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Construction of NPP Cernavoda Unit 3 & 4 Environmental Impact Assessment

Experts Statement

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ÖKOLOGIE INSTITUT

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CONSTRUCTION OF NPP CERNAVODA UNIT 3 & 4

Environmental Impact Assessment

Experts Statement

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TABLE OF CONTENTS

PART 1

INTRODUCTION

CANDU reactors are not common in Europe. The two Cernavoda units are the first of this type working in Europe. Experience with these reactors in Europe is thus limited.

NPP Cernavoda (NPPC) is located at 160 km east of Bucharest and is situated in Constanta county, at about 2 km south-east of the Cernavoda town boundary, and at about 1.5 km north-east from the first lock on the Danube-Black Sea Channel. The plant was designed to comprise five CANDU 700 MWe units. NPPC Unit 1 started operation in 1996, Unit 2 in 2007. In the process of construction of NPPC 2 an Environmental Impact Assessment (EIA) was carried out in Romania, which was followed by Romanian and also by Canadian and European NGOs. After this EIA was finished, Romania announced at first that it would like to complete the third of the 5 NPP units. Within the related announcement of the EIA, Austria stated its interest to follow this development. Meanwhile, Romania has extended its construction plan to include NPPC Unit 4, and invited Austria in 2007 to participate in the EIA and ESPOO procedure for the construction of NPP Cernavoda Unit 3 and 4.

Cernavoda NPP Units 3 and 4 will each have 720 MW gross electrical capacity. Each unit consists of a CANDU-6 Pressurized Heavy Water Reactor (PHWR). The construction period is estimated to be 64 months, commissioning is scheduled for 2013 and 2014 respectively. The design life for the nuclear units is 30 years.

The Austrian Institute of Ecology was commissioned to elaborate an Experts Statement to the EIA report.

Structure of the Experts Statement

Part I includes this **Introduction** and the section **Summary & Conclusion** (both in English and German language). These give an overview of the project and the results of the assessment of the EIA report.

Part II contains a more detailed discussion of the issues presented in the EIA report with a clear focus on problems relevant beyond the vicinity of the NPP. Part II is structured as follows:

- Discussion of alternatives
- Technical issues (design and safety of the reactor type chosen)
- Emissions and dose assessment (where mainly emissions to air are considered, since emission into the water bodies will not have significant impacts on Austria)
- Environmental radioactivity monitoring
- Radioactive waste and decommissioning
- Accident analysis
- Emergency planning
- Austrian analysis of severe accident impacts

In general, the Experts Statement contains the following items for each topic of the EIA:

- Treatment of the issue in the EIA report
- Discussion of the problem
- Conclusion

The focus of the Experts Statement is on requirements for Environmental Impact Assessment Procedures according to the European Commission's EIA directive and the Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO convention), respectively.

Concerning the review of the safety of the Cernavoda NPP guidelines of the IAEA, national regulations of EU member states, but also Canadian Regulations and the European Utilities Requirements were used as reference. A particular focus was put on potential transboundary impacts of accidents in NPP Cernavoda.

Transboundary impacts are the subject of the ESPOO convention. Based on a review of international treaties, conventions, EU law and bilateral treaties, the following items should be considered in the ESPOO-Procedure [LERCHER 2005]:

- the precautionary principle should play a dominant role when interpreting the term of "likelihood of having significant transboundary effects"
- the specific nature of the risk of operating a nuclear power plant: relatively low probability of occurrence on the one hand, but potentially disastrous consequences on the other hand
- severe accidents (beyond design basis accidents) have to be taken into consideration by determining the likelihood of having significant transboundary effects

According to the ESPOO-Convention and the EC EIA-Directive the EIA report has also to deal with the potential impact of severe accidents. A detailed analysis of design basis and beyond design basis accidents and their potential effects should form an essential part of the EIA report, too.

However, the EIA report states that emissions with significant transboundary effects are not going to happen. As long as normal operation and airborne emissions are considered, we agree with this conclusion of the EIA report. But since the EIA report does not cover sufficiently the impact of severe accidents, we present in this Experts Statement our own assessment of transboundary impacts of a severe accident in NPP Cernavoda, based on a severe accident scenario in a CANDU 6 plant from literature. With this source term and using a Lagrangian particle dispersion model, the subcontractor Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Vienna (Dr. Petra Seibert) calculated the potential transboundary impact. The results of this calculation show that regions beyond the vicinity of the plant and different parts of Europe could be significantly affected.

The Experts Statement to the Romanian EIA report refers to the documents Austria has received from Romania concerning the construction of NPP Cernavoda Unit 3 and 4 as follows:

- Environmental Impact Assessment Report for NPP Cernavoda Unit 3 and 4, quoted as EIA report [ICIM 2007, chapter-page]
- Technical Report for NPP Cernavoda Unit 3 and 4, quoted as [CITON 2006]

The translation of the EIA report into English may have caused some misunderstanding, a prompt clarification of the relevant issues would be appreciated.

The authors want to thank Dr. Helmut Hirsch for supporting their work with his knowledge and his valuable hints for improving the evaluation.

SUMMARY & CONCLUSION

The Cernavoda Nuclear Power Plant (NPP) was originally planned to comprise five CANDU reactors. Two units are already in operation, the first one since 1996, and the second one since August 2007. The construction of the next two units is the subject of this EIA procedure. The two CANDU units operating in Romania are the only reactors of this type in Europe. CANDU stands for Canadian Deuterium Uranium. These reactors have features and properties that are very different from the pressurized water reactors mostly used in Europe. The buildings for the five reactors have already been constructed (construction started for uUnit 1 in 1982, for Unit 2 in 1983). The EIA report provides no information on the conditions of these buildings after the long construction break, and whether or how the buildings have been mothballed during this period.

Discussion of alternatives

The “Analysis of Alternatives” is relevant for Austria too, with respect to the additional risk in the form of two more NPPs.

The EIA report presents the **Romanian energy strategy**, divided into:

- the “common part” with focus on existing capacities and capacities to be installed in accordance to the Romanian energy road map, and
- the “elements for scenarios differentiation” with focus on the usage of gas, coal and uranium as fuel

The **usage of renewables** for electric power generation is not considered as a separate scenario.

The EIA report gives the impression, that the “uranium scenario” is mainly Romania's contribution to the world's need of climate protection. The EIA report presents a lot of disadvantages concerning the ecologically damaging usage of coal as fuel. This is misleading, since - by carefully studying the three scenarios - one will realize that the usage of nuclear power does not change the country's future coal consumption at all. Nuclear energy shall only replace gas for electricity generation.

The **MCA (multi-criteria analysis**) is not state of the art due to the fact that some criteria are chosen quite arbitrarily while other important facts are not considered. For example, the total updated costs (CTA) criterion, as presented in the MCA, does neither explicitly consider increasing costs for planned safety improvements nor costs of nuclear waste interim storage and final disposal, nor decommissioning costs. Only under these unjustified assumptions, nuclear power can easily compete with coal power as a stand-alone alternative to the scenario based on fossil fuels.

In general we want to emphasize the fact that the „analysis of alternatives“ mainly deals with the impact of one additional unit (Unit 3) instead of the targeted two units (Unit 3 + Unit 4). Unit 2 is not considered at all. With respect to the planned **synchronous operation of all four units,** all scenario calculations would have to consider the operation of four units at the same time. In particular, the assessment of environmental and health impacts has to consider the emissions and waste generated by all four units together.

Conclusion

The zero option (non action alternative) is not considered in the EIA report. In this respect, the EIA report does not meet the requirement of the European Commission's EIA directive.

A comparison to a fourth alternative scenario, namely the maximum usage of renewables combined with the maximum increase of energy efficiency, should be implemented.

The decisive argument for the usage of uranium seems to be a financial argument, namely the expected increasing costs of gas. In the scenarios considered for comparsion, the nuclear power plant does not replace any coal-fired power plant, while it is assumed to replace a gas-fired power plant.

In the comparison of alternatives, waste from nuclear power, its toxicity and lifetime, and the impact of emissions should be considered in the same way as it has been done for the other options.

The multi-criteria analysis should consider a set of criteria “as-complete-as-possible”, not only arbitrarily chosen criteria. Therefore, all statements based on the MCA should be handled with care. The MCA, as presented in the document, is not appropriate to assess the need of the additional Cernavoda NPP units.

More details see [Part II chapter 1].

Technical issues

Reactor core

CANDU fuel is natural uranium (i.e., not enriched), the core consists of many pressure tubes instead of being confined in a pressure vessel. Heavy water is used as the coolant and moderator. The main advantage of this reactor is that fuel can be changed without shutting down the reactor. The main disadvantage is that the reactor has a **positive void coefficient** and therefore a power excursion (sudden rise of power) in case of abnormal operation (loss of coolant) cannot be excluded. Control of the reactor power requires sophisticated safety systems as well as a very complex instrumentation and control system. A loss of coolant accident with shutdown failure in a CANDU reactor could result in a rapid melting of the fuel. Because of the large size of the core, the CANDU reactor is vulnerable to **loss of regulation** incidents. The large amount of zirconium in the core (cladding and fixations of pins in the fuel bundle) provides a large steam reaction potential. The pressure-bearing components of the CANDU reactor are the pressure tubes. **Material degradation** of the pressure tubes is a persisting problem of existing CANDU plants.

Conclusion

CANDU safety systems use more active components than other reactors.

Among the components of the Emergency Core Cooling System (ECCS), only the high-pressure part is a genuinely passive system. Medium- and low-pressure emergency core cooling are both working with pumps. The EIA report does not sufficiently explain to which extent ECCS and other safety-relevant systems are controlled by active devices.

The capability of the moderator circuit to remove the residual heat in case of failure of the primary heat transfer system is also not described sufficiently.

Plant upgrades and modifications for Unit 3 and 4 compared to Unit 2 are not described in detail in the EIA report. However, in the EIA report it is stated that "*feasible improvements applied to similar NPP units as Wolsong 3 and 4"* will be included in NPPC 3 & 4 design. From the EIA report, it is not clear whether this concerns safety-relevant upgrades such as the properties of the material for the pressure tubes. the new (advanced) CANDU-6 design is praised to have thicker pressure tubes and thicker and larger calandria tubes, stainless steel feeders and headers. Will NPP Cernavoda Units-3 and 4 achieve a safety standard comparable to these new designs?

Other modifications (e.g. concerning main steam valves) are listed, but also without details.

According to the EIA report, some more modifications could be required, but these are not planned yet and therefore are not specified.

Additional information is required for an evaluation of the intended improvements.

More details see [Part II chapter 2.2.].

Containment

The CANDU 6 reactor has a **stand-alone containment** consisting of a concrete dome. On the upper part of the dome a tank mounted, containing the water inventory required for the dousing and emergency core cooling systems to be used in the case of accidents. The CANDU containment is not a passive system, as it is in most PWRs. **Ventilation dampers and dousing system** need power and instrument air.

The EIA report lacks a description of **containment behaviour** in the case of beyond-design-basis accidents (BDBA). The large zirconium inventory of the CANDU core reacts exothermically with steam at temperatures which could be reached in a severe accident. This reaction yields hydrogen. Hydrogen gas is a threat for the containment stability, because it reacts explosively with air in the containment. Mitigation by **hydrogen recombining** is not mentioned in the EIA report.

The **service building** with the main control room, heavy water purification system, ECCS low pressure heat exchangers and pumps, ventilation system, and spent fuel storage bay is located adjacent to the reactor building.

The fact that the **spent fuel pool** ("bay") is outside of the reactor building, and thus the fuelling machine has to penetrate the containment, is an indication for the challenge of containment isolation in CANDU reactors. The capacity of the spent fuel pool is sufficient for only 6 years of operation.

Reactor building and service building are **seismically qualified** corresponding to the design basis earthquake. However, external threats such as natural disasters, air plane crash and other human impacts like terrorism and sabotage are not considered in the design, because their frequency of occurrence is assumed to be very small.

Conclusion

The following important issues of containment reliability are not dealt with sufficiently in the EIA report:

- complexity of the containment systems
- strategy of enhanced diversity of systems and equipment instead of passive safety
- containment behaviour under severe accident conditions

The planned evaluation of the existing structures would be of high interest as a basis for comparing the Cernavoda containment with new NPPs in Europe. With a planned lifetime of 30 years, Cernavoda units will probably not meet current requirements as [CNSC 2005] and [EUR 2001]. This is of particular relevance because plant lifetime extension is envisaged, too.

More details see [Part II chapter 2.3].

Seismic hazard

Romania is one of the most active earthquake regions in Europe besides Italy. Earthquake risk is a much-discussed problem of the Romanian NPP.

This concerns **seismic qualification** which is of importance for the safety systems and safety related systems as well as the buildings, the reactor core design, fuelling machine and the storage pool for spent fuel. According to the EIA report, the relevant systems and buildings are designed to withstand the design basis earthquake (DBE). Clarification is needed concerning the interim fuel storage and the storage for low and intermediate level radioactive waste.

The design basis earthquake is assumed to have an intensity of 8 on the MSK–64 scale and a peak ground acceleration of 0.2 g. The return period according to the EIA report is 1 in 1000 years.

Conclusion

The **1000 years return period** chosen as design basis is comparatively brief. Nuclear regulatory authorities in Germany and France stipulate that a return period of 10,000 years is assumed as design basis. Thus, the Romanian design does not comply with good international practice. This would require to assume for the design basis of the safe shutdown earthquake (DBE) a return period of at least 10,000 years, the same as is used concerning floods.

Safety margins of the seismic design are still an important open question.

Moreover, it has to be considered that all four reactor buildings at the Cernavoda site are co-located in a small area and rely on several common systems located in common buildings. In the same area, all the spent fuel is collected in the fuel bays and there is also the interim storage. Thus, an earthquake for which the plant is not designed could lead to a large disaster.

More details see [Part II chapter 2.4].

General remarks

Maps and sections of the buildings are missing in the EIA report. Therefore the evaluation of potential impacts of external events, influence of one plant to another and effects of **common mode failures** at the site are not possible.

The EIA report provides no information about the conditions of the buildings after the long construction break, and whether or how the buildings have been mothballed during this period. At the time of grid connection of the units 3 and 4, the design of the **civil structures** will be more than 20 years old.

Emissions and dose assessment

The EIA report denies any potential for transboundary impacts of emissions. In principle, no impact is expected on Austria during normal operation. Nevertheless, the description of the emissions and the methodology of dose assessment is still relevant for the understanding of the potential impacts of design base and severe accidents and their presentation in the EIA report.

Regarding **climate and meteorological data,** the EIA report does not deal with possible future changes of the local conditions as a consequence of global climate change. There is neither a discussion of the influence of climate change on the NPP and its operation (e.g. with respect to extreme conditions, cooling, etc.) nor on pollutant diffusion and transport conditions for liquid and airborne emissions.

The EIA report presents data on **gaseous emissions** activity. The data set is incomplete, as for some years, the I-131 emission data are missing and values for particulates are not presented at all. Due to the fact that Unit 1 shall represent the three other units, measured data of emissions from Unit 1 are of major interest. A reliable monitoring system is an indispensable equipment. All missing data should be presented, if not available, an explanation why these data are missing should be given.

The EIA report compares pre-operational values of tritium concentrations in air with values during operation of NPPC-1, both at the location “Campus” Cernavoda. We want to emphasise the observed strong increase of concentrations of **tritium in air** at this location near the Cernavoda town. After start-up of Cernavoda Unit 1, the concentration increased by a factor of 50! The document also shows, again after start-up of Cernavoda Unit 1, tritium concentration in precipitation samples from Cernavoda which are higher by a factor of 10 than at other sites.

The description of the methodology for calculation of **Derived Emission Limits (DEL)** is insufficient. The expressions used to obtain the DEL values and the data entering the calculation should be given. A description of the computer program and its operation mode is missing.

The EIA report emphasizes that all the activity concentrations measured from unit 1 are within the legal limit of 5%-DEL. This statement is misleading. Basically, the fact that a single measured activity value is below the legal limit does not indicate a proper functioning of the NPP. Only the criterion for dose limitation which considers the impact of all radioactive emissions is a decisive argument for proper functionality of the plant. It is not clear whether the discussion of limits takes into account that even when all four units are under operation, dose have to remain below the limit of 1 mSv per year for the population.

Conclusion

The **methodology** for deriving radiation doses from emissions and the determination of so-called derived emission levels is not sufficiently explained in the EIA report. In this respect, the EIA does not meet the requirements of the European Commission's EIA directive and of the ESPOO Convention. It is impossible to understand how the exposure in case of DBA and BDBA was calculated from the presentation in the EIA report.

An appropriate monitoring by the Gaseous Emission Monitoring (GEM) system cannot be assessed. It has to be clarified whether each unit has a separate GEM system or all four units are monitored by one GEM system. It has to be clarified also which kind of DEL is used within the GEM system during synchronous operation of all four units: the “normal” DEL, a quarter of the DEL, or the legal limit of 5% of the "normal" DEL.

More details see [Part II chapter 3].

Environmental radioactivity monitoring

S.N. Nuclearelectrica is responsible to install and operate a monitoring program. This program is presented in the EIA report. For several media (filters, water, soil, sediment, food, milk) the type of analysis, the “minimum required detectable specific activity” and the frequencies of sampling and analysis are listed. Concerning the sampling points for the different media, only the numbers are given.

The EIA report does not contain maps of the sampling points. Also there are no descriptions of the analysis methods and of the dose assessment methods. It is not clear whether and how the population is regularly informed about the results of the monitoring program.

Conclusion

The environmental monitoring program seems not be sufficient to detect all contaminations. The quarterly analysis frequency of iodine in air seems to be too low compared to an analyzing frequency of 14 days around German NPPs [BMU 2006].

Drinking water is not measured at all.

The tritium detection limit in water (350 Bq/l) is too high compared to the technical possible detection limit of 10 Bq/l [BMU 2006] and – if drinking water is taken from underground water - to the EU limit of 100 Bq/l [EC/98/83].

The annual analysis frequency of food samples is too low compared to European recommendations of monthly respectively quarterly measurements [EURATOM 2000/473]. Also the sampling should take place in accordance to harvest times [BMU 2006].

For air continuously dose rate measurement all over the country is recommended [EURATOM 2000/473]. On 23 locations outside Cernavoda dose rates are measured, a map is missing. Because an accident could contaminate the whole country (see chapter 8) a dose rate system should be established all over Romania as it is the case f.e. in Austria [UBA 2007] and in Germany [BMU 2006].

Data about the location of the sampling points and the detailed analysis methods should be added.

The population should be informed regularly about the monitoring programs and results. More details see [Part II chapter 4].

Radioactive waste and decommissioning

In this chapter of the EIA report no comprehensive information is presented on the existing radioactive waste treatment and storage facilities on site. It is stated that existing storage facilities for LILW (low and intermediate radioactive waste) and for spent fuel will be extended in order to handle radioactive waste and spent fuel from units 3 and 4. It is also stated that a national final disposal facility for LILW and a final repository for HLW (high level radioactive waste) are planned.

But all this information is given without any details concerning capacity, design, siting or licensing procedure. Spent fuel storage and transport containers are mentioned in the EIA report but also without any details concerning their qualification and design.

Conclusion

Romania should present a thorough strategy for safe management of spent nuclear fuel and radioactive waste management before starting the construction of the new nuclear reactor units at Cernavoda.

Because of the lack of essential information concerning treatment and interim storage of radioactive waste and its impact on the environment as well as the measures for a safe treatment and long-term storage of the radioactive waste the EIA report is not in accordance to the ESPOO-Convention and the EIA Directive of the EU [EC 85/337, Annex IV 4. and 5.].

A sound spent fuel and radioactive waste management strategy also includes adequate financing of all activities and storages. Because the **fund** for financing the radioactive waste management and decommissioning is not yet established, financing is not guaranteed.

More details see [Part II chapter 5].

Accident analysis

The **accident analysis** of Cernavoda NPP is based on a system of occurrence frequencies of accident sequences and related dose limits. Accidents with a probability of occurrence less than 1E-6/a are not dealt with in the EIA report at all.

Since Romania is a member state of the European Union, the practice of AECB to disregard radiological consequences of accidents if their estimated probability of occurrence is less than 1E-6/a is not relevant for other EU member states. Romania should adapt its licensing practice to that of other member states of the EU and include severe damage frequency and analyse the potential impact of severe accidents.

In the EIA report, estimated doses for DBAs and BDBAs according to the Preliminary Safety Report of Cernavoda Unit 2 are presented. For comparison: The German radiation protection regulation allows a maximum effective dose of 50 mSv for the DBA with the worst consequences in the vicinity of the plant. According to the EIA report some of the presented DBAs would exceed this limit by far.

The conclusion of the EIA report that *"... it is clear that both DBAs and BDBAs for Cernavoda NPP have non-significant radiological consequences for the public located outside the exclusion boundary (1 km from the reactor)* [ICIM 2007, 7-25] is obviously wrong because among the presented DBAs there is an accident sequence which is said to lead to an effective dose of 151 mSv, and among the BDBAs a sequence which is said to lead to 171 mSv effective dose is found. Both can certainly not be considered as "non-significant".

Exposures exceeding 50 mSv pose a high risk for the population, and measures to minimize such high emissions should be presented in the EIA report. According to the EIA report, severe accident management is not yet implemented at NPPC Unit 1 and 2. Generic Severe Accident Management Guidelines (SAMGs) have been developed by the CANDU owners group, and specific SAMGs for NPP Cernavoda shall be developed.

Conclusion

Some of the presented DBA scenarios result in very high exposures of people in the exclusion zone, therefore it is not possible to exclude relevant radiation doses for people in larger regions. Other European countries do not allow exposures at the level reported for Cernavoda as a consequence of design base accidents. German radiation protection regulation sets a limit of 50 mSv, instead of 250 mSv as it is in Romania.

In order to discuss the potential impact of severe accidents to other countries, in the Austrian Comment to the Scoping Stage [WENISCH, 2007b] it was already requested to include more information on this topic in the EIA report. Related to that, the presentation of the accidents analysis in the EIA should give an overview on the Probabilistic Safety Assessment results for Cernavoda unit 3 and 4:

- accident scenarios
- core damage frequency
- large release frequency
- source terms (instead of dose limits)

This information is still missing, although new design requirements apply emission limits as a probabilistic safety target, instead of dose limits.

As a further conclusion we present in the last chapter of this report our own BDBA assessment, which illustrates that severe accidents in NPP Cernavoda could affect not only Romania (outside of the exclusion zone) but also other regions in Europe (depending on the actual weather conditions at the assumed time of the accident).

More details see [Part II chapter 6].

Emergency planning

In the surroundings of the NPP, four zones are defined for protective measures: a 1 km unpopulated exclusion zone, a 2 km low-population zone, and for BDBAs a 10 km short-term and a 50 km long-term emergency planning zone.

It is not sufficiently explained why the four emergency planning zones around the NPP are defined in these dimensions. The border of the town of Cernavoda with a population of 20,000 inhabitants is at a distance of less than 2 km. Therefore it is problematic to call this zone "low population zone".

Even a design basis accident might lead to a dose up to 151 mSv at the border of the exclusion zone (1 km). It cannot be excluded that in the "low population zone" also high dose values will occur. Evacuation of Cernavoda town in a short time (the 2 km could easily be covered by a radioactive cloud within minutes!) seems to be complicated. There is only one exit route out of town crossing a bridge, because the other direction of this main road leads to the NPP [WENISCH 2003].

Also intervention levels and corresponding protective measures are given that are higher than international standards [IAEA 2002]. For iodine prophylaxis, only the ingestion pathway is included for the assessment of the intervention limit disregarding inhalation during cloud passage.

It is not discussed if and how the public is going to be informed about an accident and about protective measures. The IAEA recommends information of the public if a nuclear accident happens [IAEA 2002]. Also [EURATOM 89/618] requires information of members of the public in case of a radiological emergency.

Conclusion

The four defined emergency zones (1km, 2km, 10km, 50 km) are not in accordance with current international standards: The IAEA recommends the definition of a precautionary action zone (PAZ) of 3-5 km (with a recommendation on 5 km) and an urgent protective action planning zone (UPZ) with a radius of 5-30 km [IAEA 2007]. The exclusion zone and the low population zone with 1, respectively 2, km around Cernavoda therefore are too small. The town of Cernavoda with a population of 20000 inhabitants is in a distance of 2 km. In a 10 km radius 26000 people are living.

It is not clear which protective measures will be taken in which zones and at which time.

The intervention levels triggering protective measures are too high in comparison with IAEA standards [IAEA 2002] (and also with Austrian standards). The IAEA recommends sheltering at an avertable dose of 10 mSv in a period of no more than 2 days and temporary evacuation at an avertable dose of 50 mSv in a period of no more than 1 week. According to the EIA report sheltering has to start obligatory at 30 mSv, and temporary evacuation at 300 mSv (both in the first 24 hours).

The intervention level for iodine prophylaxis is based on an inadequate radiation pathway (ingestion instead of inhalation in the first days of an accident). Therefore it should be changed to include the inhalation pathway and to be in accordance with IAEA standards and also with Austrian standards (10 mGy for critical groups, 100 mGy for adults, avertable thyroid dose in the first 7 days for inhalation). [IAEA 2002], [IntV 2007, Anlage 1]

Evacuation of the town of Cernavoda, which might be required in a severe accident, will hardly be possible under present conditions.

Romania should fulfill the IAEA standards and as a member of the EU the EU-requirements for protection planning and should therefore change its intervention values. Also information for the public according to EU-standards [EURATOM 89/618] should be planned for emergency situations. The EIA report should describe how Romania will provide information to the public about the emergency procedures in case of an accident, how the public will be alerted, and how exercises will ensure the functioning of the protection measures.

More details see [Part II, chapter 7].

Austrian analysis of severe 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 7.8E16 Bq Cs-137 [CITON 2005] and a release fraction of 20%, a source term of 1.56E16 Bq Cs-137 results, which was used in the evaluation of possible transboundary consequences of accidents at NPP Cernavoda.

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.

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). For the nested subdomains covering the regions of interest, a grid size of about 30 km x 30 km was used. Features smaller than one grid cell cannot be resolved, especially a local maximum near the NPP site.

Below we present an example derived from the calculations made for 90 different dates in the year 1995 as a part of the RISKMAP study. This year has been shown to be climatologically representative at least for the Alpine region.

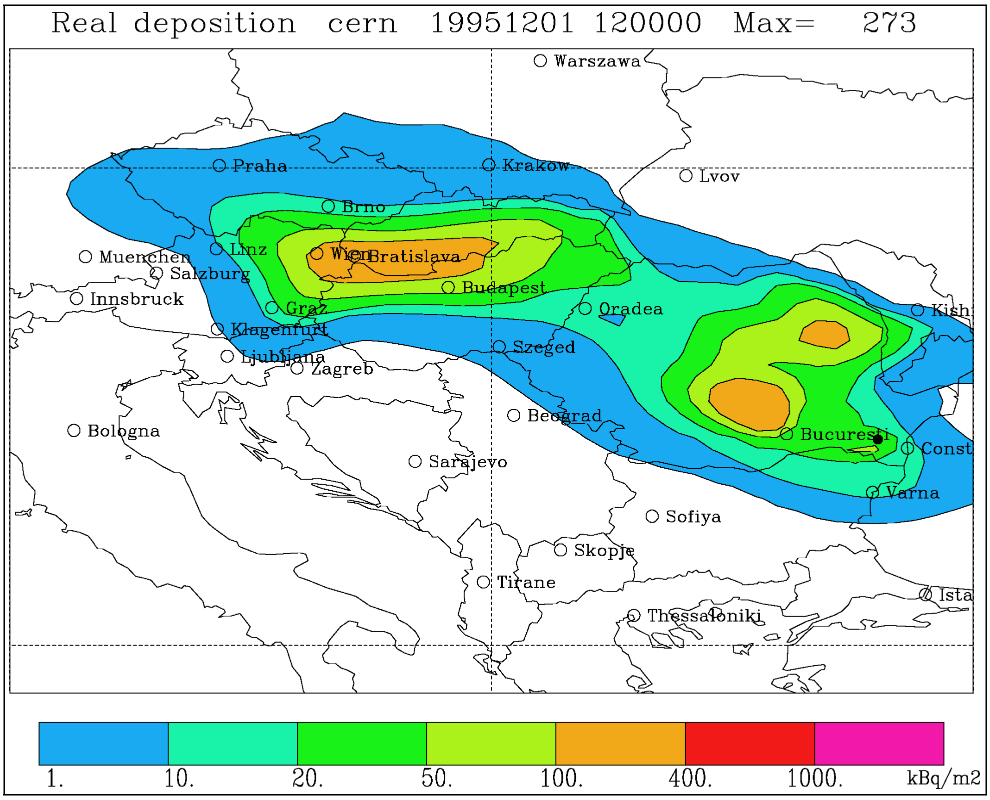

Figure 1: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 01.12.1995 at 12:00 UTC. The absolute maximum of the contamination on the evaluation grid was 273 kBq/m².

The deposition pattern of the case shown in Figure 2 reflects a complex track of the contaminated air from Romania across the border to Hungary, Slovakia and Austria, modulated by precipitation causing the deposition maxima. Two regions in Romania and a large region in northern Hungary, southern Slovakia and eastern Austria, Bratislava and Vienna included, would become highly contaminated. The Cs-137 deposition in these regions exceeds 100 kBq/m². The situation would require protection measures for the whole population such as sheltering and probably administration of stable iodine for critical groups of the population.

More details see [Part II chapter 8].

EINLEITUNG

CANDU Reaktoren sind in Europa nicht verbreitet. Die beiden Reaktorblöcke in Cernavoda sind die ersten dieses Typs, die in Europa in Betrieb genommen wurden. Die Erfahrungen mit diesem Reaktortyp in Europa sind daher beschränkt.

Das Kernkraftwerk Cernavoda liegt 160 km östlich von Bukarest in der Region Constanta, ca. 2 km entfernt von der Stadtgrenze von Cernavoda und ca. 1,5 km südöstlich der ersten Schleuse des Donau-Schwarzmeer-Kanals. Das KKW sollte mit 5 Reaktorblöcken mit je 700 MW vom Typ CANDU ausgerüstet werden. Der erste Block nahm 1996 den Betrieb auf, der zweite 2007. Im Rahmen der Errichtung von Block 2 des KKW Cernavoda wurde in Rumänien eine Umweltverträglichkeitsprüfung (UVP) durchgeführt, die nicht nur von rumänischen, sondern auch von kanadischen und europäischen NGOs beobachtet wurde. Nach Abschluss dieses UVP-Verfahrens kündigte Rumänien zunächst an, auch den dritten der 5 geplanten Blöcke fertig stellen zu wollen. Im Rahmen des dafür vorgesehenen UVP- und ESPOO-Verfahrens meldete Österreich sein Interesse an einer grenzüberschreitenden Beteiligung an. Inzwischen hat Rumänien seine Pläne auch auf Block 4 ausgedehnt und Österreich eingeladen, an dem grenzüberschreitenden UVP Verfahren für die Blöcke 3 und 4 des KKW Cernavoda teilzunehmen.

Block 3 und 4 des KKW Cernavoda sollen je 720 MW elektrische Leistung haben. Jeder Block besteht aus einem CANDU 6 Schwerwasserreaktor. Die Bauzeit soll 64 Monate betragen, die Inbetriebnahme ist für 2013 bzw. 2014 vorgesehen. Die geplante Laufzeit soll 30 Jahre betragen.

Das Österreichische Ökologie-Institut wurde beauftragt eine Fachstellungnahme zum UVP-Bericht vorzunehmen.

Aufbau der Fachstellungnahme

Teil I besteht aus dieser **Einleitung** und dem Abschnitt **Zusammenfassung & Schlussfolgerungen** (in englischer und deutscher Sprache) und gibt einen Überblick über das Projekt und die Bewertung des UVP Berichts. Teil II liegt nur in englischer Sprache vor und umfasst die detaillierte Auseinandersetzung mit den Inhalten des UVP Berichts, wobei der Schwerpunkt auf jenen Fragestellungen liegt, die nicht ausschließlich die unmittelbare Umgebung des KKW betreffen. Dieser Teil gliedert sich in folgende Themen:

- Diskussion der Alternativen
- Technische Fragen (zur Auslegung und Sicherheit des gewählten Reaktors)
- Emissionen und Dosisberechnung (hier werden hauptsächlich luftgetragene Emissionen behandelt, da von Emissionen mit dem Abwasser keine signifikanten Auswirkungen auf Österreich erwartet werden)
- Überwachung der Radioaktivität in der Umwelt
- Nukleare Abfallwirtschaft und Abbau des KKW
- Unfallanalyse
- Unfallplanung
- Österreichische Analyse der Auswirkungen schwerer Unfälle

Die Behandlung der Inhalte des UVP-Berichts in der Fachstellungnahme ist folgendermaßen gegliedert:

- Behandlung der Frage im UVP Bericht
- Diskussion der Problemstellung
- Schlussfolgerung

Der Fokus dieser Bewertung liegt auf den Anforderungen an UVP-Verfahren entsprechend der UVP-Richtlinie der Europäischen Kommission und dem Übereinkommen über die UVP im grenzüberschreitenden Rahmen (ESPOO-Konvention).

Als Vergleichsbasis zur Bewertung der Sicherheit des KKW Cernavoda wurden Richtlinien der IAEA und Vorschriften der Behörden anderer EU Mitgliedsstaaten, aber auch kanadische Vorschriften und die Anforderungen der Europäischen Stromversorger herangezogen. Besonderes Augenmerk wurde auf mögliche grenzüberschreitende Auswirkungen von Unfällen gelegt.

Grenzüberschreitende Auswirkungen sind Gegenstand der ESPOO-Konvention. Basierend auf einer Übersicht internationaler Verträge, Konventionen und EU Vorschriften sollten im Rahmen eines ESPOO-Verfahrens folgende Inhalte berücksichtigt werden [LERCHER 2005]:

- Bei der Interpretation des Begriffs „Wahrscheinlichkeit signifikanter grenzüberschreitender Auswirkungen“ sollte das Vorsorgeprinzip eine dominante Rolle spielen.
- Zu beachten ist die spezifische Natur des Risikos beim Betrieb von KKW, wo Unfälle bei zwar geringer Eintrittswahrscheinlichkeit katastrophale Auswirkungen haben können.
- Schwere (auslegungsüberschreitende) Unfälle sind bei der Bestimmung der Wahrscheinlichkeit signifikanter grenzüberschreitender Wirkungen zu berücksichtigen.

Potentielle Auswirkungen schwerer Unfälle im UVP-Bericht zu ignorieren, entspricht weder der ESPOO-Konvention noch der UVP-Richtlinie der Europäischen Kommission. Eine detaillierte Behandlung von Auslegungsstörfällen und schweren Unfällen sowie deren potentieller Auswirkungen sollten einen wesentlichen Teil des UVP Berichts bilden.

Der vorliegende UVP-Bericht behauptet, dass grenzüberschreitende Emissionen nicht vorkommen könnten. Soweit sich diese Behauptung auf luftgetragende Emissionen und den Normalbetrieb bezieht, können wir dem zustimmen. Da im UVP-Bericht Auswirkungen schwerer Unfälle nicht ausreichend behandelt werden, legen wir in dieser Fachstellungnahme eine eigene Berechnung grenzüberschreitender Emissionen infolge schweren Unfalls in Cernavoda vor. Mit einem Quellterm aus der Literatur und unter Benutzung eines Lagrange-Dispersionsmodells hat das Institut für Meteorologie, Universität für Bodenkultur, Wien (Dr. Petra Seibert) als Werkvertragsnehmer Ausbreitungsrechnungen durchgeführt. Deren Ergebnisse zeigen, dass Gebiete außerhalb der Umgebung des KKW Cernavoda und verschiedene europäische Regionen signifikant betroffen sein könnten.

Die Fachstellungnahme bezieht sich auf die Dokumente, die Österreich von Rumänien zur UVP für den Bau des KKW Cernavoda 3 und 4 erhalten hat:

- Environmental Impact Assessment Report for NPP Cernavoda Unit 3 and 4 (der UVP-Bericht für das KKW Cernavoda Block 3 und 4), zitiert als [ICIM 2007, Kapitel-Seite]

- Technical Report for NPP Cernavoda Unit 3 and 4 (der technische Bericht für das KKW Cernavoda Block 3 und 4), zitiert als [CITON 2006]

Die Übersetzung des rumänischen UVP Berichtes in die englische Sprache könnte Missverständnisse verursacht haben. Eine Aufklärung solcher Missverständnisse ist dringend erwünscht

Die AutorInnen möchten Dr. Helmut Hirsch für die Unterstützung ihrer Arbeit mit seiner Expertise und für die wertvollen Hinweise zur Verbesserung der Einschätzung danken.

ZUSAMMENFASSUNG UND SCHLUSSFOLGERUNGEN

Für das KKW Cernavoda waren ursprünglich 5 CANDU Reaktorblöcke vorgesehen. Zwei Blöcke sind bereits in Betrieb. Die Errichtung von zwei weiteren ist Gegenstand dieses UVP-Verfahrens. Die beiden CANDU Reaktoren in Cernavoda sind die ersten dieses Typs in Europa. CANDU steht für Canadian Deuterium Uranium (Kanadischer Deuterium Uran) Reaktor. Diese Reaktoren unterscheiden sich in Aufbau und Eigenschaften deutlich von Druckwasserreaktoren, den am häufigsten eingesetzten Reaktoren in Europa. Die Gebäude für die fünf Reaktoren wurden bereits errichtet (Baubeginn für Block 1 war 1982, für Block 2 1983]. Die UVP liefert weder Informationen über den Zustand dieser Gebäude nach dieser langen Bau-Unterbrechung, noch darüber ob die Gebäude während dieser Unterbrechung eingemottet waren.

Diskussion der Alternativen

Die Analyse von Alternativen ist wegen des zusätzlichen Risikos durch zwei weitere KKW auch für Österreich relevant.

Der UVP-Bericht beschreibt die **rumänische Energiestrategie** in zwei Teilen:

- der „gemeinsamen Teil“ mit Schwerpunkt auf den bestehenden Anlagen und jenen, die aufgrund der rumänischen Energie-Roadmap errichtet werden sollen
- die „Elemente zur Unterscheidung der Szenarien“ mit dem Schwerpunkt auf die Verwendung von Gas, Kohle und Uran als Brennstoff

Der Einsatz von **erneuerbaren Energien** zur Stromerzeugung als Alternative zum KKW wird nicht als eigenes Szenario betrachtet.

Im UVP-Bericht erscheint das „Uran-Szenario“ als wesentlicher Beitrag Rumäniens zum erforderlichen globalen Klimaschutz. Der UVP-Bericht beschreibt zahlreiche ökologische Nachteile der Verwendung von Kohle als Brennstoff. Diese Darstellung ist irreführend, weil sich bei sorgfältiger Durchsicht der drei Szenarien herausstellt, dass der Einsatz der Nuklearenergie den zukünftigen Kohleverbrauch des Landes nicht verändert. Nuklearenergie soll nur zum Ersatz von Erdgas verwendet werden.

Die **Multi-Kriterien-Analyse** entspricht nicht der üblichen Praxis, da einige der Kriterien völlig willkürlich gewählt wurden, während andere wesentliche gar nicht berücksichtigt sind. Zum Beispiel werden hinsichtlich der aktuellen Gesamtkosten weder die Langzeit-Kosten für die Entsorgung der nuklearen Abfälle aus Uranabbau, Brennstofferzeugung und KKW-Betrieb und aus dem Abbau des KKW noch die Kosten für die angestrebte Erhöhung des Sicherheitsstandards des KKW berücksichtigt. Unter diesen nicht zu rechtfertigenden Annahmen erscheint die Nuklearenergie als einzige Alternative den fossilen CO_2-emittierenden Kraftwerken überlegen.

Außerdem wollen wir betonen, dass sich die Analyse der Alternativen nur auf einen zusätzlichen Reaktorblock bezieht, also auf Block 3 und nicht auf Block 3 und 4, des weiteren fehlt Block 2 in der Analyse überhaupt. In Hinblick auf die Umweltauswirkungen wäre die Betrachtung der Emissionen aller 4 Reaktoren erforderlich.

Schlussfolgerungen

Im UVP Bericht wird keine Nulloption analysiert. In dieser Hinsicht entspricht die UVP nicht der UVP Richtlinie der europäischen Kommission,

Im Vergleich der Alternativen sollte als viertes Szenario der maximal mögliche Einsatz erneuerbarer Energieträger zur Stromerzeugung verbunden mit der maximal möglichen Verbesserung der Energieeffizienz betrachtet werden.

Das entscheidende Argument für die Nutzung der Kernenergie scheint ein finanzielles zu sein, nämlich der zu erwartende Anstieg des Gaspreises. In den Vergleichsszenarien ersetzt das KKW kein Kohlekraftwerk, sondern ein Gaskraftwerk.

Beim Vergleich der Alternativen müssten die Müllmengen, deren Toxizität und Langlebigkeit sowie die Emissionen und ihre Auswirkungen gleichermaßen für die Nuklearenergie wie bei den anderen Optionen behandelt werden.

Die Multi-Kriterien-Analyse sollte ein möglichst vollständiges Set an Kriterien verwenden, anstatt nur weniger willkürlich gewählter Kriterien. Die Ergebnisse dieser Analyse müssen daher mit Vorsicht betrachtet werden. Die Analyse ist nicht geeignet, die Notwendigkeit der weiteren Reaktorblöcke zu begründen.

Mehr Details siehe [Part II, Kapitel 1 (in englisch)].

Technische Fragestellungen

Reaktorkern

Der Brennstoff im CANDU Reaktor ist (nicht angereichertes) Natururan, der Reaktorkern befindet sich nicht in einem Druckkessel, sondern ist aufgeteilt auf viele Druckröhren. Schwerwasser dient als Kühlmittel und Moderator. Der wesentliche Vorteil dieses Reaktors ist, dass der Wechsel der Brennelemente ohne Abschaltung des Reaktors möglich ist. Der größte Nachteil dieses Reaktors ist der **positive Dampfblasenkoeffizient der Reaktivität**, weshalb eine Leistungsexkursion (rascher Leistungsanstieg) bei Abweichungen vom Normalbetrieb (Kühlmittelverlust) nicht ausgeschlossen werden kann. Die Leistungskontrolle erfordert komplizierte Sicherheitssysteme und ein komplexes Mess- und Regelsystem. Ein Kühlmittelverluststörfall kann im CANDU Reaktor bei Versagen der Notabschaltung zum raschen Eintritt der Kernschmelze führen. Wegen der großen Ausmaßes des Reaktorkerns ist der CANDU Reaktor anfällig für **Steuerungsprobleme**. Die große Masse an Zirkonium im Reaktorkern (Brennstabhüllrohre und deren Befestigung in den Brennelementen) stellt ein großes Potential für exotherme Reaktionen mit Dampf dar. Die Druckröhren sind die druckführenden Komponenten des CANDU Reaktors. **Materialermüdung der Druckröhren** ist ein dauerhaftes Problem bestehender CANDU Reaktoren.

Schlussfolgerungen

CANDU Sicherheitssysteme benutzen mehr aktive Komponenten als andere Reaktoren.

Im Notkühlsystem ist nur der Hochdruckteil ein völlig passives System. Mittel und Niederdruckteil arbeiten mit Pumpen und sind daher beide nicht passiv. Aus der Beschreibung der Sicherheits- und sicherheitsrelevanten Systeme geht nicht klar hervor, wie sehr diese von aktiven Bauteilen gesteuert werden.

Die Leistungsfähigkeit des Moderatorkreislaufs und des Kühlwassers in der Calandria-Wanne um die Nachwärme des Reaktorkerns bei Ausfall des Primärkühlsystems abzuführen, ist bisher nicht ausreichend nachgewiesen.

Für die Blöcke 3 und 4 vorgesehene Änderungen sind nicht im Detail beschrieben, wie z.B. die Eigenschaften des gegenüber in Betrieb befindlichen CANDU Reaktoren verbesserten Materials der Druckröhren oder der Ventile der Hauptdampfleitung. Neue, weiterentwickelte CANDU-Reaktoren werden angepriesen, die stärkere Druckröhren und stärkere und längere Calandriarohre und haben sollen, sowie Befestigungen und Anschlüsse aus rostfreiem Stahl. Einige weitere Änderungen, die nicht näher bezeichnet werden, sind noch nicht geplant.

Zur Beurteilung der beabsichtigten Verbesserungen sind genauere Informationen nötig.

Mehr Details siehe [Part II, Kapitel 2.2 (in englisch)].

Containment

Der CANDU 6 Reaktor hat ein einzeln stehendes **Beton-Containment mit Kuppel**. In deren oberem Teil befindet sich ein Tank, der das für Notfälle benötigte Wasser für das Sprühsystem und die Notkühlung enthält. Das CANDU Containment ist kein passives System. **Ventilationsklappen und Sprühsystem** benötigen Strom und Druckluft zur Steuerung.

Das **Verhalten des Containments** im Fall eines BDBA (auslegungsüberschreitender Störfall) wird im UVP-Bericht nicht diskutiert. Das große Zirkoniuminventar des CANDU Reaktorkerns reagiert exotherm, wenn es bei einer Temperatur, wie sie bei schweren Unfällen zu erwarten ist, mit Wasserdampf in Berührung kommt. Bei dieser Reaktion entsteht Wasserstoff. Dieser gefährdet die Containment-Integrität, weil er explosiv mit der Luft im Containment reagiert. Die **Rekombination von Wasserstoff** wird in der UVP nicht erwähnt.

Angrenzend an das Reaktorgebäude befindet sich das **Servicegebäude** mit dem Kontrollraum, der Schwerwasserreinigung, den Wärmetauschern und Pumpen des

Niederdruck-Notkühlsystems, dem Ventilationssystem und dem Lagerbecken für die abgebrannten Brennstäbe.

Die Tatsache, dass das **Lagerbecken** außerhalb des Reaktorgebäudes liegt und die Lademaschine für den Brennstoff das Containment durchdringt, ist ein Anzeichen für die Herausforderung an die Isolationsfunktion des Containments im CANDU Reaktor. Die Aufnahmefähigkeit des Lagerbeckens reicht für 6 Betriebsjahre.

Reaktorgebäude und Servicegebäude sind seismisch qualifiziert für das Auslegungsbeben. Einwirkung von außen durch Naturgefahren, Flugzeugabsturz oder menschliche Einwirkung wie Terror oder Sabotage sind im **Containment-Design** nicht berücksichtigt, dies wird durch deren geringe Eintrittswahrscheinlichkeit begründet.

Schlussfolgerungen

Wichtige Fragen der Zuverlässigkeit des Containments sind im UVP-Bericht nicht ausreichend behandelt:

- die Komplexität der Einschlusssysteme
- die Strategie, sich eher auf erhöhte Verschiedenheit von Systemen und Bauteilen zu verlassen als auf passive Sicherheit
- das Verhalten des Containments unter Bedingungen eines schweren Unfalls

Zum Zeitpunkt der Inbetriebnahme der Blöcke 3 und 4 wird die Konstruktion der Gebäude mehr als 20 Jahre alt sein. Die geplante Evaluierung der existierenden Baustruktur wäre daher als Grundlage zum Vergleich des Cernavoda Containments mit demjenigen neuer KKWs in Europa von größtem Interesse.

Mit einer geplanten Laufzeit von 30 Jahren werden die Cernavoda Blöcke vermutlich aktuelle Anforderungen nicht erfüllen. Das ist von besonderer Bedeutung, da auch eine Verlängerung der Laufzeit angekündigt wird.

Da Pläne und Gebäudeschnitte fehlen, ist eine Bewertung potentieller Auswirkungen durch externe Ereignisse oder Störungen in einem Block auf andere sowie der Effekte von common mode Fehlern nicht möglich.

Mehr Details siehe [Part II, Kapitel 2.3 (in englisch)].

Erdbebengefahr

Rumänien ist nach Italien eine der aktivsten Bebenregionen Europas. Erdbebengefahr ist daher ein viel diskutiertes Problem des rumänischen KKWs.

Das betrifft sowohl die Auslegung der Sicherheits- und sicherheitsrelevanten Systeme als auch der Gebäude, des Reaktorkerns, der Lademaschine und des Lagerbeckens. Der UVP-Bericht gibt an, dass alle relevanten Systeme und Gebäude einem Auslegungsbeben standhalten. Erklärungsbedarf gibt es noch für das Zwischenlager für abgebrannten Brennstoff und für das Zwischenlager für schwach- und mittelaktiven Müll.

Das Auslegungsbeben wird mit Stufe VIII nach MSK-64 und einer maximalen Beschleunigung von 0,2g (PGA) für ein tausendjähriges Beben angenommen.

Schlussfolgerungen

Eine Eintrittswahrscheinlichkeit von 1 alle 1000 Jahre für das Auslegungsbeben anzunehmen ist verhältnismäßig kurz. Die Atomaufsicht in Deutschland und Frankreich verlangt ein zehntausendjähriges Beben anzunehmen. Insofern entspricht die rumänische Auslegung nicht der guten europäischen Praxis. Nach dieser müsste Rumänien ein zehtausendjähriges Beben der Auslegung zugrunde legen, wie es bezüglich des Hochwassers auch in Cernavoda gemacht wird.

Sicherheitsreserven sind in Hinblick auf die Erdbebensicherheit eine wesentliche noch offene Frage.

Außerdem ist zu beachten, dass alle 4 Reaktorgebäude in Cernavoda dicht aneinander gereiht sind und von mehreren gemeinsamen Systemen abhängig sind, die auch im selben Gebäude untergebracht sind. Am selben Areal befindet sich auch der gesammelte verbrauchte Brennstoff in den Lagerbecken und im Zwischenlager. Ein Erdbeben, dem die Anlage nicht standhalten kann, könnte also zu einem großen Unglück führen.

Mehr Details siehe [Part II, Kapitel 2.4 (in englisch)].

Generelle Anmerkungen

Gebäudepläne und Schnitte fehlen im UVP Bericht. Eine Abschätzung möglicher folgen durch Einwirkung von Außen ist daher nicht möglich, ebenso wie die Bewertung der Einflüsse von Störfällen in einem Block auf benachbarte, sowie die von common mode Fehlern.

Der UVP Bericht enthält keine Informationen über den heutigen Zustand der Gebäude für Block 3 und 4 (nach der langen Unterbrechung er Bauarbeiten) ebenso unbekannt bleibt ob und wenn wie die Gebäude eingemottet wurden. Zur geplanten Inbetriebnahme werden die Gebäude immerhin schon 20 Jahre alt sein.

Emissionen und Dosisabschätzung

Im Prinzip sind durch den **Normalbetrieb** des KKWs keine Auswirkungen auf Österreich zu erwarten. Leider wird im UVP-Bericht die Möglichkeit grenzüberschreitender Auswirkungen generell geleugnet. Trotzdem ist die Beschreibung von Emissionen und der Dosisberechnung wesentlich zum Verständnis der Darstellung von Auswirkungen von Störfällen und schweren Unfällen im UVP-Bericht.

Hinsichtlich **Klima und meteorologischer Daten** vermissen wir im UVP-Bericht eine Diskussion zukünftiger Veränderungen aufgrund des Klimawandels und ihrer Auswirkungen auf das KKW.

Im UVP-Bericht gibt es Daten für die Aktivität der emittierten Gase von Block 1 des KKW Cernavoda. Diese Daten sind nicht vollständig, für mehrere Jahre fehlen die Angaben zu den Iod-131 Emissionen und für Aerosole gibt es gar keine Messwerte. Da Block 1 auch die drei anderen Blöcke repräsentiert, sind die Messergebnisse von Block 1 von großer Bedeutung. Zuverlässigkeit des **Monitoring-Systems** ist eine unabdingbare Notwendigkeit. Die fehlenden Daten sollten ergänzt werden, wenn sie nicht verfügbar sind, sollte eine Begründung dafür gegeben werden.

Im UVP-Bericht gibt es einen Vergleich der Tritiumkonzentration der Luft vor und nach Inbetriebnahme des KKW Cernavoda Block 1 am Messpunkt „Campus“ Cernavoda. Mit Nachdruck machen wir auf den starken Anstieg der Tritiumkonzentration in der Luft an dieser Stelle nahe der Stadt Cernavoda aufmerksam: Nach Betriebsbeginn erhöhte sich die Tritiumkonzentration in der Luft auf das sechsfache. Der UVP Bericht belegt außerdem eine zehnmal (!) so hohe Tritiumkonzentration im Niederschlag in Cernavoda verglichen mit anderen Messpunkten nach Inbetriebnahme des 1. KKW Blocks.

Die Beschreibung der Methodik zur Berechnung der **abgeleiteten Emissionsgrenzwerte** (DEL = derived emission limits) ist nicht ausreichend. Formeln und Daten, die für die Berechnung verwendet werden, fehlen. Eine Beschreibung des Computerprogramms und seiner Arbeitsweise fehlt.

Der UVP-Bericht betont, dass alle Messwerte der Aktivitätskonzentration in der Abluft von Block 1 des KKW Cernavoda unter dem administrativen Grenzwert von 5% DEL liegen. Diese Behauptung ist irreführend. Grundsätzlich reicht es nicht aus, dass einzelne gemessene Aktivitäten unter dem administrativen Grenzwert liegen, um den ordnungsgemäßen Betrieb des KKWs zu belegen. Das entscheidende Argument dafür ist das Kriterium der Dosisbegrenzung, das die Auswirkung aller radioaktiven Emissionen berücksichtigt. Unklar bleibt, ob die **Grenzwerte** so festgelegt sind, dass beim gleichzeitigen Betrieb von 4 Reaktorblöcken die Exposition der Bevölkerung das Limit von 1 mSv/Jahr nicht überschreitet.

Schlussfolgerungen

Die Beschreibung der Methodik der Dosisberechnung und Bestimmung der abgeleiteten Emissionsgrenzwerte im UVP-Bericht ist nicht ausreichend. In dieser Hinsicht entspricht der UVP-Bericht weder der UVP-Richtlinie der Kommission noch der ESPOO-Konvention. Dieser Mangel (zusammen mit anderen) macht es unmöglich, die Berechnung der Exposition bei Auslegungsstörfällen und schweren Unfällen im UVP-Bericht nachzuvollziehen.

Eine seriöse Beurteilung des Systems für die Überwachung der Radioaktivität in der Abluft ist nicht möglich. Dazu müsste erst geklärt werden, ob jeder Block einzeln überwacht wird oder ob alle 4 in einem System zusammen gefasst sind. Zweitens müsste geklärt werden, welche Art der abgeleiteten Grenzwerte vom Monitoringsystem beim Betrieb von 4 Reaktorblöcken benutzt werden: der „normale“ DEL, 25% des DEL oder der administrative Wert von 5% DEL.

Mehr Details siehe [Part II, Kapitel 3 (in englisch)].

Überwachung der Radioaktivität in der Umwelt

S.N. Nuclearelectrica ist verantwortlich für die Installation und den Betrieb eines Monitoringsystems. Dieses System wird im UVP-Bericht vorgestellt. Für verschiedene Medien (Filter, Wasser, Boden, Sedimente, Lebensmittel, Milch) werden die Art der Analyse, die *„spezifische Aktivität, die zumindest nachgewiesen werden muss“* und die Häufigkeit der Messungen und Analysen aufgezählt.

Der UVP-Bericht enthält keine Landkarten der Probenahmepunkte. Er enthält auch keine detaillierten Beschreibungen der Messmethoden und der Dosisabschätzung. Es ist nicht klar ob und wie die Bevölkerung regelmäßig über die Ergebnisse des Monitorings informiert wird.

Schlussfolgerungen

Das Umweltmonitoringprogramm scheint nicht ausreichend zu sein um alle Kontaminationen aufzudecken. Die vierteljährliche Analysefrequenz von Iod in Luft erscheint zu niedrig im Vergleich zu einer Analysefrequenz von 14 Tagen, wie sie rund um deutsche KKWs vorgeschrieben ist [BMU 2006].

Trinkwasser wird gar nicht gemessen.

Die zumindest nachgewiesene Aktivität von Tritium in Wasser (350 Bq/l) ist zu hoch im Vergleich zu den technisch machbaren Nachweisgrenze von 10 Bq/l [BMU 2006] und – falls Trinkwasser aus dem Grundwasser bezogen wird – im Vergleich zum EU-Grenzwert von 100 Bq/l für Trinkwasser [EC/98/83].

Die jährliche Analysefrequenz von Lebensmittelproben ist zu niedrig im Vergleich zu Europäischen Empfehlungen für monatliche bzw. vierteljährliche Messungen [EURATOM 2000/473]. Die Probenahme für pflanzliche Lebensmittel sollte zudem in Abstimmung mit den Erntezeiten erfolgen [BMU 2006].

Eine kontinuierliche Überwachung der Luft-Dosisrate im ganzen Land wird von der EU empfohlen [EURATOM 2000/473]. Die Dosisrate wird an 23 Orten außerhalb des KKWs gemessen, eine Landkarte fehlt. Da ein Unfalls das ganze Land kontaminieren könnte (siehe Kapitel 8), sollte ein flächendeckendes Dosisratenmessnetz in Rumänien etabliert werden wie dies etwa in Österreich [UBA 2007] und Deutschland [BMU 2006] der Fall ist.

Daten über die genau Lage der Probenahmepunkte und Details der Analyseverfahren sollten nachgereicht werden.

Die Bevölkerung sollte regelmäßig über das Monitoringprogramm und seien Ergebnisse informiert werden.

Weitere Details siehe [Part II, Kapitel 4 (in englisch)].

Nukleare Abfallwirtschaft und Abbau der KKWs

In diesem Kapitel des UVP-Berichts gibt es keine vollständige Information zu den bestehenden Einrichtungen zur Abfallbehandlung und zu den Lagermöglichkeiten am Standort. Es wird festgestellt, dass die bestehenden Lager für schwach- und mittelaktiven Müll und für den abgebrannten Brennstoff vergrößert werden sollen, um den zusätzlichen Abfall zu bewältigen. Außerdem wird erklärt, dass ein nationales Endlager für schwach- und mittelaktiven Müll und ein Endlager für hochaktiven Müll zu errichten geplant sind.

Aber diese Information wird ohne weitere Details präsentiert, z.B. hinsichtlich der Kapazität, Auslegung, Standortsuche und Genehmigungsverfahren. Behälter für den Transport und Lagerung abgebrannter Brennstäbe werden im UVP Bericht zwar erwähnt, aber ohne nähere Angaben.

Schlussfolgerungen

Rumänien sollte eine ernsthafte Strategie zum sicheren Management des radioaktiven Mülls und der abgebrannten Brennstäbe vorlegen bevor es den Bau neuer Reaktorblöcke in Cernavoda startet.

Wegen des Fehlens wesentlicher Informationen zu Behandlung und Zwischenlagerung nuklearer Abfälle und deren Umweltauswirkungen sowie des Fehlens von Maßnahmen zur sicheren Behandlung und langfristigen Lagerung entspricht der UVP-Bericht unserer Meinung nach weder der ESPOO-Konvention noch der UVP-Richtlinie der Europäischen Kommission [EC 85/337, Annex IV 4. und 5.].

Eine ordentliche Managementstrategie muss auch die Vorsorge für die nötigen Finanzmittel beinhalten. Da der Fond für die nukleare Abfallwirtschaft und den Abbau des KKWs noch nicht eingerichtet ist, fehlt auch die finanzielle Absicherung.

Mehr Details siehe [Part II, Kapitel 5 (in englisch)].

Unfallanalyse

Die Unfallanalyse für das KKW Cernavoda beruht auf einer Klassifizierung bestehend aus der Eintrittswahrscheinlichkeit für bestimmte Ereignisabläufe und der daraus resultierenden Dosis. Unfälle mit einer Eintrittswahrscheinlichkeit kleiner als 1E-6 werden im UVP-Bericht nicht behandelt.

Da Rumänien Mitglied der Europäischen Union ist, ist die Praxis der AECB, radiologische Konsequenzen von Unfällen mit einer Eintrittswahrscheinlichkeit unter 1E-6 zu ignorieren, nicht relevant für andere EU-Mitgliedstaaten.

Im UVP-Bericht werden Ergebnisse der Dosisberechnung aus dem vorläufigen Sicherheitsbericht des KKW Cenavoda Block 2 für Auslegungsstörfalle (DBA) und auslegungsüberschreitende Unfälle (BDBA) dargestellt. Die deutsche Strahlenschutz-Verordnung erlaubt eine maximale Effektivdosis von 50 mSv für den Auslegungsstörfall mit den ungünstigsten Auswirkungen in der Umgebung der Anlage. Im UVP-Bericht werden Auslegungsstörfälle aufgezählt, die dieses Limit deutlich übertreffen.

Die Schlussfolgerung des UVP-Berichts lautet, dass „es klar ist, dass sowohl DBAs als auch BDBAs des KKW Cernavoda keine signifikanten radiologischen Konsequenzen für die Bevölkerung außerhalb der Ausschluss-Zone (Radius 1 km) haben“. Diese Behauptung ist offensichtlich falsch: unter den Auslegungsstörfällen ist einer angeführt, der eine Effektivdosis von 151 mSv verursachen soll, und unter den BDBAs gibt es eine Unfallsequenz mit einer Effektivdosis von 171 mSv, jeweils an der 1 km Grenze der Auschlusszone. Beides kann zweifellos nicht als „nicht signifikante“ Dosis bezeichnet werden.

Unserer Meinung nach stellt eine Dosis von mehr als 50 mSv ein hohes Risiko für die Bevölkerung dar, und der UVP-Bericht sollte daher Maßnahmen zur Reduktion solcher Emissionen beschreiben. Im UVP Bericht heißt es, dass im KKW Cernavoda Block1 und 2 noch keine Maßnahmen für das Management schwerer Unfälle implementiert wurden. Generelle Richtlinien dafür wurden von der Gruppe der CANDU Besitzer entwickelt, spezielle Maßnahmen für das KKW Cernavoda sollen entwickelt werden.

Schlussfolgerungen

Manche der im UVP-Bericht dargestellten Auslegungsstörfälle würden eine große Exposition der Bevölkerung am Rand der Ausschluss-Zone verursachen. Daher kann auch nicht ausgeschlossen werden, dass die Bevölkerung in einem größeren Gebiet einer relevanten Dosisbelastung ausgesetzt würde. Wenn eine derart hohe Expositionen für DBAs zugelassen wird, entspricht das nicht der guten Praxis in anderen europäischen Ländern, wo nur 50 mSv als Dosisbelastung für den DBA zugelassen sind, anstatt 250 mSv wie in Rumänien.

Um mögliche Auswirkungen von Unfällen auf andere Länder beurteilen zu können wurde im österreichischen Kommentar zum Scoping-Verfahren [WENISCH 2007b] mehr Information zur Unfallanalyse gefordert:

- ein Überblick über die Ergebnisse der PSA (probabilistische Sicherheitsanalyse)
- Unfallsequenzen
- Kernschadenshäufigkeit
- Häufigkeit großer Freisetzungen
- Quellterme (anstatt Dosis)

Diese Informationen fehlen immer noch, obwohl neuere Richtlinien Emissionsgrenzwerte anstelle von Dosisgrenzwerten als probabilistische Zielwerte für die Auslegung vorgeben.

Als weitere Schlussfolgerung stellen wir im letzten Kapitel dieses Berichts unsere eigenen Annahmen und Berechnungen von Auswirkungen eines schweren Unfalls im KKW Cernavoda dar. Diese illustrieren, dass durch einen solchen Unfall nicht nur Rumänien (außerhalb der Ausschluss-Zone) sondern auch andere Regionen in Europa betroffen sein könnten (abhängig von den konkreten Wetterbedingungen zum angenommenen Zeitpunkt des Unfalls).

Mehr Details siehe [Part II, Kapitel 6 (in englisch)].

Notfallplanung

Rund um das KKW sind 4 Schutzzonen definiert, die 1 km unbewohnte Ausschlusszone, eine 2 km-Zone mit „geringer Bevölkerungsdichte“, und für BDBAs eine 10 km Zone zur Planung kurzfristiger Notfallmaßnahmen und eine 50km Zone zur Planung langfristiger Maßnahmen.

Es ist nicht ausreichend erklärt warum die vier Notfallsplanungszonen rund um das KKW in genau diesen Dimensionen definiert wurden. Die Stadtgrenze von Cernavoda mit einer Bevölkerung von 20000 EinwohnerInnen befindet sich in einer Entfernung von knapp 2 km. Daher ist es problematisch die 2-km-Zone als „Zone mit geringer Bevölkerungsdichte“ zu bezeichnen.

Da ein Auslegungsstörfall an der 1-km-Grenze zu einer Dosis von 151 mSv führen könnte, kann man nicht ausschließen, dass auch in der „dünn besiedelten Zone“ hohe Belastungen auftreten. Eine Evakuierung der Stadt Cernavoda in kurzer Zeit (die 2 km können leicht innerhalb von Minuten von einer radioaktiven Wolke erreicht werden!) könnte schwierig sein. Es gibt nur einen Fluchtweg aus der Stadt, der über eine Brücke führt, da die andere Richtung der Hauptstraße direkt zum KKW führt. [WENISCH 2003]

Es werden Interventionsgrenzwerte und die zugehörigen Maßnahmen angegeben, die höher sind als der internationale Standard [IAEA 2002]. Für die Radioiodprophylaxe wird nur der Ingestionspfad in die Abschätzung des Interventionslimits inkludiert, die Inhalation während des Durchzugs der radioaktiven Wolke wird ignoriert.

Im UVP-Bericht fehlt eine Darstellung, ob und wie die Bevölkerung über einen Unfall und über die Schutzmassnahmen informiert wird. Die IAEO empfiehlt die Information der Öffentlichkeit im falle eines Nuklearunfalls [IAEA 2002]. Auch [EURATOM 89/618] verlangt die Informationen der Öffentlichkeit im Falle eines Notfalls.

Schlussfolgerungen

Die vier definierten Zonen für die Notfallmaßnahmen (1 km, 2 km 10 km, 50 km) stehen nicht im Einklang mit aktuellen internationalen Standards: Die IAEO empfiehlt die Festlegung einer *„Precautionary Action Zone PAZ“* mit einem 3-5 km Radius (Empfehlung: 5 km), und eine *„Urgent Protective Action Planning Zone UPZ“* mit einem Radius von 5-30 km [IAEA 2007]. Die Ausschlusszone und die Zone mit „geringer Bevölkerungsdichte“ (1 bzw. 2 km) sind daher zu klein. Die Stadt Cernavoda mit einer Bevölkerung von 20000 EinwohnerInnen liegt in einem Abstand von knapp 2 km zum KKW. Innerhalb eines Radius von 10 km leben 26000 Menschen.

Es ist nicht klar welche Notfallmaßnahmen in welchen Zonen und zu welchen Zeiten getroffen werden.

Die Interventionswerte, die den Start der Notfallmaßnahmen auslösen, sind zu hoch im Vergleich mit IAEO-Standards [IAEA 2002], ebenso mit österreichischen Vorschriften. Die IAEO empfiehlt den Aufenthalt in geschlossenen Räumen ab einer vermeidbaren Dosis von 10 mSv in nicht mehr als 2 Tagen, und zeitweise Evakuierung ab einer vermeidbaren Dosis von 50 mSv in nicht mehr als 1 Woche. Im UVP-Report wird die Schwelle für den verpflichtenden Start des Aufenthalts in geschlossenen Räumen mit 30 mSv, und für die zeitweise Evakuierung mit 300 mSv angegeben – beide Werte beziehen sich auf die ersten 24 Stunden.

Der Interventionswert für die Radioiodprophylaxe basiert auf einem nicht adäquaten Inkorporationspfad (Ingestion anstatt Inhalation in den ersten Tagen nach einem Unfall). Daher sollte er so abgeändert werden, damit er in Übereinstimmung mit den Standards der IAEO, und somit auch in Übereinstimmung mit österreichischen Vorschriften, ist (10 mGy für kritische Bevölkerungsgruppen, 100 mGy für Erwachsene, jeweils vermeidbare Schilddrüsendosis in den ersten 7 Tagen durch Inhalation). [IAEA 2002], [IntV 2007, Anlage 1]

Die Evakuierung der Stadt Cernavoda, die bei einem schweren Unfall erforderlich sein könnte, wird unter den gegebenen Bedingungen kaum möglich sein.

Rumänien sollte die IAEO-Standards und als EU-Mitglied die EU-Erfordernisse für Notfallsplanung erfüllen und sollte daher seine Interventionswerte ändern. Ebenso sollte die Öffentlichkeit für Notfallsituationen entsprechend der EU-Standards [EURAOM 89/618] geplant werden. Der UVP-Bericht sollte beschreiben, wie Rumänien diese Informationen and die Öffentlichkeit bringen will, wie alarmiert werden soll, und wie die Notfallmaßnahmen geübt werden sollen.

Mehr Details siehe [Part II, Kapitel 7 (in englisch)].

Österreichische Analyse der Auswirkungen schwerer Unfälle

Basis der Abschätzung möglicher grenzüberschreitender Auswirkungen ist ein worst-case Szenario. Die Bewertung eines vollständigen Quellterms, der alle wesentlichen Nuklide umfasst, übersteigt den Rahmen dieser Stellungnahme. Als Leitnuklid wurde daher die Cs-137 Freisetzung unterstellt. Aus dem in [CITON 2005] dargestellten Kerninventar von 7.8E16 Bq Cs-137 und einer Freisetzungsrate von 20% ergibt sich ein Quellterm von 1.56E16 Bq Cs-137. Dieser wurde der Abschätzung möglicher grenzüberschreitender Auswirkungen eines schweren Unfalls im KKW Cernavoda zugrunde gelegt.

Transport, Diffusion und Deposition wurden mit dem Modell FLEXPART berechnet. FIEXPART ist frei zugänglich and wird von vielen Institutionen in der ganzen Welt verwendet.

Die Ergebnisse werden in einem Netz dargestellt (Länge und Breite). Die für Europa benutzte Darstellung ist für 1° Länge (111 km in N-S) und Breite (ca. 70 km in E-W). Für feinere Auflösung wurde ein Netz von 30 km x 30 km benutzt. Das folgende Bild ist ein Beispiel ausgewählt aus 90 Case Studies die zu verschiedenen Daten aus dem Jahr 1995 im Rahmen der RISMAP Studie berechnet wurden. Das Jahr 1995 wurde gewählt, weil es klimatologisch repräsentativ für den Alpenraum ist.

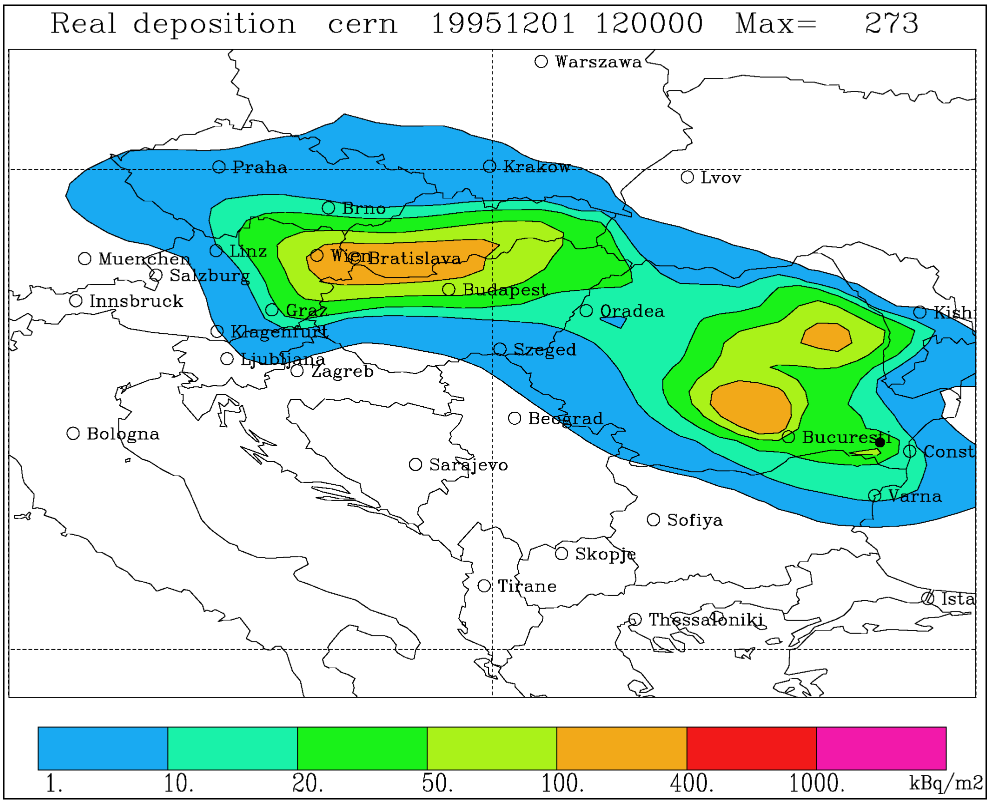

Figure 2: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 01.12.1995 at 12:00 UTC. The absolute maximum of the contamination on the evaluation grid was 273 kBq/m².

Bild 1 zeigt die Deposition unter der Zugbahn kontaminierter Luft vom KKW Cernavoda über die Grenze nach Ungarn, die Slowakei und Österreich. Zwei Regionen in Rumänien und ein größeres Gebiet im Norden Ungarns, dem Süden der Slowakei und im Osten Österreichs, inklusive Bratislava und Wien, würden stark kontaminiert. Die Cs-137 Deposition übersteigt 100 KBq/m². Diese Situation würde Schutzmaßnahmen für die gesamte Bevölkerung erforden, wie z.B. Aufenthalt in Gebäuden und vermutlich Abgabe von stabilem Iod zur Profilaxe für kritische Bevölkerungsgruppen.

Mehr Details siehe [Part II, Kapitel 8 (in englisch)].

PART II

1 DISCUSSION OF ALTERNATIVES

The chapter is relevant for Austria, with respect to the additional high risk in the form of two more Nuclear Power Plants (NPPs). Within the chapter "Analysis of Alternatives" [ICIM 2007, 5-1] the document describes the provision of renewable sources. Three alternative scenarios are presented, dealing with gas, coal and nuclear fuel as the interchangeable fuel alternatives, while the usage of renewables for electric power generation is not considered as a separate scenario. The usage of coal as fuel is picked to pieces, while the usage of uranium – compared to coal – is described as being quite harmless. The presentation of negative facts about the usage of coal is not understandable, because the "uranium scenario" does not influence the coal consumption at all due to the fact, that the amount of coal used as fuel within both the "uranium scenario" and the "coal scenario" is exactly the same. The difference lies in the gas consumption within the "coal scenario" being substituted by uranium consumption within the "uranium scenario". Furthermore, the documentation is not complete, some data are inconsistent and therefore not understandable. Last but not least, the multi criteria analysis is not state of the art due to the fact that some criteria are chosen quite arbitrarily, while other important facts are not considered.

In reference to the EIA report [ICIM 2007], the necessity of the two more NPP units cannot be assessed. This makes an accurate and more detailed analysis of this issue necessary.

1.1 Usage of renewables for electric power generation

1.1.1 Treatment of the issue in EIA report

As presented in table 5.2.3-1 [ICIM 2007, 5-15] and following tables, the renewables - referred to as "regenerables" - can be found in the common part, which represents the unchangeable part of the three presented scenarios and is either represented by the existing capacities or by the power expected to be installed in the analyzed period as per the road map [ICIM 2007, 5-8]. The document describes the provision of renewable sources in conformity with the *"average term strategy of power regenerable resources evaluation"*, promoted by Romania's Government in January 2004 [ICIM 2007, 5-9]. Three different scenarios A, B and C represent the distinguishable elements for scenario differentiation. Scenario A deals with the usage of gas. Scenario B mainly deals with the usage of lignite and pit coal and a – compared to scenario A – visibly smaller amount of gas. Scenario C deals with the usage of the same amount of lignite and pit coal as scenario B, while the small amount of gas used as fuel in scenario B is substituted by uranium.

1.1.2 Discussion of the problem

The usage of renewables for electric power generation is not considered as a separate scenario. It is not clear, whether the installation plan for biomass power plants, wind power plants, hydro power plants and solar power plants presents the absolut maximum possible usage of renewables. As long as the renewables are not discussed as an alternative scenario, the nuclear power can compete with fossile power as a stand-alone alternative to the greenhouse gas producing fossile scenario. It also can compete concerning the costs, as long as the costs of long-term waste management and safety issues of the nuclear scenario are not considered.

1.1.3 Conclusion

The maximum usage of renewables should represent a seperate scenario and should be considered in all cases of scenario competitions. At the moment, in reference to the EIA report [ICIM 2007], all statements based on the multi criteria analysis of the scenarios should be handled with care.

1.2 Reduction of coal consumption by usage of uranium

1.2.1 Treatment of issue in EIA report

The three different scenarios A, B and C represent the distinguishable elements for scenario differentiation. Scenario A deals with the usage of gas, Scenario B with lignite and pit coal, and Scenario C with lignite, pit coal and uranium. A lot of negative facts are presented about the usage of coal.

1.2.2 Discussion of the problem

The presentation of many negative facts about the usage of coal without the synchronous presentation of negative facts about uranium is not understandable. As seen in table 5.2.3-2 [ICIM 2007, 5-16], scenario C (Cernavoda Unit 3) does not decrease the usage of lignite or pit coal, it reduces the usage of gas only. The usage of 1.8 million tons conventional fuel equivalent of uranium effects in saving 1.2 billion m^3 natural gas. Neither the amount of nuclear waste being produced during uranium mining, nor the amount of nuclear waste being produced during NPP operation and decommissioning, are considered.

1.2.3 Conclusion

The misleading stand-alone presentation of negative facts about the usage of coal should be avoided. The amount of nuclear waste being produced during uranium mining and the amount of nuclear waste being produced during NPP operation and decommissioning should also be considered.

1.3 Multi criteria analysis of the scenarios

1.3.1 Treatment of the issue in EIA report

Data concerning differences among the scenarios are presented in the chapter “Analysis and Comparison of Scenarios for Electric and Thermal Power Sector”.

1.3.2 Discussion of the problem

The presented data concerning differences among the scenarios [ICIM 2007, 5.3.1-14] do not match with data of previous chapters.

Furthermore, the multi criteria analysis does not meet the requirements due to the fact that some criteria are chosen quite arbitrarily, while other important facts are not considered. Therefore the analysis is not complete.

The total updated costs (CTA) criterion does not explicitly consider increasing safety costs being expected due to up-to-date and future safety conceptions (air crash, hurricane, terrorism, ...), decommissioning costs and true costs of nuclear waste interim storage and final disposal [ICIM 2007, 5.3.1-17].

“The water stream damage is considered as comparable for all the groups provided in the analyzed scenarios” [ICIM 2007, 5.3.2.1-18]. Radioactivity is not considered at this point.

“The chemical content of the waste waters is considered as insignificant” [ICIM 2007, 5.3.2.1-19]. Tritium seems to be not considered at this point.

“The differentiation in point of soil, subsoil & underground water pollution in the analyzed scenarios has been conduced by the consideration of the generated waste quantity” [ICIM 2007, 5.3.2.2-20]. Only the quantity (volume), but not the quality (hazardousness) of waste seems to be considered at this point. A consideration of the waste quality, its truely and potential impact on earth, has to be realized. The time horizon of the long term radiotoxicity of nuclear waste can never compete with the medium term „normal“ toxicity of ashes.

1.3.3 Conclusion

The presentation should be performed in a comprehensible manner in order to make the comparative analysis understandable. Maybe this is a result from the translation to the English language only. In this case a better translation should be performed.

Furthermore, the multi criteria analysis should consider an “as-complete-as-possible” set of criteria, not only arbitrarily chosen criteria. At the moment, in reference to the EIA report [ICIM 2007], the necessity of the two more NPP units cannot be assessed.

1.4 Documentation of alternatives

1.4.1 Treatment of the issue in EIA report

The analysis study of the alternatives considering Cernavoda Unit 4 *„... has not been available on the date of this document ...”* [ICIM 2007, 5-26].

1.4.2 Discussion of the problem

The documentation is not complete. In general we want to emphasize the fact, that the „analysis of alternatives” mainly deals with the impact of one additional unit (Cernavoda Unit 3) instead of the two targeted units Cernavoda Unit 3 + Unit 4 (Cernavoda Unit 2 is not considered at all!). Only at the end of chapter 5 it is mentioned, that the consideration of Cernavoda Unit 4 will result in the increase of the differences between scenario B (additional combined cycle groups using gas as fuel) and scenario C (additional Cernavoda units using uranium as fuel), in favor of scenario C. With respect to the synchronous operation of Cernavoda Unit 1, Cernavoda Unit 2, Cernavoda Unit 3 and Cernavoda Unit 4, it is neither sufficient to emphasize the usage of the administrative limit (5%-DEL), nor to emphasize the technical identity of the two reactors (Unit 3 technically represents Unit 4). All scenario calculations have to consider the synchronous operation of all four units.

1.4.3 Conclusion

The zero option (non action alternative) is not considered in the EIA report. In this respect the EIA report does not meet the requirements of the EC’s EIA directive.

When completing the documentation, the double amount of uranium fuel, nuclear waste, tritium and aerosol particle pollution problem should be considered as well. A comparison to a new fourth alternative (scenario D), namely the maximum usage of renewables combined with the maximum increase of energy efficiency, should be implemented.

1.5 Additional considerations

- The fact, that the mining of uranium produces 80% of today’s radioactive waste volume [ARGUMENTARIUM 2007], should also be considered, when criticizing the huge amounts of waste resulted from fossil burning [ICIM 2007, 5-19]
- The fact, that the operation of NPP produces highly toxic and long term radiotoxic nuclear waste, should be considered, when presenting the toxic elements in the waste resulted from fossil burning [ICIM 2007, 5-19].
- It is true, that, concerning combustion of fossil fuels (e.g. coal) for electric power generation, *“... residue ashes include some quantities of Uran and Thorium ...” [ICIM 2007, 5-19]. The statement is misleading.”* The combustion of fossil fuels (e.g., coal) releases U-238 and Th-232 decay series radionuclides and 40K in fly ash. However, normal environmental levels of uranium and thorium are sufficiently high that changes due to emissions from coal-fired power plants are barely detectable [HEALTH CANADA 2007].

- In chapter 5.3.2.3., a listing of diseases and death risk concerning exposure of nuclear power should also be given, when presenting diseases and death risk concerning PM, SO_2 and NO_x through the usage of coal as fuel.

2 TECHNICAL ISSUES

2.1 Overview on CANDU-6 reactor properties

The two CANDU units operating in Romania are the first reactors of this type in Europe. CANDU stands for Canadian Deuterium Uranium, these reactors have features and properties very different from the pressurized water reactors, mostly used in Europe.

The fuel is natural uranium in the form of UO_2 pellets. The CANDU fuel bundle consists of 37 fuel elements, pins with zircalloy-4 claddings (bundle length 495.3 mm, diameter 102.4 mm, UO_2 weight 21.3 kg). Instead of being confined in a big reactor pressure vessel, the CANDU reactor fuel is allocated in 380 pressure tubes adjusted in as many fuel channels. Every fuel channel contains 12 fuel bundles, resulting in 4560 fuel bundles in the core.

The fuel channels where the fission process takes place are cooled by the PHTS (primary heat transfer system), using D_2O under high temperature and high pressure - 312°C, 10.3 MPa at the outlet. The pressure tube is enclosed by the calandria tube, with a small gas filled space between both tubes. The horizontal fuel channels together with the reactivity control units are arranged in a cylindrical horizontal vessel, the calandria, filled with the moderator.

D_2O is used as moderator for the fission process, at relatively low pressure and temperature. D_2O ensures the required flux of thermal neutrons for the controlled fission of natural uranium fuel.

The calandria vessel is located in a steel plated concrete enclosure, filled with light water (the calandria vault), which serves as an additional shielding and an external cooling of the calandria vessel.

The reactor fuel loading and unloading is continuous, bi-directional during the reactor at power. The reactor is provided with a heat transport system with two independent loops which transfer the heat generated in the fuel during the controlled fission reaction to four steam generators with light water at the secondary side.

Advantages of CANDU reactors

The advantages of CANDU are related to the fuel. Natural uranium plus a simple fuel assembly allow a cheap and domestic fuel fabrication. At present Romania is manufacturing the fuel for NPPC-1 and 2 at FCN Pisteti [ICIM 2007]. Combined with a relatively high energy output per unit of uranium mined, CANDU has low fueling cost compared to other reactor types. On-power refueling allows high capacity factors and on-power replacement of failed fuel.

Disadvantages of CANDU reactors

CANDU reactors have to use two different cooling media: D_2O in the PHTS and water in the secondary circuit, resulting in a large number of cooling systems and as many related systems for purification and refilling. Instead of one pressure vessel the CANDU has many pressure bearing parts (pressure tubes).

The online fuel handling system is complicated and needs regular maintenance. It requires a sophisticated system of control of the refueling machine and the heat transfer system (plugging and unplugging the refueling machine to the fuel channel). The refueling machine is a pathway for the release of „hot particles", that have broken off the fuel.

The CANDU reactor has a positive void coefficient of reactivity, implying that a loss of coolant accident could lead to a power excursion. A loss of coolant accident with scram failure in a CANDU reactor could result in a rapid melting of the fuel.

CANDU reactor is vulnerable to loss of regulation incidents, because of the large size of its core.

The large amount of zirconium in the core (cladding and fixations of pins in the fuel bundle) provides a large steam reaction potential.

The CANDU 6 containment relies on an active spray system for pressure suppression in combination with an active system for filtered air discharge.

2.2 Reactor core

2.2.1 Treatment of the issue in the EIA

The CANDU reactor core consists of pressure tubes which contain the fuel and are cooled by heavy water (D_2O). The fuel channel consists of the pressure tube, which is inside the calandria tube separated by a gap filled with CO_2 gas, the carbon dioxide provides thermal isolation and allows pressure tube crack detection.

The core consists of 380 fuel channels adjusted in the calandria. The nuclear fuel is inserted into the pressure tube by the fueling machine.

"The calandria is designed to withstand the pressure resulting from a simultaneous break [in original "brake"] *of the pressure tube and calandria tube. To limit such a pressure effect, four pressure relief ducts located in the upper part of calandria and provided with rupture disks were provided.*" [ICIM 2007, 2-2]- This statement is either a fault or self contradictory.

The calandria vessel is located in a steel plated concrete enclosure filled with light water, the calandria vault. The light water provides an additional shielding and a proper (external) cooling of calandria vessel.

The calandria assembly is seismically qualified at design basis earthquake (DBE).

Passive components are used for special safety systems in order to fulfill the allotted functions. Shutdown system 1 (SDS#1) is actuated by means of gravity and compressed springs that force the shut-off rods to be inserted into the core (normally, they are parked above the reactor core). Shutdown system 2 SDS#2 uses as actuator the compressed helium stored in a tank. When the gas is expanded the gadolinium nitrate solution stored in the injection tank is injected in moderator volume from the calandria vessel.

The only active elements are the clutch devices that sustain the shut off rods in withdrawn position (SDS#1), and the quick acting valves that initiate the helium injection (SDS#2). The clutch devices (SDS#1) are normally powered in such way that on loss of power supply the shut off rods are dropped into the core providing the system fail safe state. The quick acting valves (SDS#2) use compressed air to maintain their closed position. On loss of instrument air the valves are opened very fast by mean of compressed springs and the poison solution will be injected into the core providing the system fail safe state. [ICIM 2007, 2-26]

"The containment and emergency core cooling systems are not passive systems, the fulfillment of their associated functions necessitating power, instrument air and cooling water supplies." [ICIM 2007, 2-26]

The emergency core cooling system (ECCS) is activated in case of a loss of coolant accident. It consists of 3 sub-systems working with high, medium and low pressure and injecting water through the injection headers into the PHTS. For high pressure injection two accumulator tanks are provided, the medium pressure injection is provided by water from the dousing tank and low pressure has to be maintained by pumping the water in the containment sump through the ECCS heat exchangers back in the PHTS, for long term cooling a second water source can be activated. Similar to the shutdown systems reliability of the system is maintained by redundancy and diversity of the instrumentation for process monitoring. According to the EIA report the medium pressure ECCS pumps the water from dousing tank to ECCS, which appears to be an active system. From the description it is also not clear how the gas tank isolation valves of the accumulators in high pressure ECCS are activated, which are closed during normal operation.

Furthermore, the reliability of safety systems is maintained through the diversity of systems and equipment, and the separation of redundant systems. All safety related systems are separated in two groups. Each group is designed to shut down the reactor, remove the decay heat and confine the radioactive material. The two groups are physically separated and completely independent from initiating logic point of view.[ICIM 2007, 272f] The CANDU safety and control systems show high levels of diversity and redundancy in order to secure a safe shutdown and cooling of core.

Most of the structure, systems and components of Unit 3 and 4 will be the same as in Unit 2, which is the reference for them. According to the EIA report some modifications will be implemented in Cernavoda NPP Units 3 and 4 which are not found in Unit 2:

- the replacement of the plant digital computer control system with distributed control system
- Improvements due to the implementation of new licensing and safety requirements applicable from April 2005: e.g., CNSC R-7, regarding the containment isolation function, or qualification of some systems and components for severe accident conditions (e. g. calandria vault relief devices, ESCS), qualification of some process systems as ultimate heat sink in accident conditions (e. g. main moderator D_2O supply), or by the mitigation of radiological risk to public (e .g. main steam isolation valves). [ICIM 2007, 2-38]
- Modifications required to implement the design codes and standards of 2004, which are the latest to be recognized in the design of Unit 3 and 4. But these modifications of the plant design are not planned yet.
- Modifications imposed by operating experience and economical indicators: "It is considered that this kind of modifications may alleviate the operational problems encountered up to date, and their character becomes mandatory. Such of modifications are as follows: replacement of nuclear diaphragm valves with equivalent

> ball valves, changes of the elevation for some equipment and system connected to reactor, changes of some components associated to steam generators, complete separation of PHTS feed pumps recirculation lines, provisions for the second auxiliary boiler feedwater pump, improvement of the main control room, etc". [ICIM 2007, 2-38]

2.2.2 Discussion of the problem

The size and complexity of the CANDU core in connection with the online refueling system and the positive void coefficient of reactivity are a challenge for the safety and reliability of CANDU plants. The main pressure bearing components of the CANDU core, the pressure tubes, are exposed to the full neutron flux, with consequent weakening effects. There have been problems with delayed hydride cracking as a result of deuterium-zirconium alloy reactions in several CANDU reactors. These problems with CANDU pressure tubes persist. At Point Lepreau power station, premature degradation of the tubes resulting from aging was reported after only about 20 years of commercial operation, requiring a costly refurbishment program [ENBP 2002]. At the Korean CANDU Wolsong-1, pressure tube replacement also might become necessary before the design lifetime of 30 years is reached [KYOUNG-SOO 2003]. Hydride cracking and fretting were observed in the last years at the Cernavoda-1 plant in Romania, which only started operation in 1996 [RADU 2003].

"Improved pressure tube material was used in Wolsong 2, 3, and 4 and for the Quinshan units to reduce impurities, minimize hydrogen content and further improve fracture toughness. Optimized installation and advanced design of the pressure tubes reduce dimensional changes and increase the operating life." [AECL 2005] In the same brochure AECL emphasizes that the major components such as steam generators, coolant pumps and pressure tubes in CANDU 6 reactors are standardized and can be replaced. However, if it turns out that the lifespan of pressure tubes cannot be extended over 20 years it will be possible to replace them. [AECL 2005].

F. R. Greening, a retired nuclear scientist with 23 years experience working for OPG's Research Division in Toronto doubts that AECL and the CANDU's owner group will be able to solve the material problems of CANDU reactors and mentions also the complexity, effort and uncertainties of pressure tube inspections:

The CANDU design involves *"great engineering complexity. .... the need for hundreds of fuel channels, end fittings, feeder pipes, annulus gas supply and return lines; as well as elaborate D_2O recovery and tritium control systems - have proven to be the source of unreliability and poor performance of aging CANDU reactors, especially compared to reactors of similar age incorporating less complex designs operating around the world. Unfortunately, the most significant of CANDU's deficiencies are long-standing problems caused by technical (design) issues that remain largely unresolved to this day. ....Pressure tube research and development in the past 20 years achieved only marginal improvements in pressure tube performance. There have been problems with leakage at the pressure tube rolled joints, neutron induced creep of in-core pressure tube sections (leading to sagging), pressure tube embrittlement and hydride blister formation caused by excessive hydrogen pickup, and localized fretting corrosion. ... The complexity and inconsistent results of pressure tube inspections over the past 25 years leave the question of future CANDU pressure tube performance still very much in doubt."* [GREENING 2005].

Pressure tube failure caused by degradation can result in serious troubles: because of the positive void coefficient of reactivity any loss of coolant accident could lead to a power excursion. A loss of coolant with scram failure in a CANDU will result in rapid melting of the fuel and possibly common mode breach of the containment. [HIRSCH et al. 2005] The large zirconium inventory of the CANDU core reacts exothermically with steam at the temperature which could be reached in a severe accident, this reaction yields hydrogen and this could cause explosions and damage of the containment.

If the calandria vessel is able to withstand the pressure caused by a simultaneous break of a pressure tube and calandria tube it is said in [ICIM 2007, 2-2] no relief ducts would be necessary. Capability of calandria vessel to cope with consequences of pressure tube breaks should be clarified.

Although the large pool of relatively cool heavy water moderator provides an additional heat sink for decay heat removal, and a comparatively benign environment for control and safety instrumentation, there have been problems with unreliable neutron flux monitoring. In case of an accident it is argued the moderator could cool the decay heat of core, provided that the reactor shutdown system had stopped the fission process.

Due to its relatively large size, the core is “decoupled”, which means that neutron flux may significantly vary in different parts of the core, leading to flux oscillations. This design-inherent characteristic makes the CANDU reactor particularly vulnerable to loss-of-regulation accidents, with subsequent power excursion. The record of the industry indicates persistent failure in achieving safety system reliabilities and over-reliance on the containment as the final barrier against a large release. [HIRSCH et al. 2005]

2.2.3 Conclusions

The only genuine passive safety systems in this CANDU reactor are the two shutdown systems. Of the ECCS only the high pressure part is a genuine passive system. Medium and low pressure emergency core cooling are both working with pumps and thus are not passive. From the description of ECCS it is not clear to which extent the system is controlled by active devices.

Planned modifications for Unit 3 and 4 are not explained in detail, and some modifications are not planned yet. Therefore evaluation of the intended improvement is not possible. This is valid for the properties of the improved material compared to existing CANDU's and for other modifications (e.g. main steam valves). New (advanced) CANDU design is praised to have thicker pressure tubes and thicker and larger calandria tubes, stainless steel feeders and headers.

Capability of the moderator circuit and the cooling water in the calandria vault to remove the residual heat if the primary heat transfer system fails are not explained sufficiently.

From the description in the EIA report it is not clear which requirements the core design will meet, in particular it would be interesting to discuss to which extent the IAEA Safety Guide NS-G 1.12 [IAEA 2005] will be relevant for the Cernavoda 3 and 4 design.

2.3 Containment

2.3.1 Treatment of the issue in the EIA report

Description of the containment in the EIA encompasses both the reactor building and the containment system.

The CANDU 6 reactor has a stand-alone containment consisting of a concrete dome. The reactor building has a pre-stressed concrete structure (diameter 41.46 m with a cylindrical perimeter wall of 1.07 m thickness). The CANDU containment is not a passive system. Ventilation dampers & dousing system need power and instrument air. On the upper part of the dome there is a tank mounted, made up from a spherical reinforced concrete with the inner surface covered by a fiber glass reinforced epoxy liner. The tank is storing the required water inventory necessary in accident conditions for dousing system, emergency core cooling system, as well as the make up water for the steam generators secondary side, in case of total loss of feed water supply. [ICIM 2007, 2-47]

The reactor building is seismically qualified to the design basis earthquake (DBE). [ICIM 2007, 2-47] But external threats as natural disasters, airplane crash and other human impacts as terrorism and sabotage are not considered in the design.

Maximum design pressure of the containment is 124 kPa, which is higher than the pressure assessed to be caused by a large LOCA with failure of the dousing system. The test pressure is set at 143 kPa. „*Versus other containment designs, the above value is relatively low but acceptable because of the larger volume of the containment and of the use of a fast pressure suppression system.*" [ICIM 2007, 2-47]

The highest pressure transient would be initiated by main steam line break inside the containment. Even with a partial loss of the dousing system the containment structure would maintain its integrity [ICIM 2007, 2-47].

Design leak rate of the containment is 0.1%/day of the free air volume and 0.5%/day is employed in safety analyses [ICIM 2007, 2-81]. This point is somewhat unclear, because in technical report [CITON 2006] it is said that the allowable leak rate is 0.5 %/day at design pressure (124 kPa), and the limit of 0.1%/day is not mentioned there at all.

„The containment system represents one of the four special safety systems of the plant and the 4th physical barrier against radioactive releases to the environment.... The system includes the protection containment, the dousing system, the local air cooler system and the isolation system." [ICIM 2007, 2-79]

Function of the listed systems is explained with some detail in [ICIM 2007, 2-79f]. To provide its containment function several conditions have to be met:

- Containment airlocks: Inside and outside doors must be closed to maintain the containment pressure in case the containment isolation is required; during normal operation at least one door has to be closed; inside and outside pressure of the airlock door must be matched before opening; the door seals must be operable.
- The dousing system is designed to cope with pressure peaks resulting from LOCAs; the system consists of 6 independent dousing units and the water storage tank in the reactor building's dome. The tank contains 2000m³ water. The dousing systems relates on several valves divided in the two groups with diverse ac-

tuation systems (electrically and pneumatically). The dousing water tank also provides water (500m³) for the emergency core cooling System (ECCS).

- Isolation system is effective by closing the isolation valves/dampers on the process pipes and ducts that are passing through the perimetral wall. The R/B airlocks (equipment and personnel) and a number of as many as 32 isolation valves (dampers) associated to different process systems that penetrate the containment, are parts of the isolation system. The isolation valves are arranged in series pairs, each valve is able to isolate the containment alone. Actuation of the valves is independent from each other.
- Local air cooler (LAC) system consists of 36 LACs for cooling the areas in the reactor building and 4 fans (2 for each reactor end), to cool the calandria vault and the end shields. The purpose of the system is to maintain the temperature in the controlled areas below the design specified limit values. The quantity of heat from the controlled areas is transferred to the recirculated cooling water system and the chilled water system. A number of 16 LACs out of 36 are designated for fueling machine rooms (8) and the steam generator rooms (8), their control being both manually and automatically. These 16 LAC start is initiated by containment isolation on high pressure signal (LOCA). The remaining LACs are provided to cool equipment rooms and other areas of the reactor building at a maximum of 40°C.
- The 4 fans provide the cooling of structural elements at both ends of the calandria to ensure the temperature stays below the dry out value of 65°C.
- Actuation of the containment system is initiated by LOCA type accidents, main steam line break and nuclear fuel failure in the fueling machine rooms. Actuation signal is high pressure or radioactivity concentration. The radioactivity setpoint is selected to prevent a cumulative release higher than 4.1E11 Bq (I-131) or 7.8E14 Bq (noble gases). Initiating the total isolation (closure of all valves) needs two seconds; containment isolation signal also activates the LAC system, which is shut off automatically after the containment isolation procedure is over (24 hours after the initiating event).

Systems and buildings connected to the reactor building:

Adjacent to the reactor building the service building is located which houses among others:

- the main control room (MCR),
- D_2O moderator purification system,
- ECCS low pressure heat exchangers and pumps,
- R/B ventilation system,
- spent fuel reception bay and spent fuel storage bay

The service building is made up of a cast-in-place reinforced concrete infrastructure and a seismically braced steel superstructure closed by thermal isolation coated steel panels. The Service building is qualified at DBE and contains seismically qualified equipment.

Because of the lack of detailed plans and building sections connections and partitions between the containment and the service building cannot be discussed.

Two more important separate buildings are located in the vicinity of the reactor building:

One houses the emergency power supply and the secondary control area, in the other the high pressure emergency core cooling system is located. Both buildings are seismically designed and qualified at DBE.

The fact that the spent fuel pool is outside of the reactor building and the fueling machine has to penetrate the containment is an indication for the challenge containment isolation poses in CANDU reactors. The capacity of the spent fuel pool is sufficient for 6 years operation plus a reserve.

2.3.2 Discussion of the problem

The CANDU design requirements for the containment specified in the EIA report are dated of 1991 [ICIM 2007, 2-35]: *"The Civil structure Code Effective Dates will be the same as those used for Cernavoda 1, with some assessments to determine if the existing structures meet the April 1, 2005 basic requirements. If required, improvements to the existing civil structures will be implemented as long as the risk-cost benefit principles are followed."* [ICIM 2007, 2-35].

External impacts which could damage the containment structure are covered in chapter 7 of the EIA report [ICIM 2007, 7-1f]. The requirement to consider external events depends on the probability of their occurrence: natural risks as storm, tornado and lightning are considered to be negligible, because their frequency of occurrence is very small according to [ICIM 2007, 7-2].

A reflection of the impacts of **climate change** is not presented in the EIA report, not regarding that strong storms and even tornadoes with larger damages on infrastructure occurred more often during the last years in Europe. The same is valid concerning floods: more and bigger floods will become more frequently. Whether the safety margins for floods will be big enough is not explained in the EIA report.

Concerning the impact of **airplane crash** the probability is also regarded as very low: a 10 km radius zone around the plant is a prohibited area according to the preliminary safety report of NPP Cernavoda Unit 2. Referring to the civil air transport, [ICIM 2007, 711] concludes that the risk of an aircraft crash on the Cernavoda NPP due to the air traffic on the air routes and airports in the area is negligible even with the predicted future air traffic for the year 2030; Despite there are military objectives and airports mentioned in the NPP influence zone (30 km radius) [ICIM 2007, 7-12] it is not explained for which impacts the containment is designed (mass, velocity of the missile). Considering the long lifetime of a NPP an increase of flight traffic cannot be excluded, thus at least this issue should be considered in the BDBA analyses.

Impacts of missiles to the containment walls due to failure of equipment in the adjacent buildings of the unit (e. g. from turbine) are not discussed in the risk analysis and cannot be evaluated because only simplified illustrations and no building floor plans and sections are provided in the EIA report [ICIM 2007] as well as in the technical documentation [CITON 2006].

Regarding the **containment system** the EIA report makes clear that containment isolation relies on a complex of (active) safety systems. Their function is explained in some details. However, some information is missing: e. g. it is not clear from the EIA how many parts of the dousing system are necessary to prevent a containment failure.

Containment behavior in case of **BDBA** is not discussed in EIA report. The large zirconium inventory of the CANDU core reacts exothermically with steam at the temperature which could be reached in a severe accident, this reaction yields hydrogen. Hydrogen gas is a threat for the containment stability, because it reacts explosively with containment air. Hydrogen recombining is not mentioned in the EIA report.

2.3.3 Conclusions

From chapter 2 of the EIA report it is not clear according to which standards the containment and its systems are designed. The information given is only that Unit 1 will be the reference for unit 3 and 4. Unit 2 was designed to standards which are probably outdated now. Therefore a discussion about which Canadian and which IAEA standards will be met by the new Cernavoda NPP units is required. Concerning the containment this would be IAEA Safety Guide-1.10 [IAEA 2004].

The next generation of CANDU reactors is planned to have a containment building with steel lined 1.8 m thick walls, designed to withstand external events such as earthquakes, tornado, floods, aircraft crashes and malevolent acts [PETRUNIK 2007]. The improvement of the resistance of the containment structure of Cernavoda Unit 3 and 4 against external events to the standard of a new plant is very unlikely.

Important issues of containment reliability are not dealt with in the documentation:

- the complexity of the containment systems,
- the strategy of relying on enhanced diversity of systems and equipment rather than on passive safety,
- the containment behavior under severe accident conditions.

At the time of grid connection of the Units 3 and 4 some of the applied design codes will be more than 20 years old. The planned evaluation of the existing structures would be of high interest as a basis of comparing the Cernavoda containment with new NPPs in Europe. With a planned lifetime of 30 years, Cernavoda units will probably not be able to meet actual requirements [e. g. EUR 2001, CNSC 2005]. This is of particular relevance because plant lifetime extension is envisaged [ICIM 2007, 2-44f]

Since maps and sections of the buildings are not provided by the EIA report, evaluation of potential impacts of external events, influence of one plant on another and effects of common mode failures at the site is not possible.

2.4 Seismic hazard

2.4.1 Treatment of the issue in the EIA report

The EIA report describes the NPP site as having unique properties being a stable island in an earthquake region: even though *„... the Cernavoda NPP site can be influenced by 7 seismic sources ...”* and the zone around the Cernavoda Nuclear Power Plant is affected by faults, these faults are old and sealed and *„they didn’t move at least since Paleogene, as they are covered discordantly by Eocene and Oligocene formations in the shelf zone of the Black Sea ...”.* Moreover studies made by the Faculty of Geology of the University of Bukarest showed: *„In Cernavoda area the relief is completely different. On the right bank of the Danube, in Dobrogea, there are cliffs, some of them higher than 10 m with respect to the left bank and to the zone between the two branches closing Balta Ialomitei. Based on the studies it can be specified that this morphologic feature is due to erosion, not to active tectonic processes."* And furthermore: *„Taking into account the whole geological context and the tectonic evolution of the zone around the Cernavoda Nuclear Power Plant, on a radius of over 50 km, it results that this one is tectonically stable, without recent reactivations and without obvious elements of tectonic activity."* [ICIM 2007, 4.4-9]

Definitions [AECL 2001]:

- SDE - site design earthquake: the earthquake for which the NPP is designed so that it can still be operated (reoccurrence period T > 100 years)
- DBE - design basis earthquake: the earthquake for which the NPP is designed so that it can still be safely shut down (reoccurrence period T > 1000 years)

As values of Intensities (I) and peak ground acceleration (PGA) the two design levels have been defined by [ICIM 2007, 4.4-12]:

- SDE : I = VII degrees MSK–64, PGA = 0.1g
- DBE : I = VIII degrees MSK–64, PGA = 0.2g

"For the design, the seismic action corresponding to those two levels has been defined by the response spectra given in free field for a horizontal component." [ICIM 2007, 4.4-12].

The conclusion of two in 2005 finalized evaluations: "Probabilistic Seismic Hazard Assessment (PCRA) for Cernavoda NPP", Code 01551-PSA-IR-116, dated 2005/04/29 and the "Level 1 Probabilistic Safety Assessment. Seismic Events Analysis for Cernavoda NPP Unit 1", Code IR-01551-PSA-111, January, 2005 are quoted in the EIA report : *„The conclusions of these documents confirm the qualification level considered in the design for Cernavoda NPP for a seismic event, having an acceleration of 0.2 g, and an occurrence frequency lower than 1E-3, as it was considered in the Final Safety Report."* [ICIM 2007, 4.4-12]

2.4.2 Discussion of the problem

Romania is one of the most active earthquake regions in Europe outside of Italy. On March 4, 1977 Romania suffered the strongest earthquake in centuries. This natural phenomena lasted only 60 seconds but took the lives of 1570 people and injured another 11000. Romania is located in an area where three faults in the earth's surface converge. At the intersection of these plates lies the so-called Vrancea zone. *"This strong concentration of earthquake activity in a relatively small area of approximately 100 km x 100 km is found in only one other area of the world, in the Himalayan region of Hindu Kush"* [KAUFMANN 2001]. The distance from the Vrancea Zone to Bucharest as well as to Cernavoda is 150 to 200 km.

Earthquake risk is a much discussed problem of the Romanian NPP. This concerns seismic qualification of the safety and safety related systems as well as the buildings, the reactor core design, fueling machine and the storage pool of spent fuel. According to the EIA report the relevant systems and buildings are designed to withstand the design basis earthquake (DBE). Some clarification is required concerning the interim fuel storage and radioactive waste storage, as well as other safety relevant installations in the service building.

In the last years seismic and seismic design of NPP Cernavoda often disputed by experts and international organisations:

"*For the Cernavoda plant additional assessment is necessary to confirm the plant design margins against seismic events and the adequacy of fire protection*." [WENRA 2000]. Because the connection of earthquake intensity and acceleration are differently assessed by experts, sufficient safety margins are required in order to prevent a disaster.

[WENZEL & LUNGU 2000] assessed in an investigation the earthquake risk for Romania and found that the expected level of PGA from a Vrancea earthquake with a hundred years recurrence time for the Cernavoda area is approximately 0.3 g. This is three times higher than the SDE for the same recurrence time was established.

One of the requests of the Austrian comment to the scoping stage [WENISCH 2007b] concerned new evaluations required for the assessment of the site and the seismic qualification of the new units. The geological studies quoted in the EIA [ICIM 2007, 4.4] are from 2004, made by the University of Bucarest. There is also stated that the seismic analysis has been approved by an IAEA experts mission.

Since only results of these studies are quoted, the argumentation that the seismic qualification levels are sufficient is not sufficiently explained. Other updated important documents which were finalized by SNN and favourably approved by the IAEA - "Probabilistic Seismic Hazard Assessment (PCRA) for Cernavoda NPP", Code 01551-PSA-IR-116, dated 2005/04/29 and "Level 1 Probabilistic Safety Assessment. Seismic Events Analysis for Cernavoda NPP Unit 1", Code IR-01551-PSA-111, January 2005, are not available. Information on the seismic design safety margins is not included in the EIA report; In the EIA report for Unit 2 it was said that the safety margin would be 12.5%, which will not be enough if the PGA could be 0.3g. This is confirmed by new developments in AECL design. For future plants AECL is going to consider higher acceleration values as design basis:

„For next generation plants (ACR 1000) design basis earthquake (DBE): maximum earthquake postulated as initiating event - equivalent in approach to the Safe Shutdown Earthquake in US NRC regulations." For the reference ACR design the DBE peak horizontal acceleration is 0.3g." [AECL 2002]

The 1000 years return period chosen as design basis for DBE is comparatively brief. Nuclear regulatory authorities in Germany and France stipulate that for the DBE a probability of 1E-4 has to be assumed – equivalent to a return period of 10000 years or longer. Thus, this return period would not conform to good international practice. For floods, a return period of 10000 years is assumed also in Romania [CITON 2006]. It's not understandably why Romania does not use the same return period for earthquakes.

2.4.3 Conclusion

Safety margins of the seismic design are still an important open question. Safe shutdown of the plant has to be ensured in earthquake situations. In respect to the earthquake risk Romania does not comply to good international practice. This would require to assume for the design basis of the safe shutdown earthquake (DBE) a return period of at least 10000 years. The same as is used concerning floods.

Moreover it has to be considered that all 4 reactor buildings at the Cernavoda site are located in a small area and rely on several common systems located in common buildings. In the same area all spent fuel collected in the fuel bays and the interim storage is located. Therefore an earthquake for which the plant is not designed could lead to a large disaster.

In the last years the scientific basis for the evaluation of site seismicity and seismic design has essentially evolved: new methods for geological investigations and experiences from recent earthquake have provided new insights. The new perception is reflected by the IAEA's Safety guide NS-G-3.3: Evaluation of Seismic Hazards for Nuclear Power Plants of [IAEA 2002b]. It would be worth to discuss whether the seismic analysis has been carried out according to NS-G-3.3.

2.5 Steam Generators

2.5.1 Treatment of the issue in EIA report

The reactor is provided with a heat transport system with two independent loops which transfer the heat generated in the fuel during the controlled fission reaction, to four steam generators with light water. The saturated steam from the steam generators is expanding into the turbine, developing mechanical work and afterwards, passing through the condenser, the steam is cooled with water taken from the Danube River via an open intake duct connected to Race 1 of the Danube - Black Sea Canal (DBSC). [ICIM 2007, 1-2]

During normal plant operation there is not primary to secondary circuit coolant leakage; the only radioactive material which is transferred (by diffusion) to the secondary circuit is tritium. [ICIM 2007, 4.9-15]. Any steam generator tube failure results in the transfer of some of the coolant together with the associated radionuclides from the primary circuit to the steam generator secondary side. This results in the release of radionuclides to the environment, but the permissible limits are not exceeded. The occurrences of such failures require the reactor shutdown in order to locate and repair the failed tubes. [ICIM 2007, 4.9-16]

2.5.2 Discussion of the problem

The steam generators (SG) in CANDU reactor systems are similar to SG in pressurized water reactors. The small tubes were the heavy water is going through are exposed to high pressure and high temperature. Corrosion and abrasion are weakening the tube walls in all Steam generators. SG are not described in the EIA report although they are an essential barrier between the primary core cooling systems (PHTS) and the secondary cooling system which is not part of the nuclear system. SG tube leak rates are not mentioned in the EIA report. An indication that not all radioactive material is contained inside of the SG is the activity concentration in the air of the SG room of e.g. I-131: 0.9 Bq/m³ and H-3: 1.52E+7Bq/m³. [ICIM 2007, table 4.9.1-10]

2.5.3 Conclusion

A description of the SG with information on leak rates and considering SG aging problems is relevant for the environmental impact and therefore should be part of the documentation. Moreover the planned steam valve modifications should be explained.

2.6 Existing buildings, common buildings and systems

2.6.1 Treatment of the issue in the EIA report

The EIA report provides no information about the conditions of the buildings after the long construction break, and whether or how the buildings have been mothballed during this period. At the time of grid connection of the units 3 and 4, the design of the **civil structures** will be more than 20 years old.

"The buildings for the 5 reactors have already been constructed and for Units 3 and 4, some of the components and services are common to the other units as well. It is estimated that the civil work finalization degree for the NSP & BOP (without the hydro works) for Unit 3 is about 52 % and for Unit 4 is about 35 %; ... Water supply and sewage are finalized 49 % for Unit 3 and 30 % for Unit 4." [ICIM 2007, 1-3]

The Cernavoda CANDU 6 reactors are stand alone units. But some technological services at Cernavoda NPP are common for all units: the system for cold water supply from Danube with a common inlet construction (Race 1). Although in separate compartments for each unit, pumps and electric stations of all units are in the same building. Also the fire water intake and pump system is common for all units. Water intake and pump station building for emergency water supply is common for units 3, 4, and 5. [ICIM 2007, 2-4f]. **Common mode failure** of these systems e. g. in case of a natural disaster is not discussed in the EIA report [ICIM 2007, 2-52f].

"Units 3 and 4 will have the Unit 2 design as a reference design in respect of the design solutions and will include possible feasible improvements applied to similar NPP units as Wolsong 3 and 4. The latest editions of the design standards, quality assurance and nuclear safety standards will be adopted." [ICIM 2007, 1-3]

"The code effective date for Cernavoda NPP Unit 3 and Unit 4 project is April 1, 2005 with the exception of the codes related to the existing Civil structures, which were built to the codes at the time of Cernavoda 1. This is the case of Units 3 and 4 containments. The civil structure code effective dates will be the same as those used for Cernavoda 1, with some assessments to determine if the existing structures meet the April 1, 2005 basic requirements. If required, improvements to the existing civil structures will be implemented as long as the risk-cost benefit principles are followed." [ICIM 2007, 2 -35]

2.6.2 Discussion of the Problem

Since construction work for Cernavoda NPP has begun in the 80ies, there are obviously restrictions for the adaptation of the units to recent safety standards. This implies that **structural improvements** of the building are not easy to implement. Such improvements could be required for enhanced seismic resistance, or for protection against aircraft strike, terrorism and sabotage.

„The basic safety features of the CANDU 600 concept have not developed very much over the years. When construction of Unit 1 restarted in 1991, design improvements were introduced similar to those already implemented in the twin plants of Wolsung (South Korea), Point Lepreau and Gentilly–2 as a result of their operating experience and PSA studies. The main improvements include better separation between control and shutdown system, modification of control room design, provision for post LOCA sampling capability in the containment, etc" [WENRA 1999].

Plans for new CANDU NPP discussed in the literature, praise that next generation CANDU reactors will be designed for enhanced safety and reliability. [PETRUNIK 2007]

2.6.3 Conclusion

Maps and sections of the buildings are missing in the EIA report. Therefore the evaluation of potential impacts of external events, influence of one plant to another and effects of **common mode failures** at the site are not possible.

At the time of grid connection of the Units 3 and 4 some of the applied, design codes will be more than 20 years old. The planned evaluation of the existing structures would be of high interest as a basis for comparing the Cernavoda containments with new NPPs in Europe.

With a planned lifetime of 30 years, Cernavoda units will probably not be able to meet actual requirements [e.g. EUR 2001, CNSC 2005]. This is of particular relevance when plant lifetime extension is envisaged [ICIM 2007, 2-44]

Start of Operation for the new reactor units is planned at 2013/14. At this time the design basis of these units will be at least 10 years old; and parts which can't be modernized will likely represent the standard of the 80ies.

In general it appears that since unit 2 is said to be the reference plant for unit 3 and 4 the safety requirements follow outdated standards, e.g. 50-SG-S5 (1981) referred to in chapter 7 of the EIA report. This IAEA document has been revised in 2002 (new version: NS-G-3.1). [IAEA 2002c]

Some of the announced improvements are not planned yet; mandatory modifications concern mainly operational problems.

In particular concerning the accident analysis deficiencies on information compared to recent design guidelines and requirements are of high importance.

Several relevant systems are located in common buildings. Therefore common mode failure in case of natural disaster or other external events cannot be excluded.

3 EMISSIONS AND DOSE ASSESSMENT

In principle, there is no impact on Austria expected during normal operation conditions. However, chapter 4, “Potential Impact on Air”, of the EIA report [ICIM 2007] is still relevant for the evaluation of potential impacts on Austria, because such an impact cannot be excluded from consideration with respect to abnormal operation conditions and accidents. Potential transboundary impacts are not sufficiently treated, on the contrary, they are even denied: *“... Taking into account the minimum distance between the Cernavoda site and other countries (40 km from Bulgaria) one can conclude that the transboundary effects of the Romanian nuclear units operation are insignificant even in the case of a Design Basis Accident ...”* [ICIM 2007, 7-27].

Furthermore, the EIA report [ICIM 2007] points out, that under abnormal conditions (and therefore in case of accidents as well) there might be unmonitored releases of vapor, which could be contaminated with deuterium, tritium, radioactive aerosol particles and gases. There is no quantification of possible contaminations in case of accidents. The document does not use up-to-date meteo data and does not deal with possible future trends concerning global climate change.

At the moment, in reference to the EIA report [ICIM 2007], neither the radiological impact on neighboring countries (e.g. Bulgaria) due to normal operation, nor the radiological impact on other countries (e.g. Austria) due to abnormal operation conditions and accidents, is assessable. This makes an accurate and more detailed analysis of the potential impact on air necessary.

3.1 Climate and meteorological data

3.1.1 Treatment of the issue in EIA report

The EIA report [ICIM 2007, 4.2.1.1] and [ICIM 2007, 4.2.1.2] presents data based on meteorological studies elaborated on the basis of the recorded meteo data at Cernavoda during 1986-2003.

3.1.2 Discussion of the problem

The EIA report [ICIM 2007] does not deal with possible future trends concerning global climate change, which in our opinion will also influence the development of the regional climate. The possible change of climate and meteorological characteristic data could have an extensive and long-range influence on groundwater level, occurrence of floodings, average and maximum wind speed, wind direction, occurrence of strong gale, solar radiation, maximum precipitation quantities, maximum and minimum temperature, and others.

3.1.3 Conclusion

A discussion of the potential influence of climate change on the NPP itself and furthermore on pollutant diffusion and transport conditions is necessary. At the moment, in reference to the EIA report [ICIM 2007], neither the radiological impact on neighboring countries (e.g. Bulgaria) due to normal operation, nor the radiological impact on other countries (e.g. Austria) due to abnormal operation conditions and accidents, is assessable.

3.2 Gaseous emission

3.2.1 Treatment of the issue in EIA report

Table 4.2.3.2-1 *“Gaseous emissions activity estimated for one Unit and gaseous emissions reported at Cernavoda Unit 1”* presents data on aerosol particles emissions activity [ICIM 2007, 4.2-38]. Derived limits and estimated data are compared with measured data of Cernavoda Unit 1. Furthermore, table 4.2.1.4-7 [ICIM 2007, 4.2-25] compairs pre-operational values of tritium concentrations in air with values during operation, both at the location Campus Cernavoda.

The collection of gaseous effluents is made by the ventilation systems. The overall ventilation system is so designed that the air circulation should be carried out from low-potential contamination areas to high-potential contamination areas, and finally, after filtering, the air is exhausted through a ventilation stack [ICIM 2007, 4.2-42]. The ventilation systems are provided with air filter. The control of the gaseous radioactive effluents is performed both by filtering and automatically isolating the containment in case of detection of abnormal radioisotope concentrations. Chapter 4.2.3.1.II. presents other potential gaseous pollution sources, which are not controlled by the plant ventilation systems, namely the steam valves.

3.2.2 Discussion of the problem

The data set might be unsufficient, with respect to potential impact on air due to radioactive aerosol particles (particulates). Only estimated data on aerosol particles emissions activity are presented, the reported data are missing. Reported data are also missing for the iodine activity of some years. As demonstrated in table 4.2.3.2-1, over the time span of nine years, from 1996 to 2004, only three values for the recorded annual activity of the iodine isotope I-131 are reported, for the years 1997, 1998 and 2001. Six values are missing. Due to the fact, that Unit 1 technically shall represent Unit 2, Unit 3 and Unit 4, measured data on aerosol particles emissions activity and iodine activity concerning Cernavoda Unit 1 are of major interest.

We put emphasis on the visible increase of concentrations of radiotoxic tritium in air at the location Campus Cernavoda, as shown in table 4.2.1.4-7 [ICIM 2007, 4.2-25]. The pre-operational values of tritium in air vary between 0.03 and 0.2 Bq/m3, the minimum concentration after commissioning and activation of Cernavoda Unit 1 increased to the sixtyfold (2.0 Bq/m3), the maximum concentration to the twentyfold value (4.1 Bq/m3), with an average of 3.3 Bq/m3, under normal conditions. The targeted quadruplication of the number of operating units (Unit 1, Unit 2, Unit 3, Unit 4) will have a quadruple negative effect on the tritium concentration.

In figure 4.2.1.4-8 [ICIM 2007, 4.2-31] tritium concentrations in samples of precipitation from Cernavoda, in comparison with Calarasi, Slobozia and Bucharest show remarkable higher tritium concentration values. Attention should be payed to the logarithmic scale of the ordinate. The concentration at Cernavoda shows up to tenfold (!) higher values than at the other sites, with only operation of Cernavoda Unit 1! A similar effect is to be expected concerning other radioactive contaminated vapors and gases.

3.2.3 Conclusion

Due to the usage of the „Aerosol (Particulate) System" [ICIM 2007, 4.2-45] for determination of the aerosol particle activity, these data should be presentable, except the „Aerosol (Particulate) System" is a new installation only for Cernavoda Unit 3 and Cernavoda Unit 4, and Cernavoda Unit 1 did not have such a monitoring device. This has to be clarified.

If available, all missing data should be presented. If not available, an explanation for the missing values should be given. A properly operating monitoring system is an indispensable requirement for the release management concerning the radiological impact on air. A monitoring system failure probability of 0.66 would be too high in order to truly guarantee controlled emissions.

Only the presentation of these data enables the assessment of the radioactive impact on air caused by the synchronous operation of all four units (Cernavoda Unit 1, Cernavoda Unit 2, Cernavoda Unit 3 and Cernavoda Unit 4). At the moment, in reference to the EIA report [ICIM 2007], neither the radiological impact on neighboring countries (e.g. Bulgaria) due to normal operation, nor the radiological impact on other countries (e.g. Austria) due to abnormal operation conditions and accidents, is truely assessable.

A statement about the absolute nonradioactivity of the steam escaping from the steam valves should be given, and if the steam shows up radioactive pollution, a quantification of the estimated amount of radioactive emission (tritium, deuterium, and others) shall be figured out. At the moment, in reference to the EIA report [ICIM 2007], neither the radiological impact on neighboring countries (e.g. Bulgaria) due to normal operation, nor the radiological impact on other countries (e.g. Austria) due to abnormal operation conditions and accidents, is assessable.

3.3 Derived Emission Limits (DEL)

3.3.1 Treatment of the issue in EIA report

The methodology for calculation of Derived Emission Limits (DEL) is described [ICIM 2007, 4.9-34]. The actual process of calculating the DEL's is broken into 6 steps. Step 2 explains the necessity to develop appropriate expressions relating the release rates to the dose rates to an individual.

Table 4.2.3.2-1 *"Gaseous emissions activity estimated for one Unit and gaseous emissions reported at Cernavoda Unit 1"* presents data on aerosol particles emissions activity [ICIM 2007, 4.2-38]. Derived limits are compared with measured data of Cernavoda Unit 1. The document emphasizes: *"... By analyzing the gaseous emissions reported at Cernavoda NPP Unit 1 (represented in table 4.2.3.2-1) one remarks that all the activity concentrations are within the administrative limit of 5%-DEL ..."*.

3.3.2 Discussion of the problem

The description is not sufficient. It is not possible to re-enact which expressions are used to obtain the DEL values and which data contribute to the calculation. Exactly these expressions would explain how the emissions of the Cernavoda NPP contribute to the immissions of the country.

Furthermore it is not understandable, whether and how the dispersion factors presented in figure 4.2.1.2-1. [ICIM 2007, 4.2-17] are considered within the calculation of the DEL's [ICIM 2007, 4.9.2]. A description of the computer program (name of software) and its operation mode (algorithmus) is missing.

In this respect the EIA does not meet the requirements of the European Comission's EIA directive [EC/85/337] and of the ESPOO Convention [ESPOO 1997]. This deficiency (together with others) prevents the understanding of the calculation of the exposure in case of DBA and BDBA.

Basically, the fact that one measured activity value is located within the administrative limit does not indicate a proper function of the NPP. Both the "derived emission limit" (DEL) and the "annual emission quantity" (Q) has to be obtained first, for each relevant radionuclide. The criterion for dose limitation given in the EIA report [ICIM 2007, 4.9-36] says, that the total sum of the Quotient of Q and DEL has to be smaller than 1. Even if each emission quantity value lies within the 5%-DEL, the sum of more values within the limit can easily exceed the value 1, depending on the total number of relevant radionuclides. Only the sum (= criterion for dose limitation) is the decisive argument for proper functionality. Statements based on discrete DEL's can be missleading and should be avoided.

3.3.3 Conclusion

It is of high importance to get a more detailed methodology for calculation of DELs with complete mathematical expressions. At the moment, in reference to the EIA report [ICIM 2007], the radiological impact on air is not assessable.

The EIA report emphasizes, that all the activity concentrations measured from unit 1 are within the administrative limit of 5%-DEL. This statement is misleading. Basically, the fact that one measured activity value is located within the administrative limit does not indicate a proper function of the NPP. Only the criterion for dose limitation which considers the impact of all radioactive emissions is a decisive argument for proper functionality. It is still unclear whether the limits consider that the operation of all 4 units must not cause an exposure exceeding the dose limit of 1 mSv per year for the population.

The criterion for a proper function of the emission limiting system [ICIM 2007, 4.9-36] should be examined by consideration of all relevant radionuclides, respectively their Q's and DEL's. Particularly with regard to the synchronous operation of all four units, the criterion should also be examined under consideration of the 5%-DELs. This examination should be presented in an understandable way in order to see whether Cernavoda Unit 1 complies with the requirements. This is one necessary precondition (amongst others) to adduce Unit 1 as an instance for Unit 2, Unit 3 and Unit 4. At the moment, in reference to the EIA report [ICIM 2007], the proper functionality of Cernavoda Unit 1 is not fully assessable and therefore cannot be seen as an example for the other units.

3.4 Gaseous Effluent Monitor

3.4.1 Treatment of the issue in EIA report

The function of the **Gaseous Effluent Monitor** (GEM) is presented in the document. The GEM monitors gaseous effluents and compares actual effluent release values with limiting values. The compliance of these limiting values shall guarantee, that no individual from the population will receive a radiation dose larger that 1 mSv/year. On one hand, the usage of the administrative limit (5% DEL) is notified: „For estimation of critical groups exposure, taking also into consideration the contribution of the other radiation sources on the Cernavoda NPP site, a more restrictive administrative limit was established, representing the operating target for each nuclear power unit ... representing 5% of the allowed dose to the public ... in the event that radioactive effluent emission exceeds this operating target ... steps will be taken to identify the causes and to take practical action to remediate the situation.” [ICIM 2007, 4.2-37]. On the other hand, the document says: „The GEM ... sums up the effluents released for a week and compares the results with Derived Emission Limit DEL” [ICIM 2007, 4.2-45].

3.4.2 Discussion of the problem

The document presents the monitoring of the effluents of one unit. Synchronous operation of four units results in quadruple effluent values. During synchronous operation of all four units, the GEM system should compare the DEL with the sum of effluents of all four Units. Alternatively, if every unit has a separate GEM system (this is not presented clearly enough), a much lower DEL should come into use as the reference value for each unit. In the case of synchronous operation of four units, the maximum DEL should be 25% of the normal” DEL, in order to guarantee that the maximum allowed dose to the public of 1 mSv is still not exceeded. The best solution would be the usage of the 5%-DEL for each unit, representing the operating target for each nuclear power unit presented in the document [ICIM 2007, 4.2-37]. Since it is not clear, whether every unit has a separate GEM system and which DEL is used by the GEM, an appropriate monitoring cannot be assessed.

3.4.3 Conclusion

It has to be clarified, whether every Unit has a seperate GEM system or all four Units are monitored by one GEM system. Secondly it has to be clarified, which DEL is used within the GEM system during synchronous operation of all four units: the DEL or the 5% DEL?

4 ENVIRONMENTAL RADIOACTIVITY MONITORING

4.1 Treatment of the issue in EIA report

In the EIA report the environmental radioactivity monitoring of Unit 1 is described in chapter 6.

For several media (filters, water, soil, sediment, food, milk) the type of analysis, the "*minimum detectable required specific activity*", the frequencies of sampling and analysis are listed. Also the numbers of sampling points for the different sample media are given. [ICIM 2007, 6-10ff]

4.2 Discussion of the problem

S.N. Nuclearelectrica is responsible to install and operate a monitoring program. This program is presented in the EIA report. It is not clear if in Romania also other authorities are monitoring environmental radioactivity. It would therefore be helpful if the EIA report would give information about monitoring activities of CNCAN or other authorities. Without this information we miss an overview of radioactivity monitoring in Romania.

In the EIA report chapter 6 there are references cited in Romanian language, but there are no detailed descriptions in English and no maps of the sampling points included. Also there are no detailed descriptions of the analysis methods and of the assessment methods for dose.

The quarterly frequency of iodine analysis in air seems to be too low [ICIM 2007, 6-11]. In Germany the owner of a NPP is obliged to sample iodine in air continuously and to analyze it every 14 days [BMU 2006].

Underground water measurements have a *"minimum detectable required activity"* for tritium that seems unnecessarily high (350 Bq/l) [ICIM 2007, 6-13]. In Germany 10 Bq/l detection limit are standard [BMU 2006]. An Austrian laboratory has a detection limit of 5 Bq/l water if measured with LSC [ARC 2007].

Drinking water is not measured at all. The existing limit for tritium in drinking water according to [EC/98/83] is 100 Bq/l. Especially if drinking water is taken from underground water, 350 Bq/l as a "minimum detectable required activity" is much to high.

The frequency of sampling of food is not described clearly enough. Some vegetables have more than one vegetation period per year (f.e. salad), and if only one sample is measured once a year contamination could be underestimated. Also it is not clear if home-grown vegetables and fruits are measured and /or imported ones. It is recommended that measurements take place monthly respectively quarterly [EURATOM 2000/473], and in accordance to harvest times [BMU 2006].

The monitoring program for the different emergency planning zones is not described. For example it is not clear how the town of Cernavoda is monitored, and if monitoring is also undertaken in the 50km zone.

In [EURATOM 2000/473] basic standards for environmental radioactivity monitoring of the EU member states are given:

For air continuously dose rate measurement all over the country is recommended [EURATOM 2000/473]. In [ICIM 2007, 4.2-26f.] results of dose rate measurements are listed. It seems that on 23 locations outside the NPP dose rates are measured, a map is missing. ICIM performed in 2004 gamma dose rate measurements in a radius of 60 km around the NPP. It is not clear if these measurements were a singular action or if they are repeated continuously [ICIM 2007, 4.2-23]. It should be clarified who is responsible for a continuous dose rate measurement in Romania.

As in chapter 8 of this report is proven that an accident can contaminate even areas in Austria, it seems necessary that a dose rate system is established all over Romania.

Austria, as an example of good practice, has an Early Warning System, consisting of 336 dose rate measurement locations all over the country, with which it is possible to detect activity in air very fast. [UBA 2007]

In Germany such dose rate monitoring is also obligatory to measure continuously around NPPs [BMU 2006].

Also it is good practice to publish the dose rate data regularly. In Austria data of 96 locations are published every day by the national television company ORF in the so-called Teletext and via Internet (http://www.teletext.orf.at).

In [ICIM 2007, 6-5] it is stated that the monitoring program *“may demonstrate negligible environment impact of Cernavoda NPP operation and hence contribute to public reassurance.”* This could only be the case if the results of the monitoring program would be more detailed and if they would be published regularly. Also an independent monitoring in addition to the monitoring from S.N. Nuclearelectrica could reassure the public.

From the EIA report it is unclear whether and how the population is regularly informed about the results of the monitoring program.

4.3 Conclusion

The environmental monitoring program seems not be sufficient to detect all contaminations.

The quarterly analysis frequency of iodine in air seems to be too low compared to an analyzing frequency of 14 days around German NPPs [BMU 2006].

Drinking water is not measured at all.

The tritium detection limit in water (350 Bq/l) is too high compared to the technical possible detection limit of 10 Bq/l [BMU 2006] and – if drinking water is taken from underground water - to the EU limit of 100 Bq/l [EC/98/83].

The annual analysis frequency of food samples is too low compared to European recommendations of monthly respectively quarterly measurements [EURATOM 2000/473]. Also the sampling should take place in accordance to harvest times [BMU 2006].

For air continuously dose rate measurement all over the country is recommended [EURATOM 2000/473]. On 23 locations outside Cernavoda dose rates are measured, a map is missing. Because an accident could contaminate the whole country (see chapter 8) a dose rate system should be established all over Romania as it is the case f.e. in Austria [UBA 2007] and in Germany [BMU 2006].

Data about the location of the sampling points and the detailed analysis methods should be added.

The population should be informed regularly about the monitoring programs and results.

5 RADIOACTIVE WASTE AND DECOMMISSIONING

5.1 Low and intermediate level waste (LILW)

5.1.1 Treatment of the issue in EIA report

Treatment and temporary storage of spent ionic resins (ionic exchange resins) take place in the Spent Resins Handling System. The resins are stored in the basement of the service building, which has seismic qualification to DBE.

Organic Liquid Radioactive Wastes are collected and stored in the basement of the service building in drums authorized by CNCAN.

LILW is conditioned and stored in the Solid Radwaste Intermediate Storage (DIDR) on-site. The DIDR is seismically qualified to DBE or to Romanian standard P100-92.

This DIDR was planned for solid waste from Unit 1 and 2. *"The extension of the storage complying with U3 and U4 solid radwaste production will be analyzed."* [ICIM 2007, 2-51] There is no further information about this extension.

A national final surface disposal facility (DFDSMA) for LILW is planned to be put in operation in 2014.

5.1.2 Discussion of the problem

Data for ionic resins waste seem to be incomplete: In table 3.2.1.2-3. volume and activity of ionic resins are stated as zero in each dose rate category [ICIM 2007, 3-11].

There is no information about the planned extension of the DIDR.

Also there is no information given about the planned national repository for LILW, including possible new waste treatment facilities. It seems that such facilities will be built on site: *"All law and Intermediate level waste produced by NPP are stored on-site. For these wastes it is expected the construction of a near surface repository, equipped with an appropriate facility for waste treatment and conditioning."* [JOINT CONVENTION 2005, 15]

Missing is a strategy ("road map") for the planned final repository, including plans of the design, capacity, siting, construction, but also for the licensing and an EIA process.

In the ESPOO Convention Appendix II it is listed what content an EIA report should include, that is amongst others a description of the proposed activity, a description of the potential environment impact, and a description of mitigation measures. [ESPOO 1997] In [EC/85/337] it is asked to include significant environmental effects caused by waste into an EIA (§ 6 Art. 4 lit c).

But neither for the extension of the DIDR, nor for possible future treatment facilities, nor for the planned national final repository for LILW such specifications are given in the EIA report. Therefore the environmental impact of the LIL-radwaste of Units 3 & 4 cannot be assessed.

5.1.3 Conclusion

Romania should present thorough radioactive waste management strategy before-starting the construction of new NPPs.

Information about the extension of the existing storage DIDR is missing.

There seems to be no strategy for the planned final repository for LILW, including plans of the design, capacity, siting, construction, but also for the licensing and an EIA process.

Therefore the EIA report seems not to be in accordance to the ESPOO-Convention and the EC 85/337.

5.2 High level waste/spent fuel (HLW)

5.2.1 Treatment of the issue in EIA report

After 6 years of storage in the spent fuel bay (pool) on site the spent fuel is stored at the Interim Spent Fuel Dry Storage (DICA) close to the site for the planned Unit 5. Data on the yearly amount of spent fuel are missing in the EIA report. DICA is in operation since 2003. It is designed for waste from Unit 1 and 2 for a period of at least 50 years. For the spent fuel from Unit 3 and 4 DICA has to be extended. *“This will be made in order not to affect the technological solution already accepted and approved by the respective Authorities.”* [ICIM 2007, 2-51f.]

A national repository for HLW is planned to be put in operation in 2055.

5.2.2 Discussion of the problem

Information about the planned national repository for the spent fuel/HLW that shall be put into operation in 2055 is missing. In the Romanian National Report for the Joint Convention [JOINT CONVENTION 2005, 6] it is commented that the 50 years storage time for the spent fuel in the Spent Fuel Dry Storage can be extended up to 100 years (*“if the behaviour of the storage will be in accordance with the present suppositions”*).

“The siting of spent fuel deep geological repository was not yet addressed by Romanian regulations, as the existing strategy takes into consideration at least 50 years of dry storage.” [JOINT CONVENTION 2005, 88] It seems that further delays cannot be excluded.

Missing is a strategy (“road map”) for the planned final repository, including plans of the design, capacity, siting, construction, but also for the licensing and an EIA process.

The planned extension for the DICA is not described. Especially if the DICA will be used up to 100 years it should be proven that the casks and buildings are designed for such a long period. Also it should be stated how monitoring and safety management of the DICA will be guaranteed over a period of 100 years.

As it is the case for the LILW management, the discussion of the HLW and spent fuel management also does not fulfill Espoo and EC criteria for EIAs. Neither for the extension of the DICA nor for the planned national final repository for HLW/spent fuel a description is given in the EIA report. Therefore the environmental impact of the high level radwaste of Units 3 & 4 cannot be assessed.

5.2.3 Conclusion

Romania should present sound spent fuel and radioactive waste management before the construction and operation of new NPPs.

Information about the extension of the DICA is missing.

It is not clear if the interim dry storage will be used for 50 or 100 years, and it is not clear if it is even designed for a period up to 100 years. Also it is not stated how monitoring and safety management over such a long period of time will be organized.

There seems to be no strategy for the planned final repository for HLW/spent fuel, including plans of the design, capacity, siting, construction, but also for the licensing and an EIA process.

Therefore the EIA report seems not to be in accordance to the ESPOO-Convention and the EC 85/337.

5.3 Decommissioning

5.3.1 Treatment of the issue in EIA report

In chapter 2.3.1 of the EIA report the Decommissioning Concept is discussed. Listed are Romanian and international standards for preparing a Decommissioning Plan.

Three generic options of decommissioning are presented: the Safestore option (Deferred Dismantling), the Decon option (Immediate dismantling) and the Entomb option. The last one, the Entomb option, *"… isn´t considered a possible alternative for Cernavoda NPP Unit 3 and Unit 4."* [ICIM 2007, 2-95] It is not stated which one of the other options will be chosen.

Several criteria are listed for selecting an option, for example: *"Unavailability of the repositories for radioactive waste at the moment of final shutdown requires the option for a 'Safestore' strategy or resource allocation for the construction of intermediate storage facilities. In the case that needed costs for these facilities are included in decommissioning founds estimation, is benefit to use a waiting strategy…"* [ICIM 2007, 2-97]

For types of components estimated weights and contamination degrees are given. In total 10001 (!) tons of components are estimated, of which 84.5 % are highly contaminated. [ICIM 2007, 3-35]

5.3.2 Discussion of the problem

It is not possible to estimate if waste from decommissioning can be stored in the existing storages because information about the extensions of DIDR and DICA are missing. Because no data about the final repositories for HLW and LILW are given it cannot be guaranteed that the waste from decommissioning can be safely stored at all.

It is not clear what option will be chosen for decommissioning. There is no estimation of the costs for the different options.

In [WENISCH 2007b] the question was raised if decommissioning and dismantling will be subject of another EIA process before closure of the plant. This question was not answered in the EIA report.

In [WENISCH 2007b] it was also asked if waste arising during lifetime from incidents/accidents or aging could be stored in the storage at the NPP. This question cannot be answered because information about the extension of the storages is incomplete.

5.3.3 Conclusion

From the existing data it cannot be proven that the wastes arising from decommissioning can be stored in the existing storages because information is missing about the extension of the storages. Also information is missing about the planned final repositories.

The costs are not estimated. Financing is not guaranteed by now.

5.4 Financing of the radioactive waste management

5.4.1 Treatment of the issue in EIA report

The National Agency for Radioactive Waste (ANDRAD) is responsible for the coordination of the financing. The “Decommissioning and radioactive wastes ultimate repository fund” has not been established by now. [ICIM 2007, 3-3]

Discussion of the problem

Because the fund for financing of the radioactive waste management and decommissioning has not been established by now, adequate financing for radwaste treatment and storage seems not to be guaranteed.

Also there is no information about the estimated costs of decommissioning.

5.4.2 Conclusion

A sound spent fuel and radioactive waste management strategy is a condition for the construction and operation of new NPPs. Such a management strategy also includes adequate financing of all activities and storages. Because the fund for financing of the radioactive waste management and decommissioning has not been established by now financing is not guaranteed.

6 ACCIDENT ANALYSES

6.1 Treatment of the issue in the EIA report

The accident analysis of Cernavoda NPP is based on a system of occurrence frequencies of accident sequences and related dose limits [ICIM 2007, table 7.4-6]. The analysis includes loss of coolant accidents (LOCA), steam generator tube rupture, main steam pipe break, and loss of feedwater accidents. These events are analysed under the assumption of unavailability of a special safety system. Another type of events is assessed as initiating events (IE) in Probabilistic Safety Assessment (PSA) [ICIM 2007, table 7.4.3.]. These events imply, besides LOCAs,

- failure of electric power, instrument air, service water or plant computer control,
- loss of steam generators (SG),
- failures of fuel handling, and
- events during reactor shutdown

Design basis accidents:

"Category A events are deterministically analysed. Conservative assumptions are used for initial plant conditions and mitigating systems availability, which impose the most stringent conditions on safety system design. The category A events are called Design Basis Events; their analysis is the subject of Chapter 15 of a NPP Preliminary/Final Safety Report." [ICIM 2007, 7-14]

"The frequency limit recommended by AECB for evaluation of the events with radiological consequences is 1E-6 events/year and thus a consequence analysis is not required for event sequences occurring with less than this frequency limit." [ICIM 2007, 7-15]

The table below presents all the DBA sequences and their classification according to the EIA report [ICIM 2007, 7-21].

Table 1: Acceptance criteria (occurrence frequency and public dose limit) for category A and B events [ICIM 2007 table 7.4-6]

Event class (as per C-6 document)	Occurrence frequency (events/ reactor x year)	Public individual dose limit (mSv)	
		Whole body	Tyroid
1	$10^{-2} \leq f < 1$	0,5	5
2	$10^{-3} \leq f < 10^{-2}$	5	50
3	$10^{-4} \leq f < 10^{-3}$	30	300
4	$10^{-5} \leq f < 10^{-4}$	100	1000
5	$f < 10^{-5}$	250	2500

The presentation of analysis results in the EIA report [ICIM 2007, 7-16, table 7.4.1] allows the conclusion that, provided that one of the two shutdown systems is available, most initiating events can be controlled, exceptions are large LOCA, multiple

SG tube rupture and FW pipe break. LOCA coincident with failure of ECCS injection or loop isolation, or coincident with containment failure would lead to relevant emissions (event class 5), this assessment is confirmed by table 7.4.7 of the EIA report [ICIM 2007, 7-23].

The results presented in the table below [ICIM 2007, table 7.4.7.] show the estimated doses for DBAs according to the Preliminary Safety Report of Cernavoda Unit 2.

Table 2: Individual doses due to the DBAs with the most severe radiological consequences, estimated at exclusion zone boundary [ICIM 2007, table 7.4.7.]

Event	Class as per C-6	**Individual dose** (mSv)	
		Tyroid	Effective
Large LOCA	3	1.60	0.451
Feeder break with flow stagnation	2	2.96	0.387
Fuel channel flow blockage	2	4.23	0.861
End fitting failure	2	2.10	0.393
Main steam line break outside containment	3	1.30	0.444
Steam generator single tube break followed by loss of class IV electric power	4	0.606	0.261
Large LOCA, with ECCS unavailable	5	147	17.4
Feeder break, with ECCS unavailable	5	44.2	7.10
Large LOCA, with containment isolation unavailable	5	1080	80.3
Feeder break, with containment isolation unavailable	5	1860	151
Fuel channel flow blockage, with containment isolation unavailable	5	16,5	4,08
End fitting failure, with containment isolation unavailable	5	1030	109

Beyond design basis accidents

In the EIA report some "non-design-base accidents" are presented, which are covered by the Preliminary Safety Report of Cernavoda Unit 2 [ICIM 2007, table 7.4.8.]. It is stated that: "*... it is clear that both DBAs and BDBAs for Cernavoda NPP have non-significant radiological consequences for the public located outside the exclusion boundary (1 km from the reactor)* [ICIM 2007, 7-25].

Table 3: *Individual doses due to (BDBAs considered in PSAR) estimated at exclusion zone boundary [ICIM 2007 table 7.4-8]*

Event Description	AECB (CNSC) C-6 Class	Dose (mSv) Thyroid	Dose (mSv) Effective
Reactor main coolant system large LOCA plus loss of Class IV power plus Failure of Containment Isolation Logic	NDB	1970	171
Flow blockage in any single reactor fuel channel assembly plus total failure of containment atmosphere cooling equipment.	NDB	3.94	0.763
End fitting failure plus total failure of containment atmosphere cooling equipment.	NDB	2.04	0.404
Pressure tube/calandria tube failure plus total failure of containment atmospheric cooling equipment	NDB	2.02	0.312
Reactor main coolant system large LOCA plus total failure of containment atmosphere cooling equipment.	NDB	1.69	0.46

According to the EIA report a further treatment of core damage accidents is not required, because:

"The radiological accident analysis dealing with damage of the fuel bundles is conservatively bounded by another event. End fitting failure plus failure to close of the containment isolation devices associated with a single containment subsystem for the system most critical for radioactive release from containment" that is analysed in Chapter 15 of PSAR [ICIM 1007, 7-1]. The analysis of this accident results in an effective dose of 109 mSv , which is well below the dose limits specified for Class 5 events, i.e. 250 mSv according to an email of SITON [ICIM 2007, Ref. 7-19]. We want to emphasize that this scenario covers obviously only the failure of one pressure tube.

6.2 Discussion of the problem

Since Romania is a member state of the European Union, the practice of AECB to disregard radiological consequences of accidents if their probability of occurrence is less than 1E-6/a is not relevant for other EU member states. Romania should adapt its licensing practice to that of other member states of the EU.

Dose limits according to EURATOM 96/29 are defined as follows:

- for members of the public: effective dose 1 mSv/a and a maximum of 5 mSv over 5 consecutive years;
- for exposed workers: 20 mSv /a and a maximum of 50 mSv in 1 year, if the sum of 5 consecutive years is ≤100 mSv

The two tables above show the estimated doses for DBAs and BDBAs according to the Preliminary Safety Report of Cernavoda Unit 2. The German radiation protection regulation allows a maximum effective dose of 50 mSv for that DBA which has the worst consequences in the vicinity of the plant. According to table 7.4.7. three of these DBAs exceed this limit clearly. Exposures exceeding 50 mSv pose a high risk for the population and measures to minimize such high emissions should be described in the EIA report.

The new regulatory standard being developed by the Canadian Nuclear Authority also poses new reference dose limits for members of the public. The effective dose limit for anticipated operational occurrences shall be 0.5 mSv and for design basis accidents 5 mSv [CNSC 2005]. Not even 50% of the DBAs are under this 5 mSv limit.

Unfortunately no source terms for the DBAs with such high emissions are given in the EIA report.

Accidents with a probability of occurrence less than 1E-6/a are not dealt with in the EIA report at all. This is argued with the strong concept of CANDU preventing a rapid development of the accident. Nonetheless severe accidents cannot be excluded. Overheating of the zircalloy cladding during a LOCA is possible and in case of a large LOCA even damage of the cladding cannot be excluded. [DORIA 2001]

Beyond design basis events are assumed to be prevented by the existing design safety features (two independent diversified and equally capable shutdown systems and a redundant number of standby and emergency diesel generators). The CANDU safety analysis already includes scenarios with the failure of emergency core cooling in which the heat removal is provided by the moderator.

"For scenarios with more core degradation, the capability of the calandria to provide a spreading of the corium and sufficient heat removal area for core debris as well as the additional capability of the concrete reactor vault as ultimate heat sink are still to be analyzed and the corresponding management procedures defined." [WENRA 2000] In the technical documentation [CITON 2006] it is explained that overheating of the core is slowed down due to the moderator and calandria vessel cooling systems. As a conclusion *„the time durations in which some DBA can evaluate as severe accidents (Calandria vessel failure due to the concrete erosion to a typical CANDU 6 plant are as follows: Loss of electrical power supply 133h and Large LOCA: 128 h"* [CITON 2006]. The long time span is said to help the plant personnel to take proper measures to mitigate the consequences of the accident [CITON 2006].

However, the limits of these systems are not explained and there is no information on the scenarios which are not covered. Since detailed information on eventual improvements planned for NPPC Unit 3 and 4 regarding the material used for fuel cladding is lacking, safety margins concerning fuel overheating and damage are not clear.

Severe accident management has not yet been implemented at Cernavoda Unit 1 and 2. But according to the EIA report the generic Severe Accident Management Guidelines (SAMGs) developed by the CANDU Owners Group (COG) shall be used as input data in for PSA Level 2. Specific SAMGs for NPP Cernavoda shall be developed, too. Level 2 PSA is scheduled for 2009 and will include severe accidents. [ICIM 2007, 7 7-26]

Since PSA results for core damage are not presented in the EIA report, some results from literature are quoted below:

a. Summary of CANDU PSA results for internal events according to [SNELL and JAITLY, 2001]:

Total **severe core damage frequency** for:

Wolsong 2	6.1E-6 per reactor year
Darlington	3.8E-6 per reactor year
CANDU 6 (KEMA)	4.6E-6 per reactor year
shutdown failure:	3.0E-8 per reactor year (typical)

b. NPP Cernavoda Unit-1:

For NPPC Unit 1 a PSA level 1 has been carried out, the results are presented in the National Report to CNS. [ROMANIA CNS REPORT 2004]. This report gives the following core damage frequencies:

5th percentile	6.10E-6 per reactor year
Mean Value	1.37E-5 per reactor year
95th percentile	2.72E-5 per reactor year

This PSA, however, does not include external events. (A full-scope PSA was announced that should be carried out until the end of 2004).

- For early core damage due to failure to trip the reactor and failure to maintain the reactor subcritical a CDF of 8.24E-7/a is given, and
- for early core damage due to failure of all heat sinks the CDF is given as1.28E-5/a.[ROMANIA CNS REPORT 2004].

It appears that the **Canadian Nuclear Authority** is going to impose stricter limits on CANDU nuclear power plants. A new regulatory standard is developed by this Authority. Safety goals for these CANDU reactors are defined as follows:

- “LARGE RELEASE FREQUENCY (LRF): The sum of frequencies of all events sequences that can lead to release to the environment of more than 1E15 Bq of Cs 137 shall be less than 1E-6 per plant year.
- SMALL RELEASE FREQUENCY (SRF): The sum of frequencies of all event sequences that can lead to release to the environment of more than 1E15 Bq of I 131 shall be less than 1E-5 per plant year.
- CORE DAMAGE FREQUENCY (CDF): The sum of frequencies of all events sequences that can lead to significant core degradation shall be less than 1E-5 per plant year.

The above safety goals shall include contribution of facility-originated events (equipment failure, operator errors, internal fire, internal floods and external events).” [CNSC 2005]

This regulatory standard shall apply to CANDU NPPs constructed after January 1, 2005. [CNSC 2005]. It should be valid for Cernavoda Unit-3 and 4, too.

The **European Union** has no common safety standards, but the the biggest European electricity providers have formulated their own requirements on NPP safety, which are stricter than that of the IAEA [INSAG 3 1999]. Even if the EU requirements consider only LWRs in detail, the goals for accidental release of radioactive substances are in principle independent of the reactor type, because these goals concern radiation protection. It would be worth to discuss whether NPPC 3 and 4 will be able to meet this requirements:

Probabilistic safety goals of European utilities [EUR 2001]:

- Core damage frequency: < 1E-5 / reactor year,
- Frequency of release > limited impact: 1E-6/reactor year,
- Early or large release frequency: 1E-7/ reactor year

Accidents with limited impact shall generate a release of at most 0.1% of the core inventory: 4E15 Bq of I-131, 4E14 Bq of Cs-137, and ~1E14 Bq of Sr-90. [EUR 2001]

Beyond design basis accident (BDBA) analysis is of particular interest for regions outside the vicinity of the NPP Cernavoda. The conclusion of the EIA report that “*... it is clear that both DBAs and BDBAs for Cernavoda NPP have non-significant radiological consequences for the public located outside the exclusion boundary (1 km from the reactor)”* [ICIM 2007, 7-25] is obviously wrong because among the presented DBAs accident sequence which is said to lead to 151 mSv and among the BDBA a sequence which is said to lead to 171 mSv effective dose is listed, which both can certainly not be considered as non-significant. Furthermore, neither a source term nor a sufficient description of the methods used for the dispersion and dose calculation presented in the EIA so that this statement cannot be corroborated.

Event sequences involving severe core damage (loss of structural integrity of the core) in CANDU reactors are the following ones:

- rapid reactivity excursion, initiated e.g. by LOCA, followed by failure to shut down the reactor (rapid development until release to environment (10-20h)
- failure to remove the decay heat from the core (one to several days)

The development of a severe accident in CANDU reactors involves the following steps: heating up of the fuel, core disassembly, calandria vessel failure, corium-concrete interaction and unfiltered release from containment, due to overpressure or explosion. [THOMPSON 2000].

6.3 Conclusion

Some of the presented DBA scenarios result in very high exposures of people in the exclusion zone, therefore it is not possible to exclude relevant radiation doses for people in larger regions. If such high doses are allowed to result from design base accidents, this practice does not comply with good practice in other European countries, where an exposure limit of 50 mSv is allowed for a DBA, instead of 250 mSv as it is in Romania.

Exposures exceeding 50 mSv pose a high risk for the population, and measures to minimize such high emissions should be presented in the EIA report. According to the EIA report, severe accident management is not yet implemented at NPPC Unit 1 and 2. Generic Severe Accident Management Guidelines (SAMGs) have been developed by the CANDU owners group, and specific SAMGs for NPP Cernavoda shall be developed.

To include the source terms into the presentation of the severe accident analysis is important in particular for the assessment of emissions and their impact to a larger region and in particular to other countries. Without delivering source terms, time tables and energy involved in the accident sequence, understanding of the results concerning exposure presented in the EIA report is not possible.

In order to discuss the potential impact of accidents to other countries in the Austrian Comment to the Scoping Stage [WENISCH, 2007b] it was requested to include more information on this topic in the EIA report. In particular, the presentation of the accidents analysis in the EIA should give an overview on the PSA results for Cernavoda unit 3 and 4:

- accident scenarios,
- core damage frequency,
- large release frequency
- source terms (instead of dose limits)

This information is still missing, although new design requirements apply emission limits as a probabilistic safety target, instead of dose limits.

7 EMERGENCY PLANNING

7.1 Treatment of the issue in EIA report

Around the NPP several zones are defined for protective measures [ICIM 2007, 7-29f.]:

For design basis accidents:

- 1 km unpopulated exclusion zone
- 2 km low population zone

For beyond design basis accidents:

- 10 km short term emergency planning zone
- 50 km long-term emergency planning zone

Also intervals of intervention levels and corresponding protective measures are given ICIM 2007, 7-32, table 7.5.-3.]:

- For sheltering the intervention level is 3 – 30 mSv whole body effective dose (effective dose to critical organs 30 – 300 mSv).
- Intervention level for evacuation is 30 – 300 mSv whole body effective dose (300 – 3000 mSv critical organ effective dose).
- For stable iodine administration the effective thyroid dose is between 30 – 300 mSv (compared to ingestion dose in the first 24 hours).

The dose compared to these intervention levels relates to the first 24 hours.

Below the lower intervention level no protective measures are planned. If the dose will be greater than the higher level the measures will be applied, and if the dose will be in between the particular intervention levels, measures can or should be applied, but it is not obligatory to do so.

7.1.1 Discussion of the problem

First we want to emphasize that the title of chapter 7.5 in the EIA report *(“Measures to reduce the Cernavoda NPP Risk”*) is misleading: This chapter does not deal with minimization of the risk of the NPP itself and not with severe accident management, but with emergency measures for protection of the population.

It is not explained properly why the four emergency planning zones around the NPP are defined in these dimensions. The so-called short-term (10 km) and long-term (50 km) zones are defined according to IAEA recommendations from 1997 [IAEA 1997, cited in ICIM 2007 Ref 7-7]. Current recommendation of the IAEA are different: A precautionary action zone (PAZ) of 3-5 km (with a recommendation on 5 km) and an urgent protective action planning zone (UPZ) with a radius of 5-30 km should be defined [IAEA 2007].

An exclusion zone and a low population zone with 1, respectively 2, km therefore are too small. The town of Cernavoda with a population of 20000 inhabitants is in a distance of 2 km. Therefore it is problematic to call this zone “low population zone”. In a 10 km radius 26000 people are living.

Even a design basis accident can lead to a dose up to 151 mSv at the border of the exclusion zone (1 km). It cannot be excluded that in the “low population zone” also such high dose values will occur. Evacuation of Cernavoda town in a short time (the 2 km could easily be covered by a radioactive cloud within minutes!) seems to be complicated because there is only one exit route out of town crossing a bridge, because the other direction of this main road leads to the NPP [WENISCH 2003]. In case of an accident potentially requiring an evacuation of Cernavoda town a second exit route should be available.

It is not clear which protection measures are planned for which zone.

The presented intervention levels are higher than international standards published by the IAEA [IAEA 2002]. The levels proposed by the IAEA are defined as generic optimized intervention levels:

- for sheltering 10 mSv of avertable dose in a period of no more than 2 days
- for temporary evacuation 50 mSv of avertable dose in a period of no more than 1 week; in some countries 100 mSv
- for iodine prophylaxis is 100 mGy of avertable committed absorbed dose to the thyroid due to radioiodine

In Cernavoda sheltering has to start at an intervention level of 30 mSv (external dose plus intake in the first 24 hours), while the IAEA recommends 10 mSv (avertable dose in a period of no more than 2 days).

Evacuation in Cernavoda has to start at a level of 300 mSv (external dose plus dose from intake in the first 24 hours), while the IAEA recommends 50 mSv (avertable dose in a period of no more than 1 week).

Iodine prophylaxis in Cernavoda has to start if the ingestion dose in the first 24 hours for the thyroid is at least 300 mSv (effective dose for the thyroid). The IAEA recommends an avertable dose of 100 mGy for the thyroid. It is not understandable why only the ingestion dose is considered for definition of Cernavoda´s intervention levels. Inhalation is the most important iodine pathway in the very first phase of an accident and should therefore be considered in intervention level assessment as it is done by the IAEA. Therefore the Romanian value cannot be compared with the international standard.

The harmonization of intervention levels with neighboring countries that are possibly affected by an accident at Cernavoda is asked for in the Austrian “Interventionsverordnung” [IntV 2007]. As it is shown in chapter 8 in this report an accident can also affect Austria and other European countries.

It is not discussed if and how the public is going to be informed about an accident and about protective measures. The IAEA recommends information of the public if a nuclear accident happens [IAEA 2002]. Also [EURATOM 89/618] requires information of members of the public in case of a radiological emergency.

7.1.2 Conclusion

The emergency planning zones are not properly explained, it is not clear which protective measures will be taken in which zones.

The four defined emergency zones (1km, 2km, 10km, 50 km) are not in accordance with current international standards: The IAEA recommends the definition of a precautionary action zone (PAZ) of 3-5 km (with a recommendation on 5 km) and an urgent protective action planning zone (UPZ) with a radius of 5-30 km [IAEA 2007]. The exclusion zone and the low population zone with 1, respectively 2, km around Cernavoda therefore are too small. The town of Cernavoda with a population of 20000 inhabitants is in a distance of 2 km. Therefore it is problematic to call this zone “low population zone”. In a 10 km radius 26000 people are living.

In case of an accident potentially requiring an evacuation of Cernavoda town a second exit route should be available.

The intervention levels, which mark the starting point for protective measures, are too high in comparison with IAEA standards [IAEA 2002] (and also with Austrian standards). The IAEA recommends sheltering at an avertable dose of 10 mSv in a period of no more than 2 days and temporary evacuation at an avertable dose of 50 mSv in a period of no more than 1 week. According to the EIA report sheltering has to start obligatory at 30 mSv, and temporary evacuation at 300 mSv (both in the fist 24 hours).

The intervention level for iodine prophylaxis is based on an inadequate radiation pathway (ingestion instead of inhalation in the first days of an accident). Therefore it should be changed to include the inhalation pathway and to be in accordance with IAEA standards and also with Austrian standards (10 mGy for critical groups, 100 mGy for adults, avertable thyroid dose in the first 7 days for inhalation). [IAEA 2002], [IntV 2007, Anlage 1]

Romania should fulfill the IAEA standards and as a member of the EU the EU-requirements for protection planning and should therefore change its intervention values. Also information for the public according to EU-standards [EURATOM 89/618] should be planned for emergency situations.

8 AUSTRIAN ANALYSIS OF SEVERE ACCIDENT'S IMPACTS

8.1 Severe accident source term assessment

Since the EIA report provides no source terms for the presented DBA and BDBA scenarios data from literature had to be used in order to conduct the investigation of the consequences a severe accident could have to regions outside of the vicinity of the plant, for Austria and other European countries as well.

CANDU 6 core inventory is not presented in the EIA and in the latest version of the technical documentation [CITON 2006]. But in [CITON 2005] the radioactive inventory calculated by ORIGEN-S Code for a CANDU 6 is provided, and was used to define a source term for the long range transport scenario.

Release fractions were not found in literature, but for a prior study some data were received from Gordon Thompson from the Institute for Resource and Security studies [THOMPSON 2004]:

- For early core damage, the release fractions were 0.3 (I), 0.2 (Cs)
- For late core damage, the release fractions were 0.15 (I), 0.09 (Cs)
- For late core damage with containment bypass via ECCS, the release fractions were 0.16 (I), 0.1 (Cs),

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 well beyond the scope of this report. Only the source term for Cs-137, as a characteristic, leading nuclide, is considered. With a core inventory of 7.9E16 Bq Cs-137 [CITON 2005] and a release fraction of 20%, a source term of 1.57E16 Bq Cs-137 results, which was used in the evaluation of possible transboundary consequences of accidents at NPP Cernavoda.

8.2 Methodology

a. 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 1998], see model homepage at http://zardoz.nilu.no/~andreas/flextra+flexpart.html.

The version developed for the project RISKMAP [ANDREEV 1998] and [HOFER 2000] and [RISKMAP 1995] was used here. Meteorological input data are gridded fields from the European Centre for Medium-Range Weather Forecasts (ECMWF) with 1 degree 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 and width. For the nested subdomains covering the regions of interest, a grid size of about 30 km x 30 km was used. Features smaller than one grid cell cannot be resolved, especially the local maximum near the NPP site.

b. Dose estimation

Deposition values are presented on maps with a specific colour scale. This scale was chosen with respect to the dose limits of EURATOM 96/29. A simple conversion factor to derive dose estimates from the total Cs-137 depositions is applied.

This factor is based on results of previous calculations carried out with mainframe COSYMA. This code, designed for the assessment of radiological consequences of NPP accidents, considers all relevant nuclides and delivers various dose values as endpoints. In the calculations mentioned, it was fed with a source term for a BDBA at Temelin NPP, and run for three years of meteorological data (total of 8760 runs per year). For each run, the grid point in Austria with the highest dose was selected, and the dose was related to the Cs-137 deposition in this grid element. The dose considered here is the effective dose equivalent for all nuclides and all exposure pathways (without ingestion) for the first year after the accident. The result is shown in Figure 1. As the wet cases are considered more relevant for the transport distances considered here (longer than from Temelin to adjacent Austria), the boundary towards the wet cases is used to derive the dose conversion factor. This factor is 4.8E-8 Sv / (Bq Cs-137 m²). Because ingestion is not included in this dose consideration, the dose is underestimated.

This dose factor is representative if the accident is assumed to be in winter. If the accident would happen during the vegetation period, the potential exposure in the first year could be considerably higher (up to 80% of the total exposure could be caused by ingestion).

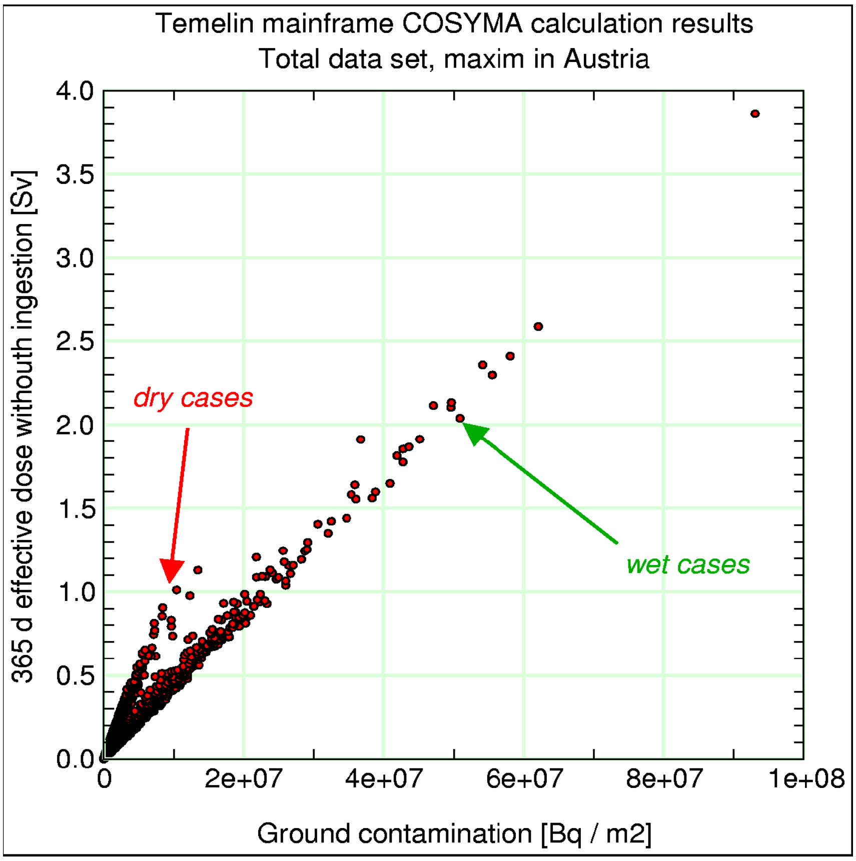

Figure 1: Correlation between first year effective dose (without ingestion) and Cs-137 soil contamination, calculated by Mainframe-COSYMA for the NPP Temelin and the maximal contaminated grid point in Austria.

As a result the following scale is used in the figures in the next section:

Cs-137 activity concentration	**effective dose in the first year after accident (approximately)**	**corresponding limit**
kBq/m²	**mSv/ y**	
1	0.05	
10	0.5	
20	1	population (average)
50	2.5	
100	5	population (maximum)
400	20	exposed workers (average)
1000	50	exposed workers (maximum)

8.3 Selection of cases

Selected cases are presented which would lead to severe radiological impacts in various European countries. These cases were preselected from the calculations made for 90 different dates in the year 1995 as a part of the RISKMAP study. This year has been shown to be climatologically representative at least for the Alpine region. The selection criterion was that severe transboundary effects are simulated, and that in each case a different geographic region is affected. The RISKMAP simulations produced output on a coarse domain convering all of Europe, and on a finer grid for a nested domain covering Central and Western Europe. For some of the cases, the simulations have been repeated with the nested domain shifted to a position covering better the impact of the specific case shown. In these cases, a hypothetical release time deviating from the RISKMAP dates may have been used if the resulting deposition pattern was found to be of more interest. If not otherwise indicated, results are always from nested domains.

This procedure does not include an estimate of the probability of such cases. We aim to demonstrate here that severe adverse effects in other countries are possible and thus have to be included in the EIA. From other studies that we have performed, however, we can confirm that such meteorological conditions are not too infrequent.

8.4 Results and discussion

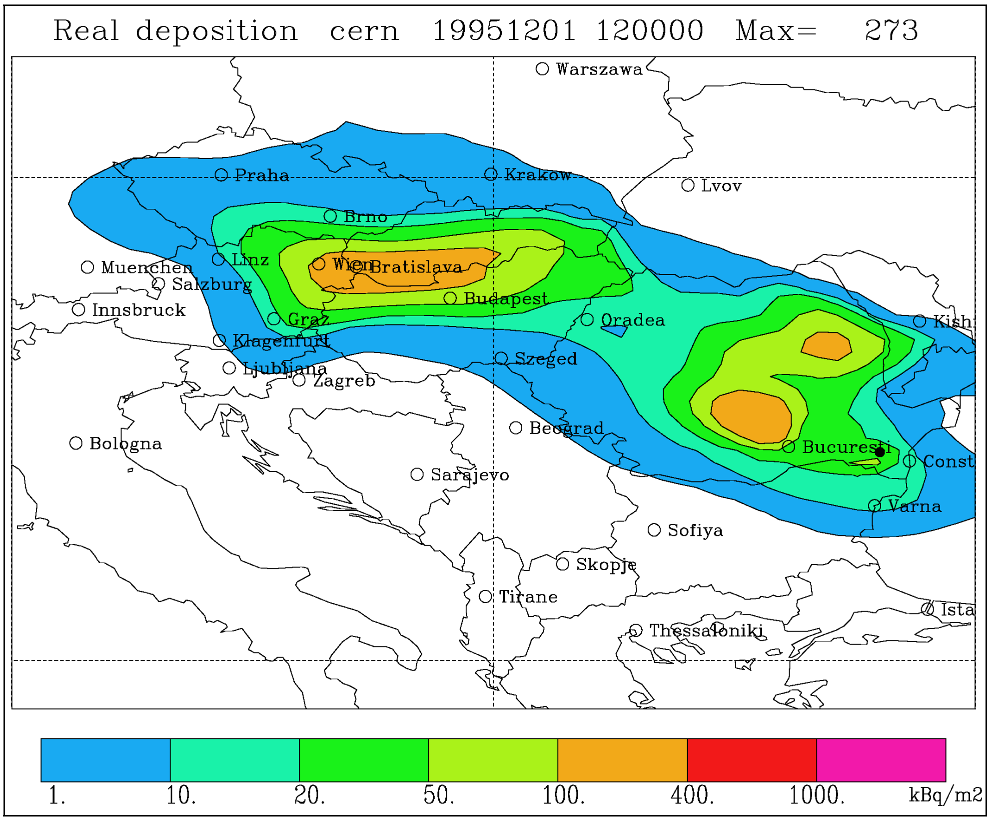

Figure 2: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 01.12.1995 at 12:00 UTC. The absolute maximum of the contamination on the evaluation grid was 273 kBq/m².

The deposition pattern of the case shown in figure 2 reflects a complex track of the contaminated air from Romania across the border to Hungary, Slovakia and Austria, modulated by precipitation causing the deposition maxima. Two regions in Romania and a large region in northern Hungary, southern Slovakia and eastern Austria, Bratislava and Vienna included, would become highly contaminated. The Cs-137 deposition in these regions exceeds 100 kBq/m², this could lead to doses above the limit of 5 mSv. The situation would require protection measures for the whole population such as sheltering and probably administration of stable iodine for critical groups of the population.

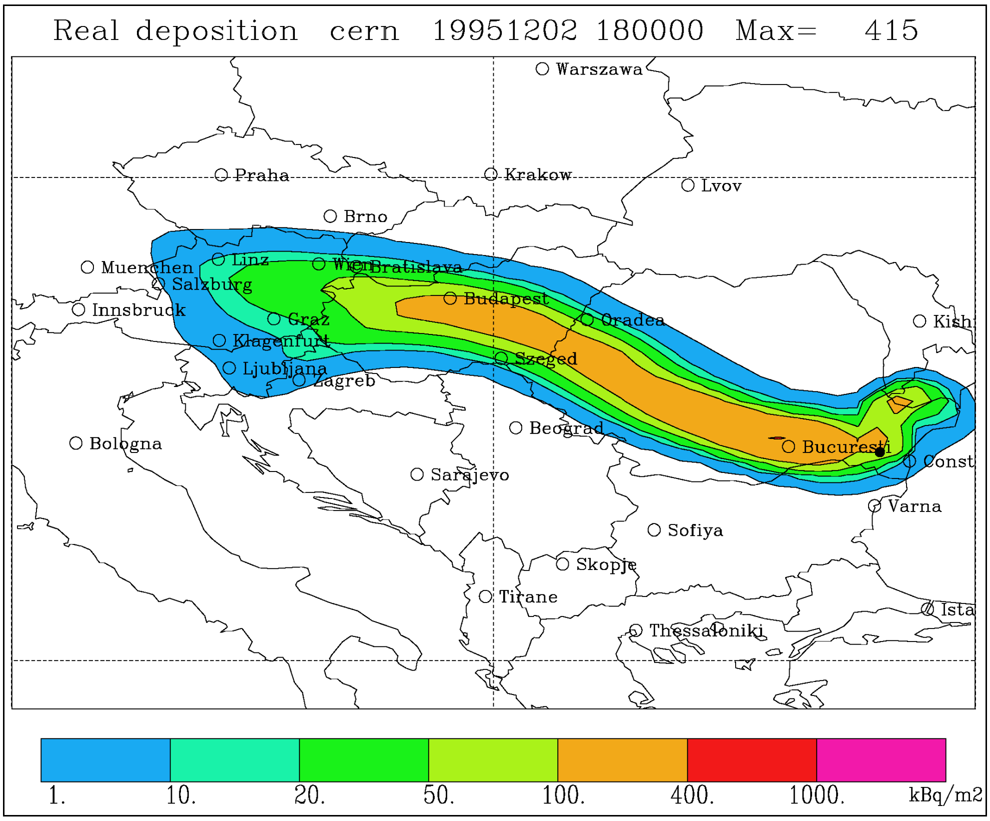

Figure 3: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 12.02.1995 at 18:00 UTC. The absolute maximum of the contamination on the evaluation grid is 415 kBq/m².

In the weather conditions of the case shown in figure 3, the contaminated air moves in the same direction as in Figure 2, but linked to a different precipitation pattern, a strip from the NPP site through Romania and Hungary would be heavily contaminated. The area contaminated with more than 100 kBq/m² includes Bucuresti and Budapest.

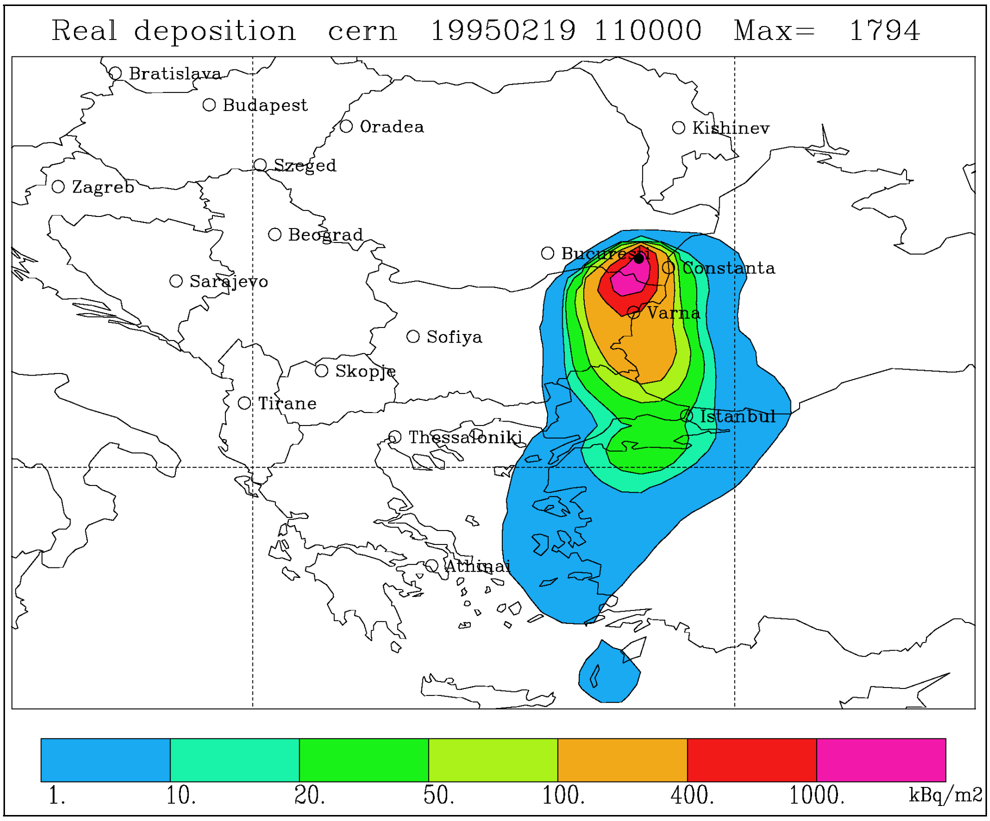

Figure 4: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 19.02.1995 at 11:00 UTC. The absolute maximum of the contamination on the evaluation grid is 1794 kBq/m².

In the case shown in figure 4, the region between the NPP site and Varna in neighboring Bulgaria would be most affected. In this region, 400 kBq/m² would be exceed with more then 1000 kBq/m² in the most affected part. The holiday resorts on the Romanian coast of the Black Sea, as ell as the whole of the Bulgarian Black Sea cost, would be contaminated by more than 100 kBq/m².

As figure 5 illustrates, it is possible for radioactive material to travel through Bulgaria and Serbia towards Austria and then along the northern edge of the Alps into southern Germany and Switzerland. A Cs-137 deposition of 20 kBq/m² would be exceeded along the whole path, with precipitation-related spots over 100 kBq/m² in southeastern Austrian and over 50 kBq/m² in southern Germany.

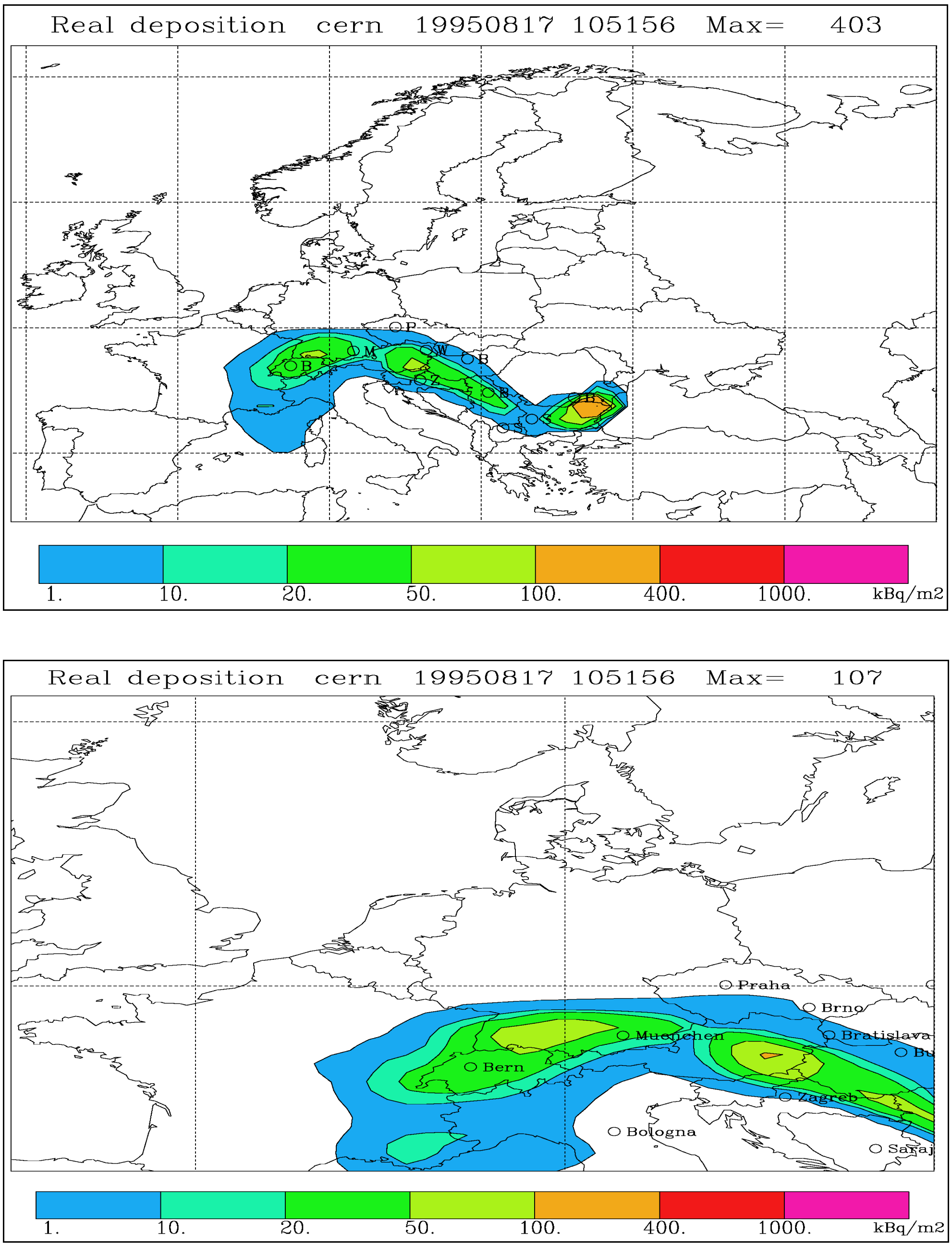

Figure 5: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 17.08.1995 at 10:52 UTC. Top: Coarse domain covering Europe, with an absolute maximum of the contamination of 403 kBq/m²; bottom: nested domain for Central Europe with a maximum deposition of 107 kBq/m²

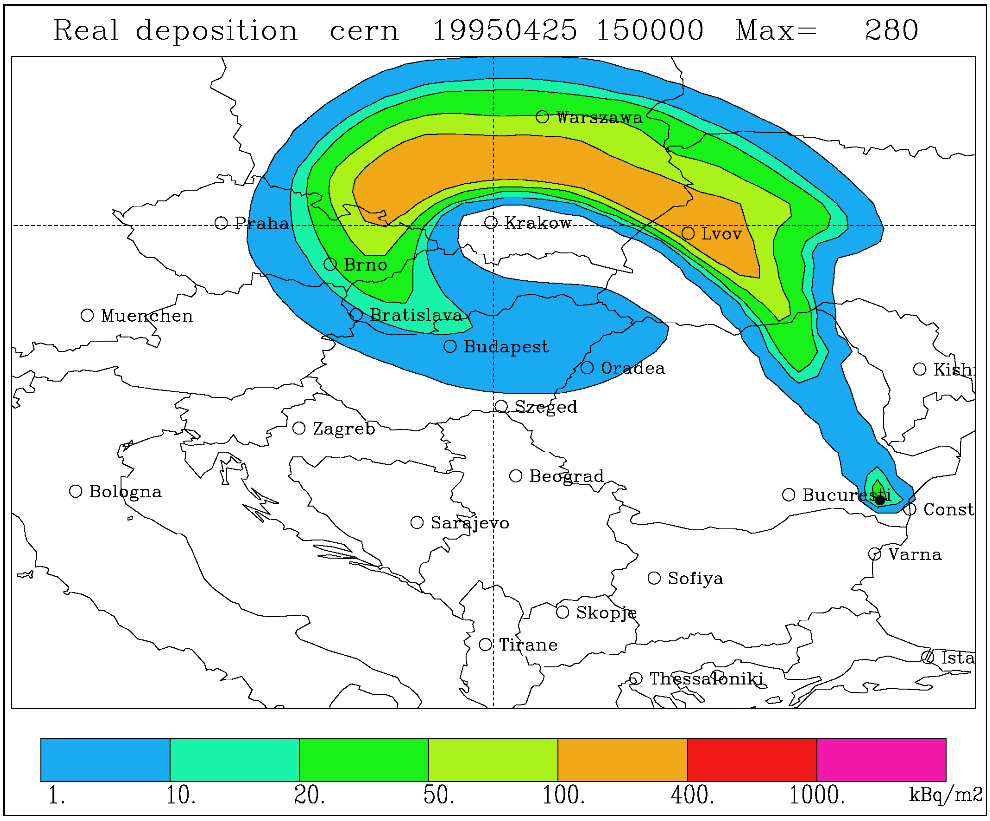

Figure 6: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 25.04.1995 at 15 UTC. The absolute maximum of the contamination on the evaluation grid is 280 kBq/m².

The case shown in figure 6 affects mainly the western Ukraine with its centre Lvov and southern Poland, with more than 100 kBq/m². This case is a typical example for a situation where precipitation causes the maximum contamination to occur far from the release location.

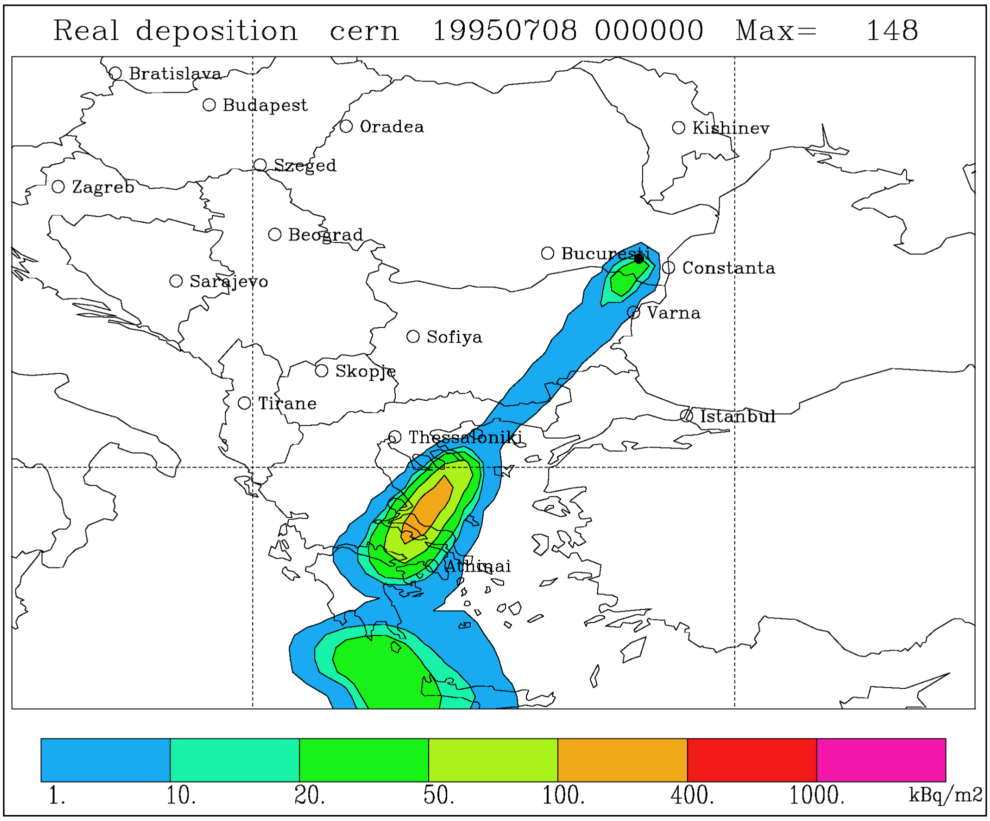

Figure 7: Total deposition of Cs-137 [kBq/m²] from a hypothetical BDBA at NPP Cernavoda with release of radioactivity on 07.08.1995 at 00 UTC. The absolute maximum of the contamination on the evaluation grid is 148 kBq/m².

Figure 7 illustrates that Greece is also potentially affected by accidental releases from NPP Cernavoda. The case shown is associated with contamination of the centre of Greece, including the western parts of Euboa. Athens is on the border of the 20 kBq/m², indicating the potential severity of the impact on the country.

Though not represented by a figure, Turkey, which lies downwind of the NPP Cernavoda in many cases, could be severely affected, including its largest city, Istanbul.

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10 GLOSSARY

AECB	Atomic Energy Control Board
ANDRAD	National Agency for Radioactive Waste
BDBA	beyond design basis accident
Bq/m^3	Becquerel / cubic meter
CANDU	Canada Deuterium Uranium (pressurized heavy-water power reactor)
CDF	core damage frequency
CNCAN	National Commission for Nuclear Activity Control
CNS	Convention on Nuclear Safety
CNSC	Canadian Nuclear Safety Commission
Cs	caesium
CTA	Romanian abbreviation for “total updated costs”
DBA	design basis accident
DBE	design basis earthquake
DEL	derived emission limit
5%-DEL	administrative limit (5% Derived Emission Limit)
DICA	interim spent fuel dry storage
DIDR	solid radwaste intermediate storage for LILW
DFDSMA	planned national final surface disposal facility for LILW
ECCS	emergency core cooling system
EIA	environmental impact assessment
FW	feed water
GEM	gaseous effluent monitor
HLW	high level radioactive waste
I	iodine
ICIM	Romanian abbreviation for “National Institute of Research and Development for Environmental Protection”
IE	initiating ivent
LILW	low and intermediate level radioactive waste
LOCA	loss of coolant accident
LWR	light water reactor
m^3	cubic meter
mSv	milli Sievert
MCA	multi criteria analysis
NDB	non design base

NPP	nuclear power plant
NPPC	nuclear power plant Cernavoda
NOx	nitrogene oxides
PHTS	primary heat transfer system
PSAR	preliminary safety assessment report
PM	particulate matter
PSA	probabilistic safety analysis
Q	quantity
SG	steam generator
SO_2	sulfuride oxide
UTC	french abbreviation for “coordinated universal time”
WENRA	Western European Nuclear Regulators Association

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