than releases of Cs-137, and not by a factor of 10 as assumed in the EIA Report).

Furthermore, the INES 6 accident which is the most severe accident assessed in the EIA Report does not constitute a worst-case scenario.

In an Expert Statement concerning the EIA scoping documents for the Temelin unit 3 & 4 project (PAURITSCH et al. 2008), a Cs-137 source term of 25,000 TBq was assumed for accident consequence calculations, i.e. 250 times the amount assumed for the INES 6 accident in the EIA Report. This source term – for containment bypass via a steam generator tube leakage, which is covered – has been derived for German Konvoi PWRs and was considered as typical for the five PWR types discussed in the EIA scoping documents for Temelin (which include the EPR). The source term for BWRs can be expected to be of the same order of magnitude (SSK 2004).

25,000 TBq of Cs-137 correspond to about 5% of the EPR core inventory. Even this does not constitute the maximum conceivable release. Other accident scenarios (failure of reactor pressure vessel at high pressure or containment bypass via uncovered steam generator tube leakage) can lead to caesium releases of more than 50% of the core inventory.

Severe accidents with releases considerably higher than 100 TBq of Cs-137 cannot be excluded for the reactor types under consideration; although their probability is below 5E-7/a. There is no convincing reason why such accidents should not be addressed in the EIA Report; quite to the contrary, it would appear rather evident that they should be included in the assessment since their effects can be widespread and long-lasting and even countries not directly bordering Finland, like Austria, can be affected.

The information contained in the EIA Report so far does not permit a meaningful assessment of the effects of conceivable accidents at the new Fennovoima NPP on Austrian territory.

The analysis of a severe accident scenario which is at least approaching a true worst-case, like the scenario mentioned above (25,000 TBq Cs-137), would close this gap and allow a discussion of potential effects on Austria.

### 6.1.3 Conclusion

Severe accidents with releases considerably higher than 100 TBq of Cs-137 cannot be excluded for the reactor types under consideration, even if their probability is below 5E-7/a. Such accidents should be included in the assessment in the EIA Report since their effects can be widespread and long-lasting and even countries not directly bordering Finland, like Austria, can be affected.

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

## 6.2 Assessment of Transboundary Impact

### 6.2.1 Treatment in the EIA Report

Chapter 8.18.2 of the EIA deals with cross-boundary impacts of severe accidents. The methodology applied is the same as the one presented in Chapter 7.14 for the general discussion of accidents. A release of 100 TBq Cs-137 is taken as scenario representing a severe accident. Then it is explained that a Gaussian model is used and that the German regulatory model is applied. The Cs-137 deposition at the distance of 1,000 km is 0.28 kBq/m$^2$. The calculations are presented in Table 8-51, but this table is a mere extract from the Table 8-47. The EIA discerns so-called “typical weather conditions” and “unfavourable weather conditions”. Details of these weather conditions are only given with respect to precipitation, not wind, stability and mixing heights. “Typical” conditions are dry, while for “unfavourable” conditions it is assumed that precipitation occurs at the receptor point but not elsewhere; the precipitation rate assumed is not given.

### 6.2.2 Discussion

The Cs-137 deposition at the distance of 1,000 km is, according to Table 8-51, 0.28 kBq/m$^2$. If we were scaling this result according to our source term (25,000 TBq is 250 times larger than 100 TBq considered in the EIA), 70 kBq/m$^2$ would result. The deposition values under “unfavourable” conditions are not presented in the form of tables, the graphical display shows only the 20 km radius and the text mentions fallout at 50 km. Interestingly, the caption of Table 8-51 reads “Fallout following a severe reactor accident at chosen distances both in typical weather conditions.” and there is empty space below the Table. The word “both” in combination with the empty space may indicate that originally also the values for unfavourable conditions were presented, but taken out later. This may have occurred in a hurry after finishing the bulk of the EIA Report, as in this caption the word “Table” is in Finnish language. It would be interesting to see the results for “unfavourable conditions”.

Moreover, the EIA Report presents only one set of results of the dispersion calculation for all three proposed sites.

The EIA seems to have adopted some kind of “worst-case” method to assess the possible impact of severe accidents. While this is an acceptable approach in principle, here it suffers from the fact that the “worst-case” with respect to the emission is rather arbitrarily taken as 100 TBq Cs-137.

The approach using a Gaussian model in combination with precipitation only at the receptor is acceptable for a “worst-case” approach at least within the typical range of validity of such a model, which is about 20 km (the range shown in Figures 8-109 and 8-109 is also 20 km). However, not presenting the detailed parameters used in the calculation is a serious shortcoming as thus it is not possible to see whether really worst-case meteorological conditions were applied. With respect to transboundary effects, the Gaussian model is not normally considered appropriate for such distances. The question arises as to whether this model can at least be used as an estimate for upper limits, because more realistically changing wind directions will rather lead to lower values. The answer, however, cannot be given without knowing the details of the dispersion model, especially with respect to lateral and vertical dispersion. Furthermore, no values are presented for the unfavourable weather conditions at distances beyond 50 km. In summary, it is not easy to infer the consequences in Austria of possible severe accidents from the EIA Report.

The Fennovoima EIA does not explain how the use of a Gaussian model for long distances is justified. State of the art dispersion calculation tools are available in Finland; e.g. SILAM, which uses meteorological data from the Finnish Meteorological Institute (TVO 2008). This model was used, for example, in the EIA process for the new NPP in Lithuania.

If the assumed source term is upscaled to a more realistic value and takes into account effects of precipitation, the results in the report would at least suggest relevant consequences also in Austria, while with the 100 TBq source term such consequences would not be expected.

In the EIA Report no details of the dispersion calculations concerning the different sites are presented, only a list of cities in different diameters from the sites (FENNOVOIMA 2008, p.346). In chapter 9 “Comparision between alternatives and assessment of significant impacts”, no differences between the sites are mentioned concerning the environmental impact of radioactive emissions: “The plant's radioactive emissions will be so low that they will not have any detectable impact on people or the environment” (FENNOVOIMA 2008, p. 359). This approach is not appropriate to consider transboundary emissions caused by accidents.

### 6.2.3 Conclusion

In the EIA Report it is explained that a Gaussian model is used for dispersion calculation and that the German regulatory model is applied. Moreover, the EIA Report presents only one set of results of the dispersion calculation for all three proposed sites. Furthermore, no values are presented for the unfavourable weather conditions at distances beyond 50 km.

The EIA seems to have adopted some kind of “worst-case” method to assess the possible impact of severe accidents. 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$^2$.

The use of a Gaussian model for assessment of transboundary impacts with unfavourable weather conditions as a worst-case is an acceptable approach, but in the EIA it suffers from the fact that the “worst-case” with respect to the emission is rather arbitrarily taken as 100 TBq Cs-137. **In summary, it is not easy to infer the consequences in Austria of possible severe accidents from the EIA Report.**

If one upscales the result of the EIA according to the more realistic accident source term of 25,000 TBq which is 250 times larger than the 100 TBq considered in the EIA, 70 $kBq/m^2$ would result. This result is approximately the same as presented by the Austrian assessment below.

# 7 AUSTRIAN ANALYSIS OF TRANSBOUNDARY ACCIDENT IMPACTS

For the estimation of possible transboundary impacts, a worst-case scenario for the release is assumed. The determination of a complete source term, including all important nuclides, is by far beyond the scope of this report. Only the source term for Cs-137, as a characteristic nuclide, is considered. With a core inventory of 510,000 TBq (5.1E17 Bq) and a release fraction of 5%, a source term of 25,500 TBq Cs-137 results, which was used in the evaluation of possible transboundary consequences of accidents at the proposed sites.

Transport, diffusion and deposition were calculated with the Lagrangian particle dispersion model FLEXPART for selected real weather situations.

## 7.1 Dispersion model

Transport, diffusion and deposition were calculated with the Lagrangian particle dispersion model FLEXPART. FLEXPART is a model suitable for the meso-scale to global-scale calculations, which is freely available and used by many groups all over the world (STOHL et al. 1998), see model homepage at **http://zardoz.nilu.no/~andreas/flextra+flexpart.html**.

The version developed for the project RISKMAP (ANDREEV et al. 1998, HOFER et al. 2000, RISKMAP 1995) was used here. Meteorological input data are gridded fields from the European Centre for Medium-Range Weather Forecasts (ECMWF) with 1° resolution. The RISKMAP version of FLEXPART produces surface contamination due to deposition (sum of dry and wet deposition) as endpoint. The only species considered is aerosol-bound caesium-137, which is used as a characteristic nuclide.

The output is evaluated on a latitude-longitude grid. For the domain covering the whole of Europe, the grid cells have 1° length (111 km in N-S) and width (approx. 70 km in E-W). Features smaller than one grid cell cannot be resolved, especially the local maxima near NPP sites.

## 7.2 Methodology

In a first step, the 90 cases studied in the RISKMAP project were taken as a base. Each case represents a release on a different day in the year 1995, with the time of the release being varied to cover all hours of the day and about 5 days between two subsequent releases. Releases are assumed to last 1 h and to be equally distributed between 50 and 1,000 m above ground. This high value for the release height is because in RISKMAP catastrophic releases were studied which probably are associated with strong heat releases. The source term discussed above was applied to the site of the Loviisa NPP which is close enough to the proposed southerly sites to be used as a substitute, especially considering that Austria is about 1,500 km away. We found one period, in July, when Austria might receive relevant contamination from an accident at the Loviisa site, and a few more which might turn into such situations upon closer examination with a more dense timing of the hypothetical releases.

In a second step, we then looked more in depth into the July case, performing additional dispersion calculations with the same RISKMAP methods but higher temporal density of the releases for the three proposed sites Kampuslandet (near Loviisa, 60.35°N/26.43306°E), Hanhikivi (70 km SE of Oulu, 64.53333°N/24.26667°E), and Karsikkoniemi (near the Swedish border, 65.63333°N/24.71667°E). The release height has been reduced to 50 to 200 m above ground.

## 7.3 Results and Discussion

### 7.3.1 Results from Step 1

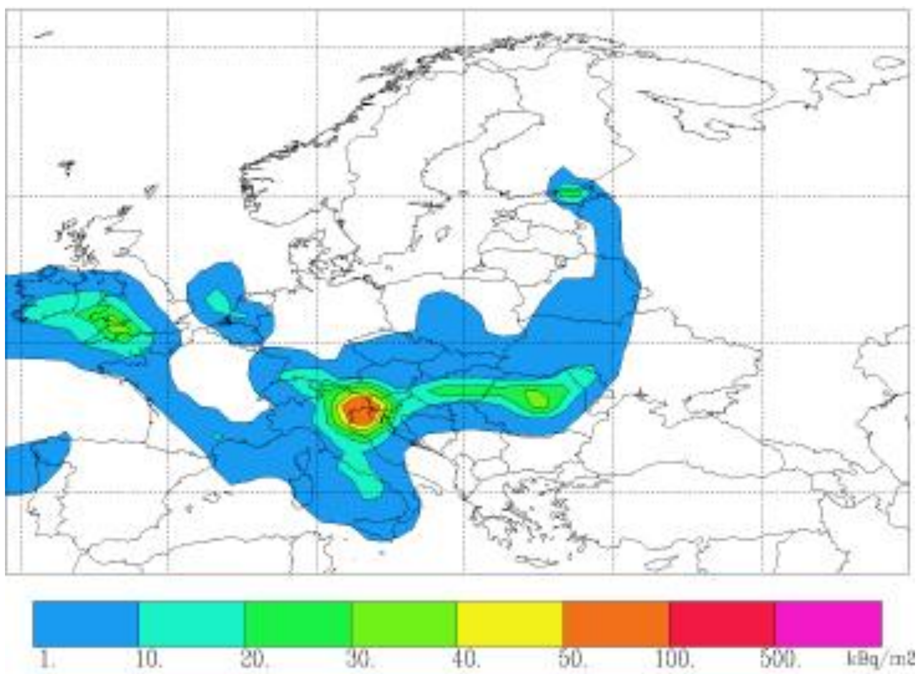


*Figure 3: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP near Loviisa, assuming a release of 25,500 TBq in the hour after 1995-07-28 03:00. Output grid size is 1°.*

For a release from Loviisa on 28 July 1995 around 03 UTC (figure 3), we find a contamination band extending southeastward from the site through Russia, Belarus and Ukraine into Romania. In Romania, the intensity of the deposition increases from below 10 to around 30 kBq/m$^2$, an indication of transport in dry whether first and then coming under precipitation causing wet deposition.

This change in the weather is also marked by the change in the transport direction, first southward with northerly winds, then westward with easterly winds. The contaminated air arrives then over northeastern Italy where intensified precipitation would cause contamination of up to 66 kBq/m$^2$. This contamination area would include southern and western Austria with values between 20 and 50 kBq/m$^2$. Then the contaminated air would be split into various parts, one moving to the UK where it would come again under precipitation and cause contamination of about 30 kBq/m$^2$. This case shows a couple of relevant features:

- It is a very clear example of how precipitation can cause the main contamination area to occur for from the NPP site – in this case, spread over the 1-degree grid cell, near the NPP only less than 30 kBq/m$^2$ would be found.
- It illustrates that transport patterns don't need to be straight (as implied e.g. in the classical Gaussian model).
- Also it shows that even after a rather long and indirect transport, amounts of contamination are possible that would be considered as requiring protection measures for children in the south of Austria.

For the site near Loviisa we found two consecutive hypothetical accident dates in November. The first one is associated with a release on 2 November 1995 at 16 UTC and it would lead to severe contamination around the site, then air being transported over the Baltic Sea and through Germany, finally reaching the border region of Germany, Austria and Switzerland. Austria, in the city of Bregenz, would just receive 10 kBq/m². However, fewer rain before could easily increase this value. The next release time studied, 6 November 1995 at 17:32 UTC, leads to a transport of the contaminated air straight to the south, impacting the Baltic countries and Romania (figure 4). One can imagine that a release at an intermediate time might have hit Austria directly.

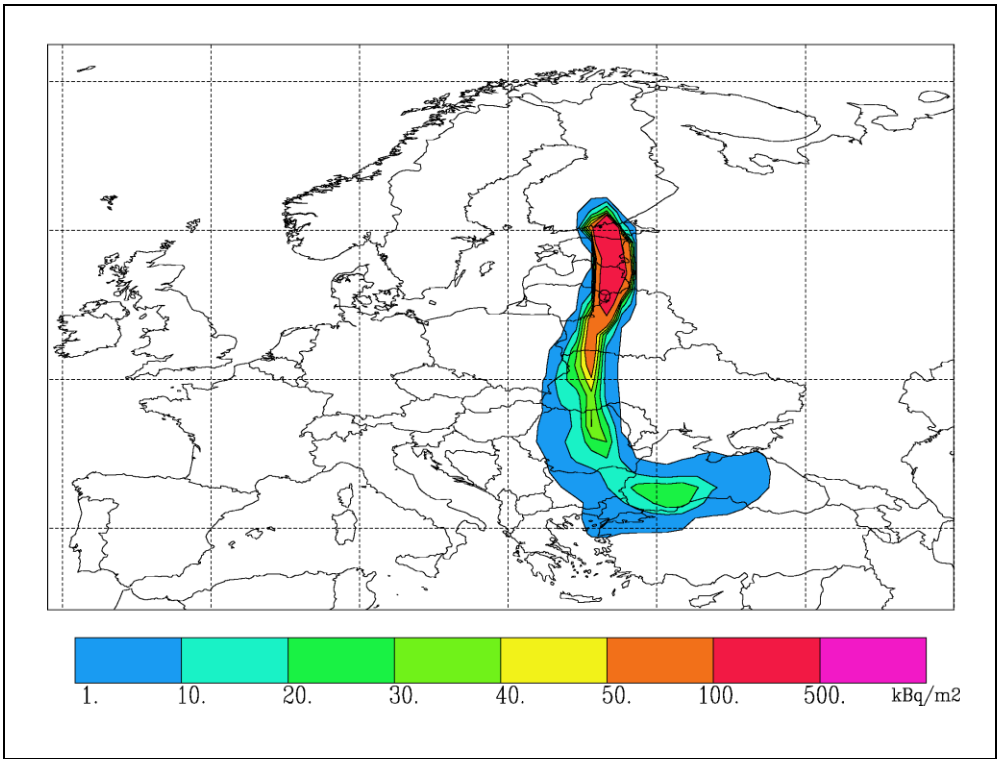


*Figure 4: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP near Loviisa, assuming a release of 25,500 TBq in the hour after 1995-11-06 17:32. Output grid size is 1°.*

### 7.3.2 Results from Step 2

Now we turn to the newly made calculations for the proposed reactor sites. These calculations differ by a lower release height and more weather situations being studied within a time frame of a few days at the end of July.

For Kampuslandet and the same release time already studied with Loviisa, this approach yields very similar results, as expected (figure 5). According to the lower release height, the contamination values are a bit higher.

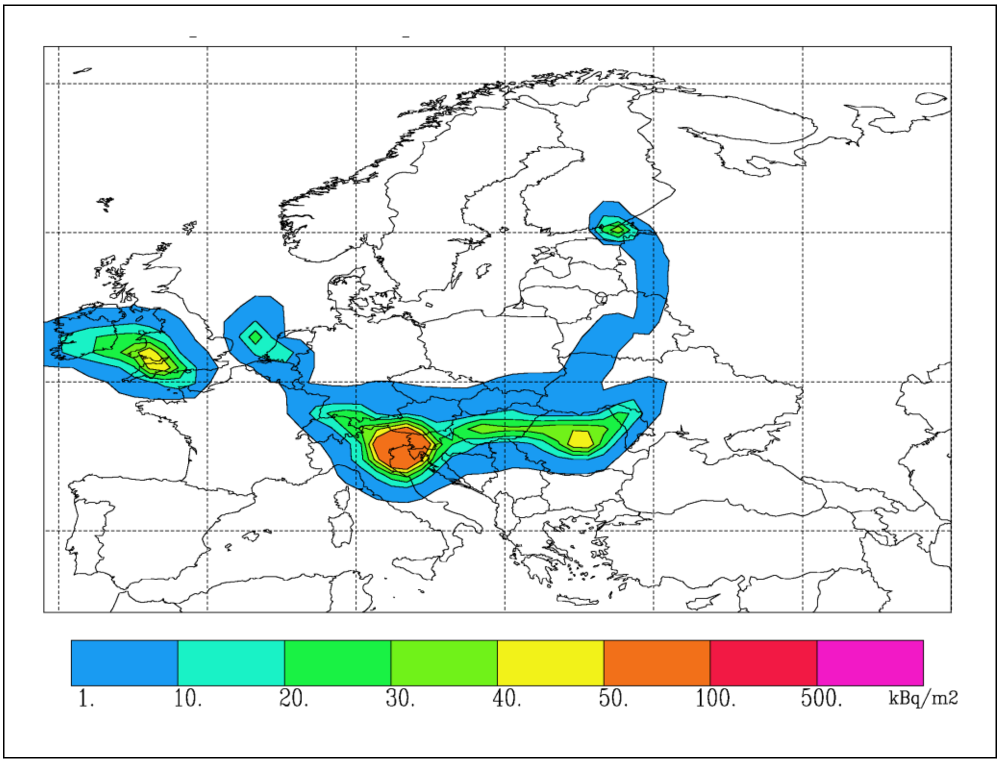


*Figure 5: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP at Kampuslandet (near Loviisa), assuming a release of 25,500 TBq in the hour after 1995-07-28 03:00. Output grid size is 1°.*

If the release at Kampuslandet is assumed 3 hours later (figure 6), the south of Austria would receive above 50 kBq/m$^2$ on a larger area, and almost all of Hungary would be contaminated above 100 kBq/m². With a slightly different weather pattern, such contamination could also hit the eastern part of Austria. Also with releases on 30 July contamination of large parts of Austria is simulated. In the case of a release at 09 UTC, the centre of contamination would be in Czech Republic and touch the north of Austria.

If a deposition of 50 kBq/m$^2$ is exceeded in Austria as it is indicated in figure 6, during spring and summer food bans and restriction in livestock farming would be necessary if such a situation were to become reality. 50 kBq/m$^2$ correspond to an effective dose of 2.5 mSv for the first year, which implies the Austrian warning scale level 2 requiring protection measures for children, expectant and breast-feeding mothers (RAHMENEMPFEHLUNGEN 1992). The new order for intervention in radiological emergencies (INTV 2007) recommends sheltering for risk groups if an effective dose of 1 mSv in seven days could be exceeded. Because the largest part of the dose will be received in the first week after an accident it cannot be excluded that the intervention limit for seven days could also be exceeded.

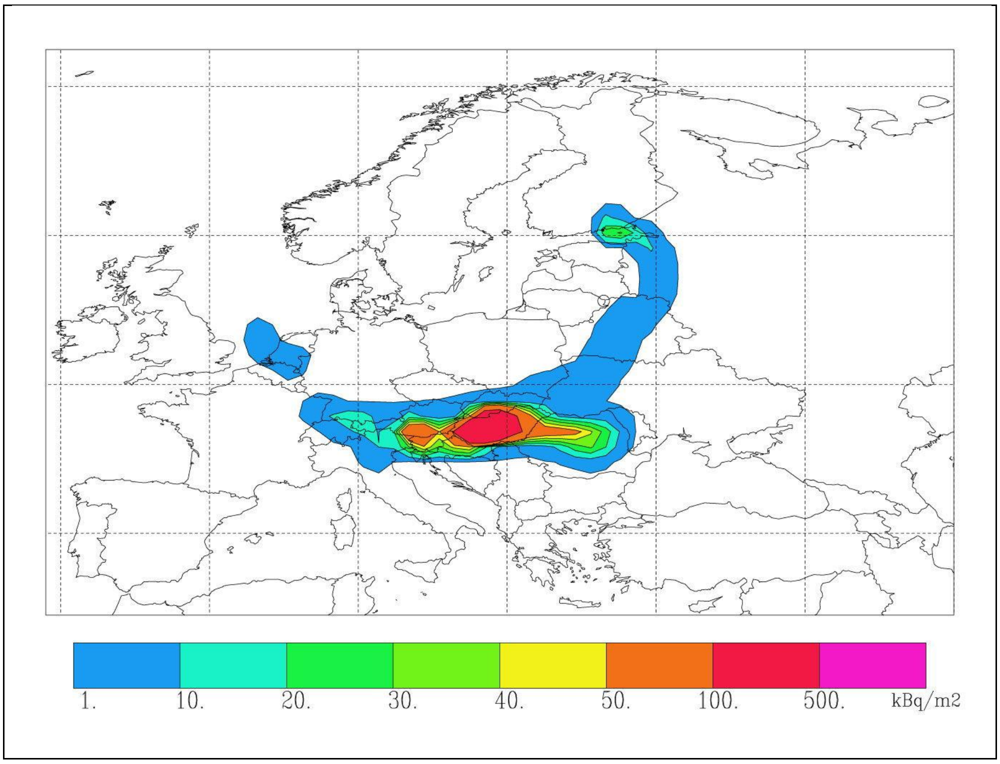


*Figure 6: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP at Kampuslandet (near Loviisa), assuming a release of 25,500 TBq in the hour after 1995-07-28 06:00. Output grid size is 1°.*

At the more northern site of Hanhikivi, a release on 30 July 1995 at 03 UTC was found to have the most negative consequences for Austria (figure 7). The central part of the country would be contaminated with more than 40 $kBq/m^2$ and the whole area to the east of the line Salzburg – Klagenfurt would be contaminated with more than 10 $kBq/m^2$.

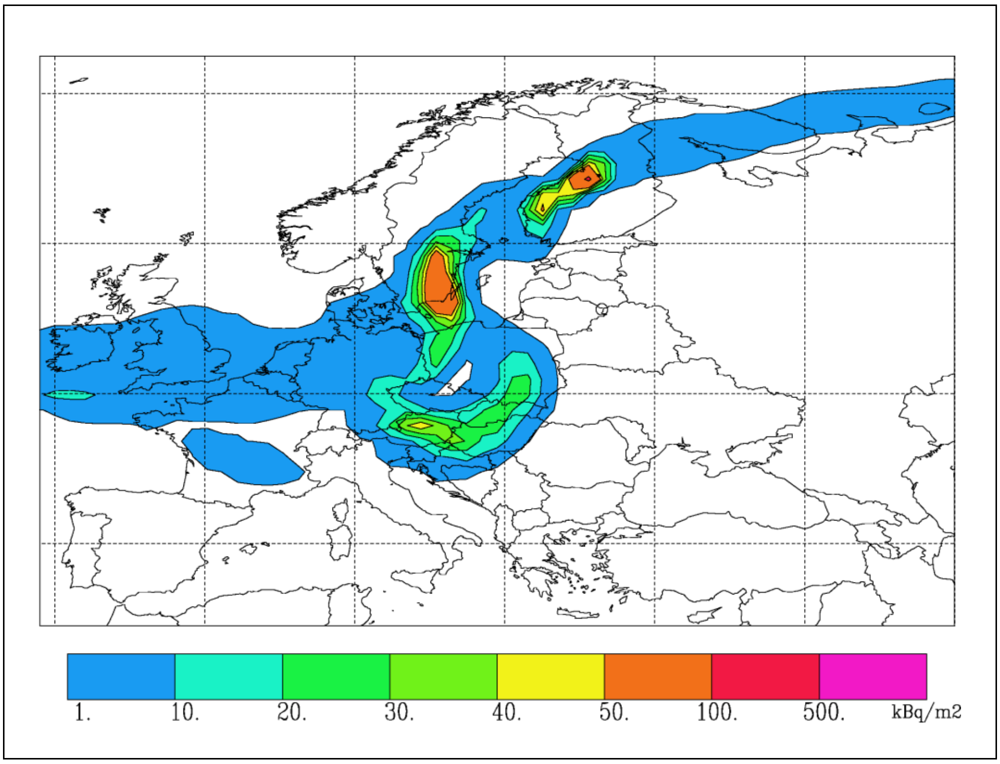


*Figure 7: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP at Hanviki, assuming a release of 25,500 TBq in the hour after 1995-07-30 03:00. Output grid size is 1°.*

Finally, for the northernmost site Karsikkoniemi two dates with similar impact on Austria were found in the investigation period, with releases on the 28th at 21 UTC and on the 29th at 15 UTC, July 1995. Both lead to contamination between 10 and 30 kBq/m² in the eastern part of Austria, the first one more in the south, the second one more in the north (figure 8).

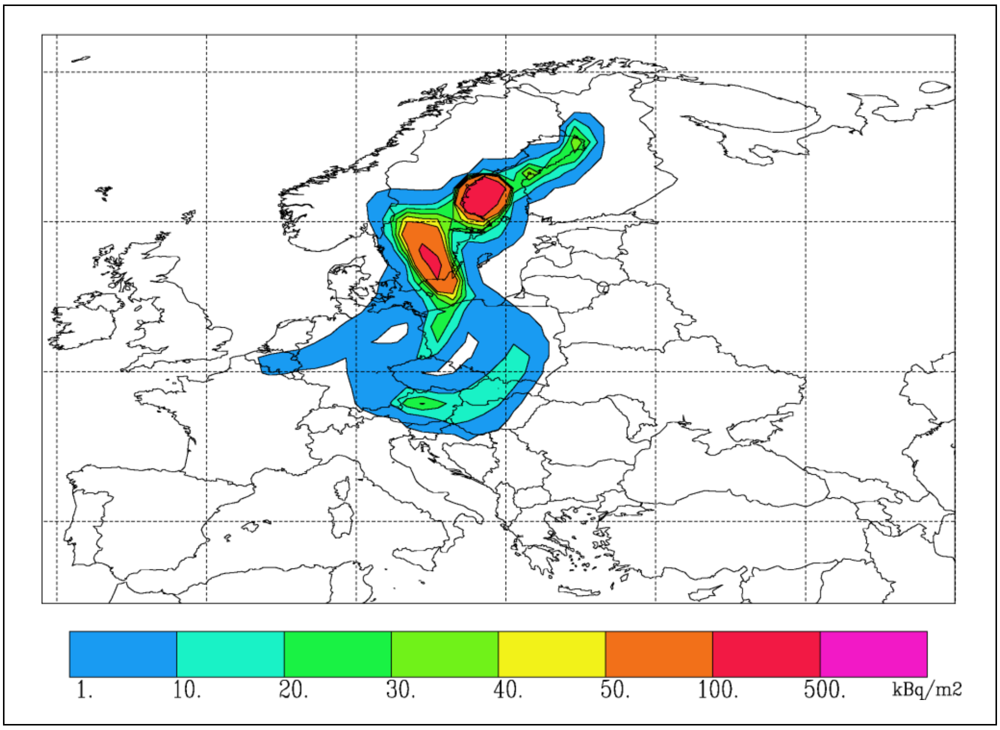


*Figure 8: Example of deposition of Cs-137 over Europe resulting from a hypothetical severe accident in the new NPP at Karsikkoniemi, assuming a release of 25,500 TBq in the hour after 1995-07-29 15:00. Output grid size is 1°.*

Though one must be careful not to rely too much on such case studies, the conclusion seems to be obvious, and is in agreement with the expectations simply based on distance: the more northerly the site of the NPP was, the smaller would be the impact for Austria in a given synoptic situation (leading to impact on Austria from releases in Finland in general), though of course not for any given fixed release time. In the present case, roughly a factor of 2 is found between the two northern sites on one hand and the southern site on the other hand.

We can also revert to results of a previous unpublished study on behalf of the Austrian Ministry of Environment (SEIBERT et al. 2004), which combined a large multi-year trajectory data base with the RISKMAP deposition calculations to infer possible risks for Austria in the form of maps. However, this study was based on a much larger source term. For such a large source term and a moderate severity of the impact on Austria (warning level 2), the corresponding map indicates a similar climatological probability for all the proposed sites which is on the order of a few percent. However, if we would assume the source term to be one order of magnitude less (then it would be about a factor 2 smaller than the source term used above), the probability would drop a little to about 1% for the southern sites while dropping dramatically to 0.1% or less for the northern sites. This means that the difference between the proposed sites, with respect to potential impact on Austria, would strongly depend on the magnitude of the source term considered. For source terms on the order of 1E16 Bq (10,000 TBq) Cs-137, the risk from the northern sites is much smaller than from the southern side, while for a catastrophic source term on the order of 1E17 Bq (100,000 TBq) even the northerly sites can produce impact on Austria at the warning scale level 2 (requiring protection measures for children, expectant and breast-feeding mothers) at a relevant climatological frequency.

The presentation of the results of the Austrian analysis of transboundary impacts of a potential severe accident in a NPP at one of the sites proposed by Fennovoima proves that an impact on central and even southern European regions cannot be excluded. Moreover, the results emphasize the importance of a serious evaluation and discussion of the severe accident scenarios for Generation III reactors in the framework of the transboundary EIA.

# 8 RADIOACTIVE WASTE MANAGEMENT

## 8.1 Management of Operating Waste

### 8.1.1 Treatment in the EIA Report

„Operating waste refers to solid and liquid low- or medium-level waste generated in handling radioactive liquids and gases, and in maintenance and repair work carried out in the controlled area." (FENNOVOIMA 2008, p. 84). Medium-level waste has an activity content between 1 MBq/kg and 10,000 MBq/kg. The waste is characterized on the basis of its chemical, physical and radiological properties, compressed, cut in pieces or solidified. Subsequently, low level waste is packed in steel-containers or boxes, medium-level waste in boxes made of concrete or in cylindrical tanks.

The estimated quantities of operating waste vary according to the chosen reactor type: A boiling water reactor of 1,300 MW produces a total of about 280 $m^3/a$, a pressurized water reactor about 200 $m^3/a$ (FENNOVOIMA 2008, p. 84).

Fennovoima Oy is planning to dispose of their medium and low-level operating waste in underground repositories which are either of the rock cave type (preliminary storage capacity: 29,000 $m^3$) or of the rock silo type (preliminary storage capacity: 43,000 $m^3$). Four separate caves have been foreseen 30–100 meters below ground, depending on the geological properties of the final disposal area (FENNOVOIMA 2008, p. 86). A concrete slab will be the foundation of the disposal – it shall prevent seeping waters from spreading into the environment. The waters generated in the area will be collected in a well and are treated if necessary before being drained into the environment. Wastewater from the storage will be to a liquid waste treatment plant if required (FENNOVOIMA 2008, p. 315). The waste will be transported through a tunnel to the repository, which is sealed after the cave is not used any more. The EIA Report says that the repository will not cause significant environmental impacts.

### 8.1.2 Discussion

Fennovoima's EIA Report does neither specify the exact type of storage which is going to be used (with differences in capacity), nor the site of the planned storage. This is most likely due to the fact that Fennovoima Oy has not decided on the type of NPP they are going to use yet and therefore cannot estimate the total of operating waste that will accumulate.

### 8.1.3 Conclusions

Fennovoima Oy should give details about the site of the storage and its depth. Information about the geological suitability of the considered sites for the storage should be provided as well.

## 8.2 Interim Storage of Spent Nuclear Fuel

### 8.2.1 Treatment in the EIA Report

Fennovoima Oy indicates that the quantity of produced spent fuel will amount to 40–60 tons a year, which entails an estimated total sum of 2,500–3,500 tons during the planned 60 years of operation (FENNOVOIMA 2008, p. 86). The choice of reactor type shall lead to no significant difference concerning final disposal of spent fuel (FENNOVOIMA 2008, p. 88).

The spent fuel will be disposed of in several steps: After the removal of the fuel rods they are moved into a water pool in the reactor hall for cooling and remain there for some years. Subsequently they are transferred to interim storage where they are left for several decades. During the transfer the fuel assemblies are kept in water to protect them from damage and the environment from their radiation (FENNOVOIMA, p. 315). After interim storage about one-thousandth of the radioactivity immediately after the removal will remain. There are two possibilities of interim storage: storing in an -water pool or dry storage away from the reactor. Dry storage would be located outdoors or in a dedicated storage building; wet storage – for example – in a building made of steel-reinforced concrete. Active waste-water would be treated in the plant's wastewater treatment plant and exhaust air would be lead to the power plant's ventilation exhaust shaft and monitored. Fennovoima declares in its EIA-report that interim storage would not cause significant environmental impacts and would not differ between the alternative location municipalities (FENNOVOIMA 2008, p. 316).

### 8.2.2 Discussion

The EIA-report of Fennovoima specifies neither which alternative of interim storage the company intends to use nor the planned duration of the storage – it merely says that the interim storage is going to be situated in the plant area (FENNOVOIMA 2008, p. 89).

The choice of interim storage is essential for assessing national and international aspects of security.

The IAEA reports that concerns have been expressed on the wet type storage facilities (IAEA 2007, p. 38). Among other things the enhanced vulnerability of wet storage facilities to terrorist attacks has been criticized: An attack that „partially or completely drained a spent fuel pool could lead to a propagating zirconium cladding fire and the release of large quantities of radioactive materials to the environment“ (US NATIONAL RESEARCH COUNCIL 2005).

Loss of coolant and a subsequent fire can also occur accidentally either due to earthquakes of very large magnitude or the drop of spent fuel casks – although the probability of this kind of accident is considered to be very low (NRC 2001, p. 3-16; p. 3-36).

In addition the source term in case of a severe accident is higher for wet storage – as it stores a „large inventory of radioactivity under a relatively vulnerable shielding“ (IAEA 2005, p. 12).

As the burnup is not specified, its influence on the source-term can't be evaluated.

### 8.2.3 Conclusions

For a demonstration of proper waste management it is essential that Fennovoima Oy declares its planned type of interim storage as well as the planned construction site, its capacity and the schedule of the construction works. The intended duration of interim storage should also be clarified.

## 8.3 Final disposal of spent nuclear fuel

### 8.3.1 Treatment in the EIA Report

After interim storage the spent fuel is moved to final storage. The company Posiva Oy is currently developing solutions for geological final disposal of spent fuel. These solutions follow the KBS-3 concept: The spent fuel is airtight encapsulated in a five cm layer of copper reinforced with iron and surrounded with bentonite clay to protect it against corrosion and possible strains of bedrock. The bentonite clay expands by absorbing large quantities of water and acts as a buffer that prevents radioactive substances from escaping. The capsules are buried in tunnels in a depth of about 500 m – the bedrock has to be geologically stable and free of large cracks. Bedrock and groundwater models are used to choose the repository area, therefore test drillings are necessary.

Fennovoima's EIA-Report states, that it is most likely, that there will not be any release of radioactive substances for millions of years. It is declared that even if spent fuel was released from the disposal capsules, the substances would mainly remain in the bentonite barrier and the caused radiation dose at the surface would be at the level of current natural background radiation (FENNOVOIMA 2008, p. 317).

According to the Nuclear Energy Act Fennovoima Oy is responsible for the cost of maintenance and management of the nuclear waste until the final disposal is sealed – in addition the producer has to pay a preparation charge to the nuclear waste fund administered by the Ministry of Employment and the Economy.

### 8.3.2 Discussion

Geological final deposal is considered the safest long-term method of storing high level radioactive waste and spent fuel at present (COMMISSION OF THE EUROPEAN COMMUNITIES 2002). But no country worldwide is yet operating such a geological repository.

Posiva has already carried out feasibility investigations for geological final deposition – the site for the NPP Loviisa and Olkiluoto is going to be situated in Olkiluoto – but waste disposal will not take place there before 2020 (FENNOVOIMA 2008, p. 90). From 1997 to 1999 the first EIA procedure for the final disposal was carried out for 9,000 tons of spent fuel (equals spent fuel from six NPPs) (POSIVA n.y.)

Fennovoima Oy's EIA-report does not explicitly name Posiva as responsible company for the final disposal of the NPP's spent fuel. It is not clarified either whether Fennovoima Oy intends to use Posiva's planned final disposal unit in Olkiluoto for their spent fuel and which storage-capacity will be needed for the spent fuel.

Posiva has submitted an EIA Report about the expansion of the repository's capacity by 3,000 tons on the 31st Oct. 2008. The repository would have space for 12,000 tons if the EIA was accorded and could then additionally contain the spent fuel of the NPP Loviisa-3 (POSIVA 2008). An additional need of capacity for the spent fuel of Fennovoima was not mentioned in this EIA.

### 8.3.3 Conclusion

Radioactive waste management is presented in the EIA report in a very general manner. Different technological options for interim storage, final disposal of spent fuel and high and intermediate level radioactive waste are described but without concrete decisions on technology and location of the facilities. It appears that Fenovoyma has not yet developed a comprehensive nuclear waste management strategy.

Fennovoima Oy should clarify whether they intend to store their spent fuel in Olkiluoto like the other NPPs of Finland. The needed capacity has to be stated along with a feasibility study of the possible expansion.

In case it is intended to construct a separate storage facility, a schedule of the completion as well as information on the site should be provided in order to be able to estimate the required duration of interim storage and the subsequent security aspects, and to assess whether the planned site fulfils the geological requirements.

# 9 OPEN QUESTIONS

**Chapter 4: Description of the Project and Procedure**

1. How can an exchange of information between the competent authorities of Austria and Finland be established covering the results of feasibility studies?
2. The new Finnish Climate and Energy Strategy aims at reducing electricity consumption in Finland – how will the new objectives be considered during the EIA procedure and the Decision-in-Principle?
3. Which criteria will be decisive for the site selection?

**Chapter 5: Reactor Types**

1. Which priority will be given to safety aspects, compared to other aspects, for the selection of the reactor type? Is it sufficient that a reactor type fulfils the safety requirements; or will there be an attempt to optimize safety (i.e. to select, if possible, among reactor types fulfilling the regulatory requirements, the type with the most advantageous safety characteristics)?
2. Is it possible to present an overview on significant differences between the reactor types under consideration in order to evaluate possible implications for the selection of a reactor type, with the focus on the large release risk due to a severe accident? For example, significantly different experiences with reactor types, basically different safety approaches as well as significant differences in PSA results should be regarded as indicators for this discussion and evaluation.
3. Which documents will be available for foreign states participating in the cross-border EIA during the selection procedure of the reactor type and how will they be informed about decisions?

**Chapter 6: Accident Analysis**

1. Why has no realistic worst-case source term been assumed for the transboundary impact assessment? (Severe accidents with releases considerably higher than 100 TBq of Cs-137 cannot be excluded for the reactor types under consideration.)
2. The Cs-137 deposition at the distance of 1,000 km is, according to Table 8-51, 0.28 $kBq/m^2$. But there are no values presented for the unfavourable weather conditions at distances beyond 50 km. What are the consequences (in terms of deposition and doses) under so-called unfavourable weather conditions at 1,000 km? What are the consequences at 1,500 km?
3. How are unfavourable conditions defined (wind speed, dispersion category or categories, mixing height)?
4. Why does the impact assessment not use the Finnish SILAM model and realistic weather data for the assessment of long range transport of radioactive substances?

**Chapter 8: Radioactive Waste Management**

1. Has Fennovoima asked for an agreement for disposal of spent fuel in the deep geological repository at Olkiluoto?
2. Is a further enlargement of the capacity of the deep geological repository at Olkiluoto feasible?
3. Has Fennovoima elaborated plans for another final storage as an alternative?

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# 11 GLOSSARY

ABWR ................ Advanced Boiling Water Reactor

a ......................... Year

AP ...................... Advanced Passive

APWR ................ Advanced Pressurized Water Reactor

BDBA ................. Beyond Design Base Accident

BWR................... Boiling Water Reactor

CD...................... Core Damage

CDF.................... Core Damage Frequency

Cs....................... Caesium

DBA.................... Design Base Accident

EC ...................... European Commission

EIA ..................... Environmental Impact Assessment

EPR.................... European Power Reactor

EU ...................... European Union

EUR.................... European Utilities Requirements

Fortum................ Fortum Heat and Power Oy

GE...................... General Electric

I .......................... Iodine

IAEA................... International Atomic Energy Agency

LILW................... Low and Intermediate Level Waste

LO-3 .................. Loviisa Unit 3

LOCA ................. Loss of Coolant Accident

LRF .................... Large Release Frequency

LWR ................... Light Water Reactor

MEE ................... Ministry of Employment and the Economy (former MTI)

mSv.................... Milli-Sievert

MTI..................... Ministry of Trade and Industry, since Dec 2007: Ministry of Employment and the Economy (MEE)

MW..................... Megawatt

MWe................... Megawatt electric

NGO................... Non Governmental Organisation

NPP.................... Nuclear Power Plant

NRC ................... Nuclear Regulatory Commission (USA)

OL-4 ................... Olkiluoto Unit 4

PSA.................... Probabilistic Safety Assessment

PWR................... Pressurized Water Reactor

r.a....................... Reactor year

RPV.................... Reactor Pressure Vessel

STUK ................. Finnish Radiation and Nuclear Safety Authority

Sv....................... Sievert

SWR................... Siedewasserreaktor, Boiling Water Reactor

t/a ....................... Tonnes per year

TBq .................... Tera Becquerel

TVO.................... Teollisuuden Voima Oy

TWh ................... Tera-Watthours, 1,012 Wh

WNA................... World Nuclear Association

YVL .................... Regulatory Guides on Nuclear Safety

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Within the framework of the cross-border Environmental Impact Assessment (EIA) concerning the construction of new nuclear power plants in Finland, an Expert Statement was elaborated on behalf of the Umweltbundesamt.

The Expert Statement stresses the relevance of the proposed project for Austria. Based on data provided by the EIA documentation and publicly accessible information regarding the proposed types of nuclear reactors, dispersal models were used to verify if Austria might be affected. Significant impacts cannot be excluded on the basis of the current know-how about Generation III reactors.

The Expert Statement concludes with recommendations and open questions related to the quantity and quality of the EIA documentation, which should be respected by the responsible authorities of Finland.

Documents for download:
http://www.umweltbundesamt.at/uvpkkwfennovoima

ISBN 3-85457-994-2