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Construction of a NPP in Belarus

Report on the Bilateral Consultations on May10th 2010 according to Article 5 of the Convention on environmental impact assessment in a transboundary context

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ÖSTERREICHISCHES ÖKOLOGIE INSTITUT

CONSTRUCTION OF A NPP IN BELARUS

Report on the Bilateral Consultations on May 10th 2010 according to Article 5 of the Convention on environmental impact assessment in a transboundary context (Espoo Convention)

Helmut Hirsch
Antonia Wenisch

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Project management

Franz Meister, Umweltbundesamt

Authors

Helmut Hirsch, Scientific consultant

Antonia Wenisch, Austrian Institute of Ecology

Layout and typesetting

Elisabeth Riss, Umweltbundesamt

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CONTENT

ZUSAMMENFASSUNG UND SCHLUSSFOLGERUNGEN

Im Jahr 2009 entschied die Regierung von Weißrussland, ein Kernkraftwerk (KKW) mit einer elektrischen Leistung von 2300–2400 MW zu errichten. Österreich beteiligt sich an der grenzüberschreitenden Umweltverträglichkeitsprüfung. Vom Umweltbundesamt wurde das Österreichische Ökologie-Institut in Zusammenarbeit mit Dr. Helmut Hirsch mit der Ausarbeitung einer Fachstellungnahme beauftragt. Im weiteren Verfahrensverlauf waren dieselben ExpertInnen an Konsultationen beteiligt. Der hier vorliegende Bericht stellt die Ergebnisse des Verfahrens und die Schlussfolgerungen der ExpertInnen dar.

Weißrussland wählte das russische Reaktorprojekt KKW 2006, eine VVER-Anlage der Generation 3[1]. Die weißrussische Regierung ist überzeugt, dass dieser Reaktor modernen internationalen Standards der nuklearen Sicherheit entspricht.

Die Begutachtung der vorläufigen Umweltverträglichkeitserklärung (UVE) (REPORT 2009) behandelte im Wesentlichen die Sicherheits- und Risikoanalyse mit dem Ziel, festzustellen, ob die UVE verlässliche Schlussfolgerungen hinsichtlich möglicher grenzüberschreitender Auswirkungen von Emissionen erlaubt. Um diese Aufgabe zu erfüllen, müssten Sicherheitsmerkmale sowie Ausrüstung und Maßnahmen zum Management schwerer Unfälle in der UVE im Detail dargestellt werden. In der österreichischen Fachstellungnahme (UMWELTBUNDESAMT 2009) wurden insgesamt 20 offene Fragen formuliert.

Im März 2010 erhielt Österreich die Antworten auf diese Fragen (REPLIES 2010). Die AutorInnen der österreichischen Fachstellungnahme bewerteten die Antworten aus Weißrussland in einem weiteren Bericht (UMWELTBUNDESAMT 2010), der wiederum Weißrussland übermittelt wurde. Als Ergebnis der Einschätzung wurde festgestellt, dass einige Fragen ausreichend beantwortet und einige Missverständnisse ausgeräumt wurden. Mehrere Fragen waren offen geblieben und einige weitergehende Fragen wurden zur Diskussion im Rahmen der Bilateralen Konsultation am 10. Mai 2010 in Wien formuliert.

Wegen Zeitmangels konnten nicht alle Fragen der österreichischen ExpertInnen während der Konsultation beantwortet werden. Aus der bis dahin durchgeführten Debatte wurde klar, dass manche Fragen derzeit nur sehr allgemein beantwortet werden können, da die spezifische Auslegung des KKW Belarus noch nicht vorliegt. Deshalb kam man überein, nur eine Auswahl der wichtigsten Fragen, die bei der Konsultation nicht behandelt wurden, den weißrussischen Experten schriftlich zu übermitteln. Die Antworten zu diesen Fragen erhielt Österreich im Juni 2010 (ANSWERS 2010). Diese Antworten werden im vorliegenden Konsultationsbericht berücksichtigt:

Der erste Teil der Konsultation betraf die **Auswahl des KKW-Typs**. Aufgrund der gemeinsamen Geschichte verfügt Weißrussland über größeres Wissen zu russischen, als zu westlichen Reaktoren und entschied sich deshalb für den neuesten Typ des russischen Druckwasserreaktors (DWR), das KKW 2006 mit zwei Reaktorblöcken des Typs VVER 1200. Gemäß der weißrussischen Machbarkeitsstudie entspricht diese Leistung dem weißrussischen Bedarf.

[1] VVER = russische Abkürzung für Druckwasserreaktor

Das KKW 2006 ist die Grundlage für die Konstruktion des für Weißrussland vorgeschlagenen Reaktors. Die speziellen Details der Konstruktion des weißrussischen KKW werden jedoch erst später bestimmt. Weißrussland hofft, von den Erfahrungen der derzeit in Bau befindlichen russischen Projekte und dem geplanten baltischen KKW 2006 (KKW Kaliningrad), bei dem der Baubeginn ebenfalls früher erfolgen wird als beim weißrussischen KKW, zu profitieren. All diese Reaktorblöcke werden eine elektrische Leistung von 1170 MW haben. Diese KKW sollen ihren Betrieb aufnehmen, bevor das KKW Belarus in Betrieb genommen wird.

Es gibt zwei unterschiedliche Ausführungen des KKW 2006, die von zwei verschiedenen Konstruktionsbüros entworfen wurden:

- Konstruktionsbüro in St. Petersburg: KKW-2006 VVER-1200/V491
- Konstruktionsbüro in Moskau: KKW-2006 VVER-1200/V392M

Weißrussland hat sich für die Ausführung VVER-1200/ V491 entschieden, bei welcher aktive Sicherheitssysteme vorherrrschen. Diese Systeme werden von den weißrussischen Experten als sehr effizient beschrieben, was durch die guten Erfahrungen mit Reaktoren des Typ V320 belegt wird. Zudem werden weiter entwickelte Systeme hinzugefügt, wie das doppelte Containment und der Corecatcher (Auffangvorrichtung für den Reaktorkern). Diese Neuerungen werden die bestehenden Sicherheitssysteme harmonisch ergänzen, um neuen Sicherheitskriterien wie z. B. den EUR (European utilities requirements) zu entsprechen.

In beiden **Designvarianten** der VVER der Generation 3 werden außerdem passive Sicherheitssysteme hinzugefügt: am wichtigsten zur Eindämmung schwerer Unfälle ist das passive System zur Wärmeabfuhr über den Dampferzeuger.

Weißrussland selbst verfügt noch nicht über ausreichende Kenntnisse zur Konstruktion eines KKW. Das Institut Belnipienergoprom gilt als Generalunternehmer für die Planung des KKW Projekts, fungiert aber meistens nur als Koordinator, während die Detailplanung vom russischen Konstruktionsbüro durchgeführt wird. Insgesamt sind 17 Organisationen beteiligt – einschließlich der Nationalen Akademie der Wissenschaften und zweier Organisationen aus der Ukraine.

Die meisten Designparameter aus der UVE (REPORT 2009) stammen vom russischen Konstruktionsbüro in St. Petersburg. Manche Parameter wurden von den weißrussischen Verantwortlichen als Ziel vorgegeben, z. B. der Kapazitätsfaktor.

Flugzeugabsturz und Erdbebenrisiko wurden bei der **Auswahl des Standorts** in Betracht gezogen. Der Standort (Ostrovets) wurde wegen einiger kleinerer Komplikationen an den anderen Standorten bevorzugt. Die Region Ostrovets ist abseits von Flugkorridoren und großen Industriekomplexen und weist ein geringes Erdbebenrisiko auf. Andere Standorte liegen auf Kalkablagerungen (was unvorteilhaft sein kann, aber nicht unbedingt ein Hindernis wäre). Die Standortwahl wurde noch nicht offiziell bestätigt – aber die Präferenz für den Standort Ostrovets wurde deutlich geäußert.

Corecatcher und passives Wärmeabfuhrsystem über den Dampferzeuger wurden mit Hilfe technischer Skizzen erklärt, die für das Verständnis ihrer Funktion sehr nützlich waren. Leider wurde diese Präsentation der österreichischen Delegation während der Bilateralen Konsultation nicht übergeben.

Hinsichtlich der **Sicherheitssysteme halfen** die Präsentationen und Antworten der weißrussischen Delegation, die Funktion der neuen Systeme zu verstehen. Allerdings wurde dabei auch klar, dass die Details der Auslegung noch nicht vorhanden sind und erst später – während des fortschreitenden Entwicklungsprozesses – ausgearbeitet werden.

Die Informationen, die Österreich erhielt, waren daher eher allgemein und nicht detailliert.

Von den in der schriftlichen Beantwortung der nach der Konsultation noch offen gebliebenen Fragen (ANSWERS 2010) wurden die geforderten Informationen zu auslösenden Ereignissen für Auslegungsstörfälle und schwere Unfälle (DBA und BDBA), zu den untersuchten Szenarien und deren Eintrittswahrscheinlichkeit (für VVER-1000) und zu den vier Arten von untersuchten schweren Unfällen übermittelt.

Schlussfolgerungen

Die **Auswahl des KKW Belarus** wurde durch die gemeinsame Geschichte der Entwicklung der Kernenergienutzung in Weißrussland und Russland begründet. Die **Auswahl der Reaktorvariante**, die sich stärker auf die aktiven Sicherheitssysteme stützt, wurde durch die große Erfahrung mit aktiven Systemen im VVER-1000/V320 gerechtfertigt. Dieser Zugang ist sowohl plausibel als auch vorsichtig.

Hinsichtlich **externer Ereignisse** wurde plausibel dargestellt, dass das Containment des VVER-1200 über große Sicherheitsreserven verfügt und Belastungen durch Flugzeugabsturz und Explosionen aushält, die wesentlich höher sind als die Auslegungsbasis.

Die **Auslegung des Corecatchers** hat einen grundlegenden Nachteil – der geschmolzene Reaktorkern bleibt in einer sehr kompakten Form, mit einem für die Kühlung sehr ungünstigen Verhältnis von Oberfläche zu Volumen. Weitere Informationen zum Corecatcher werden erst während des detaillierten Auslegungsprozesses verfügbar sein. Allerdings ist nicht vorstellbar, dass der oben angeführte Nachteil beseitigt werden kann, da dies eine wesentliche Veränderung im Reaktordesign erfordern würde.

Hinsichtlich der **übrigen Sicherheitssysteme** wurde deutlich, dass die spezielle Auslegung der Anlage noch nicht verfügbar ist, da sie erst später ausgearbeitet werden wird. Die Österreich übermittelte Information war zwar hilfreich für das allgemeine Verständnis, jedoch nicht ausreichend zur Beurteilung des spezifischen Projekts.

Die Szenarien für **auslegungsüberschreitende Unfälle (BDBA)**, die in der Diskussion und in den UVE Dokumenten betrachtet wurden, scheinen nur Szenarien ohne Containmentversagen zu umfassen (die nur zu vergleichsweise kleinen, nicht konservativen Quelltermen führen). Zu diesen Szenarien werden keine Details zur Verfügung gestellt. Außerdem werden für diese Szenarien verschiedene Quellterme erwähnt, wobei die Bandbreite der radioaktiven Emissionen bis zu zwei Größenordnungen beträgt. Diese Unterschiede wurden nicht erklärt.

Konkrete **Unfallanalysen für das KKW Belarus** wurden noch nicht durchgeführt. Solche Analysen sollten während der detaillierten Auslegungsphase verfügbar gemacht werden. Diese sollten auch Szenarien mit großen Freisetzungen beinhalten, z. B. mit frühem Containmentversagen.

Der Grenzwert für die Eintrittswahrscheinlichkeit eines Kernschmelzunfalls ist 10^{-6}/Jahr. Aus der Übersicht über die Informationen, die wir von Weißrussland erhalten haben und aus anderen UVE Berichten von russischen KKW´s wird klar, dass Weißrussland ein Ausschlusskriterium für die Eintrittswahrscheinlichkeit schwerer Unfälle einzieht: schwere Unfälle werden daher nur bis zu einer Eintrittswahrscheinlichkeit von 10^{-7} pro Reaktor und Jahr in Betracht gezogen. Nach Meinung der österreichischen ExpertInnen können Unfälle mit geringerer Eintrittswahrscheinlichkeit nicht grundsätzlich ausgeschlossen werden. Wegen der Beschränkungen und Unsicherheiten probabilistischer Analysen sollten Unfälle nicht allein auf der Basis probabilistischer Argumente aus der weiteren Betrachtung ausgeschlossen werden.

Zweifellos sind probabilistische Studien aber hilfreich bei der Bewertung der Risiken. Deshalb sollte die **probabilistische Risikobewertung** für das KKW Belarus nach Fertigstellung der Auslegungspläne zur Verfügung gestellt werden. Wir erwarten, dass diese Studie auch die Darstellung der Unsicherheiten, der nicht berücksichtigten Faktoren etc., enthält, wie dies in probabilistischen Risikoanalysen üblich sein sollte.

Kurz zusammengefasst bestehen **offene Punkte**, zu denen ergänzende Informationen von weißrussischer Seite bereit gestellt werden sollten:

Kurzfristig zu beantwortende offene Punkte:

- Eine Stellungnahme zur Auslegung des Corecatchers und der potentiellen Nachteile der gewählten Konstruktion.
- Die systematische Darstellung aller auslegungsüberschreitenden Unfallszenarien (BDBA), die bisher in den Dokumenten erwähnt wurden, mit detaillierterer Erklärung des Unfallablaufs und einer Begründung der Auswahl.
- Stellungnahme zu den Vor- und Nachteilen probabilistischer Methoden, aus Sicht der weißrussischen Experten. Insbesondere erwarten wir eine Begründung für das Ausschlusskriterium 10^{-7}/Jahr für schwere Unfälle.

Langfristig zu beantwortende offene Punkte:

- Informationen zur konkreten Auslegung des Corecatchers
- Informationen zur konkreten Auslegung der anderen Sicherheitssysteme
- Informationen zu den Unfallanalysen, die speziell für das KKW Belarus durchgeführt werden
- Informationen zu probabilistischen Risikoananalysen, die speziell für das KKW Belarus durchgeführt wurden

SUMMARY AND CONCLUSIONS

The Russian project NPP-2006 of the Generation III VVER was chosen for the Belarusian NPP. The government of Belarus is convinced that this project conforms to modern international nuclear safety and radiation protection requirements. The Austrian review of the Preliminary EIA Report (REPORT 2009) was focused mainly on the safety and risk analysis, with the goal to assess if the EIA allows making reliable conclusions about the potential impact of transboundary emissions. For that purpose, safety features, equipment and procedures for severe accident management should be explained in detail. In total 20 open questions were formulated in the Austrian Expert Statement (UMWELTBUNDESAMT 2009). In March 2010 Austria received the answers on these questions (REPLIES 2010). The Authors of the Expert Statement also evaluated the Answers given by Belarus and summarized their evaluation in a further report (UMWELTBUNDESAMT 2010), which was submitted to Belarus. As a result of this assessment some questions were found to be sufficiently answered, some misunderstandings could be clarified and several questions were formulated for follow up and discussion on the Bilateral Consultation, which took place in Vienna on May 10th 2010.

Because of time constraints, during the consultation not all questions posed by the Austrian experts have been answered. From the previous debate it was clear that some of our questions cannot be answered now (except in a general, not project-specific manner), because the specific design of the NPP in Belarus is not finished. Therefore it was agreed that only a selection of the most relevant questions which had not been discussed should be answered by the Belarusian experts in written form. The answers to these open questions were submitted to Austria in June 2010 and were also considered in this consultation report:

The first part of the consultation concerned the selection of the plant type. Because of their common history, Belarus has better knowledge of Russian reactors, than on Western ones and therefore decided for the newest type of the Russian PWR: AES (NPP) 2006 with VVER 1200. Two units are to be constructed. According to a Belarusian feasibility study, the capacity of this plant is suitable for Belarus.

NPP 2006 provides the design basis for the proposed reactor. The specific design features of the Belarusian project are to be defined later. Belarus hopes to gain experience from the NPP 2006 plants, which are now under construction and from the Baltic NPP, which will also start construction before the Belarusian plant. All these plants will have an electric output of 1170 MWe and will be in operation before the NPP Belarus will be commissioned.

There exist two different NPP 2006 designs, from two different design organizations:

- St. Petersburg design office: NPP-2006 VVER-1200/V491.
- Moscow design office: NPP-2006 VVER-1200/V392M

Belarus has chosen V491 where active safety systems are predominant. These active systems are said to be very efficient, as positive experience with VVER V320 shows. Now more sophisticated features will be added, like double containment and core catcher; those will harmoniously complement existing safety systems as required to fulfill new safety criteria like EUR (European utilities requirements). There are passive systems added in both designs of 3rd Generation VVER: most important is the passive heat removal system from steam generators for BDBA.

Belarus does not yet possess skills to design a NPP. The Institute Belnipienergoprom is the general designer, but mostly it serves as the co-ordinating body for the project, and the design work is done by the Russian designer office. 17 organizations are involved – including institutes of the National Academy of Sciences and two organizations from Ukraine.

Most design parameters in the EIA REPORT 2009 are provided by the Russian designer in St. Petersburg. Some parameters are target values set by Belarus, for example the capacity factor. Plane crash and earthquake risk are taken into account for the siting. The preferred site (Ostrovets) was selected because of minor complications at the other sites: Ostzrovets is a region away from flight corridors and large industry, and has also a low earthquake risk. Other considered sites are located at chalk deposits (which is disadvantageous, but not necessarily prohibitive). The selection has not yet been officially confirmed – but it is clear that the Ostrovets site has first priority.

Core catcher and passive heat removal system from steam generators were explained with the help of technical illustrations, which are useful for the understanding of their functions. Unfortunately this presentation was not handed over to the Austrian delegation during the Bilateral Consultation.

Regarding safety systems, the presentations and answers given by the Belarus delegation helped to understand the functioning of the new systems. However, it also became clear, that the specific design of the plant is not available yet and will be elaborated later, during the detailed design process. Thus, the information provided to the Austrian side was of general nature and not specific.

In the ANSWERS 2010 the requested information concerning DBA and BDBA initiating events, analysed scenarios with probability of occurrence (for VVER 1000) and the 4 types of BDBAs was provided.

Conclusions

The selection of the plant has been justified by the common history of nuclear energy development in Belarus and Russia. The selection of the plant variant relying more strongly on active safety features has been justified with extensive experience with active systems in VVER-1000/V320 plants. This approach is both plausible and cautious.

Regarding external impacts, it is plausible that the containment building of the VVER 1200 has large safety margins and can withstand loads considerable higher than the design basis loads for aircraft crash and explosions.

The basic design of the core catcher is beset with a fundamental disadvantage – the molten core stays in a very compact form, which results in an unfavourable surface-to-volume ratio for cooling. Further information on the core catcher will become available as the detailed design for NPP Belarus proceeds. However, it is not foreseeable that the disadvantage outlined above will be remedied since this would require far-reaching changes in the reactor design.

Regarding other safety systems, it became clear, that the specific design of the plant is not available yet and will be elaborated later. Thus, the information provided to the Austrian side was, although helpful for a general understanding, of a general nature and not specific.

The scenarios for BDBAs presented in the discussion and in the EIA documents all appear to belong to scenarios without containment failure (leading to comparatively low, non-conservative source terms). No details for these scenarios were provided. Furthermore, for those scenarios different source terms are mentioned, spanning almost two orders of magnitude; the differences were not explained.

Specific analyses for the NPP Belarus have not been performed yet. Such analyses should be made available in the course of the detailed design phase. They should include scenarios with large releases, for example with early containment failure.

The limit for the probability of a core damage accident is 10^{-6}/yr. From the overview on all the information we received from Belarus and from EIA reports on Russian NPPs it is clear that there is a cut-off value for the probability of severe accidents: Only beyond design basis accident with a probability of occurrence > 10^{-7} per reactor and year are considered. Accidents with a risk < 10^{-7} per reactor and year are classified as practically impossible. In the opinion of the Austrian experts, such accidents are not to be excluded in principle. Due to the limits and shortcomings of probabilistic analyses, accidents should not be excluded from consideration on the basis of probabilistic arguments alone.

Nevertheless, probabilistic studies are helpful for evaluating reactor hazards. Hence, a probabilistic risk assessment should be made available for the Belarus NPP, after its design is finished. We expect that this assessment will include a discussion of uncertainties, factors not included etc., as should every probabilistic analysis.

In brief, there are several points for which additional information should be provided by the Belarusian side:

Short-term issues:

- Statement on the basic design of the core-catcher and the potential disadvantages of this design.
- Systematic presentation of all BDBA scenarios mentioned so far, with more detailed explanation of accident sequences and the reason for selection.
- Statement on the merits and shortcomings of probabilistic methods, as seen by the Belarusian experts, in particular discussion of the justification of the cut-off value of 10^{-7}/yr for severe accidents.

Long-term issues:

- Information on the detailed design of the core-catcher.
- Information of the detailed design of other safety systems.
- Information on accident analyses performed specifically for the NPP Belarus.
- Information on probabilistic risk analyses performed specifically for the NPP Belarus.

1 INTRODUCTION

In 2009, the government of Belarus decided to construct a nuclear power plant (NPP) with a capacity of 2,300–2,400 MWe. Austria takes part in the transboundary Environmental Impact Assessment (EIA) for the construction of the NPP in Belarus. The Umweltbundesamt (Environment Agency Austria) has assigned the Austrian Institute of Ecology, in cooperation with Dr. Helmut Hirsch, scientific consultant, to elaborate an expert statement on the EIA Report presented by Belarus.

The Russian project NPP-2006 of the Generation III VVER was chosen for the Belarusian NPP. The government of Belarus is convinced that this project conforms to modern international nuclear safety and radiation protection requirements. The Austrian review of the EIA Report was focused mainly on the safety and risk analysis, with the goal to assess if the EIA allows making reliable conclusions about the potential impact of transboundary emissions. For that safety features, equipment and procedures for severe accident management should be explained in detail. In total 20 open questions were formulated by the Austrian experts. In March 2010 Austria received the answers on these questions. The Authors of the Expert Statement also evaluated the Answers given by Belarus and summarized their evaluation in a further report, which was submitted to Belarus. As a result of this assessment some questions were found to be sufficiently answered, some misunderstandings could be clarified and several questions were formulated for follow up and discussion on the Bilateral Consultation, which took place in Vienna on May 10th 2010.

In the following chapters we refer to the documents as follows:

- "Substantiation of investments in construction of the nuclear power plant in the republic of Belarus – Environmental impact assessment" as (REPORT, 2009);
- Construction of a NPP in Belarus – Expert Statement on the Preliminary EIA Report, A. Wenisch, H. Hirsch, A. Wallner; Umweltbundesamt Report 0250, Vienna 2009, (UMWELTBUNDESAMT 2009);
- Replies to expert opinion on preliminary report on EIA of the Belarusian NPP carried out on request of the federal ministry of Agriculture, Forestry, ecology and water management, A.N. Rykov, A.I. Strelkov. as (REPLIES 2010).
- Construction of a NPP in Belarus – Assessment of Replies to the Questions posed in the Austrian Expert Statement on the Preliminary EIA Report , A. Wenisch, H. Hirsch (UMWELTBUNDESAMT 2010)
- Answers to the questions of Austria which have not been considered during consultations on May 10, 2010 Vienna (ANSWERS 2010)

The present consultation report summarizes the information and discussion at the bilateral consultation and presents assessment and conclusions of the Austrian experts team. This report follows the same main issues as the previous report.

2 SELECTION OF THE NPP TYPE

2.1 Background

The Russian project NPP-2006, a Generation III Russian Pressurized Water Reactor (PWR) with 1,200 MWe (VVER.1200/V491 further V-1200) was chosen for the Belarusian NPP. In the EIA some other types were compared to this reactor as alternative options.

The main reason to select VVER-1200/V491 was experience with equipment and safety systems in prototype units, according to the EIA Report. However, no operating experience has been gained so far in proper VVER-1200 prototypes. There is operating experience from an earlier model, the VVER-1000/V428 (an advanced version of VVER-1000). Thus, compared to other PWR types, experience relevant for VVER-1200 is not significantly more comprehensive.

It was reported in a technical magazine that there are two variants of VVER-1200, V-392M and V 491. Passive safety systems prevail in the former, whereas the latter focuses more on active systems (NEI 2009). There is no discussion in the EIA Report why V-491 was chosen and not V-392M.

Also in the (REPLIES 2010) no construction times for the VVER projects which are mentioned are provided; however, this would be required for assessing to which extent construction delays as have been observed for the EPR have also occurred for this reactor type.

More importantly, the features of the respective designs relevant for safety are not mentioned as a criterion. A comparison of such design features would be of high relevance for the type selection (for example regarding emergency core cooling system, emergency feedwater systems, features of the containment, electrical and I&C systems).

It would have been appropriate to provide some in-depth information about this selection process (indicators and criteria used, methodology applied). In particular, it would have been of interest to learn which role the differences regarding active and passive safety systems have played in this process, and how the advantages and disadvantages of passive safety systems are generally seen by the Belarus side.

2.1.1 Questions for the consultation

1. Could the relative merits and shortcomings of the PWR, as compared with BWR and CANDU, be elaborated in more detail?
2. Could the experience with recent VVER-projects be elaborated in more detail, in particular regarding the construction schedules?
3. Has there been no comparison of the safety significant design features of the PWR types under consideration? If no – could it be justified why this has not been taken into account? If yes – could the results be provided?
4. What were the indicators and criteria applied in the comparison – could some more detailed information be provided? Which methodology was applied to combine the indicators and criteria and arrive at an overall judgment?

5. Which importance was given in the comparison process to the basic character of the safety systems – active or passive? How are the advantages and disadvantages of passive safety systems seen by the Belarus side?

2.2 Information received at the consultation

Merits and shortcomings of Reactor types in principle are well known; the Belarusian delegation emphasizes that PWRs are worldwide the mostly used NPP type.

Because of their common history, Belarus has better knowledge of Russian reactors, than on Western ones. But they have studied also information on projects from Areva, Westinghouse and Toshiba.

The logic behind the selection process was to use the accumulated knowledge of other countries in NPP development. The experts were mostly Belarusians, having worked in Russian nuclear industry. For example, the chief engineer Mr. Bondar was involved in the start-up of Tianwan NPP in China.

Construction schedules for PWR´s in Russia, France and China were studied by the Belarusian side. The schedules are very similar. Construction schedule for Russian projects:

- Prototype: Novovoronesh-5: 6–12 months preconstruction stage and all in all, about 5 yrs. +/- 6 months.
- 1st Gen VVER 1000/320 (1000 MWe): 4–5 yrs, were all on schedule in Ukraine and Russian Federation.
- 2nd Gen, NPP 91/99 (1070 MWe): Tianwan/China – would have been on schedule, but had some problems with steam generators (fault of design organization – Russia offered different solutions than China wanted to build. Regulatory body in Russia required rectification by Chinese company).
- 3rd Gen, NPP 2006 (1170 MWe): Novovoronesh- II and Leningrad-II (1170 MWe), under construction.

Compared to this, the EPR in Finland is 18 months behind schedule. Furthermore, the EPR would have too big output capacity for the Belarusian grid.

VVER 1200 was selected on basis of available information. NPP 2006 is the design basis, specific design features are to be defined later. The Belarusian feasibility study found that the NPP should have a capacity as NPP-2006 project, which is about 1,200 MWe. Belarus hopes to gain experience from the NPP 2006 plants, which are now under construction, and from the Baltic NPP, which will also start construction earlier. All these plants will have an electric output of 1170 MWe and will be in operation before the NPP Belarus will be commissioned.

The design of AES 2006 includes: passive heat removal system, double containment. The latter is very important for Belarus, because of their experience with the Chernobyl reactor. For Belarus reliability and the number of safety features was of relevance for their selection of AES 2006. In particular, it was said that components in the VVER series have been improved over a long term and therefore are well tested.

There exist two different designs, because of two different design organizations:

- St. Petersburg design office: NPP-2006 VVER-1200/V491.
- Moscow design office: NPP-2006 VVER-1200/V392M.

Belarus has chosen V491 were active safety systems are predominant. These active systems are said to be very efficient, as positive experience with VVER V320 shows. Now more sophisticated features will be added, like double containment and core catcher; those will harmoniously complement existing safety systems. This is required, because Norms also are evolving and fulfillment of new criteria like EUR is expected by electricity companies.

There are passive systems added in both designs of 3rd Generation VVER: most important is the passive heat removal system from steam generators for BDBA. It can have air-cooled and liquid-cooled coolers; depends on specific design (detail design phase) and provides cooling for 3–5 days without personnel intervention.

According to the Belarusian experts, the project fulfills all requirements of EUR, IAEA etc.

All DBAs can be managed by active systems. For control of BDBA, active and passive safety systems are provided (core catcher plus double containment, as well as heat removal system as mentioned).

2.3 Assessment

All in all, the selection process of the plant type has been made plausible. Based on the experience at hand, it is not clear whether construction schedules will indeed be met; however, this is not an issue particularly relevant for plant safety.

The selection of the plant variant relying more strongly on active safety features has been justified with the extensive experience with active systems in VVER-1000/V320 plants. This approach is both plausible and cautious.

The specific design of the Belarusian NPP has not yet been developed. This will be further discussed in the section below.

3 DESCRIPTION OF THE PROJECT

3.1 Background

The **resistance of the VVER-1200 against external impacts** (which depends to a considerable extent, but not exclusively, on the wall thickness of the containment building) as specified in the EIA Report is, in some cases, inferior to that of modern Generation II PWRs. In the EIA Report, the airplane crash the building has to withstand is not specified.

In the Replies 2010 data on the thickness of the **internal and external containment** hull are provided differentiating between cylinder and dome, as requested.[2] Furthermore, the width of the gap between the two covers is specified.

It is noteworthy that the **aircraft crash** of a plane with 5.7 tons, and the speed – 100 m/s. represents a considerably smaller load than those assumed for many newer Generation II plants. For example, 20 tons and 215 m/s are assumed for German pre-konvoi and konvoi plants, corresponding to the crash of a Phantom fighter-bomber. A design on the basis of such loads also offers a degree of protection against the crash of a large commercial airliner.)

It appears that the design basis **earthquake** (SL-2 according to IAEA safety guides) has a maximum horizontal ground acceleration 0.25 g (as already mentioned in the EIA report, p. 41), corresponding to intensity 8 on the MSK-64 scale. The SL-1 earthquake (an earthquake which can be assumed to occur during the lifetime of the plant) is associated with a ground acceleration of 0.12 g (intensity 7 on the MSK-64 scale). For an earthquake of intensity 8 on the MSK-64 scale, a horizontal ground acceleration of 0.25 g appears somewhat low; however, this depends on the local characteristics of the underground.

It is clarified that the **maximum shock wave** which the cover can sustain has a pressure of 30 kPa, and a duration of impact of 1 second. (REPLIES 2010)

While a number of basic data concerning the reactor design and operational parameters are provided in the EIA Report, there is no detailed description of the **safety systems** which are mentioned. It is not possible to gain a comprehensive picture of the functioning and reliability of those systems. Several technical features are presented as new in the EIA Report which already are implemented in many currently operating Generation II plants.

The **high-pressure boron injection system** consists of four channels (4x50% redundancy) and is located inside the containment. Basically, this is a system with hydraulic accumulators as they are already widely used in PWRs operation today (Generation II plants). Further details will become available in the course of the project.(REPLIES 2010)

The purpose of the **corium localization device** is the reduction of the radiological consequences of a large accident. The most important task in this case is the preservation of containment integrity..The device is a vessel below the bottom of the reactor pressure vessel in which the corium is to be collected and

[2] Thickness of internal cover: cylindrical part 1200 mm, spherical part 1000 mm; external cover: cylindrical part 800 mm; spherical part 600 mm; gap between covers 1800 mm

cooled by water. Radioactive releases inside the containment and hydrogen formation is to be minimized by the design. Containment failure pressure should not be exceeded. Functioning should be completely passive for at least 72 hours. It is pointed out that tests of this system have been carried out the Tianwan NPP in China. (REPLIES 2010) The description of this important safety system should be confirmed in detail.

The purpose of the **passive system for heat removal from the steam generators** is to minimize radioactive discharges in case of a primary-to-secondary leakage. The system consists of four parallel trains (4x33.3% redundancy). The heat is transferred to tanks located outside the reactor containment. Containment failure pressure is to be avoided with the aid of this system.(REPLIES 2010) However, the description of this system is not very clear.

3.1.1 Questions for the Consultation

6. The CAPACITY FACTOR given in the EIA Report (about 96%) is very high. What is the basis for this assumption?
7. How is the assumption of 5.7 tons, 100 m/s justified; which considerations led to this assumption?
8. Is it likely that the containment building does have some safety margins in addition to the assumptions stated?
9. How is the assumption of 30 kPa for 1 second justified; which considerations led to this assumption?
10. Is it likely that the containment building does have some safety margins in addition to the assumptions stated
11. Could the methodology for determining the earthquake loads – in particular for the SL-2 earthquake – be explained? (Definition of seismic zones; determination of maximum earthquakes for each zone; determination of the attenuation functions etc.)
12. Can a detailed description of the corium localization device be provided? How has the functioning of this device been proven (tests, computer simulations)? In particular, how can it be guaranteed that steam explosions can be avoided?

3.2 Information received at the consultation

Belarus does not yet possess skills to design a NPP. The Institute Belnipienergoprom is the general designer, but mostly it serves as the co-ordinating body for the project, and the design work is done by the Russian designer office. 17 organizations are involved – including institutes of the National Academy of Sciences and two organisations from Ukraine.

The Belarusian delegation explained that the **capacity factor** of 96% is part of the design specifications, meaning it is a target value. In fact it is expected that 90% will be reached, which is said to be a realistic assumption.

The **containment design parameters** are from the Russian designer i.e. the St. Petersburg design office. The design office in Moskow has different parameters: 20 t/200 m/s. The Belarusian delegation emphasized that the local impact (by the turbine) on the containment hull is decisive not the weight of the plane. However, it was acknowledged in the discussion that apart from local impact (relevant for penetration), the overall momentum of the plane (relevant for shaking of the building) as well as the amount of fuel (relevant for thermal loads) are also relevant.

Besides that, it was explained, that the selected site is far away of flight corridors. There is enough time for the air defence to intervene in case it is necessary. The double containments provide a great safety margin for disasters, also for other external impacts as explosions.

Earthquake was considered during the site selection: For three candidate sites geology and seismicity was investigated by Institutes of the National Academy of Sciences.

Investigations were a long process in three stages: 1st stage 1996–1998, when work was halted. 2nd and 3rd stage 2005 – now. With stations are monitoring microseismicity.

Two IAEA expert missions were supervising this process. According to the Belarusian experts, the IAEA experts confirmed that Belarus conducted an unprecedented survey.

The chosen site (Ostrovets) was selected because of minor complications at the other sites. (The selection has not yet been officially confirmed – but it is clear the Ostrovets has first priority). Other considered sites are located at chalk deposits (which is disadvantageous, but not necessarily prohibitive).

In general Belarus has low seismic activity. Based on the research the design basis earthquake with a return period of 10,000 years should be MSK 6. However, MSK 7 could also be accepted because NPP 2006 can withstand MSK 8 (SL-2). Hence, a large margin exists.

Core catcher: Belarusian delegation explained that this is a system which should never be needed. It is a localization system: A simple strong reservoir for trapping and containing corium, cooling it and keeping it sub-critical.

Walls are made of reinforced concrete. Inside the device is a sacrificial material, containing boron-carbid. The core catcher is cooled by water from a special tank (inside containment). Water circulates around core catcher and also in pipes in the concrete wall. Thus, it does not touch the corium, unless the core catcher fails. But the concrete structure is very massive. As opposed to EPR, the corium stays in a very compact form in the core catcher, which results in an unfavorable surface-to-volume ratio for cooling.

Reaction of boron-carbide with molten core could not be explained since the detailed design for NPP Belarus is not yet specified. The concept for the Chinese NPP assumed an entire mixing of corium with the sacrificial material (the latter making up 2% of the total; it also contains other elements but boron). Extensive calculations for those processes have been performed for the Chinese NPP.

Passive heat removal system from steam generators: No operator involvement required; completely passive, operates even in case of total station black out (SBO). This system is destined for the case of complete loss of feedwater; it has 4 parallel trains. Each train provides heat removal for 3 days and more. Emergency heat removal tanks (1000 m³) are arranged outside of containment above SG , constantly filled with water. Before this system is initiated, all active systems come into play. HPI, LPI, EFWS.

If all these active systems fail, this system initiates. Steam flow occurs via pipe from SG – into cooling tanks, back via heat exchangers to SG. The valves in the connection pipes from SG to cooling tanks are shut during normal operation. But trains are constantly heated; so there is no heat impact when the system is needed. The valves open by drop of pressure; for their opening no power is required (analogous to hydroaccumulators which are part of ECCS). If pressure goes down in the secondary circuit, the valves open. Valves can also be opened and shut from main control room and the system can be used for planned FW supply.

There are large water reservoirs. Alternatively, the system can also be air cooled. Belarus will very likely use the water tank option.

3.3 Assessment

Regarding external impacts, it is plausible that the containment building of the VVER-1200 has large safety margins and can withstand loads considerable higher than the design basis loads for aircraft crash and explosions.

The basic design of the core catcher is beset with a fundamental disadvantage – the molten core stays in a very compact form, which results in an unfavourable surface-to-volume ratio for cooling. Further information on the core catcher will become available as the detailed design for NPP Belarus proceeds. However, it is not foreseeable that the disadvantage outlined above will be remedied since this would require far-reaching changes in the reactor design.

Regarding other safety systems, it became clear, that the specific design of the plant is not available yet and will be elaborated later. Thus, the information provided to the Austrian side was, although helpful for a general understanding, of a general nature and not specific.

4 PROJECT TARGETS & DESIGN LIMITS

4.1 Background

The quantitative probabilistic targets appear to be fulfilled by the NPP-2006. It is important to note that the NPP-2006 was developed from NPP-92, which is certified by European Utility Requirements (EUR). Thus, it is plausible that NPP-2006 also fulfills the EUR.

It is stated that the limit for the probability of a core damage accident is 10^{-6}/yr, and for large releases which require short-term countermeasures beyond the site 10^{-7}/yr.

In case of releases with a probability of 10^{-7}/yr or higher, evacuation of the population should not become necessary at distances of more than 800 m from the reactor. Protective measures like sheltering or iodine prevention are limited to a 3 km zone around the NPP.

In the Replies 2010 it is stated clearly that the probabilistic targets cover all operating conditions as well as all initiating factors. It is pointed out that a probabilistic analysis will be carried out in the course of the further development of the Belarus NPP project.

The reference to the probabilistic analysis which is planned in the future could be understood to imply that an answer is not possible at the moment, but could be provided later.

However, since CDF and LRF values for the VVER-1200 have been provided in the EIA report, probabilistic analyses for the VVER-1200 clearly have already been performed and it should be possible to obtain an answer to the question, at the present time, based on those analyses.

4.1.1 Questions for the Consultation

15. Can it be confirmed that the CDF and LRF values for the VVER-1200 provided in the EIA report cover all plant conditions as well as internal and external initiating factors?

At this point the systematic discussion of our questions ended in a more broader debate of severe accidents and risk assessment.

4.2 Information received at the consultation

The Belarusian delegation explained, that they mostly deal with analogues, taken from forerunner plants. All EUR requirements are taken into account in the project. Hence, all required situations are included in the quoted PSAs.

So far, there are no special figures for Belarus NPP. The idea of EIA was to consider the worst-case scenarios – LOCA and Station Blackout with LRF in the order of 10^{-7}. Source terms are from analogue stations (Novovoronesh II, Leningrad II, Baltic station etc.). EUR – Criteria for limited impact are fulfilled by Leningrad II and Baltic.

In Scandinavian countries, there is a limit of 100 TBq Cs-137 for large releases. The figure for a BDBA worst-case scenario for analogous reactors provided in the REPLIES (2010) is higher by a factor 3.5.

At the consultation, an accident scenario with release of 53 TBq Cs, 41 TBq Sr, 15 TBq Ru, 3,470 TBq I and 9,300 TBq noble gases was presented for BDBA (the isotopes were not specified). A dispersion calculation based on this scenario led to very small doses in greater distances. However, it was based on the assumption that the containment remained intact, with a leak rate of 0.02%/hr.

Other BDBA source terms which were mentioned: Chinese NPP 20 TBq Cs-137 LRF, Baltic NPP 5 TBq.

4.3 Assessment

The scenarios for BDBAs presented in the discussion and in the EIA documents all appear to belong to scenarios without containment failure (leading to comparatively low, non-conservative source terms). No details for these scenarios were provided. Furthermore, for those scenarios different source terms are mentioned, spanning almost two orders of magnitude; the differences were not explained.

Risk assessment of the EPR as it was published by AREVA in the framework of generic licensing in the USA shows that early containment failure, with larger releases can not be excluded in principle.

Analysis for Belarusian NPP have not yet been done, specifically. Analogous analyses were done by Kurchatov-Institute. Details on the analysis cannot be given because Belarus does not have this information or is not allowed to disperse it.

Probability of early containment failure would be $< 10^{-7}$. But limitations and shortcomings of PSA must be clear. It is problematical to exclude a BDBA scenario from consideration on probabilistic arguments alone.

These issues are not resolved. There is still need for debate.

5 OPEN QUESTIONS AFTER CONSULTATION

Because of time constraints, during the consultation not all questions posed by the Austrian experts have been answered. After the discussion of question 15. instead of continuing the prepared questions a presentation was held on emergency planning.

From the previous debate we learned, that some of our questions cannot be answered now (except in a general, not project-specific manner), because the specific design of the NPP in Belarus is not finished. In the following we present the most relevant questions which are still open. These questions concern project targets & design limits and accident analysis.

5.1 Project targets & design limits

5.1.1 Background

The quantitative probabilistic targets appear to be fulfilled by the NPP-2006. It is important to note that the NPP-2006 was developed from NPP-92, which is certified by European Utility Requirements (EUR). Thus, it is plausible that NPP-2006 also fulfills the EUR.

It is stated that the limit for the probability of a core damage accident is 10^{-6}/yr, and for large releases which require short-term countermeasures beyond the site 10^{-7}/yr.

In case of releases with a probability of 10^{-7}/yr or higher, evacuation of the population should not become necessary at distances of more than 800 m from the reactor. Protective measures like sheltering or iodine prevention are limited to a 3 km zone around the NPP.

In the Replies 2010 it is stated clearly that the probabilistic targets cover all operating conditions as well as all initiating factors. It is pointed out that a probabilistic analysis will be carried out in the course of the further development of the Belarus NPP project.

The reference to the probabilistic analysis which is planned in the future could be understood to imply that an answer is not possible at the moment, but could be provided later.

However, since CDF and LRF values for the VVER-1200 have been provided in the EIA report, probabilistic analyses for the VVER-1200 clearly have already been performed and it should be possible to obtain preliminary answers to the questions concerning probabilistic analyses, at the present time, based on those analyses.

5.1.2 Open Questions from Consultation

16. Could a listing be provided of the internal and external initiating factors which have been taken into account in the probabilistic safety analysis for the VVER-1200?

17. A probabilistic analysis clearly has already been performed for the VVER-1200 basic design AES 2006, since values for CDF and LRF are available. Is it possible to provide information on the uncertainties of this probabilistic analysis (for example, by providing the 95% fractiles)?

5.2 Information received from Belarus after the Consultation

The following categories of initial (initiating[3]) events are presented (ANSWERS 2010):

1. Violation of normal condition of operation
2. Design accidents (design basis accidents /DBA)
3. Out-of-design accidents (beyond design basis accidents / BDBA)

A second list presents groups of initial events connected with violation of condition for normal power operation and DBAs:

- disturbance in heat removal from secondary cooling circuit
- decrease of coolant heat consumption of the primary cooling circuit
- abnormalities of reactivity and power distribution
- disturbance of coolant quantity of primary circuit
- radioactive discharge from a subsystem or component
- failure of the protective cover of the reactor
- LOCA with leak in atmosphere or the secondary circuit

The third list presents groups of initial events intended for safety analysis and substantiation of acceptance criteria. This list includes incidents in other parts of the NPP like auxiliary systems, events in the course of fuel handling and external events.

[3] Inserted by the authors

The forth and last list presents the spectrum of accidents with WWER 1000 reactor (V-428), including probabilities:

Group of Accidents	Initial Event	Probability of Event 1/Year
I Design accidents		
I Group	Spectrum of the accidents with leak of the coolant from the first contour to the second contour	
I.I	Steam generator (SG) heat-exchange tube rupture with further reactor shut-down cooling at a rate of 60^0C/h	$<10^{-3}$
I.2	Leak from the first contour to the second within SG (D_y <100 mm)	$< 5\times10^{-4}$
2 Group	Decompression of the first contour within the limits of leakproof zone	
2.1	Discharge of control elements of control and protection system at drive case rupture	$<10^{-3}$
2.2	Decopmpression of hydrocylinder	$< 2\times10^{-4}$
3 Group	Decompression of the contours with radioactive media outside the limits of the leakproof capacity	
3.1	Rupture of reactor instrumentation line or other lines which contain the coolant of the first contour at failure of the localizing fittings	$< 2\times10^{-4}$
3.2	Decompression of gas circuit	$< 10^{-4}$
3.3	Decompression of the contour with liquid radioactive waste	$< 10^{-4}$
4	Accidents with transport-technological operations with fuel	$< 10^{-4}$
II Out-of-Design-Basis Accidents		
1 Group	Spectrum of the accidents with degradation of reactor core and slow increase of pressure in a containment	
1.1	Failure of all the ac sources for 24 hours	$< 4\times10^{-7}$
1.2	Loss of the coolant at small breaks with a failure of the active part of the system of the active zone emergency cooling	$< 5\times10^{-8}$
1.3	Loss of the coolant at large breaks with a failure of the active part of the system of the active zone emergency cooling	$< 3\times10^{-10}$
2 Group	Steam pipeline rupture outside and inside of the shelter wall (before direct-admission gate valve) with simultaneous rupture of one heat-exchange tube in abnormal steam generator (SG)	$<10^{-8}$

5.3 Accident analysis

5.3.1 Background

In the EIA Report no information has been provided about which DBA scenarios have been analyzed. Under the headline "Accident scenarios" only meteorological scenarios are presented. A source term is presented for the maximum DBA.

Several BDBA source terms are presented, but without description of the initiating events and the progress of the emergency situation. Furthermore, it is unclear whether the source terms are derived from deterministic or probabilistic assessments. That is also the case for the BDBA emission scenario in Chapter 5 "Transboundary impact", which is designated as the "most severe" BDBA scenario. Source terms which are presented without further explanation regarding the underlying assumptions are of little informative value.

For two BDBA release scenarios, the fulfillment of the EUR requirements is demonstrated in the EIA Report. These releases are smaller than those corresponding to the "most severe" scenario mentioned above. No explanation is provided in the EIA Report as to why they were selected for checking the fulfillment of the EUR requirements.

All severe accidents considered in the EIA Report lead to rather small releases – about a fraction of 10^{-4} or less of the Cs-137 inventory. No uncertainties of the presented results are given in the EIA Report.

The conclusion of the EIA Report, which states that no greater source terms than the presented limited releases could occur is not sufficiently substantiated. For all existing reactors and also for the new Generation III reactors now under construction, severe accidents with a release in the range of some percent of the Cs-137 inventory (2–20%) are not excluded. Even if the frequency of occurrence of accidents with a large release appears very small according to PSA, such severe accident source terms should be considered in the transboundary EIA. It should be taken into account that PSA results do not include all relevant factors, and some factors which are included are beset with large uncertainties.

From the REPLIES 2010 it is still unclear which DBA and BDBA were analyzed.

In the Replies it is explained that the consequences of the most serious BDBA (beyond design base accident) have been considered. Among **four types of BDBA** the most serious consequences, from the point of view of the radiation damage, result from the BDBA of the **third type:** This is described as a station blackout, failure of the core cooling, which leads to serious damage of the fuel, but without containment breach. It is said to be an accident of level 5 on the international nuclear event scale (INES).

5.3.2 Open Questions from Consultation

24. In your Replies compared to the Preliminary EIA Report a new worst case source term is presented: 3100 TBq I-131 and 350 TBq Cs-137. Please explain, why this source term is chosen.
28. Is it possible to present a systematical listing of considered DBA and BDBA scenarios?
29. Is it possible to present more details on the types of BDBA scenarios (besides station blackout)?

5.4 Information received from Belarus after the Consultation

In the ANSWERS 2010 it is explained that the discharge presented in the Replies 2010 (see question 24) which is assumed as a worst case scenario derived from WWER 1000 V320 plant. ANSWERS 2010 states that this discharge is a conservative estimation for a BDBA. The maximum discharge of NPP 2006 is from the "Preliminary Report on Substantiation of Safety of the Leningrad NPP-2, Chapter 15, (SpbAEP FSUE, 2007). A short description of the two phases of the release is given in the ANSWERS 2010. The probability of this event is in the order of 10^{-7}.

The requested **listing of design basis accidents** is presented in the following table:

List of design-basis accidents

Name of Mode
Spectrum of ruptures of steam lines inside and outside of the containment up to the maximum diameter of the steam pipeline Indeliberate closure of cutoff valve on a steam line with the subsequent non-fit of pulse-emergency gear of the abnormal SG which leads to emergency decrease of to pressure in the system of steam lines of the working steam
Rupture of the pipeline of a feed water
Instant jamming of a shaft of a reactor coolant pump Rupture of a shaft of the reactor coolant pump
Wrong loading and operation of fuel assemblies in inadequate position Spectrum of the accidents with discharge of the absorber of the system of control and protection (in each case simultaneously one absorber of the system of control and protection)
Indeliberate opening and non-fit of the pulse-emergency gear of pressure compensator Accident with a leak of the coolant as a result of a spectrum of ruptures of the pipes with diameter up to 100 mm inclusive within the boundaries of pressure of the first contour: - without exposure of the active zone; - with exposure of the active zone. Accident with a leak of the coolant as a result of a spectrum of ruptures of the pipes with diameter of more than 100 mm up to 850 mm
Leak or damage of the systems which contain radioactive gas Accidents at fuel overload Accidents inside of the containment with the container of the spent fuel
Damage outside the containment of the lines containing the coolant of the first contour: - compensatory leak; - uncompensatory leak.
Fast reactor plant shutdown cooling at a rate of 60oC/h after rupture of the SG tube
Separation of a cover of SG collector of the first contour and the subsequent damage of SG cover of the second contour Separation of a cover of SG collector of the first contour (equivalent diameter of 0,043 m)

Also a list of BDBA is presented in the ANSWERS 2010:

List of out-of-design-basis accidents

Name of the accident
Loss of all the sources of power supply of the Nuclear Power Plant except for storage batteries for 24 hours
Leak of the reactor vessel with a rate of no more than 10 t/h
Accident with separation of a reactor pit
Long-term termination of removal of residual heats to the final absorbent at: - at stopped reactor; - at overloading
Reactor shutdown cooling at operation of one steam generator
Spectrum of ruptures of steam lines inside and outside of the containment up to the maximum diameter of the steam pipeline with rupture of one tube in a steam generator

The four types of BDBA were characterized in the answer of question 29 as follows:

1. LOCA inside containment; with safety systems operating normally and there are **violations in functioning of a containment shell**.
2. LOCA and failure of some systems of emergency cooling.
3. Station black out with DG not possible to start within 24 hours.
4. Leak of coolant from the primary to the secondary circuit.

5.5 Assessment

Question 16 has been answered; listings of internal and external initiating events have been provided. However, there is some lack of clarity, in particular regarding the connection between the second and third list.

The second list appears to cover initiating events during operation, whereas pts. 1–4 of the third list concerns events during shut-down. Pts. 5–11 of the third list cover external events, which are relevant for all plant states.

Apart from these apparent shortcomings in the structure of the answer, the information provided is of very general nature. For example, the transients in the second list correspond to those listed in the IAEA Safety Guide on level 1 PSA[4]. This is probably due to the fact that specific information on the Belarus NPP cannot be provided yet since the specific design process for this plant is only beginning.

Question 17 remains completely open – no information has been provided on the uncertainties of the PSA results.

Question 24 is answered in a brief and general manner only. However, the origin of the source term in question is made clear, and it is also made clear that this source term is regarded as conservative. Specific information on the Belarus NPP will be available later as the specific design process evolves.

Questions 28 and 29 also are answered in a general manner.

It has become clear in all cases that specific information for the NPP Belarus cannot be provided because they will be elaborated in the following specific design process.

From the overview on all the information we received from Belarus and from EIA reports on Russian NPPs it is clear that there is a cut-off value for the probability of severe accidents: Only beyond design basis accidents are considered with a probability of occurrence > 10^{-7} per reactor and year (the limit for the probability of a core damage accident is 10^{-6}/yr). Accidents with a risk < 10^{-7} per reactor and year are classified as practically impossible. In the opinion of the Austrian experts, such accidents are not to be excluded in principle. Due to the limits and shortcomings of probabilistic analyses, accidents should not be excluded from consideration on the basis of probabilistic arguments alone.

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[4] IAEA: Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants; Specific Safety guide No. SSG-3, Vienna 2010

Nevertheless, probabilistic studies are helpful for evaluating reactor hazards. Hence, a risk assessment should be made available for the Belarus NPP, after its design is finished. We expect that this assessment will include a discussion of uncertainties, factors not included etc., as should every probabilistic analysis.

Some references are given in the ANSWERS 2010:

"Preliminary Report on Substantiation of Safety of the Leningrad NPP-2, Chapter 15 the Analysis of Accidents Book 7, (SpbAEP FSUE, 2007). Is there a possibility to achieve this part of the Leningrad NPP-2 Safety Report?

For a better understanding of the Russian safety conception the Belarusian experts recommend in their ANSWERS 2010 to read the following documents:

Particular qualities of safety conception of NPP-2006 design for Leningrad NPP-2 site, Onufrienko S.V., Bezlepkin V.V., Molchanov A.V., Svetlov S.V, Solodovnikov A.S., Semashko S.E.

(Особенности концепции безопасности проекта АЭС-2006 на площадке ЛАЭС-2,
Онуфриенко С.В., Безлепкин В.В., Молчанов А.В., Светлов С.В., Солодовников А.С., Семашко С.Е)

Unfortunately these references are incomplete, therefore it was not possible to achieve them. In a web research only an abstract of the first reference could be found as a contribution in a Russian journal from 2008 (www.tiajmash.ru/ref/ref0802.doc). Since this journal is not available in Austria we ask you to send us a copy of these references.

6 GLOSSARY

Yr .... year, Jahr

AES .... Atomnaja Electrostancija, translates into nuclear power plant (NPP)

BDBA .... Beyond Design Basis Accident

CDF .... Core Damage Frequency

CLI .... Criteria for Limited Impact

Cs .... Caesium

DBA .... Design Basis Accident

DWR .... Druckwasserreaktor, English: PWR

ECCS .... Emergency Core Cooling System

EIA .... Environmental Impact Assessment

(UVE)

EPR .... European Power Reactor

EUR .... European Utilities Requirements

g .... ground acceleration

I .... Iodine

IAEA .... International Atomic Energy Agency

ICRP .... International Commission on Radiation Protection

INSAG .... International Nuclear Safety Group

kPa .... Kilo Pascal

LRF .... Large Release Frequency

mGy .... Milli Gray (energy dose)

mSv .... Milli Sievert (dose)

MW .... Megawatt

MWe .... Megawatt electric

NPP .... Nuclear Power Plant

NPP-92 .... Russian type of PWR, predecessor model of NPP-2006 (=AES-92)

NPP-2006 .... Russian type of PWR (= AES-2006)

NRC .... Nuclear Regulatory Commission (USA)

PSA .... Probabilistic Safety Assessment

PWR .... Pressurized Water Reactor

Sr .... Strontium

TBq .... Tera Becquerel

UVE .... Umweltverträglichkeitserklärung (English: EIA Report)

UVP .... Umweltverträglichkeitsprüfung (English: EIA)

VVER .... Vodo-Vodyanoy Energeticheskiy Reactor (PWR)

7 REFERENCES

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PERSPEKTIVEN FÜR UMWELT & GESELLSCHAFT **umweltbundesamt**

Umweltbundesamt GmbH
Spittelauer Lände 5
1090 Wien/Österreich

Tel.: +43-(0)1-313 04
Fax: +43-(0)1-313 04/5400

office@umweltbundesamt.at
www.umweltbundesamt.at

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