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EIA NPP KHMELNITSKY 3&4 PROCEDURE 2019

Final Expert Statement (Consultation Report)

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SUMMARY

At the Khmelnitsky site in Ukraine, the state enterprise "National Nuclear Energy Generating Company Energoatom" is preparing the completion of nuclear power plant units 3 and 4 (KhNPP-3&4). At the site, two units VVER-1000/V-320 are already in operation.

Construction of KhNPP-3&4 started in 1985/1986 and was halted due to the 1990 moratorium on the construction of nuclear power units in the former USSR. In 2005, the Cabinet of Ministers of Ukraine decided to renew the construction. The reactor VVER-1000/V-392 (Atomstroyexport) was chosen and this decision became law in 2012. Due to the deteriorating relations between Ukraine and Russia this law ceased to be in force in 2015. Later on, Energoatom chose Škoda JS a.s. as the reactor supplier.

An environmental impact assessment (EIA) under the Espoo Convention started in 2010. Austria has participated in this procedure since 2011 and submitted an expert statement (UMWELTBUNDESAMT 2013[1]) in 2013; in August 2013 bilateral consultations with the Ukrainian side took place. Due to the above mentioned situation the EIA procedure was suspended in 2015. Another expert statement was commissioned (UMWELTBUNDESAMT 2019) when the EIA procedure was restarted in 2017. Bilateral consultations and a public hearing were held on June 13, 2019 in Vienna. The consultation report at hand assesses the answers the Ukrainian side during the consultations.

The objective of the Austrian participation in the Espoo procedure is to give recommendations on minimising or even eliminating possible significant adverse impacts on Austria.

Overall and procedural aspects

According to the Espoo Convention a description and an assessment of reasonable alternatives and also the no-action alternative have to be included in the environmental impact assessment documentation. In this regard the information in the EIA documentation is not sufficient.

Several safety relevant aspects will have to be examined and approved during further licensing procedures by the nuclear authority of Ukraine. A detailed safety assessment of the project is not available at the present stage of the project preparation. It is appreciated if the Austrian side will be given the possibility to discuss the promised parts of the Preliminary Safety Analysis Report under the pertinent "Bilateral Agreement".

Information on the status of the Ukraine-EU-Energy Bridge project was given during the bilateral consultations. This project, which is still in preparation, should serve to enable the electricity export of KhNPP-2 to raise funds for the completion of KhNPP-3&4. For Austria it is important that financing issues do not have detrimental impact on nuclear safety and security.

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[1] It can be downloaded at: http://www.umweltbundesamt.at/umweltsituation/uvpsup/espooverfahren/espoo_ukraine/kkwkhmelnitsky34/

Spent fuel and radioactive waste

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore the EIA should assess the nuclear waste management.

The Ukrainian side has provided the Austrian side with additional information on spent fuel and radioactive waste.

In June 2019, the Cabinet of Ministers approved a concept for the management of spent fuel of NPPs for the period up to 2024, supposedly fulfilling the requirements of Council Directive 2011/70/EURATOM[2]. It is recommended that the Austrian government follows up on this issue under the pertinent “Bilateral Agreement”.

Reactor Type

From an expert’s point of view any NPP to be commissioned for the first time should meet state of the art safety requirements in full. But given the current broad agreement on European and international level that “deferred plants” may be considered as “existing plants” this expert statement is based on the concept of reasonably practicable safety improvements.

For the completion of KhNPP-3&4, it is planned to use the buildings and structures already built in the 1980s. Information about the conditions of the existing buildings, structures and equipment are not provided in the EIA documents. During the consultations, it was explained that 2009-2013 restoration and repair works were performed, based on the 2005-2009 survey. However, some of the important works (for example repair of concrete structures) have not been finished.

Furthermore, the survey 2005-2009 was based on a service lifetime of 75 years. But today’s service lifetime is considerably longer, about 100 years. For this reason alone, the old survey cannot prove that the old structures are fit to complete KhNPP 3&4.

A new survey to confirm the durability and reliability of the building and structures is on-going. It is to be welcomed that the result of the survey will be made available to the Austrian side.

The EIA documents do not provide information about the resistance against external impacts of the KhNPP-3&4. Information was provided during the consultations: For the new survey, requirements from the 1970s and 1980s were replaced by newer requirements. However, the survey is almost exclusively based on regulations from 2006. The severe accident in Japan in March 2011 led to an increase in the international safety requirements for external hazards. From a safety point of view, requirements for the completion of a nuclear power plant with an operating lifetime of at least 50 years should reflect most recent research results and developments in international standards.

The investigation of the components which were delivered 20 to 30 years ago is in progress. Several components are physically and technologically obsolete and cannot be used. It is a positive fact that the result of the investigation of the components will be made available to Austria.

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[2] https://kosatka.media/en/category/elektroenergiya/news/ukraina-planiruet-vyvozit-oyat-na-specializirovannye-inostrannye-predpriyatiya, seen 26 June 2019

An ageing management programme (AMP) is not mentioned in the EIA documents. For Ukraine, the first Topical Peer Review (TPR) based on Directive 2014/87/EURATOM revealed several deviations from the safety expectations for an acceptable ageing management in Europe. One of these issues is of particular concern for KhNPP-3&4 because it refers to delayed NPP projects. (ENSREG 2018) Ukraine included only completed buildings in the ageing management program. However, this approach is not justified because the structures and equipment of KhNPP 3&4 are already ageing despite the fact the plant is not in operation.

For the period between the investigation of components and the start of regular AMP, ageing phenomena should be addressed adequately.

All in all, no convincing evidence showed that the existing building, structures and equipment are in a condition for a least 50 years of safe operation.

The improved VVER-1000/V-392B safety concept (with passive safety systems) for the completion of KhNPP-3&4 was selected and approved in 2008. The VVER 1000/V-320 design on the contrary does not comply with modern safety standards.

Key safety feature of the envisaged KhNPP-3&4 is the external cooling of the molten core in case of a core melt accident. The development of this feature for the "In Vessel Melt Retention" (IVMR) is still underway, for example at the reference units at the Temelín NPP. Furthermore, it has to be highlighted that NPP designs developed in the 1980s, such as the VVER-1000/V-320, only partly meet modern design principles concerning redundancy, diversity and physical separation of redundant subsystems or the preference of passive over active safety systems. (see IAEA 2016a, WENRA 2013) But all this design principles are necessary to reduce the risk of an accident.

According to WENRA (2013), the WENRA Safety Objectives for new NPPs shall be used as a reference for identifying reasonably practicable safety improvements for "deferred plants" like KhNPP-3&4. However, the EIA documents do not mention this WENRA safety objectives. According to information provided at the consultations, a systematic evaluation of the KhNPP-3&4 design deviations from the current international safety standards and requirements had been carried out. The results were not reported on. The main problem is, however, that requirements for new nuclear power plants are not applied. More importantly, there is no convincing evidence that every reasonably practicable safety improvement has been made.

Incidents and accidents without involvement of third parties

A systematic analysis of design basis accidents (DBA) and beyond design basis accidents (BDBA) is not presented in the EIA documents; only the radiological consequences of one DBA and one BDBA are discussed. The considered BDBA is a loss of coolant accident with the failure of the active systems of the emergency core cooling and the sprinkler system. This BDBA does not constitute a worst case scenario. To calculate the possible (transboundary) consequences of this BDBA, it was assumed that the core melt will remain within the reactor pressure vessel (RPV). This assumption is not duly justified, because this feature is not available yet. Furthermore, if this feature could be realized it would only reduce the risk of radioactive release in most but not in all severe accident scenarios.

To assess the consequences of BDBAs, it is necessary to analyse severe accidents, including those with containment failure and containment bypass. These kinds of severe accidents are possible for the VVER 1000/V-320 reactor type. This type of severe accidents cannot be excluded although their probability is below a specific value.

The results of the EU stress tests have revealed that the severe accident management (SAM) (i.e. the prevention of severe accidents and the mitigation of its consequences) at the Ukrainian NPPs shows a lot of shortcomings. Comprehensive improvements are required by the regulator; however, further improvements are recommended by the ENSREG peer review team. This is one example for the gap between the Ukraine and the EU safety standards and requirements.

According to current international requirements for new nuclear power plants (IAEA 2012 and WENRA 2013), accident sequences with early or large releases have to be practically eliminated. The concept of "practical elimination" of early or large releases is not mentioned for KhNPP-3&4 in the EIA documents. ENERGOATOM (2017a) states the probability of severe accidents (e.g. with containment failure) that could have a major release are negligible. Moreover, "practical elimination" cannot be demonstrated by showing the compliance with a general probabilistic value. According to IAEA (2016a) the low probability of occurrence of an accident with core melt is not a reason to omit the protection of the containment against the conditions generated by such an accident.

Also, in this case there is no convincing evidence that every reasonably practicable safety improvement has been made towards "practical elimination".

External hazards

The information provided in the EIA documents shows that the site evaluation is not complying with current international requirements, because the requirements quoted are outdated. During the consultations it became clear that a site evaluation according to the current IAEA safety requirement has not been performed.

According to SNRIU (2017), the seismic hazards have to be re-evaluated, the feasibility study was approved with the condition to elaborate and/or clarify the calculation of the peak ground acceleration (PGA). The lacking probabilistic seismic analysis is under preparation. No information was provided on when this analysis will be completed and whether the results will be used for the completion of KhNPP 3&4.

The 2011 feasibility study has been approved with the condition that an in-depth assessment of the impact of extreme external events of natural and man-made nature as well as their combinations will be included in the Preliminary Safety Analysis Report (SNRIU 2012b). This condition is not included in conditions for the approval of the current FS (SNRIU 2017).

According to WENRA (2013), the safety assessment for new nuclear power plants should demonstrate that threats from external hazards are either removed or minimized as far as reasonably practicable. The answer confirms that such an analysis takes place later, i.e. at the design stage. However, this procedure is not fully justified in terms of safety for KhNPP 3&4, since part of the buildings and structures have already been constructed. To be able to assess whether they meet the requirements, it would be necessary to know now which external impacts they would have to withstand.

Incidents and accidents with involvement of third parties

The effects of third parties' involvement (terrorist attacks or acts of sabotage) can have a considerable impact on nuclear facilities and thus also on the KhNPP-3&4 in Ukraine. Nevertheless, they are not mentioned in the EIA documents for KhNPP-3&4. In comparable EIA documents such events were addressed to some extent.

The answers during the consultations on the June 13, 2019 in Vienna confirmed that the Ukrainian regulator does not require the protection of KhNPP-3&4 against an intentional crash of a commercial aircraft. This does not meet the WENRA requirements for new nuclear power plants, but from Ukraine's point of view KhNPP 3&4 is not a new nuclear power plant but an existing one and therefore such protection is not required. Furthermore, it has to be noted that KhNPP 3&4 is not protected against an accidental crash of a commercial aircraft as the probability of such a crash is estimated to be very low.

This topic is in particular important, as the wall thickness of the reactor building/containment of KhNPP-3&4 is only about 1,000-1,200 mm. Therefore, the units could be vulnerable against terror attacks (including airplane crash).

A recent assessment of the nuclear security in the Ukraine points to shortcomings compared to necessary requirements for nuclear security: The 2018 NTI Index assesses nuclear security conditions related to the protection of nuclear facilities against acts of sabotage. With a total score of 70 out 100 points, Ukraine ranked only 30 out of 45 countries, which indicates a low protection level. It has to be pointed out that the low scores for "Insider Threat Prevention" and "Cybersecurity" indicate deficiencies in these issues.

It is a positive fact that regulations regarding cyber security will be improved. But the regulations concerning attacks by so-called insiders (internal perpetrators) should be also improved. The International Physical Protection Advisory Service (IPPAS) assists states, upon request, in strengthening their national nuclear security regimes, systems and measures. It is recommended that Ukraine asks for this IAEA service.

Transboundary Impacts

Comprehensive information is given about the calculation of the transboundary transfer of releases from accidents at KhNPP-3&4, but the calculated ground depositions of iodine-131 and caesium-137 neither for the distance to Austria nor for any other distance were given. This information is important for Austria. In case ground contamination would surpass a certain threshold a set of agricultural intervention measures would be triggered in Austria.

But even more important, severe accidents with releases considerably higher than assumed in the EIA documents cannot be excluded for the KhNPP-3&4, even if their probability is required to be below a specific value. Such worst case accidents should be included in the assessment since their effects can be widespread and long-lasting and even countries not directly bordering Ukraine, like Austria, can be affected.

Because of the lack of analysis of the worst case scenarios, the conclusion of the EIA documents concerning transboundary effects is not appropriate.

The results of the calculations made by the Austrian Institute of Ecology (1998) indicated that a severe accident (worst case scenario) at KhNPP would contaminate several regions in Europe. For the Eastern part of Austria, the calculation resulted in values up to approx. 1,000 kBq/m² of caesium-137 contamination (which is about 5 times the highest values measured in Austria in 1986).

Furthermore, the results of the flexRISK project indicated that after a severe accident, the average caesium-137 ground depositions at most areas of the Austrian territory would be higher than the threshold for agricultural intervention measures (e.g. earlier harvesting, closing of greenhouses). Therefore, Austria could be affected by a severe accident at KhNPP-3&4.

ZUSAMMENFASSUNG

Am KKW-Standort Khmelnitsky in der Ukraine beabsichtigt der staatliche Atomenergiekonzern Energoatom die Fertigstellung der Atomkraftwerksblöcke 3 und 4 (KhNPP-3&4). An diesem Standort sind bereits zwei WWER-1000/V-320 Reaktoren in Betrieb.

Die Errichtung des KKW KhNPP-3&4 begann 1985/1986 und wurde aufgrund des Moratoriums für die Errichtung von KKW in der ehemaligen UdSSR im Jahre 1990 abgebrochen. Im Jahre 2005 beschloss der Ministerrat der Ukraine, die Errichtung wieder aufzunehmen. Es wurde der Reaktor WWER-1000/V-392 von Atomstrojexport ausgewählt und durch ein Gesetz im Jahre 2012 beschlossen. Aufgrund der sich verschlechternden Beziehung zwischen Ukraine und Russland trat das Gesetz im Jahre 2015 außer Kraft. Energoatom entschloss sich dann für Škoda JS a.s als Reaktorlieferanten.

Eine Umweltverträglichkeitsprüfung (UVP) gemäß Espoo-Konvention begann 2010. Österreich beteiligte sich an diesem Verfahren ab 2011 und übermittelte 2013 eine Fachstellungnahme (UMWELTBUNDESAMT 2013[3]). Im August 2013 fanden bilaterale Konsultationen mit der ukrainischen Seite statt. Aufgrund der geschilderten Situation wurde das UVP-Verfahren im Jahre 2015 unterbrochen. Ein weiteres Expertengutachten (UMWELTBUNDESAMT 2019) wurde in Auftrag gegeben, als das UVP-Verfahren im Jahre 2017 wieder aufgenommen wurde. Bilaterale Konsultationen und eine öffentliche Anhörung wurden am 13. Juni 2019 in Wien abgehalten. Der vorliegende Bericht evaluiert die Antworten der ukrainischen Seite bei den Konsultationsgesprächen.

Das Ziel der Teilnahme Österreichs an dem Espoo-Verfahren ist, Empfehlungen zur Minimierung oder wenn möglich Verhinderung von möglichen erheblichen nachteiligen Umweltschäden für Österreich zu geben.

Allgemeine und prozedurale Aspekte

Laut Espoo-Konvention ist eine Beschreibung und Prüfung vernünftiger Alternativen wie auch der Nullvariante in der UVP-Dokumentation zu inkludieren. In dieser Hinsicht ist die Information in der UVP-Dokumentation unzureichend.

Einige sicherheitsrelevante Aspekte werden während der nächsten Phasen des Genehmigungsverfahrens von der Atomaufsichtsbehörde der Ukraine überprüft und genehmigt werden müssen. Eine detaillierte Sicherheitsbewertung des Projekts steht beim gegenwärtigen Stand der Projektvorbereitung nicht zur Verfügung. Die österreichische Seite würde es begrüßenswert finden, wenn die angekündigten Teile des vorläufigen Sicherheitsberichts (PSAR) im Rahmen des Bilateralen Nuklearinformationsabkommens diskutiert werden könnten.

Während der bilateralen Konsultationen wurde über den Status des Projekts für eine Energiebrücke zwischen Ukraine und EU informiert. Dieses Projekt ist noch in Vorbereitung und soll dem Stromexport aus dem Reaktor KhNPP-2 dienen, um Mittel für die Fertigstellung von KhNPP-3&4 zu erwirtschaften. Für Ös-

[3] Download unter: http://www.umweltbundesamt.at/umweltsituation/uvpsup/espooverfahren/espoo_ukraine/kkwkhmelnitsky34/

terreich ist es wichtig, dass diese Finanzierungsfragen keine negativen Auswirkungen auf die nukleare Sicherheit und Sicherung haben.

Abgebrannte Brennelemente und radioaktive Abfälle

Abgebrannte Brennstäbe und radioaktiver Abfall können negative Umweltfolgen haben und daher sollte deren Entsorgung in der UVP bewertet werden.

Die ukrainische Seite stellte der österreichischen Seite weitere Informationen über abgebrannte Brennstäbe und radioaktive Abfälle zur Verfügung.

Im Juni 2019 verabschiedete das Ministerkabinett ein Konzept für das Management von abgebranntem Brennstoff aus KKW für den Zeitraum bis 2024, welches die Anforderungen der EU-Richtlinie 2011/70/EURATOM[4] erfüllen soll. Es wird der österreichischen Regierung empfohlen, diese Frage im Rahmen des bilateralen Nuklearinformationsabkommens zu beobachten.

Reaktortyp

Aus Expertensicht sollte jedes KKW bei seiner Erstgenehmigung die sicherheitsanforderungen des Standes von Wissenschaft und Technik vollständig erfüllen. Angesichts der breiten Zustimmung auf europäischer und internationaler Ebene, wonach Kraftwerke mit Bauverzögerungen als „bestehende Kraftwerke" betrachtet werden können, geht diese Fachstellungnahme vom Konzept der vernünftigerweise durchführbaren Sicherheitsverbesserungen aus.

Für die Fertigstellung von KhNPP-3&4 sollen die bereits in den 1980er Jahren errichteten Gebäude und Strukturen verwendet werden. Über den Zustand der existierenden Gebäude, Strukturen und Anlagen gibt es in der UVP-Dokumentation keine Angaben. Bei den Konsultationsgesprächen wurde erläutert, dass von 2009–2013 Renovierungen und Reparaturen durchgeführt wurden, die von einer 2005–2009 durchgeführten Untersuchung ausgingen. Dennoch wurden einige wesentlichen Arbeiten (etwa die Reparatur von Betonkonstruktionen) nicht abgeschlossen.

Auch geht die Untersuchung von 2005–2009 von einer 75-jährigen Betriebsdauer aus. Doch die heutige Betriebsdauer ist deutlich länger, sie bewegt sich bei etwa 100 Jahren. Allein aus diesem Grund kann die alte Untersuchung nicht nachweisen, dass die alten Konstruktionen für die Fertigstellung von KhNPP 3&4 geeignet sind.

Eine neue Überprüfung der Langlebigkeit und Zuverlässigkeit der Gebäude und Konstruktionen wird zurzeit durchgeführt. Die österreichische Seite begrüßt, dass das Ergebnis der Untersuchung zur Verfügung gestellt wird.

Die UVP-Dokumente beinhalten keine Informationen über die Widerstandsfähigkeit von KhNPP-3&4 gegenüber externen Einwirkungen. Bei den Konsultationen wurde darüber informiert, dass für die neue Untersuchung die alten Anforderungen aus den 1970er und 1980er Jahren durch neue ersetzt wurden. Dennoch geht die Untersuchung von nahezu ausschließlich von 2006 stammenden Vorschriften aus. Der schwere Unfall im März 2011 in Japan führte zu einer Er-

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[4] https://kosatka.media/en/category/elektroenergiya/news/ukraina-planiruet-vyvozit-oyat-na-specializirovannye-inostrannye-predpriyatiya, Zugriff am 26 June 2019

höhung der internationalen Sicherheitsvorschriften für externe Gefährdungen. Im Sinne der nuklearen Sicherheit haben die Anforderungen an die Fertigstellung eines Kernkraftwerks mit einer mindestens 50-jährigen Betriebsdauer die neuesten Forschungsergebnisse und Entwicklungen internationaler Standards zu beachten.

Die Untersuchung der vor 20 bis 30 Jahren gelieferten Komponenten läuft zurzeit. Einige Komponenten sind materialbedingt und technologisch obsolet und können nicht verwendet werden. Es ist zu begrüßen, dass die Ergebnisse der Überprüfung der österreichischen Seite zur Verfügung gestellt werden.

Die UVP-Unterlagen erwähnen kein Programm zum Alterungsmanagement (AMP). Im Fall der Ukraine ergab die erste Topical Peer Review (TPR) gemäß Richtlinie 2014/87/EURATOM, dass einige Abweichungen von den Sicherheitserwartungen an ein akzeptables Alterungsmanagement in Europa bestehen. Eines dieser Themen ist für KhNPP-3&4 besonders wichtig, weil es sich auf verzögerte KKW-Projekte bezieht (ENSREG 2018). Die Ukraine unterstellte nur fertiggestellte Gebäude dem Programm zum Alterungsmanagement. Doch diese Vorgangsweise ist nicht gerechtfertigt, weil die Konstruktionen und Anlagen von KhNPP-3&4 bereits der Alterung unterliegen, selbst wenn das Kraftwerk noch nicht Betrieb ist.

In der Periode zwischen der Untersuchung der Komponenten und dem Start des regulären Alterungsprogramms AMP sollten die Alterungserscheinungen adäquat berücksichtig werden.

Generell ist festzuhalten, dass keine überzeugenden Beweise vorliegen, wonach die bestehenden Gebäude, Konstruktionen und Anlagen in einem Zustand wären, der eine Mindestbetriebsdauer von 50 Jahren garantieren würde.

Das verbesserte Sicherheitskonzept der WWER-1000/V-392B (mit passiven Sicherheitssystemen) für die Fertigstellung von KhNPP-3&4 wurde 2008 ausgewählt und genehmigt. Das Design der WWER-1000/V-320 erfüllt hingegen nicht moderne Sicherheitsstandards.

Wesentlich für die Sicherheit der geplanten Reaktoren KhNPP-3&4 ist die externe Kühlung des geschmolzenen Kerns im Falle eines Kernschmelzunfalls. Die Entwicklung der Funktion „In Vessel Melt Retention“ (IVMR), das Auffangen der Kernschmelze im Reaktordruckbehälter, ist z. B. bei den Referenzanlagen des KKW Temelín noch nicht abgeschlossen. Zu betonen ist auch, dass die KKW-Designs, die in den 1980er Jahren entwickelt wurden – wie die WWER-1000/V-320 –, die modernen Auslegungsprinzipien bei der Redundanz, der Diversifizierung und physischen Trennung der redundanten Subsysteme, sowie der Bevorzugung von passiven gegenüber aktiven Systemen nur teilweise erfüllen (s. IAEA 2016, WENRA 2013). Doch sind alle diese Auslegungsprinzipien zur Verringerung des Unfallrisikos notwendig.

Laut WENRA (2013) sollen die WENRA-Sicherheitsziele für neue KKW auch als Referenz für die vernünftigerweise praktikablen Sicherheitsverbesserungen für „Kraftwerke mit Bauverzögerung“ wie KhNPP-3&4 angewendet werden. Doch die UVP-Dokumentation beinhaltet dieses WENRA-Sicherheitsziel nicht. Laut Informationen aus der Konsultation wurde eine systematische Untersuchung der Designabweichungen gegenüber den aktuellen internationalen Sicherheitsstandards und Sicherheitsanforderungen für KhNPP-3&4 durchgeführt. Über die Ergebnisse wurde nicht berichtet. Das Hauptproblem liegt jedoch darin, dass die Anforderungen an neue Kernkraftwerke nicht zur Anwendung kommen. Auch liegen keine überzeugenden Beweise vor, wonach jede vernünftigerweise durchführbare Sicherheitsverbesserung unternommen wurde.

Störfälle und Unfälle ohne Beteiligung Dritter

Eine systematische Analyse der Auslegungsstörfälle (DBA) und Auslegungsstörfall überschreitenden Unfälle (BDBA) wird in den UVP-Unterlagen nicht präsentiert, sondern es werden nur die Strahlenfolgen eines DBA und eines BDBA behandelt. Der betrachtete BDBA ist ein Kühlmittelverlustunfall mit dem Versagen der aktiven Systeme für die Kernnotkühlung und das Sprinklersystem. Dieser BDBA stellt nicht das Worst Case Szenario dar. Um die möglichen (grenzüberschreitenden) Folgen dieses BDBA zu berechnen wurde angenommen, dass die Kernschmelze innerhalb des Reaktordruckbehälters (RDB) bleiben würde. Diese Annahme ist nicht gerechtfertigt, weil diese Einrichtung noch nicht zur Verfügung steht. Und selbst wenn diese Einrichtung eingebaut werden würde, so dient sie der Reduktion der radioaktiven Freisetzung bei vielen, aber nicht allen schweren Unfallszenarien.

Um die Folgen von BDBA zu bewerten, ist es notwendig, eine Reihe von schweren Unfällen zu untersuchen, einschließlich derer mit Containment-Versagen und der schweren Unfälle mit Cointainment-Bypass. Beim Reaktortyp WWER 1000/V-320 sind schwere Unfälle dieser Art möglich. Diese schweren Unfälle können nicht ausgeschlossen werden, auch wenn deren Wahrscheinlichkeit unter einem bestimmten Wert liegt.

Die Ergebnisse der EU-Stresstests zeigten auf, dass das Management schwerer Unfälle (SAM), d.h. die Prävention von schweren Unfällen und die Minderung von deren Konsequenzen, bei ukrainischen KKW noch eine Reihe von Schwächen aufweist. Umfassende Verbesserungen werden von der Aufsichtsbehörde gefordert, allerdings empfahl das ENSREG Peer Review Team noch weitere Verbesserungen. Dies ist eines der Beispiele für die Kluft bei den Sicherheitsstandards und Sicherheitsanforderungen zwischen Ukraine und EU.

Die aktuell geltenden internationalen Anforderungen an neue Kernkraftwerke (IAEA 2012 und WENRA 2013) fordern den praktischen Ausschluss von Unfallsequenzen mit frühen oder großen Freisetzungen. Das Konzept des „praktischen Ausschlusses“ von frühen oder großen Freisetzungen wird in den UVP-Unterlagen für KhNPP-3&4 nicht genannt. Laut ENERGOATOM (2017a) wäre die Wahrscheinlichkeit schwerer Unfälle (z.B. mit Containmentversagen) mit größeren Freisetzungen vernachlässigbar gering. Außerdem kann der „praktische Ausschluss“ nicht nachgewiesen werden, indem die Übereinstimmung mit einem allgemeinen Wahrscheinlichkeitswert angeführt wird. Laut IAEA (2016a) ist eine geringe Eintrittswahrscheinlichkeit von Kernschmelzunfällen kein Grund, den Schutz des Containments gegen die bei diesem Unfall eintretenden Bedingungen zu vernachlässigen.

Auch in diesem Fall liegtkein ausreichender Nachweis vor, dass alle vernünftigerweise durchführbaren Sicherheitsverbesserungen für den „praktischen Ausschluss” unternommen wurden.

Externe Gefährdungen

Die UVP-Unterlagen zeigen auf, dass die Standortprüfung den aktuellen internationalen Anforderungen nicht entspricht, weil die zitierten internationalen Anforderungen veraltet sind. Die Konsultationen zeigten, dass es zu keiner Standort-Evaluierung nach aktuellen Sicherheitsanforderungen der IAEO gekommen ist.

Laut SNRIU (2017) ist die seismische Gefährdung zu überprüfen, die Machbarkeitsstudie wurde mit der Bedingung genehmigt, dass die Berechnung der Maximalen Bodenbeschleunigung (peak ground acceleration, PGA) zu erläutern bzw. zu klären ist. Die fehlende probabilistische Analyse der Seismik ist in Vorbereitung. Es wurde allerdings nicht darüber informiert, wann die Ergebnisse vorliegen werden und ob sie für die Fertigstellung von KhNPP 3&4 angewendet werden.

Die Machbarkeitsstudie von 2011 wurde unter der Bedingung genehmigt, dass eine vertiefte Prüfung der Auswirkungen von extremen externen Ereignissen – natürlichen und vom Menschen verursachten – wie auch deren Kombination im PSAR, dem vorläufigen Sicherheitsbericht, enthalten sein wird. (SNRIU 2012) Diese Bedingung fehlt in der Aufzählung der Bedingungen, die die Genehmigung der aktuellen Machbarkeitsstudie auflistet. (SNRIU 2017)

Laut WENRA (2013) sollten die Sicherheitsbewertungen für neue Kernkraftwerke nachweisen, dass die Bedrohungen aus externen Gefährdungen beseitigt oder soweit vernünftigerweise durchführbar minimiert werden. Die Antwort bestätigt, dass diese Analyse zu einem späteren Zeitpunkt durchgeführt wird, nämlich in der Designphase. Doch ist diese Vorgangsweise bei der Sicherheit von KhNPP-3&4 nicht ganz gerechtfertigt, da Teile der Gebäude und Konstruktionen bereits errichtet wurden. Um prüfen zu können, ob diese die Anforderungen erfüllen, müssten die externen Einwirkungen jetzt bekannt sein, denen die Anlagen gegenüber widerstandsfähig sein sollen.

Störfälle und Unfälle mit Beteiligung Dritter

Eingriffe Dritter (Terrorangriffe und Sabotage) können erhebliche Auswirkungen auf Nuklearanlagen haben und somit auch auf KhNPP-3&4 in der Ukraine. Dennoch werden diese in den UVP-Unterlagen für KhNPP-3&4 nicht angeführt. Vergleichbare UVP-Unterlagen behandeln diese Art von Ereignissen bis zu einem bestimmten Grad.

Die Antworten bei den Konsultationen am 13. Juni in Wien bestätigten, dass die Atomaufsicht der Ukraine keinen Schutz von KhNPP--&4 gegen den beabsichtigten Absturz von Verkehrsflugzeugen verlangt. Dies widerspricht den WENRA-Anforderungen für neue Kernkraftwerke – aber aus ukrainischer Sicht ist KhNPP 3&4 kein neues KKW und daher ist diese Art von Schutz nicht vorgeschrieben. Darüber hinaus ist anzumerken, dass KhNPP-3&4 nicht gegen unbeabsichtigte Abstürze von Verkehrsflugzeugen ausgelegt ist, da die Wahrscheinlichkeit solcher Abstürze als sehr gering eingeschätzt wird.

Diese Frage ist von besonderer Bedeutung, da die Wanddicke des Reaktorgebäudes/Containments von KhNPP-3&4 nur 1.000-1.200 mm beträgt. Daher könnten die Reaktorblöcke durch Terrorangriffe (einschließlich Flugzeugabstürze) beschädigt werden.

Eine jüngst durchgeführte Bewertung der nuklearen Sicherung in der Ukraine verwies auf Schwachstellen gegenüber den notwendigen Anforderungen: Der 2018 NTI Index bewertet die Bedingungen der nuklearen Sicherung bei den Nuklearanlagen gegenüber Sabotageakten. Die Ukraine kam mit einer Gesamtpunkteanzahl 70 von 100 nur auf Platz 30 von 45 in der Länderreihung, was auf ein geringes Schutzniveau hinweist. Ebenso ist anzuführen, dass die niedrige Bewertung beim „Schutz vor Insiderbedrohung“ und „Cybersicherheit“ Defizite in diesen Bereichen aufzeigt.

Es ist zu begrüßen, dass die Vorschriften zur Cybersicherheit verbessert werden. Doch auch die Vorschriften zu Angriffen von sogenannten Insidern (Angreifer von innen) sollten verschärft werden. Der International Physical Protection Advisory Service (IPPAS) unterstützt Staaten auf Anfrage bei der Stärkung ihrer Regime, Systeme und Maßnahmen der nationalen nuklearen Sicherung. Der Ukraine wird empfohlen, diesen Service der IAEO in Anspruch zu nehmen.

Grenzüberschreitende Auswirkungen

Es wurde umfassende Information über die Berechnungen zur grenzüberschreitenden Verfrachtung von Freisetzungen bei Unfällen in KhNPP-3&4 zur Verfügung gestellt, doch die berechneten Bodendepositionen für Iod-131 und Cäsium-137 wurden weder für die Entfernung nach Österreich oder eine andere Entfernung angeführt. Diese Daten sind für Österreich wichtig, denn bei Überschreitung eines bestimmten Schwellenwerts der Kontamination, würde eine Reihe von Interventionsmaßnahmen in Österreich ausgelöst.

Noch bedeutender ist, dass schwere Unfälle mit deutlich höheren Freisetzungen als in den UVP-Unterlagen angenommen, für KhNPP-3&4 nicht ausgeschlossen werden können, auch wenn deren Wahrscheinlichkeiten unter einem bestimmten spezifischen Wert zu bleiben haben. Solche schwersten Unfälle sollten in der UVP berücksichtigt werden, da deren Auswirkungen weitreichend und langfristig sein können und selbst Länder betreffen, die nicht an die Ukraine angrenzen, wie etwa Österreich.

Da keine Analysen zu den schwersten Unfallszenarien vorgelegt wurden, ist die Schlussfolgerung der UVP-Dokumente betreffend grenzüberschreitender Folgen nicht ausreichend.

Die Berechnungen des Österreichischen Ökologieinstituts (1998) zeigten, dass ein schwerer Unfall (Worst Case Szenario) im KKW KhNPP-3&4 mehrere Regionen Europas kontaminieren würde. Für die Ostregion Österreichs würden laut Berechnungen ca. 1.000 kBq Cäsium-137/m² erreicht werden (das entspricht etwa dem fünffachen Wert des höchsten im Jahre 1986 gemessenen Wertes).

Auch zeigten die Berechnungen des flexRISK-Projekts, dass nach einem schweren Unfall die durchschnittliche Cäsium-137 Bodenkontamination in den meisten Gebieten Österreich das Interventionsniveau für landwirtschaftliche Maßnahmen überschreiten würde (z. B. vorgezogene Ernte, Schließen von Gewächshäusern). Somit wäre Österreich von schweren Unfällen im KKW KhNPP-3&4 betroffen.

РЕЗЮМЕ

Державне підприємство «Національна атомна енергогенеруюча компанія «Енергоатом» веде підготовку до завершення будівництва 3 і 4 атомних блоків (ХАЕС № 3 та 4) на Хмельницькому майданчику в Україні. На майданчику вже діють дві реакторні установки типу ВВЕР-1000/В-320.

Будівництво енергоблоків ХАЕС № 3 та 4 розпочалося у 1985-1986 роках. У зв'язку з введенням в 1990 році в СРСР мораторію на спорудження нових енергоблоків АЕС будівництво енергоблоків № 3 та 4 Хмельницької АЕС було припинено.

У 2005 році Кабінет Міністрів України вирішив, відновити будівництво. Було вибрано реакторну установку типу ВВЕР-1000/В-392 (Атомстройекспорт), що було закріплено на рівні закону в 2012 році. У зв'язку з погіршенням відносин між Україною та Росією, цей закон було скасовано в 2015 році. Пізніше Енергоатом обрав постачальником реактора - Škoda JS a.s.

Відповідно до положень Конвенції Еспо, у 2010 році було розпочато оцінку впливу на навколишнє середовище (ОВНС). Австрія бере участь у цій процедурі з 2011 року та у 2013 році подала експертну заяву (UMWELTBUNDESAMT 2013[5]); у серпні 2013 року відбулися двосторонні консультації з українською стороною. У зв'язку з вищезгаданою ситуацією процедура ОВНС була припинена в 2015 році. Коли у 2017 році процедура ОВНС була поновлена, австрійська сторона подала нову експертну заяву (UMWELTBUNDESAMT 2019). 13 червня 2019 року у Відні відбулись двосторонні консультації та громадські слухання. В звіті оцінюються відповіді української сторони під час консультацій.

Метою участі австрійської сторони в процедурі Еспо є надання рекомендацій щодо мінімізації або навіть усунення можливого значного негативного впливу на Австрію.

Загальні та процедурні аспекти

Згідно з Конвенцією Еспо, в документацію з оцінки впливу на навколишнє середовище має бути включений обґрунтований опис альтернатив технологічного характеру планової діяльності, а також опис «нульового варіанту» (варіант без проекту). Таким чином інформація, представлена у документації з ОВНС не є достатньою.

Деякі аспекти, пов'язані з безпекою, повинні бути розглянуті та узгоджені при видачі ліцензії ядерним регулятором України. На даному етапі детальна оцінка безпеки проекту не доступна. Ми будемо вдячні, якщо австрійській стороні буде надана можливість обговорити з українською стороною обіцяні частини Попереднього звіту по обгрунтуванню безпеки згідно з чинною двосторонньою угодою.

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[5] Доступне за посиланням: http://www.umweltbundesamt.at/umweltsituation/uvpsup/espooverfahren/espoo_ukraine/kkwkhmelnitsky34/

Під час двосторонніх консультацій була надана інформація про стан проекту Україна-ЄС-Енергетичний міст. Цей проект, який досі готується, повинен служити для того, щоб забезпечити можливість експорту електроенергії ХАЕС-2 для залучення коштів для завершення будівництва ХАЕС-3 та 4. Для Австрії важливо, щоб питання фінансування не завдали шкоди ядерній безпеці та безпеці.

Відпрацьоване паливо та радіоактивні відходи

Відпрацьоване паливо та радіоактивні відходи можуть спричинити несприятливий вплив на навколишнє середовище, тому в ОВНС має бути проведена оцінка поводження з ядерними відходами.

Українська сторона надала австрійській стороні додаткову інформацію про поводження з відпрацьованим паливом та радіоактивними відходами.

У червні 2019 року Кабінет Міністрів схвалив концепцію поводження з відпрацьованим паливом з АЕС на період до 2024 року. Очікується, що Концепція відповідає вимогам Директиви Ради 2011/70/EURATOM[6]. Рекомендується, щоб уряд Австрії тримав це питання під контролем в рамках згаданої “двосторонньої угоди”.

Тип реактора

З професійної точки зору, будь-яка АЕС, що вводиться в експлуатацію вперше, повинна повністю відповідати сучасним вимогам безпеки. Але, враховуючи нинішню загальну згоду на європейському та міжнародному рівнях, що «відкладені підприємства» можуть розглядатися як «існуючі блоки, ця експертна заява побудована на принципі практично досяжних заходів для підвищення безпеки.

Для завершення будівництва енергоблоків ХАЕС № 3 та 4 планується використати будівлі та споруди, що були побудовані в 1980-х роках. В документах ОВНС не наведено інформацію про стан існуючих будівель, споруд та обладнання. Під час консультацій було надано пояснення, що роботи з відновлення та ремонту протягом 2009-2013 років було виконано на основі дослідження 2005-2009 років. Однак деякі важливі елементи роботи (наприклад, ремонт бетонних конструкцій) ще не завершено.

Крім того, дослідження 2005-2009 проводилось з розрахунку на строк експлуатації 75 років. Сьогоднішній строк експлуатації є значно довшим, і становить близько 100 років. Саме тому, колишнє дослідження не є доказом, що старі конструкції підходять для завершення ХАЕС № 3 і 4.

Наразі проводиться нове дослідження для підтвердження довговічності та надійності будівель та споруд. Буде вітатися надання результатів цього дослідження для ознайомлення австрійській стороні.

В документах ОВНС не міститься інформація про стійкість енергоблоків ХАЕС № 3 та 4 до зовнішніх впливів. Під час консультацій була надана інформація, що вимоги у новому дослідженні 1970-х і 1980-х років було

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[6] https://kosatka.media/en/category/elektroenergiya/news/ukraina-planiruet-vyvozit-oyat-na-specializirovannye-inostrannye-predpriyatiya, доступ 26 червня 2019 року

замінено на більш сучасні. Проте дослідження майже виключно базується на нормативних актах 2006 року. Серйозна аварія в Японії в березні 2011 року призвела до підвищення міжнародних стандартів стійкості до зовнішніх впливів. З точки зору безпеки, будівництво атомної електростанції з терміном експлуатації не менше 50 років можливо за умови врахування висновків найсучасніших досліджень та міжнародних стандартів.

Ведеться обстеження компонентів, які були поставлені 20-30 років тому. Деякі компоненти є фізично і технічно застарілими і не придатні для використання. Позитивним результатом є той факт, що результати обстеження компонентів будуть надані Австрії.

Програма управління старінням (AMP) не згадується в документах з ОВНС. Перша

Тематична експертна оцінка (TPR) відповідно до Директиви 2014/87/EURATOM виявила, що в Україні існує ряд відхилень від очікуваного рівня безпеки пов'язаного з управлінням старінням в Європі. Одне з таких відхилень викликає особливе занепокоєння у випадку з ХАЕС № 3 та 4, оскільки це стосується стандартів безпеки для відкладених проектів АЕС. (ENSREG 2018) Україна включила в программу управління старінням лише завершені будівлі. Однак цей підхід не є виправданим, оскільки структури та обладнання ХАЕС № 3 та 4 вже старіють, незважаючи на те, що блок не працює.

У проміжок часу між обстеженням компонентів і початком рутинної AMP необхідно адекватно враховувати явище старіння.

Загалом, на сьогодні немає переконливих доказів того, що існуючі будівлі, споруди та обладнання в змозі забезпечити безпечну експлуатацію протягом мінімум 50 років.

У 2008 році була обрана та затверджена вдосконалена концепція безпеки ВВЕР-1000/В-392Б (з пасивними системами безпеки) для завершення будівництва ХАЕС № 3 та 4, а конструкція ВВЕР1000/В-320, навпаки, не відповідає сучасним стандартам безпеки.

Основною характеристикою безпеки у реакторних установках, вибраних для ХАЕС № 3 та 4, є зовнішнє охолодження розплавленого ядра у випадку аварії з розплавленням активної зони. Розробка системи для “Утримання розплаву в корпусі реактора» (IVMR) досі продовжується, наприклад, на референтних блоках АЕС «Темелін». Крім того, необхідно підкреслити, що конструкція АЕС, розроблених в 1980-х роках, таких як ВВЕР-1000/В-320, лише частково відповідає сучасним принципам проектування в плані резервування, різноманітності і фізичного розділення резервних підсистем, переваги пасивних систем над активними системами безпеки. (див. IAEA 2016, WENRA 2013). Проте ці принципи проектування є обов’язковими для зменшення ризику аварії.

Згідно з положеннями WENRA (2013), стандарти безпеки WENRA для нових АЕС також мають бути еталоном, для визначення обґрунтовано можливого підвищення безпеки на “відкладених станціях”, таких як ХАЕС № 3 та 4. Проте в документах з ОВНС стандарти WENRA не згадуються. Згідно з інформацією, наданою на консультаціях, було проведено системну оцінку відхилень на ХАЕС № 3 та 4 від існуючих міжнародних стандартів та вимог безпеки. Про результати не повідомлялося. Однак головна проблема полягає в тому, що в якості критерію не застосовувались вимоги до нових атомних електростанцій. Найважливішим є те, що немає переконливих доказів того, що було проведене кожне обгрунтоване і практично доцільне підвищення рівня безпеки.

Інциденти та аварії без участі третіх осіб

В документах з ОВНС немає систематичного аналізу проектних аварій (DBA) та надпроектних аварій (BDBA); описано лише радіологічні наслідки однієї проектної аварії і однієї запроектної аварії. Розглянута запроектна аварія передбачає протікання теплоносія з відмовою активних систем аварійного охолодження активної зоні і спринклерної системи. Така задпроектна аварія не є найгіршим сценарієм. Для розрахунку можливих (транскордонних) наслідків такої аварії передбачалося, що розплав ядра залишатиметься в корпусі реактора (RPV). Це припущення не є належним чином обґрунтованим, оскільки ця функція поки не доступна. Крім того, якщо цю функцію реалізують, це лише зменшить ризик викиду радіоактивних речовин у більшості, але не в усіх сценаріях важких аварій.

Для того, щоб оцінити наслідки BDBA, необхідно проаналізувати цілий ряд важких аварій, у тому числі при руйнуванні захисної оболонки, та при байпасуванні захисної оболонки. Для реактора типу ВВЕР1000/В-320 існує ймовірність виникнення таких важких аварій. Ці серйозні випадки не можна виключати, хоча їхня ймовірність є нижчою від визначеної величини.

Результати стрес-тестів ЄС показали, що управління важкими аваріями (SAM) (тобто запобігання важким аваріям та пом'якшення їх наслідків) на українських АЕС має багато недоліків. Регулятор вимагає комплексних покращень; однак, група експертів ENSREG рекомендує подальші вдосконалення. Це один з прикладів невідповідності української сторони стандартам та вимогам безпеки ЄС.

Відповідно до сучасних міжнародних вимог до нових атомних електростанцій (МАГАТЕ 2012 та WENRA 2013), аварійні послідовності з ранніми або великими викидами мають бути практично усунутими. Концепція «практичного усунення» ранніх або великих викидів не згадується документах з ОВНС енергоблоків ХАЕС № 3 та 4. ЕНЕРГОАТОМ (2017a) стверджує, що ймовірність виникнення важких аварій (наприклад, з руйнуванням захисної оболонки), при яких можуть статись великі викиди, є незначною. Крім того, незважаючи на те, що можна встановити імовірнісні цілі, не можна декларувати «практичне усунення» основуючись на відповідності загальному імовірнісному значенню. Згідно МАГАТЕ (2016): низька ймовірність виникнення аварії з розплавом активної зони не є причиною не вживати заходів для захисту від наслідків такої аварії.

У цьому випадку немає переконливих доказів того, що було проведено кожне обгрунтоване і практично доцільне підвищення рівня безпеки для «практичного усунення» важких аварій.

Зовнішні небезпеки

Інформація, наведена в документах ОВНС, показує, що оцінка майданчика не відповідає сучасним міжнародним вимогам, оскільки використані міжнародні рекомендації застаріли. Під час консультацій з'ясувалося, що оцінка місцевості відповідно до поточних вимог безпеки МАГАТЕ не проводилася.

За даними Держатомрегулювання (2017), необхідно заново оцінити сейсмічний ризик, ТЕО було схвалене з умовою розробки та/або уточнення розрахунку пікового значення прискорення на рівні грунту майданчика (PGA). Ймовірнісний сейсмічний аналіз, якого бракує, знаходиться в стадії підготовки. Не було надано жодної інформації про те, коли цей аналіз буде завершений і чи будуть враховані його результати для завершення ХАЕС № 3 і 4.

Техніко-економічне обґрунтування 2011 року було схвалено за умови, що буде проведено і включено в Попередній звіт з безпеки (SNRIU 2012) поглиблену оцінку впливу зовнішніх екстремальних подій природної і техногенної природи, а також їх комбінацій. Цю умову не включено в умови затвердження чинного ТЕО (Держатомрегулювання (2017).

Згідно з WENRA (2013), оцінка безпеки для нових атомних електростанцій повинна демонструвати, що загрози від зовнішніх небезпек або усунені, або мінімізовані, наскільки це практично можливо. Відповідь підтверджує, що такий аналіз проводиться пізніше, тобто на стадії проектування. Проте ця процедура не є ефективною для підвищення безпеки на ХАЕС № 3 та 4, оскільки частина будівель і споруд вже побудована. Для того, щоб оцінити, чи відповідають вони вимогам, необхідно знати, до яких зовнішніх явищ вони повинні бути невразливими.

Інциденти та аварії з залученням третіх осіб

Вплив третіх сторін (терористичні напади або диверсії) може мати значний вплив на ядерні об'єкти, а отже, і на енергоблоки ХАЕС № 3 та 4 в Україні. Проте, в документах ОВНС для енергоблоків ХАЕС № 3 та 4 про них не згадується. У аналогічних документах з ОВНС подібні проблеми були вирішені в деякій мірі.

Відповіді під час консультацій 13 червня 2019 року у Відні підтвердили, що український регулятор не вимагає захисту ХАЕС 3 та 4 від навмисного падіння комерційного літака. Це не відповідає вимогам WENRA для нових атомних електростанцій, але з точки зору України ХАЕС № 3 та 4 не є новою атомною електростанцією, а існуючою, і тому такий захист не потрібний. Крім того, слід зазначити, що блоки ХАЕС № 3 та 4 не захищені від випадкового падіння комерційного повітряного судна, оскільки ймовірність такої аварії оцінюється як дуже низька.

Ця тема є особливо важливою, оскільки товщина стін будівлі/захисної оболонки енергоблоків ХАЕС № 3 та 4 становить лише близько 1000–1200 мм. Таким чином, блоки можуть бути вразливими до терористичних атак (включаючи падіння літака).

Нещодавня оцінка ядерної безпеки в Україні вказує на недоліки у порівнянні з відповідними стандартами ядерної безпеки: Індекс ядерної безпеки, розроблений Глобальною ініціативою зі зменшення ядерної загрози в 2018 році, оцінює рівень безпеки ядерних об'єктів в контексті їх захисту від диверсій. Україна набрала 70 балів зі 100 можливих і посіла лише 30 місце з 45 країн, що свідчить про низький рівень захисту. Слід зазначити, що низькі бали в категоріях "Запобігання внутрішнім небезпекам" та „Кібербезпека" вказують на недоліки в цих сферах.

Позитивним є той факт, що буде вжито заходів для кібербезпеки. Але законодавство проти атак так званих інсайдерів (внутрішніх порушників), також має бути покращено. Міжнародна консультативна служба з питань фізичного захисту (IPPAS) допомагає державам, за їх запитом, зміцнювати свої національні режими, системи та заходи з ядерної безпеки. Рекомендується, щоб Україна звернулася за цією послугою МАГАТЕ.

Транскордонний вплив

Наведено вичерпну інформацію про розрахунок транскордонного перенесення викидів від аварій на ХАЕС № 3 та 4, але розраховані грунтові відкладення йоду-131 і цезію-137 не розраховано ні для відстані до Австрії, ні для будь-якої іншої. Ця інформація є важливою для Австрії. У випадку, якщо забруднення ґрунту перевищить певний поріг, в Австрії буде запроваджено комплекс заходів втручання у процеси сільського господарства.

Ще важливішим є те, що важкі аварії з викидами, що значно перевищують передбачені в документах з ОВНС, не можуть бути виключені для енергоблоків ХАЕС № 3 та 4, навіть якщо їхня ймовірність буде нижче встановленої величини. В оцінку мають бути включені найгірші сценарії, оскільки їхні наслідки можуть бути настільки широкомасштабними і тривалими, що навіть країни, які безпосередньо не межують з Україною, такі як Австрія, можуть постраждати.

Через відсутність аналізу найгірших сценаріїв, висновок документів ОВНС про транскордонний вплив не є адекватним.

Результати розрахунків Австрійського інституту екології (1998) свідчать про те, що важка аварія (найгірший сценарій) на ХАЕС призведе до забруднення деяких регіонів Європи. Для східної частини Австрії розрахунок показав забруднення цезієм-137 на рівні приблизно 1000 кБк/м2 (що майже в 5 разів перевищує найвищі значення зафіксовані в Австрії в 1986 році).

Крім того, результати проекту flexRISK вказують на те, що у випадку важкої аварії середній вміст цезію-137 на більшості районів території Австрії перевищить поріг для проведення сільськогосподарських робіт (наприклад, ранній збір врожаю, закриття теплиць). Таким чином, Австрія може постраждати від важкої аварії на енергоблоках ХАЕС № 3 та 4.

1 INTRODUCTION

In Ukraine, the state enterprise "National Nuclear Energy Generating Company Energoatom" is preparing the completion of the construction of the nuclear power plant units 3 and 4 (KhNPP-3&4) at the Khmelnitsky site. At this site, two units VVER-1000/V-320 are already in operation.

The project has a long history and the document prepared by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU 2017) provides an overview: The construction of KhNPP-3&4 started in September 1985 and June 1986, respectively. Due to the 1990 moratorium on the construction of nuclear power units in the former USSR, the construction of KhNPP-3&4 was ceased. In 2005, the Cabinet of Ministers of Ukraine decided to renew the construction. A tender for the reactor model was opened in 2008, resulting in selecting the Russian reactor VVER-1000/V-392, which was approved in 2009. In 2011, the feasibility study was submitted and approved after SNRIU has completed a "state expert review of nuclear and radiation safety" in March 2012, followed by the adoption of a corresponding law in September 2012.

Due to the deteriorating relations between Ukraine and Russia, this law ceased to be in force in 2015. Later on, Energoatom replaced the reactor vendor with a European supplier, Škoda JS a.s. (EXPLANATION n.d.) An updated and revised feasibility study was submitted, again assessed by SNRIU during another "state expert review of nuclear and radiation safety" in 2017 and approved in April 2017. On July 5, 2018, a Ukrainian government committee approved the adapted feasibility study for the KhNPP-3&4; on July 26, the feasibility study was approved by the Cabinet of Ministers of Ukraine. (ECOACTION 2018) The competent authority is the Ministry of Energy and Coal Industry of Ukraine.

An environmental impact assessment (EIA) under the Espoo Convention (1991) started in 2010. Austria has participated in this procedure since 2011. An expert statement was commissioned by the former Austrian Ministry of Agriculture, Forestry, Environment and Water Management (UMWELTBUNDESAMT 2013[7]), expert consultations between the Ukrainian and the Austrian side were conducted in August 2013. The procedure was suspended in 2015 due to the political developments in Ukraine.

In spring 2017 the Ukrainian side informed the Austrian side about the continuation of the transboundary environmental impact assessment under the Espoo Convention, several documents in English were notified, the Austrian side had additional parts of the Environmental Report translated into German. The Austrian Ministry for Sustainability and Tourism commissioned the Environment Agency Austria to provide an expert statement assessing the recently submitted documents. This expert statement (UMWELTBUNDESAMT 2019) was submitted to the Ukrainian side in May 2019. Bilateral consultations were held in Vienna on June 13, 2019. Also, a public hearing was held in Vienna on June 13, 2019.

This consultation report evaluates the results of the bilateral consultations and of the public hearing. The objective of the Austrian participation in the Espoo

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[7] http://www.umweltbundesamt.at/umweltsituation/uvpsup/espooverfahren/espoo_ukraine/kkwkhmelnitsky34/

procedure is to give recommendations to minimise or even eliminate possible significant adverse impacts on Austria resulting from the project. These recommendations are listed in this consultation report.

Since 1998 Austria and Ukraine have a bilateral agreement on information exchange and cooperation in nuclear safety and radiation protection. (BGBL 1998) Even though until today no meetings under this agreement were conducted, it is recommended that some topics that arose during the EIA procedure should be discussed bilaterally in regular intervals.

2 OVERALL AND PROCEDURAL ASPECTS OF THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

2.1 Summary of the expert statement

The EIA documents that were published in Ukraine were not identical to those published in Austria for public participation, and vice-versa.

According to the Espoo Convention a description and an assessment of reasonable alternatives and also the no-action alternative have to be included in the environmental impact assessment documentation. In this regard the EIA documentation is not sufficient.

The KhNPP-3&4 project should become part of the Ukraine-EU-Energy Bridge project aiming at exporting electricity from KhNPP-2 to raise funds for KhNPP-3&4. Whether the Energy Bridge project will be realized is not clear at this moment. More information would be appreciated how to compensate in case for the loss of funding to prove that enough budget is available to invest into measures. For Austria it is important that financing issues do not have detrimental impact on nuclear safety and security.

However, it has been longstanding EU policy that power trading with third countries would be pre-conditioned by strict compliance with the economic and ecological principle of reciprocity.

2.2 Questions, answers and assessment of the answers

Question 1

- *What information is included in the EIA documents that were published in Ukraine for public participation but were not submitted to Austria?*

Answer of the Ukrainian side

In the presentation at the bilateral consultations, the Ukrainian side stated that the EIA report was revised in 2016 and the BDBA-management systems and other related information had been changed. (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

Not the entire EIA Report (OVOS 2019a) that was published in Ukraine was notified to Austria, only the last part. On the other hand, (sub)chapters of volume 13 that were submitted to Austria (OVOS 2019 b-k) were not included in the EIA Report published in Ukraine. This question intended to clarify these differences between the documents prepared for the Ukrainian and the Austrian public; this question has not been answered.

Question 2

- *When will the promised parts of the Preliminary Safety Analysis Report be submitted to Austria?*

Answer of the Ukrainian side

In general, the Preliminary Safety Analysis Report (PSAR) is developed at the stage of licensing the power unit design. At this stage, all procedural issues regarding the EIA and the final decision for the construction of the two units construction would have been completed and the law of Ukraine on the location of two new nuclear facilities would have been adopted. In the next step, the NPP design would be developed, taking into account all modifications and improvements made in the feasibility study. (ENERGOATOM AND JSC KIEP 2019a)

During the discussion at the bilateral consultations, the Ukrainian side confirmed that those parts of the PSAR, which are relevant for the transboundary aspects, will be submitted to the Austrian side.

Assessment of the answer

The question has been answered.

Question 3

- *What is the timetable for the next steps of the EIA procedure?*

Answer of the Ukrainian side

The EIA Report had been developed in the scope of the feasibility study (FS) in 2011 and updated in 2016. According to the Ukrainian legislation, the final decision for the completion of units' construction has to be approved by the Parliament of Ukraine by a law. Thus, the Ukrainian legislation envisages three stages of design (FS, basic design, design). The EIA update has to be developed at the design stage. (ENERGOATOM AND JSC KIEP 2019a)

After the EIA procedure completion, a national and a transboundary EIA report will be prepared by the Ukrainian Ministry of Environment. These reports will include the obligatory requirements. Together with the feasibility study these reports are the basis for the Parliament`s decision on the law. The EIA reports will be published and also submitted to Austria.

Parts of the feasibility study and SNRIU's evaluation will also be submitted.

Assessment of the answer

The information about the procedure largely corresponds to information provided in the bilateral consultations of 2013 (see UMWELTBUNDESAMT 2019, chapter 2.3).

The adoption of the "Law of Ukraine On Placement, Design and Construction of Power Units № 3, 4 at Khmelnitsky NPP" by the Verkhovna Rada (Parliament) will be the final decision. For this decision, the national and transboundary EIA have to be finalized, and the updated feasibility study has to be approved. While the updated feasibility study was reviewed in 2017 by SNRIU and approved by the Cabinet of Ministers of Ukraine in July 2018, the final EIA reports can only be approved once the EIA procedure is completed.

The question has not been fully answered.

Question 4

- *What is the status of the Ukraine-EU-Energy Bridge project?*

Answer of the Ukrainian side

On the status of the Energy Bridge project, the Ukrainian side made a presentation on June 13, 2019 in Vienna. (ENERGOATOM 2019b)

Completed actions are: June 15, 2015 resolution on the initiation of the project, an effectiveness analysis of a public-private-partnership, a positive conclusion of the Ministry of Economic Development and Trade of Ukraine, a decision of the Ministry of Energy and Coal Industry of Ukraine on the implementation of a public-private-partnership and the establishment of a competition commission to select a private partner.

The results of this competition are expected soon.

Next steps are: a long-term contract between Energoatom and the private partner, electricity exports from Khmelnitsky-2 to the EU via Poland (Rzeszów), creation of a long-term financial asset through this electricity exports to secure the obligations in the KnNPP-3&4 project and raising a loan from Barclays Bank for construction of KhNPP-3&4.

Assessment of the answer

The question has been answered.

Question 5

- *If the Ukraine-EU-Energy Bridge project fails, how will the completion of KhNPP-3&4 be funded?*

Answer of the Ukrainian side

In its presentation the Ukrainian side stated that in case of failure, the issue of financing the construction KhNPP-3&4 will be solved on national level. (ENERGOATOM 2019b)

In the public hearing the Ukrainian side specified that introducing increased domestic electricity prices would be an option.

Assessment of the answer

For the near future the fate of the Energy Bridge will remain unclear:

- The anticipated funding of the upgrade and an extension of the existing transmission infrastructure between Khmelnitsky and Rzeszow was evaluated as not eligible (REKK 2018, p. 40f.; ENERGY COMMUNITY 2018)
- The tender for selecting a private partner which has started in January 2019 hasn't been completed.
- Barclays Bank has not yet committed to providing a loan.

2.3 Conclusions and final recommendations

According to the Espoo Convention a description and an assessment of reasonable alternatives and also the no-action alternative have to be included in the environmental impact assessment documentation. In this regard the EIA documentation is not sufficient.

Information on the status of the Ukraine-EU-Energy Bridge project was given during bilateral consultations. This project should serve to enable the electricity export of KhNPP-2 to raise funds for the completion of KhNPP-3&4. For Austria it is important that financing issues do not have detrimental impact on nuclear safety and security.

Final recommendation

1. It is recommended that financing issues do not have detrimental impact on nuclear safety and security.

3 SPENT FUEL AND RADIOACTIVE WASTE

3.1 Summary of the expert statement

Important information on the management of the spent fuel and radioactive waste from KhNPP-3&4 was lacking in the EIA documents: The expected inventory of spent fuel from KhNPP-3&4 was not given. Information on the status of the central interim storage where the spent fuel from KhNPP-3&4 is to be stored was lacking. No information was provided about the planned options for the back-end of the fuel chain (reprocessing, final disposal in Ukraine, international disposal?).

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore the EIA should assess the nuclear waste management. In the expert statement the following list of questions was asked to get more information on the status of nuclear waste management. To answer these questions (ENERGOATOM 2019c) the Ukrainian side provided a presentation on spent fuel and radioactive waste to the Austrian side at the bilateral consultations.

3.2 Questions, answers and assessment of the answers

Question 1:

- *What is the expected inventory of spent fuel and radioactive waste from operation of KhNPP-3&4?*

Answer of the Ukrainian side

About 5,300 spent fuel assemblies will be used during 60 years[8] of operation of KhNPP-3&4.

Solid radioactive waste:

- Low level waste: 8,700 m^3
- Intermediate level waste: 180 m^3
- High level waste: 12.6 m^3

Liquid radioactive waste:

- Residue 1,740 m^3
- Waste filters: 132 m^3

Conditioning will reduce the volume of both solid and liquid wastes 7-10 times and 3-7 times by, respectively. (ENERGOATOM 2019c)

Assessment of the answer

The question has been answered.

[8] In other EIA documents, a planned operation time of 50 years is envisaged.

Question 2:

- *What is the status of the central interim storage facility for spent fuel?*

Answer of the Ukrainian side

In its presentation the Ukrainian side provided information on the history of the central interim storage facility CSFSF for spent fuel, on the delivered equipment and showed many pictures documenting the construction progress. (ENERGOATOM2019c) Over 75% of the project have been completed and the first complex is scheduled for commissioning in 2020.

The CSFSF is constructed by the US company Holtec International. Four storage systems for spent fuel will be built. A dry storage technology will be used, using a two-barrier system.

The planned capacity is 12,010 spent fuel assemblies from VVER-1000 and 4,519 from VVER-440. This capacity should be sufficient for all Ukrainian NPPs including KhNPP-3&4. Its design life is 100 years, start of pilot operation in 2020.

In the presentation, Energoatom also stated that the CSFSF will be filled up to design capacity with spent fuel in 45-50 years.

Assessment of the answer

The question has been answered.

If the information is correct that the CSFSF will be full after 45-50 years, the question arises how the spent fuel from the rest of the operation time of KhNPP-3&4 (50 years) will be managed.

Question 3:

- *What is planned for the back-end of the fuel cycle/chain? Is spent fuel reprocessing in Russia still under consideration?*

Answer of the Ukrainian side

A plan for geological disposal is in development under the framework of the INSC-U4.01/14B project, which is part of the cooperation instrument in the field of nuclear safety between EU and Ukraine. (ENERGOATOM 2019c) The project is in the review state (task 2).

See also question 6

Assessment of the answer

The plan for a national deep geological disposal is in the very beginning. No information on a timetable has been given. No information has been given when and how the decision for the national geological disposal versus export for reprocessing will be made.

Question 4:

- *Is an international cooperation for final disposal of spent fuel and/or radioactive waste planned?*

Answer of the Ukrainian side

No information has been given regarding the option of a multinational repository.

In the development project of the national geological disposal companies from France, Germany and Sweden have been contracted. (ENERGOATOM 2019c)

Assessment of the answer

The question has not been answered. Information about a possible cooperation in a multinational repository should be given in future bilateral contacts between the Ukrainian and the Austrian side.

Question 5:

- *Which interim and final storages for radioactive waste are in operation in Ukraine, will their capacity be sufficient to dispose of all radioactive waste from operation of KhNPP-3&4?*

Answer of the Ukrainian side

A final storage is in operation at the Vektor site, and one at Buryakovka site.

Information is given on the management of spent fuel and vitrified high level waste from existing NPPs.

Assessment of the answer

According to the NATIONAL REPORT (2017), Buryakivka has practically exhausted its capacities. The capacities of the Vektor site were not given.

The question if there is enough capacity in the interim and final storages for the radioactive waste resulting from KhNPP-3&4 was not answered.

Question 6:

- *How can the safe storage of spent fuel and radioactive waste be ensured if the interim storage and final disposals will not be ready in time?*

Answer of the Ukrainian side

If the CSFSF will not be ready in time, or if the capacity will not be sufficient, spent fuel will be sent for long-term storage with subsequent processing to the Russian Federation or to France (La Hague). A cooperation project between Energoatom and the French company Orano is being developed.

In absence of a deep geological disposal the lifetime of CSFSF can be extended. The manufacturer of the main equipment of the CSFSF is developing methods for ageing management of the systems and components. (ENERGOATOM 2019c)

Assessment of the answer

The first step of a cooperation project between Energoatom and the French Orano (La Hague) has already been signed[9].

In addition to these two options, the long-term operation of the CSFSF is envisaged. More information particularly regarding ageing management would be appreciated.

3.3 Conclusions and final recommendations

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore the EIA should assess the nuclear waste management.

The Ukrainian side has provided the Austrian side with additional information on spent fuel and radioactive waste. In June 2019, the Cabinet of Ministers approved the concept of the State Economic Program for the Management of Spent Nuclear Fuel (SNF) of Nuclear Power Plants (NPP) for the period up to 2024[10]. According to this document, the state program is being set up in line with the requirements of Council Directive 2011/70/EURATOM. Information on this program was not provided to the Austrian side.

Final recommendation

1. According to the concept of the State Economic Program for the Management of Spent Fuel of Nuclear Power Plants for the period up to 2024, the state program is being set up in line with the requirements of Council Directive 2011/70/EURATOM. It is recommended that the Austrian government follows up on this issue under the pertinent “Bilateral Agreement”.

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[9] https://www.orano.group/country/china/en/about-us/our-news/china-group-news/2018/may/orano-signs-a-new-contract-with-ukraine-on-the-field-of-spent-fuel-reprocessing, seen 26 June 2019

[10] https://kosatka.media/en/category/elektroenergiya/news/ukraina-planiruet-vyvozit-oyat-na-specializirovannye-inostrannye-predpriyatiya, seen 26 June 2019

4 REACTOR TYPE

4.1 Summary of the expert statement

In chapter 3 of ENERGOATOM (2017a), the envisaged main technical solutions of KhNPP-3&4 are described. As a result of negotiations with potential suppliers of reactor equipment, the decision was taken to use the VVER-1000 reactor facility manufactured by Škoda JS a.s., which complies with all established regulatory documents of Ukraine and the requirements of the International Atomic Energy Agency (IAEA).

As a reference reactor, the VVER-1000/V-320, implemented at the Temelín NPP, is considered.[11] The planned operating time of the power units KhNPP-3&4 is 50 years. The units will work in base load operation with the option of load following.

According to ENERGOATOM (2017a, p. 8), the VVER-1000 project of Škoda JS a.s. will provide the following additional systems and means for control of beyond design basis accidents (BDBA), including severe accidents:

- hydrogen control and removal systems;
- systems of filtered release of pressure from the containment;
- systems for external cooling of the reactor pressure vessel during severe accidents.

Ex-vessel coolability and In Vessel Melt Retention (IVMR)

Key safety feature of the envisaged KhNPP-3&4 reactor units is the external cooling of the molten core in case of a core melt accident. The development of this feature for the “In Vessel Melt Retention” (IVMR) is still underway, for example at the reference units at the Temelín NPP.

As part of the outcome of the EU Stress Tests in 2012, several areas for further research in the field of Severe Accident Management have been identified. One of these areas concerns the feasibility of In Vessel Melt Retention (IVMR) for VVER 1000 reactors. In 2012, several research institutes and utilities in Europe (and also in the Russian Federation) started to work on this topic. Currently the EC project HORIZON 2020 IVMR continues to deliver more findings on this topic. New large experimental facilities are designed to measure critical heat flux (CHF) at the outer surface of the RPV lower head under more realistic configurations and flow conditions. (JRC 2016, ZDAREK 2017)

Existing building, structures and equipment

According to ENERGOATOM (2017a), the planned construction of the KhNPP-3&4 counts on using the existing structures of the reactor compartment and other facilities built in the 1980s.

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[11] The National Nuclear Generating Company Energoatom approved the turbine unit on the basis of the project K-1000-60/1500-2M produced by Turboatom JSC.

According to ENERGOATOM (2017b), the construction availability of the power units is assessed as:

- 75% for unit 3 (85 items of equipment were installed, including tanks, heat exchangers, filters, etc.)
- 28% for unit 4.

Furthermore, the use of the equipment stored in a warehouse facility at the KhNPP site (storing around 20,000 components of equipment for KhNPP-3&4) is mentioned. Information about the conditions of the existing buildings, structures and equipment is lacking in the EIA documents.

During the consultations in 2013, the Ukrainian side stated that all structures can be used for the completion of units 3 and 4, all the existing structures are in an operable condition. This was the result of a survey done before the preparation of the FS. The only safety relevant building, which has already been completed, is the building of the back-up diesel generator of unit 3. (MINUTES 2014)

An over 10-year-old survey performed between 2005 and 2009 concluded that the **existing buildings and structures** are in an operable condition – no reference to a more recent survey is made in the EIA documents. To evaluate the durability and reliability of the building and structures of KhNPP-3&4. a new survey is scheduled for this year.

The Austrian expert team is critical about the condition of the existing structures and buildings, because no convincing evidence on sufficient protection against weather impacts exists.[12]

In 2017, SNRIU conducted a state expert review of nuclear and radiation safety (NRS) of the updated/revised feasibility study (FS) of "Construction of Khmelnitsky NPP units No. 3 and 4. According to SNRIU (2017), the FS was approved upon several conditions, including: conduction a compulsory research at project stage and providing relevant justifications in the Preliminary Safety Analysis Report (PSAR) regarding the use of existing buildings and structures of units 3 and 4.

Protection against external hazards

The EIA documents do not provide information against which external impacts the existing buildings were originally designed, and whether the structures and buildings still comply with today's requirements and will for 50 years operation time.

All in all, no clear evidence was presented to prove that the existing building, structures and equipment are in a condition to ensure 50 years of safe operation.

Ageing Management Programme

An ageing management programme (AMP) is not mentioned, despite the fact that ageing of the more than 30 years old structures, buildings and equipment is an issue even without operational loads. The adverse effect of ageing depends also

[12] Pictures show that some structures have been standing in water and were unprotected over the last years, see https://bellona.ru/2015/10/05/khaes-cancelled/ (seen 02 May 2019).

on the inspection, restoration and protection measures taken (AMP). The first Topical Peer Review (TPR) based on Article 8e of Directive 2014/87/EURATOM focused on Ageing Management. In the course of the TPR, national results have been evaluated through the peer review process, complementing the national assessments For Ukraine, this assessment revealed several deviations from the safety expectations for an acceptable ageing management in Europe. (ENSREG 2018)

One of the issues assessed is of particular concern for KhNPP-3&4 because it refers to delayed NPP projects.[13] According to ENSREG (2018), this “TPR expected level of performance” is not performed in the Ukraine.

The (cancelled) reactor type V-392B

In 2008, the Ministry of Energy and Coal Industry of Ukraine ran a tender to select a reactor for the KhNPP-3&4, the results – the choice of reactor type VVER-1000/V-392 – was approved by the Cabinet of Ministers of Ukraine. (SNRIU 2012)

The main difference between the reactor units V-320 and its improved variant V-392B[14] consists of additional safety systems, which provide a significant safety level increase. The highlights of this reactor type compared with the VVER-1000/V-320 are passive safety systems[15]. The design of the VVER 1000/V-320 does not comply with modern safety standards.

Although advanced VVER-1000 with different reactor types and enhanced safety features have been available for several years, Ukraine now plans the construction of two units of the Generation II VVER-1000/V-320; they have already been built.

Design weaknesses of the VVER-1000/V-320

In November 2007, the EC-IAEA-Ukraine Project “Safety Evaluation of Ukrainian Nuclear Power Plants” was launched to perform an overall safety assessment of all operational Ukrainian nuclear power plants. Ukrainian NPPs are found to be compliant with only 172 out of 194 requirements of IAEA NS-R-1 “Safety of Nuclear Power Plants: Design”, already published in 2000. (ENSREG UCR 2012). The EIA documents do not explain how the KhNPP-3&4 units will solve the various shortcomings of the VVER1000/V-320 reactors in general and in Ukraine in particular, however, this is of high interest.

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[13] *During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified, and appropriate measures are implemented to control any incipient ageing or other effects*

[14] The reactor models V-392 and V-392B are different reactor types, however - although it is clear that V-392B has been selected - the names of the reactor types are used synonymously in the IAS (2011).

[15] Details on the passive safety systems have not been provided. Their functionality under severe accident conditions is not proven yet.

Plugging of ionization chamber (IC) channel

An analysis performed during an EU pre-accession instrument (PHARE project) in Bulgaria at units 5&6 of the VVER-1000/V-320 Kozloduy NPP discovered a vulnerability of this design consisting in early containment melt-through via ionization chamber (IC) channels situated around the reactor pit.

In 2011, the plugging of the bottom of IC channels with plugs made from high-temperature-resistant materials (Titanium Carbide) was suggested. The overall implementation process of mounting of the plugs took two years (performed during the annual outages) for units 5&6 in 2013-2014 respectively. (POPOV 2017) In the EIA documents it is not mentioned whether plugging of the IC channels is foreseen for KhNPP-3&4.

High-energy pipelines of the secondary circuit at NPP Temelín

The high-energy pipelines at the Temelín NPP (VVER 1000/V-320) are located between the containment and the turbine hall at the level of the 28.8 m platform without partition walls and without protection. In the case of break of a pipeline, it may be consequential damage to other lines and components, and thus to an accident that can no longer be controlled. Many modifications had been implemented that improved the technical condition of high-energy pipelines of the secondary circuit at Temelín NPP. (BMLFUW 2016)

No information was provided in the EIA documentation, how the issue of high-energy pipelines will be dealt with at KhNPP-3&4.

Project targets and international requirements

SNRIU (2017) concludes that the FS largely adhere to the requirements of NRS norms, rules and standards, requirements of the SNRIU and the provisions of international organizations' documents regarding new NPPs. However, a detailed analysis of the implementation of safety criteria will be carried out at the "project stage" when preparing a preliminary Safety Analysis Report (SNRIU 2017).

According to WENRA (2010), the units KhNPP-3&4 are so-called deferred plants – "plants projects originally based on design similar to currently operating plants, the construction of which halted at some point in the past and is now being completed with more modern technology." The WENRA "Safety Objectives for New Power Reactors" should be also used as a reference for identifying reasonably practicable safety improvements for deferred plants (WENRA 2010).

The application of WENRA safety objectives for KhNPP-3&4 is not mentioned in the EIA documents.

In 2014, WENRA published a revised version of the Safety Reference Levels (RLs) for existing reactors developed by the Reactor Harmonisation Working Group (RHWG). The objective of the revision was to take into account lessons learned of the TEPCO Fukushima Daiichi accident. (WENRA 2014) A major update of the RLs was the introducing the concept of Design Extension Conditions (DEC). According to WENRA (2014) as part of the defence-in-depth, analysis of Design Extension Conditions (DEC) shall be undertaken with the purpose of further improving the safety of the nuclear power plant. The analysis shall identify reasonably practicable provisions that can be implemented for the prevention of severe accidents. (WENRA 2014)

NPP design developed in the 1980s, like the VVER-1000/V-320, only partly fulfil these design principles.

All in all, it is not clear to which extent the current requirements and recommendations of WENRA will be applied for KhNPP-3&4.

4.2 Questions, answers and assessment of the answers

Question 1

- *Against which external impacts were the existing buildings originally designed, which requirements for the original design has to be applied, what loads were taken in account?*

Answer of the Ukrainian side

A1: "After excluding insignificant impacts, the following types of effects are considered:

- Fire for external reasons;
- External explosion;
- Seismic effects;
- Tornado;
- Plane crash.

External explosion: The civil structures of the reactor compartment and the backup diesel power plants have been designed, taking into account the loads produced by the impact of the air-shock wave with the following parameters:

- Overpressure at the shock wave front $\Delta P\phi$=30 kPa;
- Duration of the compression phase τ+=1s,

which is an order of magnitude higher than the parameters of a possible air-shock wave at the border of the industrial site.

Fires: Buildings, structures and rooms where the fire can lead to mass destruction of people, failure of nuclear power plant safety systems, dangerous secondary fire factors are equipped with the fire safety systems that ensure the lowest possible probability of occurrence and spread of fire.

Seismic effects: In the design of the power unit, the civil structures of buildings and structures have been designed taking into account the following seismic effects:

- Reactor compartment – 7 points;
- Turbine department – 7 points;
- Special building – 6 points;
- Overpass between the reactor compartment and the special building – 6 points;
- Backup diesel power plants in power units – 7 points.

Tornado: The design considers the following parameters of tornado:

- Tornado intensity class K = 2.75 (in the calculation, the increased tornado class K = 3.4 with its corresponding characteristics was adopted conservatively);
- Annual probability of tornado across through any given point: $14x10^{-7}$ area/year;
- Maximum speed of tornado wall rotation: $V_к$ = 76 m/s;
- Maximum forward speed of a tornado U_k = 19 m/s;
- Length of the passage zone: $L_к$ = 13.3 km;
- Zone width S_k = 133 m;
- Pressure drop, $\Delta p_к$ = 70 hPa (700 kgf/m^2).

Plane crash: The typical design considers the fall of a SESNA type light aircraft as an initial impact. It showed the absence of vulnerability of building structures with respect to this impact. In addition, at this stage, it is proved that the risk from external extreme impacts associated with the fall of aircraft on buildings and structures of the unit is negligible ($2x10^{-8}$ /per year) compared with the risk from internal initiators. In connection with the above, the loads from impacts when a passenger aircraft is dropped are not taken into account when calculating PO.” (ANSWERS REACTOR TYPE 2019b)

Assessment of the answer

The question has been answered.

Originally the KhNPP 3&4 are designed to withstand five external loads: Fire for external reasons; external explosion; seismic effects; tornado und plane crash.

Question 2

- *Do the structures and buildings still comply with these requirements and will they continue to do so for the operation time of 50 years?*

Answer of the Ukrainian side

A2: “Results of survey of KhNPP 3&4 buildings and structures

As per Order of the Cabinet of Ministers of Ukraine № 281-p dated July 21, 2005, a survey and assessment of technical condition of KhNPP 3-4 buildings and structures were performed. The survey was carried out by JSC «Kiev Research and Development Institute «Energoprojekt» from 2006 to 2008 and consisted of the following stages:

- reconnaissance survey;
- survey of as built (turnover) documentation;
- visual inspection;
- instrumental measurements;
- drawing conclusions of the survey results;
- development of proposals for repair and recovery works;
- forecast for durability (remaining life) of building structures.

The following fully or partially mounted buildings and structures have been surveyed:

Unit 3

- reactor building - 3;
- turbine house - 3, incl. the turbine hall, the deaerator compartment, the addition for electrical engineering equipment;
- cooling water intake - 3;
- standby diesel-generator plant – 4 with fuel storage tanks;
- outdoor transformer-3 installed in the additions (incl. transformer roll tracks, oil cooler buildings and oil catch tanks);
- flexible foundations between turbine hall and open switch yard;
- gallery between turbine hall-2 and turbine hall-3;
- scaffold bridge for process pipelines between reactor building-3 and special building;
- scaffold bridge for process pipelines between turbine house-2 and turbine house-3;
- cable conduits with cable man-holes between the addition for electrical engineering equipment and cooling water intake -3;
- closed discharge channel with service building and siphon outlet;
- filter house (bottom);
- valve chamber;
- flexible connections.

Unit 4

- reactor building -4);
- foundations for nitrogen receiver (near of reactor building -4);
- turbine house -4), incl. the turbine hall and deaerator compartment;
- cooling water intake -4;
- standby diesel-generator plant -5;
- outdoor transformer -4 with emergency oil discharge tank;
- flexible foundations between turbine hall and open switch yard;
- gallery between turbine hall-3 and turbine hall-4;
- scaffold bridge for process pipelines between reactor building-4 and special building;
- scaffold bridge for process pipelines between turbine house -3 and turbine house-4;
- valve chamber -4;
- closed discharge channel -4.
- cable man-holes near of standby diesel-generator plant-5;
- cable conduit between cooling water intake -4 and the addition for electrical engineering equipment.

Conclusions on assessment and durability forecast for building structures[16] №3,4

It was accepted within the life evaluation project that the age of structures was in average 20 years, and that they should maintain their characteristics in compliance with the design and regulatory requirements until KhNPP-3&4 decommissioning, including the period needed to complete the construction (which is estimated as 5 years), design life (estimated as 40 years), and decommissioning period (10 years).

Thus, the following assessment criteria were accepted for:

- Lifetime assessment – maximum time from the erection of structures to the end of their lifetime, which is equal to 75 years;
- Residual life assessment - maximum time from the end of the survey to Unit decommissioning, which is equal to 55 years.

Based on calculations and survey results, the lifetime assessment demonstrated that:

- The strength of concrete for the most essential structures and reactor containment is ensured for the whole lifetime period of 55 years, without the consideration of remedial measures;
- Average carbonation depth of the protective layer estimated by the end of lifetime provides the protective functions for the whole lifetime period of 55 years. In locations where the anticipated depth of the protective layer does not protect the steel reinforcement bars, adequate measures should be taken to slow down the carbonation process;
- Based on the condition of reinforcing bars, the life of structures will be ensured after replacements of installed but not concrete-embedded reinforcement cages and protruding reinforcing bars.
- Based on the condition analysis of building structures and life calculations, it was concluded that provided the package of remedial measures is implemented, KhNPP 3 & 4 buildings and structures will be reliably operated during 55 years.“ (ANSWERS REACTOR TYPE 2019a)

Assessment of the answer

The question has been answered. However, no evidence was presented to prove that the *structures and buildings will continue to comply with the requirements for the operation time of 50 years*.

The calculation for the 2005-2009 survey was based on a service life of 75 years. But today’s service lifetime is considerably longer, it is about 100 years (construction age and completion period: 38 years - before 25 years, operation time: 50 years - before 40 years, decommissioning period: 10 years, totalling 98 years).

[16] Report №43-473.211.018.OT00, №43-610.211.001.OT05

Question 3

- *What are the differences of the previous requirements in the 1980s years and the current requirements concerning the resistance against external hazards?*

Answer of the Ukrainian side

A3: “The current regulatory framework used nowadays in the design of NPP buildings and structures has the following discrepancies with the previous requirements used at the time of the design development.“ (ANSWERS REACTOR TYPE 2019a)

Table 1: Comparison of requirements. (ANSWERS REACTOR TYPE 2019a)

№	Previous requirements	Current Requirements	Changes
1	SNiP II-21-75 SNiP 2.03.01-84	DBN V.2.6-98:2009	Consideration of non-linear deformation model
2	SNiP II-6-74 SNiP II-7-81	DBN V.1.2-2:2006	1 Characteristic value of wind pressure – 520 Pa. 2 Characteristic value of the ground snow load – 1,330 Pa 3 Structural loads have been supplemented with specific hazards of shock wave, possible tornado, earthquakes, and extreme climatic hazards
3		PiN AE-5.6	New documents
4		NP 306.2.208-2016	New documents
5		NP 306.2.141-2008	New documents
6	SNiP II-6-74	DBN V.1.2-14-2009	Consideration of Partial Safety Factor for the 1st group of limit states
7	SNiP 2.02.01-83	DBN V.2.1-10-2009	Consideration of design model “building – foundation –base mat”.

Assessment of the answer

The question has been sufficiently answered. While specific requirements are not given, the years of the specific requirements are listed. Requirements from the 1970s and 1980s were replaced by newer requirements. However, with one exception the newer requirements are over 10 years old and from the period before the severe accident in Japan in March 2011, which led to an increase in the international safety requirements for external hazards.

Question 4

- *Which external loads shall the ongoing survey of the buildings and structures of KhNPP-3&4 take into account?*

Answer of the Ukrainian side

Table 2: Loads and hazards taken into account (ANSWERS REACTOR TYPE 2019a)

№	Loads and hazards	Regulatory Document
1.	Impacts on buildings and structures caused by static weight of structures and ground	
1.1	Weight of load bearing and building envelope structures	DBN V.1.2-2:2006
1.2	Ground weight and pressure	DBN V.1.2-2:2006
1.3	Fixed equipment loads	DBN V.1.2-2:2006
1.4	Weight of equipment filling components	DBN V.1.2-2:2006
1.5	Pressure of gases, fluids, and solids in vessels and pipelines	DBN V.1.2-2:2006
1.6	Re-deployed or replaced equipment loads	DBN V.1.2-2:2006
1.7	Vertical loads of overhead and gantry cranes with low characteristic value	DBN V.1.2-2:2006
1.8	Loads of movable lifting and handling equipment (with full characteristic value)	DBN V.1.2-2:2006
2	External hazards	
2.1	Wind loads	DBN V.1.2-2:2006
2.2	Extreme winds	PiN AE - 5.6 DBN V.1.2-2:2006
2.3	Tornados	PiN AE - 5.6 DBN V.1.2-2:2006 RD 95 10444-91 IAEA 50-SG-S11A
2.4	Snow loads with low characteristic value	DBN V.1.2-2:2006
2.5	Snow loads with full characteristic value	DBN V.1.2-2:2006
2.6	Extreme snow	PiN AE - 5.6 DBN V.1.2-2:2006
2.7	Ambient temperature range	
2.8	Temperature loads with low characteristic values	DBN V.1.2-2:2006
2.9	Temperature loads with full characteristic value	DBN V.1.2-2:2006
2.10	Extreme ambient temperatures	PiN AE - 5.6
	Earthquakes	
2.11	Design basis earthquake	NP 306.1.02/1.034-2000 PNAE G-10-007-89 NP 306.2.208-2016 DBN V.1.1-12:2014
2.12	Maximum considered earthquake	NP 306.1.02/1.034-2000 PiN AE - 5.6 PNAE G -10-007-89 NP 306.2.208-2016 DBN V.1.1-12:2014
2.13	Subsidence and tilting of structures (effects of basemat deformations accompanied by a fundamental change in the ground structure related to its increased watering or by subsidence in underground mining areas or sinkholes)	PiN AE - 5.6 DBN V.1.2-2:2006
3	Industrial and other anthropogenic activity	
3.1	Shock wave due to an explosion possible at this or nearby facility, passing transport etc.	PiN AE - 5.6 DBN V.1.2-2:2006
3.2.	Aircraft crash, including its parts and components	PiN AE - 5.6 PNAE G -10-007-89 IAEA 50-SG-S5
4	Technology-related hazards / loads	
4.1	Normal operating conditions	PNAE G -10-007-89
4.2	Abnormal operational occurrences	PNAE G -10-007-89
4.3	Maximum design-basis accident	PNAE G -10-007-89

oads and hazards	Regulatory Document
	PiN AE - 5.6

Assessment of the answer

The question has been answered. External loads were not listed, only the regulations to be applied. The survey is almost exclusively based on regulations from 2006. For technology-related hazards and aircraft crash even regulations from the year 1989 were applied. Newer regulations from 2014 and 2016 are used only for earthquakes. As mentioned earlier, the severe accident in Japan in March 2011 led to an increase in the international safety requirements for external hazards. From a safety point of view, requirements for the completion of a nuclear power plant with an operating lifetime of at least 50 years should reflect most recent research results and developments in international standards.

Question 5

- *What is the time schedule for the necessary improvement of the ageing management programme (AMP) based on the findings of the Topical Peer Review (TPR) based on Article 8e of EU Directive 2014/87/EURATOM?*

Answer of the Ukrainian side

There is no answer given in the presentations. During the 13 June 2019 consultations in Vienna, this question was declared beyond the scope. The modified question "*When will Ukraine implement the results of the TPR for the units 3 and 4?"* was not answered either.

Assessment of the answer

The question has not been answered.

Complementing the national assessments, the Topical Peer Review (TPR) on Ageing Management evaluated national results with the peer review process.,. All countries' AMP were assessed against the expected TPR performance level.[17] For Ukraine this assessment revealed that there are several deviations from these safety expectations. One of these issues is of particular concern for KhNPP-3&4 because it refers to delayed NPP projects. Furthermore, in Ukraine, the scope of the overall ageing management programme is not reviewed and, if necessary, updated, in line with the new IAEA Safety Standard. (ENSREG 2018)

All in all, the AMP applied in the Ukraine does not meet the European requirements. Moreover, the AMP did not take into account the existing structures and the equipment stored for KhNPP 3&4.

[17] In this context a TPR expected level of performance" for ageing management is the level that should be reached to ensure consistent and acceptable management of ageing throughout Europe

Question 6

- *Are the existing buildings, structures and equipment for KhNPP3&4 included in the AMP?*

Answer of the Ukrainian side

A6: "Ageing management programme (AMP) covers buildings and structures important to safety. AMP purpose is to ensure ageing management of buildings and structures, to protect them from degradation within the limits established by nuclear safety standards and regulations during the whole lifetime period. Now the AMP includes the Special Auxiliary Building due to the fact that it was designed according to the original project for 4 (four) power units of Khmelnitsky NPP. All other buildings and structures for KhNPP 3&4 will be included in the AMP after their commissioning." (ANSWERS REACTOR TYPE 2019a)

It was clarified during the consultations on the 13 June 2019 in Vienna, the AMP is implemented for units 1 and 2 only but not for 3 and 4 because these buildings are not ready.

Assessment of the answer

The question has been answered. It was explained Ukraine included only completed buildings in the ageing management program. However, this approach is not justified because the structures and equipment of KhNPP 3&4 are already ageing despite the fact the plant is not in operation. For the period between the investigation of components and the start of regular AMP, ageing phenomena should be addressed adequately.

Question 7

- *Please provide information about the ongoing restoration programme.*

Answer of the Ukrainian side

A7: "Repair and recovery works:

The following repair and recovery works were completed:

Started in 2009; completed in 2013. Completed activity:

Scaffold bridge for process pipelines:

- steelwork cleaning, priming and paining - 6393 m^2, (100%);
- repair of concrete structures – 100%.

Reactor building:

- steelwork cleaning and priming -35444 m^2;
- steelwork painting –31447m^2 (98%);
- restoration of concrete surfaces –10700m^2 (70%);
- installation of water scavenge pipeline;
- installation of temporary compressed-air pipeline.

Turbine hall:

- steelwork cleaning, priming and painting –52857m^2; (99%)
- completion of temporary roofs;
- thermal circuit closure;
- repair of concrete structures –60%.

Stand-by diesel-generator plant:

- steelwork cleaning, priming, painting – 2695 m^2; (100%)
- repair of reinforced concrete structures - 40%.

Cooling water intake:

- steelwork cleaning and priming – 760 m^2 (100%)
- protection of reinforced concrete structures– 420 m^2. (100%)

Scaffolds and galleries:

- steelwork cleaning, priming and painting -587 m^2(100%).;

Following the building and structures survey of KhNPP units 3 and 4 the «Programme for Completion of Repair and Restoration Works at KhNPP 3 and 4» will be developed." (ANSWERS REACTOR TYPE 2019a)

During the consultations on the June 13, 2019 in Vienna, it was explained that a heating system was installed in unit 3 to prevent further deterioration of the buildings. In addition, the announcement was made that Austria will receive the results or a summary of the 2019/20 studies. This will probably not take place within the framework of the EIA procedure, but within the framework of the bilateral agreement that provides a platform to discuss such issues.

Assessment of the answer

The questions/request has been answered. It is explained which work is done between 2009 and 2013, based on the survey performed from 2005-2009. While most of the works have been completed, some of the important works not yet. The restoration and repair of concrete structures and surfaces is only 40 to 70% complete.

Question 8

- *Please provide information about the condition of the existing buildings, structures and equipment of the units 3 and 4 (including pictures).*

Answer of the Ukrainian side

A8: "Equipment Available at KhNPP Storage Facilities
that can be Applicable for Kh3/4

In 1987-1997, considerable amount of equipment was supplied to KhNPP site for construction of its power units. As per Kh3/4 Pre-construction Preparatory Measure Plan, KhNPP experts developed relevant programmes and performed examination, reconditioning, and preservation of equipment already installed at KhNPP 3 & 4 and equipment available at storage facilities. Reports were developed based on the examination results. The “List of Equipment Pre-delivered for Initial V-320 Reactor Project that can be Integrated into the New Construction Project for Kh3/4” and “List of Equipment Pre-delivered for Initial V-320 Reactor Project and can be used for Auxiliary and Temporary Systems during Kh3/4 Construction” were developed and approved. At present, preservation and reconditioning works were carried out for equipment installed at KhNPP 3 and for big number of equipment available at storage facilities.

Condition of Kh3/4 Equipment Available at Storage Facilities

KhNPP experts performed previous review of documentation stored in archives of Logistics Department for equipment applicable for further use. The review demonstrated that not all manufacturing documentation was available.

Works are in progress to compile a package of documents *(lists of equipment, terms of references)* for carrying out total revision of equipment previously supplied to KhNPP, and estimating its preservation cost. After having examined equipment, developed a database, taken decisions on its use and preservation, it will become clear which equipment needs repair or replacement of components, and renewal of manufacturing and installation documentation for its further use during Kh3/4 construction.

Examination reports were prepared where the following data were specified:

- Available manufacturing documentation per each item of equipment listing the missing documents;
- Compliance of storage conditions with requirements in engineering documentation;
- Metal inspection data for individual inspected components and units (conclusions, reports);
- Scope and lists of materials required for preservation and reconditioning activities;
- Decisions on equipment applicability.

Today, assessment has been completed for 3715 items of equipment that was split into the following groups:

- *Group 1.* Equipment applicable for further use within Kh3/4 process systems;
- *Group 2.* Equipment that can be used for Kh3/4 after missing components are supplied or can be included into replacement pool for KhNPP and other Ukrainian NPPs as a whole unit or by parts;
- *Group 3.* Equipment not further applicable for its intended purpose.“ (ANSWERS REACTOR TYPE 2019a)

Table 3: Group 1 Equipment applicable for further use within K3/4 process systems (ANSWERS REACTOR TYPE 2019a)

Equipment	Quantity, pcs
Heat Exchanger	54
Hermetically sealed door, hatches	160
Hermetic penetration	45
Hydraulic Damper	158
Tank	8
Pressurizer	1
ECCS Tank	2
Bubbler	2
Steam Generator	4
Polar Crane	1
Refueling Machine and accessories	1
Reactor Coolant Pump	4
Primary Coolant Loop	4

During the consultations in Vienna on 13 June 2019, it was explained that not all components can be used anymore, as they are physically and technologically obsolete. It is very important that safety is guaranteed. During the consultations, pictures of the plant and its components dating from 2019 were shown. The components stored and already installed were inspected. Work was carried out together with the Ministry responsible for construction from 2006 to 2008. A new investigation is currently taking place and should be completed by 2020. The Ukrainian side offered to submit the report (summary or/and results) of the investigation.

Assessment of the answer

The investigation of the components which were delivered 20 to 30 years ago is in progress. Several components are physically and technologically obsolete and cannot be used.

It is to be welcomed that the result of the investigation of the components will be provided.

Question 9

- *Does the design of units 3 and 4 differ from the design of units 1 and 2 of the KhNPP? If so, in which areas?*

Answer of the Ukrainian side

A9: "The completion design initially includes those upgrades that were performed at all Ukrainian NPPs with VVER-1000, moreover, additional systems for management of beyond the design basis accidents and mitigate the severe accidents consequences were included." (ANSWERS REACTOR TYPE 2019b)

Assessment of the answer

The question has been answered.

However, it is not detailed explained which upgrades are performed at all Ukrainian NPPs with VVER-1000 reactors.

Question 10

- *Is there a systematic evaluation of the KhNPP-3&4 design deviations from the current international safety standards and requirements envisaged?*

Answer of the Ukrainian side

A10: "This assessment was carried out during the feasibility study, with its results considered in the design taking into account completion of the KNPP units 3 and 4." (ANSWERS REACTOR TYPE 2019b)

Assessment of the answer

The question has been answered.

It was stated that a systematic *evaluation of the KhNPP-3&4 design deviations from the current international safety standards and requirements* review had been carried out. The result was unfortunately not delivered. However, the real problem is the fact, that current safety requirements for new NPPs are not required for KhNPP-3&4, but only the requirements for NPPs in operation.

Question 11

- *Is it planned to plug the IC channels like in Kozloduy 5&6 or will this shortcoming be prevented by design changes?*

Answer of the Ukrainian side

A11: "This upgrade is performed at all Ukrainian NPPs with VVER-1000, of course, this vulnerable feature of the reactor vessel will be eliminated in the VVER-1000 design at KhNPP -3 and 4." (ANSWERS REACTOR TYPE 2019b)

During the consultations on 13 June 2019 in Vienna, it was stated that this modernization is currently being carried out for all VVER 1000 reactors in the Ukraine.

Assessment of the answer

The question has been answered.

Question 12

- *Will the WENRA safety objectives for new nuclear power plant be applied for KhNPP-3&4? Will the concept of defence-in-depth be implemented according to those WENRA safety objectives?*

Answer of the Ukrainian side

A12: “SE NNEGC “Energoatom” considers this activity as the completion of the power units construction of which was earlier terminated. Therefore, all WENRA requirements applicable to the operating units are considered, where it is achievable.“ (ANSWERS REACTOR TYPE 2019b)

*Currently “Khmelnitsky NPP power units №3,4 construction” Project is considered as the completion of power units which previously were decided to suspend of their construction. All requirements of WENRA, relative to the operating units are taken into account, where it is achievable. (ENERGOATOM 2019a)

Assessment of the answer

The question has been answered. However, there is no convincing evidence that every reasonably practicable safety improvement has been made.

Question 13

- *Which are the improvements of the design, material etc. of the reactor pressure vessel (RPV) and steam generator (SG) compared with these components used at the reactor type V-320? In general, how will the safety requirements according to IAEA NS-R-1 “Safety of Nuclear Power Plants: Design”, (2000) be dealt with at the KhNPP-3&4?*

Answer of the Ukrainian side

A13: “The Reactor vessels and steam generators of VVER-1000 reactors fully comply with the requirements of NS-R-1, as evidenced by the results of the IAEA’s “Project Safety” mission conducted in 2010 at all power units of Ukrainian NPPs.” (ANSWERS REACTOR TYPE 2019b)

During the consultations on 13 June 2019 in Vienna, it was stated that new steam generators are likely to be purchased. However, this decision will only be taken after the law on the completion of KhNPP 3&4 has been passed. After a positive parliament decision on the NPP completion, government’s technical specifications will be known and decision on the components to be used or purchased taken.

Assessment of the answer

The question has been answered. However, in November 2007, the EC-IAEA-Ukraine Project ‘Safety Evaluation of Ukrainian Nuclear Power Plants” was launched to perform an overall safety assessment of all operational Ukrainian nuclear power plants. Ukrainian NPPs were found to be compliant with only 172 of 194 requirements of IAEA NS-R-1 (Safety of Nuclear Power Plants: Design), already published in 2000. I (ENSREG UCR 2012).

According to SNRIU (2016), the work on two issues (equipment qualification; qualification of steam generator pilot-operated relief valves and BRU-A valves) is still in progress and will eliminate the non-compliance within the Comprehensive (Integrated) Safety Improvement Programme for Nuclear Power Plants.

It was not explained when these measures should be taken for the already stored parts of KhNPP 3&4.

Question 14

- *Is it foreseen to include all improvements of NPP Temelín regarding the issue of high energy pipelines to KhNPP-3&4? Or is an adequate physical separation of the feed water and steam lines ensured by design?*

Answer of the Ukrainian side

A14: "The separation of high-energy pipelines is performed at Ukrainian NPPs by installing appropriate supports and motion limiters, and, of course, these solutions will be implemented at KhNPP -3 and 4." (ANSWERS REACTOR TYPE 2019b)

Assessment of the answer

The question has been answered.

Question 15

- *What is the current status of research for the feature of ex-vessel cooling of the reactor pressure vessel for the VVER 1000/V-320? When will this safety feature be ready for implementation at the reference reactor in Temelín? Is this feature also intended for implementation at the other reactors in Ukraine or other countries?*

Answer of the Ukrainian side

A15: "The updated version of the feasibility study for the KhNPP -3 and 4 considers availability of an external cooling system for the reactor vessel, which is currently undergoing experimental justification in the Czech Republic. The test results have already demonstrated the feasibility of heat removal from the reactor vessel during its melting and retention of the melt inside the vessel; that is, prevention of the beyond-the-vessel phase of the severe accident." (ANSWERS REACTOR TYPE 2019b)

During the consultations in Vienna on the 13 June 2019, it was stated that the ex-vessel cooling implementation for the other VVER 1000 in the Ukraine is under consideration.

Assessment of the answer

The question has been answered. However, the development of the key safety feature of the units KhNPP-3&4, the external cooling of the molten core is ongoing, but far from realization at the Temelín NPP.

Since 2012, several research institutes and utilities in Europe (and also in the Russian Federation) started working on this topic. Currently the EC project HORIZON 2020 IVMR is continuing to provide more findings on this topic. New large experimental facilities are designed to measure critical heat flux (CHF) at the outer surface of the RPV lower head under more realistic configurations and flow conditions. Full height experimental facilities are necessary for validation data, and they should be designed as closely as possible to the real conditions. (JRC 2016, ZDAREK 2017)

Question 16

- *Are there different legal requirements for new and operating reactors in Ukraine?*

Answer of the Ukrainian side

A16: "The KhNPP -3 and 4 design complies with requirements of all regulatory documents effective in Ukraine. The Technical Requirements to the design include an attachment with detailed requirements set forth by the SNRIU." (ANSWERS REACTOR TYPE 2019b)

Assessment of the answer

The answer above does not clearly answer the question. However, the consultations clarified that different regulations (for example different probabilistic goals) are applied for new and existing NPPs.

4.3 Conclusions and final recommendations

From an expert's point of view any NPP to be commissioned for the first time should meet state of the art safety requirements in full. But given the current broad agreement on European and international level that "deferred plants" may be considered as "existing plants" this expert statement is based on the concept of reasonably practicable safety improvements.

For the completion of KhNPP-3&4, it is planned to use the buildings and structures already built in the 1980s. During the consultations, it was explained that 2009-2013 restoration and repair works were performed, based on the 2005-2009 survey. However, some of the important works (for example repair of concrete structures) have not been finished.

Furthermore, the survey 2005-2009 was based on a service lifetime of 75 years. But today's service lifetime is considerably longer, about 100 years. For this reason alone, the old results cannot prove that the old structures are fit to complete KhNPP 3&4.

A new survey to confirm the durability and reliability of the building and structures is on-going. It is to be welcomed that the result of the survey will be made available to the Austrian side.

For the new survey, requirements from the 1970s and 1980s were replaced by newer requirements. The survey is almost exclusively based on regulations from 2006. As mentioned earlier, the severe accident in Japan in March 2011 led to an increase in the international safety requirements for external hazards. From a safety point of view, requirements for the completion of a nuclear power plant with an operating lifetime of at least 50 years should reflect most recent research results and developments in international standards.

The investigation of the components which were delivered 20 to 30 years ago is in progress. Several components are physically and technologically obsolete and cannot be used. It is a positive fact that the result of the investigation of the components will be made available to Austria.

For Ukraine, the first Topical Peer Review (TPR) based on Directive 2014/87/EURATOM revealed several deviations from the safety expectations for an acceptable ageing management in Europe. One of these issues is of particular concern for KhNPP-3&4 because it refers to delayed NPP projects. (ENSREG 2018)

Ukraine included only completed buildings in the ageing management program. However, this approach is not justified because the structures and equipment of KhNPP 3&4 are already ageing despite the fact the plant is not in operation.

All in all, no convincing evidence showed that the existing building, structures and equipment are in a condition for a least 50 years of safe operation.

Key safety feature of the envisaged KhNPP-3&4 reactor units is the external cooling of the molten core in case of a core melt accident. The development of this feature for the "In Vessel Melt Retention" (IVMR) is still underway, for example at the reference units at the Temelín NPP. Furthermore, it has to be highlighted that the NPP design developed in the 1980s, such as the VVER-1000/V-320, only partly meet modern design principles concerning redundancy, diversity and physical separation of redundant subsystems or the preference of passive over active safety systems. (See IAEA 2016b, WENRA 2013) But all this design principles are necessary to reduce the risk of an accident.

According to WENRA (2013), the WENRA Safety Objectives for new NPPs should also be used as a reference for identifying reasonably practicable safety improvements for "deferred plants" like KhNPP-3&4. However, the EIA documents don't mention these WENRA safety objectives.

According to information provided at the consultations, a systematic *evaluation of the KhNPP-3&4 design deviations from the current international safety standards and requirements* had been carried out. The results were not reported on. The main problem is, however, that requirements for new nuclear power plants are not applied. More importantly, there is no convincing evidence that every reasonably practicable safety improvement has been made.

Final Recommendations

1. It is recommended to finish the survey of the conditions of the buildings, structures and equipment before taking any decision regarding the specific project completion. The survey should take into account the protection against external hazards (natural and man-made) according to current international requirements. The prediction should include the expected service life time. It is recommended that the results of the survey be subject to an international review.
2. It is recommended that for the period between the investigation of components and the start of regular AMP, ageing phenomena should be addressed adequately.
3. It is recommended to implement all available technical design improvements of VVER-1000/V320 reactor at KhNPP-3&4.
4. It is recommended to apply the WENRA Safety Objectives for new NPP to assess the nuclear safety of KhNPP-3&4. According to WENRA, this document should be used as a reference for identifying reasonably practicable safety improvements for "deferred plants" such as KhNPP-3&4.
5. It would be welcomed if convincing evidence that every reasonably practicable safety improvement has been made would be made available.
6. At the design stage of the project it should be evaluated by an external review that the NPP will meet current international and European safety standards.
7. It is appreciated that the result of the survey/assessment of the existing structures, buildings and equipment will be provided.[18]
8. The following information concerning the project should be part of the **Preliminary Safety Analysis Report** that will be provided to the Austrian side[19]:
   a. Information about the applied national requirements and international recommendations
   b. Updated justification on the condition of the existing structures, buildings and equipment
   c. A systematic evaluation of the KhNPP-3&4 design deviations from the current international safety standards and requirement.

[18] During the bilateral consultations, it was agreed to provide the results of the survey.

[19] During the bilateral consultations, it was agreed to provide relevant parts of the Preliminary Safety Analysis Report as soon as it becomes available.

5 INCIDENTS AND ACCIDENTS WITHOUT INVOLVEMENT OF THIRD PARTIES

5.1 Summary of the expert statement

A systematic analysis of design basis accidents (DBA) and beyond design basis accidents (BDBA) is not presented in the EIA documents; only the radiological consequences of one DBA and one BDBA are discussed:

- Maximum Design Basis Accident (MDBA), a scenario with a guillotine rupture of the main circulation pipeline, which leads to a leak equivalent diameter of 2x850mm (this accident is postulated as the DBA in the regulations);
- Beyond Design Basis Accident (BDBA), same scenario as MDBA with the failure of the active systems of the emergency cooling of the core (ECCS) and operating sprinkler system. (ENERGOATOM 2017a, p. 33; see also IAS 2011, p. 43)

The releases of the radiologically relevant radionuclide iodine (I-131) and caesium (Cs-137) are as follows:

MDBA:	I-131: 1.1 TBq	Cs-137: 0.023 TBq
BDBA:	I-131: 88 TBq	Cs-137: 0.45 TBq

The calculated probability of the considered BDBA is $4*29 \cdot 10^{-7}$ per reactor and per year. (ENERGOATOM 2017a, p. 33; see also IAS 2011, annex E).

This BDBA does not constitute a worst-case scenario. To calculate the possible (transboundary) consequences of this BDBA, it was assumed that the core melt will remain within the reactor pressure vessel (RPV). This assumption is not duly justified, because features to ensure the retention of the corium in the RPV (In-Vessel Melt retention - IVMR) are not available yet. Furthermore, if this feature could be realized it would only reduce the risk of a radioactive release in most but not in all severe accident scenarios.

In order to assess the consequences of BDBAs, it is necessary to analyse a range of severe accidents, including those with containment failure and containment bypass. These kinds of severe accidents are possible for the VVER 1000/V-320 reactor type. These types of severe accidents cannot be excluded, although their probability is below a specific value. This applies also for the KhNPP-3&4, and in addition it is possible that the condition of existing structures, buildings and systems could further increase the probability of severe accidents. Severe accidents with considerably higher releases than assumed in the EIA documents cannot be excluded for the considered reactor type even though their calculated probability is below a specific value.

A report published in 2012 by the Norwegian Radiation Protection Authority (NRPA) calculated the potential consequences in Norway after a hypothetical accident at the new nuclear power plant Leningrad II. The severe accident scenario, which was selected by Enconet, was based on a Level 2 PSA for a VVER-1000/V-320 model. The calculation was based on the most severe radiological consequences that could occur as a result of a “credible” accident scenario. The source term of this scenario was calculated to 2,800 TBq (0.85% of core inventory) for Cs-137 and 26,700 TBq (0.85% of core inventory) for I-131 (NRPA 2012). These source terms are considerably higher compared to those used in the EIA-documents.

During the consultations in Kiev on August 28, 2013, the Ukrainian side explained that according to the regulatory requirements, deterministic and probabilistic safety analyses of all DBAs and BDBAs will be performed at the project stage. During the consultations, the Ukrainian side also promised to provide the parts of the PSAR that deal with transboundary consequences. But because the PSAR is the property of the operator, it cannot be promised to deliver the whole report. (MINUTES 2014)

Severe Accident Management (SAM)

The results of the EU stress tests have revealed that the severe accident management (SAM) (i.e. the prevention of severe accidents and the mitigation of its consequences) at the Ukrainian NPPs shows a high number of shortcomings. Comprehensive improvements are required by the regulator; however, further improvements are recommended by the ENSREG peer review team. This is one example of the gap between the Ukraine and the EU safety standards and requirements.

Several measures, mainly the use of mobile generators and pumps, are required to enhance the safety of the operating NPPs in Ukraine. During the consultations, it was explained that those measures will be also included in the project KhNPP-3&4. However, it was also stated that the KhNPP-3&4 will be designed in a way that these safety improvements will not be necessary. This statement referred to the construction of a reactor type V392B. It should be clarified which of the required safety improvements the current KhNPP-3&4 design includes.

Several measures to enhance the safety of the existing NPPs are part of the Comprehensive (Integrated) Safety Improvement Program (C(I)SIP). According to SNRIU (2016), all C(I)SIP measures were to be implemented in 2012–2017, but the programme was extended to 2020 by the Resolution of the Cabinet of Ministers of Ukraine because of delays in obtaining EBRD/Euratom loan for partial financing of C(I)SIP, difficulties in tendering for procurement of equipment and increase in the number of measures due to post-Fukushima measures.

Demonstration of practical elimination

According to current international requirements for new nuclear power plants (IAEA 2012 and WENRA 2013), accident sequences with early or large releases have to be practically eliminated[20]. The concept of “practical elimination” of early or large releases is not mentioned for KhNPP-3&4 in the EIA documents. ENERGOATOM (2017a) states the probability of severe accidents that could result in a major release are negligible as:

- re-criticality of the melt;
- "severe" accident with a bypass of the containment;
- "severe" accident at high pressure in the reactor installation;
- "severe" accident with failure of the containment after the emergency process has been reduced to "low pressure scenarios".

[20] Accident sequences with early or large releases could be considered to have been practically eliminated if it is physically impossible for the accident sequence to occur or if the accident sequence can be considered with a high degree of confidence to be extremely unlikely to arise

However, ‘practical elimination’ cannot be demonstrated by showing the compliance with a general probabilistic value. According to IAEA (2016a) the low probability of occurrence of an accident with core melt is not a reason to omit the protection of the containment against the conditions generated by such an accident.

Also in this case there is no convincing evidence that every reasonably practicable safety improvements has been made towards “practical elimination”.

JPEE (2018) provided an overview over the options for addressing the phenomena connected with a severe accident for VVER 1000/V320 reactors. Most of the design features and prevention and mitigation measures have already been implemented at Kozloduy NPP. However, it was pointed out, that the issues related to external steam explosion are underlined for further study.

External hazards

The information provided in the EIA documents shows that the site evaluation is not complying with current international requirements, because the quoted international recommendations are outdated. The site was selected and approved for a 4,000 MW NPP according to legal requirements from 1975. The KhNPP site is located in a tornado hazardous area. Thus, the location can only be used as a site for new reactors if appropriate technical provisions are taken.

External events are of particular concern for the KhNPP site where (after commissioning KhNPP-3&4) four reactors will be operated. A comprehensive site analysis can contribute to minimizing the probability of a severe accident with significant adverse environmental impacts. On the design of new nuclear power plants, the current WENRA document WENRA 2013) concluded**: “**The safety assessment for new reactors should demonstrate that threats from external hazards are either removed or minimized as far as reasonably practicable.”

The EIA documents do not provide sufficient information on external hazards evaluation for the KhNPP-3&4.

According to SNRIU (2017), the seismic hazards have to be re-evaluated; the FS was approved with the condition to elaborate and/or clarify the calculation of the peak ground acceleration (PGA).

The 2011 Feasibility Study (FS) has been approved with the condition that an in-depth assessment of the impact of extreme external events of natural and man-made nature as well as their combinations will be included in the Preliminary Safety Analysis Report (SNRIU 2012b). This condition is not included in conditions for the approval of the current FS (SNRIU 2017).

According to the current WENRA document for existing NPPs (WENRA 2014) nuclear power plant should be designed to withstand impacts such as earthquakes or flooding with an exceedance probability of 10^{-4}/year. Where it is not possible to calculate these probabilities with an acceptable degree of certainty, an event shall be chosen and justified to reach an equivalent level of safety. The EIA documents do not provide information about the WENRA requirement/recommendations to be applied for the KhNPP-3&4.

5.2 Questions, answers and assessments of answers

Question 1

- *Which of the design features and additional prevention and mitigation measures for severe accident management of the Kozloduy NPP (JPEE 2018) have to be applied for KhNPP-3&4 (see table 1)?*

Answer of the Ukrainian side

A1: "Analysis of the upgrades related to the prevention and mitigation of the beyond design basis and severe accidents showed that all the upgrades listed in the table will be implemented at KhNPP Power Units 3 and 4 after as soon as they are justified in PSAR at the licensing stage." (ENERGOATOM AND JSC KIEP 2019a)

The following table give more information to this topic.

Table 4: Project «Power units №3,4 of Khmelnitsky. NPP construction». Safety enhancements which are necessary for implementation. Building Structure Inspection. Presentation No. 1 at the bilateral consultations 13 June 2019, Vienna. (ENERGOATOM 2019a)

Phenomenon	Design features NPP Kozloduy	Additional measures for Kozloduy NPP to prevention and elimination	Additional measures at KhNPP power units No. 3.4
Core melt	Active medium and emergency injection of low pressure system; Passive hydraulic tanks emergency injection of low pressure boron	Additional diesel generators; Qualification of some systems to work as security systems; Water injection into the reactor core or SG using mobile fire-fighting equipment for extreme conditions.	Implemented during the design. As a technical solution is taken into account in the adjusted feasibility study. Will be clarified at the "Design" stage.
High pressure core melt	Primary circuit depressurization system; Safety valves; Sprinkler system.	Qualification of some systems to work as security systems	Implemented during the design. Technical solution accounted in the revised feasibility study. Will be clarified at the "Design" stage: designing an additional pressure line from the primary circuit; IPU KD qualified for water, steam and steam-water mixture will be used
RPV Failure	Hold inside the RPV (by injecting water into the RPV)	External cooling of the RPV with water	Implemented during the design. Technical solution accounted in the adjusted feasibility study. Will be clarified at the "Design" stage

Phenomenon	Design features NPP Kozloduy	Additional measures for Kozloduy NPP to prevention and elimination	Additional measures at KhNPP power units No. 3.4
External steam explosion	Missing. Dry vault.	Additional research is needed in the case of flooding the mine to keep the melt inside the RPV.	It is implemented during the design in the framework of the development of the RPV cooling system. Excess steam is discharged through the holes provided in the supporting structure of the RS (openings are organized during the manufacture of the support ring)
Through melting of the basis	Holding the melt inside the RPV by water injection.	Plugging the channels of the ionization chambers located in the walls of the reactor shaft; Outer shell events.	Implemented during the design. Through ionization chambers channels are excluded at the design and construction stage of KhNPP power units #. 3.4
Excess pressure in the containment shell	Containment sprinkler system (early phase); Increased free space of the containment shell.	Filtered dump (scrubber).	Implemented in the project as a regular system
Hydrogen detonation	Increased free space of the containment shell	Hydrogen recombiners; Long-term maintenance of the integrity of the containment (risk of release in the late phase).	Implemented in the project as a regular system
Containment bypass	Accident management (coolant leakage from the first circuit to the second using appropriate procedures).	Extracorporeal events (distribution of corium, cooling of corium using water); Long melt cooling.	It is implemented during the design in the framework of the development of the RPV cooling system.
Accident in cooling pool of spent fuel.	Water level and temperature control; Emergency water supply system.	Uniform distribution of heat in cooling pool of spent fuel. Water injection into spent fuel pool using mobile fire-fighting equipment for extreme conditions.	Implemented in the project by installing regulators on the pressure pipelines in the cooling pool and additional level gauges in the cooling pool to determine the reduced level, additional thermocouples are taken into account. The injection of water into the spent fuel pool using mobile fire-fighting equipment is provided by the project.

Assessment of the answer

The question has been answered in as much detail as possible considering the information already available at the time of the EIA process.

The answer stated at one point that all measures will be implemented, and that prove will be justified under the SAR. Simply put: At this stage is it unclear which safety standard will be applied to KhNPP 3&4.

However, as shown in the table above the main severe accident phenomena are addressed. It would be of interested to receive information about the solutions implemented in the design stage.

It would be appreciated if information on the additional measures to prevent and mitigate severe accidents at KhNPP 3& 4 could be provided at a later stage.

Question 2

- *Have all of the recommendations by the ENSREG peer review team listed in the Country Report of the EU stress tests to further improve the SAM be considered for KhNPP-3&4?*

Answer of the Ukrainian side

A2: "All ENSREG peer review team recommendations listed in the Country Report of the EU stress tests will be taking into account at the stage of licensing in design of the units 3,4 at KhNPP."

Assessment of the answer

The question was answered in as much detail as possible considering the information already available at the time of the EIA process.

It would be appreciated if information on the implementation of all ENSREG recommendations at KhNPP 3& 4 could be provided at a later stage.

Question 3

- *Which measures of the "Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs (C(I)SIP) have to be implemented for KhNPP-3&4? Which of the measures are not necessary because of design improvements of the VVER-1000/V-320 for KhNPP-3&4?*

A3: "All Safety Improvement Program activities are taken into account; it is expected that the decision on the feasibility of their implementation will be taken at the design stage." (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

The question has been answered.

Question 4

- *Which requirements have the filtered venting systems to fulfil, particularly regarding earthquake resistance?*

Answer of the Ukrainian side

A4: "From the safety perspective, this system should be referred to systems important to safety. As to seismic classification, this equipment should be assigned the first category of seismic resistance (capacity) according to NP 306.2.208.2015, in other words, the equipment that will keep retain the operation capability in case of the maximum design earthquake (or SSE)" (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

The question has been answered.

It is positive that the filtered venting system must be designed to withstand a stronger earthquake than the design earthquake. However, the earthquake assessment does not meet current international requirements.

Question 5

- *What is the time schedule for the implementation of all required SAM features, and has the implementation of all SAM features including the ex-vessel cooling to be finished before commissioning KhNPP-3&4?*

Answer of the Ukrainian side

A5: "The external cooling of the reactor vessel will be designed at the stage of licensing and implemented before the commissioning of the KhNPP-3 and 4 units. This also applies to all beyond-design-basis and severe accident management systems that are included in the feasibility study." (ENERGOATOM AND JSC KIEP 2019a)

It was confirmed during the consultations in Vienna on 13 June 2019 that the implementation of ex-vessel cooling is a precondition for the commissioning of units 3 and 4.

Assessment of the answer

The question has been answered.

It is a positive fact that KhNPP 3&4 will not go into operation before the ex-vessel cooling will be implemented. However, it should be noted that this system is still under development.

Question 6

- *Which initiating events (external and internal) will be considered for the accident analyses?*

Answer of the Ukrainian side

A6: "A complete list of analyzed source events during the anticipated operational occurrences, design accidents, beyond design basis accidents and technogenic accidents will be included in the project applying the combined deterministic and probabilistic approaches in accordance with the national legislation requirements and IAEA recommendations at the stage of Design." (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

The question has been answered in as much detail as possible considering the information already available at the time of the EIA process.

The answer confirms that such an analysis takes place later, i.e. at the design stage. However, this procedure is not fully justified in terms of safety for KhNPP 3&4, since part of the buildings and structures have already been constructed. To be able to assess whether they meet the requirements, it would be necessary to know now which external impacts they would have to withstand.

However, it would be appreciated if information about the list of the initiating events (external and internal) that will be considered for the accident analyses could be provided at a later stage.

Question 7

- *Is the KhNPP site today in compliance with current IAEA requirements?*

Answer of the Ukrainian side

A7: "The KhNPP site was originally designed to accommodate 4 power units. This site fully complies with all international requirements as evidenced by the positive results of the IAEA Project Safety mission as well as the results of stress tests developed according to WENRA requirements." (ENERGOATOM AND JSC KIEP 2019a)

During the consultations on the 13 June 2019 in Vienna, the Ukrainian side recalled that the site had been selected in 1970 and does not need to be re-examined. It was also stated that an IAEA OSART mission confirmed the site is suitable.

Assessment of the answer

The question has been answered. But the answer revealed that a site evaluation according to the current IAEA safety requirements was not performed.

The above mentioned OSART (Operational Safety Review Team) mission took place in October 2007. However, the IAEA's OSART programme assists Member States in strengthening the safety of their nuclear power plants during commissioning and operation. Thus, the OSART mission evaluates the operation of the NPPs but not the site characteristics. An IAEA Site and External Events design Review (SEED) at the Khmelnitsky site has never been conducted.

Question 8

- *Please provide more details regarding the calculation of the seismic hazard. When will the seismic PSA for KhNPP-3&4 be developed? What are the results of the seismic PSA for KhNPP 1&2?*

Answer of the Ukrainian side

A8: "Seismic PSA will be developed for Units 3 and 4 at the stage of design licensing in the scope of preliminary SAR.

Regarding Units 1,2: At present, in accordance with TP0.OB.1678.TP-OZ_20.02.2019_2-13283 "On the procedure for assessing the seismic resistance of equipment, pipelines, buildings and structures of KhNPP power units No. 1 and 2" the following can be highlighted:

The seismicity of the KhNPP power unit No. 1 and No. 2 construction site was initially determined by microseismic zoning, taking into account the subgrading and groundwater levels. The seismicity of the site is estimated to match 5 points for the design-basis earthquake and 6 points for the maximum design earthquake (or SSE).

In 1998-2001, the institute KIIZI "Energoprojekt" and Institute of Geophysics of the National Academy of Sciences of Ukraine carried out the additional instrumental research of the seismic hazards around the KhNPP site. The results of this work were included in the Technical Report on the Results of the Seismic Hazards Survey; it confirmed the seismic hazard assessment for the KhNPP site (5 points for DBE, and 6 points for SSE), which was adopted in the design. The studies performed to obtain the calculated accelerogram showed that the peak acceleration at ground level in the horizontal direction (PGA) does not exceed 0.08g.

According to the IAEA recommendations (SSG-9), the PGA under the SSE, regardless of the initial earthquake resistance of the NPP site, should not be lower than 0.1 g.

Taking into account the results of the additional 1998-2001 investigation of the KhNPP site as well as the IAEA recommendations on the minimum PGA level and seismic stability margin, the PGA level for the SSE is sufficient for the KhNPP site and takes into account the 25% PGA margin = 0.08g. PGA = 0.1g level was accepted by the SNRCU as acceptable for the KhNPP site.

At present, to clarify the seismic characteristics of the KhNPP site as part of the Safety Enhancement Program activity No.18102 "Implementation of seismological monitoring systems for NPP sites" it is planned to build in the area of the KhNPP site a network of seismological observation points. Based on the results of the observations, refined DBE and SSE levels and characteristics for the KhNPP site will be obtained (in accordance with the deadlines for the implementation of the Safety Enhancement Program activity №18102; according to the Safety Enhancement Program schedule, this work should be completed before the end of 2021)." (ENERGOATOM AND JSC KIEP 2019a)

During the consultations on the 13 June 2019 in Vienna, the Ukrainian side explained that so far only deterministic studies have been carried out. Probabilistic seismic analyses are still under preparation.

Assessment of the answer

The question has been partly answered.

The seismic hazard assessment is outdated because it was performed 20 years ago. A new assessment is ongoing but according to the information provided it is mainly based on the new monitoring system. The missing probabilistic analysis is still ongoing. It has not been stated when this analysis will be completed and whether the results will still be used for the completion of KhNPP 3&4. It would be of interest to get information about the seismic hazard assessment after completion.

It would be appreciated if information about the result of the seismic hazard could be provided at a later stage.

Question 9

- *Please provide more information about the protection measures against tornadoes and time schedule for implementation.*

Answer of the Ukrainian side

A9: "All structures take into account the effects of tornadoes. For the so-called sprinkling pools in all power units, the measures to prevent the coolant from being carried away from the surface have been taken, and Bubbler Tank is supposed to be fed from mobile pumping units." (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

The question has been answered.

Question 10

- *What are the parameters of the maximum aircraft crash (plane mass and speed) the buildings of the KhNPP-3&4 can withstand? Regarding external explosions, what are the maximum shockwave overpressures the buildings can withstand?*

Answer of the Ukrainian side

- A10: "The typical design considers the fall of a SESNA type light aircraft as an initial impact. It showed the absence of vulnerability of building structures with respect to this impact.
- In addition, at this stage, it has been proven that the risk from external extreme impacts associated with the fall of aircraft on buildings and structures of the unit is negligible ($2x10^{-8}$ 1/per year) as opposed to the risk from internal initiating events. Therefore, it was decided to ignore the loads from impacts from a dropping passenger aircraft in the reactor compartment calculations.
- *External explosion:* The civil structures of the reactor compartment and the backup diesel power plants have been designed, taking into account the loads produced by the impact of the air-shock wave with the following parameters:

- Overpressure at the shock wave front ΔPф=30 kPa;
- Duration of the compression phase τ+=1s,
- which is an order of magnitude higher than the parameters of a possible air-shock wave at the border of the industrial site." (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

The questions have been answered.

However, it was confirmed again that the KhNPP 3&4 will be designed to withstand a crash of a light aircraft (Cessna) which is not in compliance with the current international standards for new NPPs (see also assessment of questions 1-3 of chapter 6)

Question 11

- *Why is the condition of SNRIU (2012b) to include an in-depth assessment of the impact of extreme external events of natural and man-made nature as well as their combination in the Preliminary Safety Analysis Report not included in the conditions for the approval of the current FS by SNRIU (2017)?*

Answer of the Ukrainian side

- A11: "FS does not contain PSAR. All requirements of the regulator will be implemented and shown at the stage of design and PSAR." (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

This question has not been answered. It is recommended to address this issue with the SNRIU under the pertinent "Bilateral Agreement".

5.3 Conclusions and final recommendations

The considered BDBA during the EIA procedure does not constitute a worst case scenario. To calculate the possible (transboundary) consequences, it was assumed that the core melt will remain within the reactor pressure vessel (RPV). This assumption is not duly justified, because the specific feature is not available yet. Furthermore, if this feature could be realized it would only reduce the risk of radioactive release in most but not in all severe accident scenarios. It is not decided, which design features and additional prevention and mitigation measures for severe accident management have to be applied for KhNPP-3&4.

It is a positive fact that KhNPP 3&4 will not go into operation before the ex-vessel cooling will be implemented. However, it should be noted that this system is still under development.

The results of the EU stress tests have revealed that the severe accident management (SAM) at the Ukrainian NPPs shows many shortcomings. Comprehensive improvements are required by the regulator; however, further improvements are recommended by the ENSREG peer review team. This is one example for the gap between the Ukraine and the EU safety standards and requirements.

According to current international requirements for new nuclear power plants (IAEA 2012; WENRA 2013), accident sequences with early or large releases have to be practically eliminated. The concept of "practical elimination" is not mentioned for KhNPP-3&4 in the EIA documents. ENERGOATOM (2017a) states the probability of severe accidents that could have a major release are negligible. According to IAEA (2016a) the low probability of occurrence of an accident with core melt is not a reason to omit the protection of the containment against the conditions generated by such an accident

To assess the consequences of BDBAs, it is necessary to analyse severe accidents with containment failure and containment bypass. These kinds of severe accidents are possible for the VVER 1000/V-320 reactor type. This type of severe accidents cannot be excluded although their probability is below a specific value.

According to WENRA (2013), the safety assessment for new nuclear power plants should demonstrate that threats from external hazards are either removed or minimized as far as reasonably practicable. The answer confirms that such an analysis takes place later, i.e. at the design stage. However, this procedure is not fully justified in terms of safety for KhNPP 3&4, since part of the buildings and structures have already been constructed. To be able to assess whether they meet the requirements, it would be necessary to know now which external impacts they would have to withstand.

The information provided in the EIA documents shows that the site evaluation is not complying with current **international requirements**, because the quoted international recommendations are outdated. During the consultations it became evident that a site evaluation according to the current IAEA safety requirement has not been performed.

According to SNRIU (2017), the seismic hazards have to be re-evaluated, the FS was approved with the condition to elaborate and/or clarify the calculation of the peak ground acceleration (PGA). The lacking probabilistic seismic analysis is under preparation. No information was provided on when this analysis will be completed and whether the results will be used for the completion of KhNPP 3&4.

It is to be appreciated that the filtered venting system must be designed to withstand a stronger earthquake than the design earthquake. However, the earthquake assessment does not meet current international requirements.

It was confirmed again that the KhNPP 3&4 will be designed to withstand a crash of a light aircraft (Cessna). However, this is not in compliance with the current international standards for new NPPs.

Final Recommendations

1. It is recommended that for KhNPP-3&4, practical elimination of accident sequences has to be demonstrated with state-of-the-art probabilistic and deterministic methods, fully taking into account the relevant WENRA publications.
2. It is recommended to demonstrate for KhNPP-3&4 that threats from external hazards are either eliminated or minimized as far as reasonably practicable using the method according to the WENRA Safety Objectives for new Nuclear Power Plants (Position 6).
3. Usage of current IAEA and WENRA safety guides and requirements for the evaluation of the external hazards is recommended.
4. It is recommended to address the issue why the inclusion of an in-depth assessment of the impact of extreme external events of natural and man-made nature as well as their combination in the PSAR is not a condition for the approval of the current FS by SNRIU (2017) under the pertinent “Bilateral Agreement”.
5. Providing information at a later stage would be appreciated regarding
   a. additional measures to prevent and mitigate severe accidents that will implemented at KhNPP 3& 4.
   b. measures according to ENSREG Stress Test recommendation at KhNPP 3& 4
   c. the list of the initiating events (external and internal) that will be considered for the accident analyses
   d. the result of the seismic hazard assessment.
6. The parts of **Preliminary Safety Analysis Report**[21] that will be provided to the Austrian side should include the following information concerning accident analyses and the results of the PSA (Level 1, 2 und 3):
   a. Core damage frequency (CDF) and severe accidents with (early) large releases (L(E)RF)
   b. Contribution of internal events as well as internal and external hazards to CDF and L(E)RF
   c. List of the design basis accidents (DBA) and beyond design basis accidents (BDBA)
   d. Source terms of the most important release categories including releases from the spent fuel pools
   e. Time spans needed to restore the safety functions after the loss of heat removal and/or station-blackout and cliff edge effects
   f. Justification of the BDBA(s) that is/are chosen to calculate possible transboundary consequences
7. The parts of **Preliminary Safety Analysis Report** that will be provided should include the following information concerning site evaluation and external hazards:
   a. Presentation of the results of current studies on natural hazards (in particular earthquakes, floods and extreme weather conditions)

[21] During the bilateral consultations, it was agreed to provide relevant parts of the Preliminary Safety Analysis Report as soon as it becomes available.

b. Description of the method used to determine the relevant external hazards
c. List of external events to be considered (including their justification) and their characteristics
d. Information on the combination of external events taken into consideration
e. Data on the required safety margins for the NPP design basis (in particular for earthquakes)
f. Consideration of multi-unit accidents and accidents in the spent fuel pools.

6 INCIDENTS AND ACCIDENTS WITH INVOLVEMENT OF THIRD PARTIES

6.1 Summary of the expert statement

The effects of third parties (terrorist attacks or acts of sabotage) can have a considerable impact on nuclear facilities and thus also on the KhNPP-3&4 in Ukraine. Nevertheless, they are not mentioned in the EIA documents for KhNPP-3&4. In comparable EIA documents (e.g. for the new NPP in the Slovak Republic (Bohunice 3) such events were addressed to some extent. (JESS 2015)

Although precautions against interference by third parties cannot be discussed in detail in the EIA process for reasons of confidentiality, the necessary legal requirements should be set out in the EIA documents. In particular, the EIA documents should include detailed information on the requirements for the design against the targeted crash of a commercial aircraft. This topic is in particular important, as the wall thickness of the reactor building/containment of KhNPP-3&4 is only about 1,000-1,200 mm. Therefore, the units could be vulnerable against terror attacks (including airplane crash).

Because of the thin walls the impact of an airplane crash could cause a major damage of the reactor building. In this case, it has to be assumed that the reactor's cooling circuit will be damaged and that safety and control systems because of debris and fire will also suffer major damage. If the pipelines of the cooling system or the reactor pressure vessel itself are damaged, it would be irrelevant if the emergency cooling system still functioned, since it would no longer be able to be effectively fed in. Such a case would thus in a short time – within a few hours – lead to the meltdown of the reactor core. Radioactive substances will be released from the melted fuel and, since the containment will have been destroyed, they can get into the atmosphere with practically no delay or retention inside the building.[22] (UMWELTBUNDESAMT 2019)

In 2013, the resistance of KhNPP-3&4 against the accidental or deliberate crash of a large (commercial) airplane was not required by the Ukrainian regulator. The bilateral consultations in Kiev on the 28 August 2013 clarified that neither national legislation nor international recommendations include requirements concerning the stability of the containment building against acts of terror (including airplane crash). The requirement is only at a draft stage in the WENRA document. If this draft document passes and will become Ukrainian legislation, or the IAEA adopts such a requirement before the final decision on the KhNPP-3&4, acts of terror including deliberate airplane crashes will be taken into account. (MINUTES 2014)

A recent assessment of the nuclear security in the Ukraine points out shortcomings: The 2018 NTI Index assesses nuclear security conditions related to the protection of nuclear facilities against acts of sabotage. With a total score of 70 out 100 points, Ukraine ranked only 30 out of 45 countries, which indicates a

[22] In all studies on risks such a scenario – a core meltdown with open containment – is regarded as the worst conceivable scenario. It leads to particularly large and – even worse – to particularly early releases of radioactivity. The time available for taking protective measures against the disaster is very short.

low protection level. It has to be pointed out that especially the low scores for "Insider Threat Prevention" and "Cybersecurity" indicate deficiencies in these issues. (NTI 2018)

It is unclear whether the physical protection for KhNPP-3&4relies on requirements which are fully up to date, because it was set up in line with a law from the year 2000. (UMWELTBUNDESAMT 2013)

The IAEA grants supports to member States by undertaking and organizing advisory security assessments and peer-review missions through its International Physical Protection Advisory Service (IPPAS). An IPPAS mission assesses a state's existing practices in the light of relevant international instruments and IAEA nuclear security publications. (IAEA 2014a) Until now, no International Physical Protection Advisory Service (IPPAS) were performed or envisaged for Ukraine. (IAEA 2019)

6.2 Questions, answers and assessments of the answers

Questions 1-3

- *What are the requirements with respect to the planned NPP design against the deliberate crash of a commercial aircraft?*
- *Is the protection of KhNPP-3&4 against the crash of a commercial aircraft required by the Ukrainian regulation? Or will such a requirement provided for?*
- *Have the recommendations of WENRA 2013 (Position 7: Intentional crash of a commercial airplane) been or will they be fully incorporated into the Ukrainian regulations?*

Answers of the Ukrainian side

A1. "There are no such requirements in the national legislation. From the point of view of accounting this initial event in the PSA, all initial events are considered with a probability of more than 10E-7. The probability of an initial event with the fall of the aircraft is 2E-8." (ENERGOATOM AND JSC KIEP 2019a)

A2: "There is no such requirement in the national regulations." (ENERGOATOM AND JSC KIEP 2019a)

A3: "These requirements can be implemented and taken into account only if the new power units are constructed." (ENERGOATOM AND JSC KIEP 2019a)

During the consultations on 13 June 2019 in Vienna, it was clarified that this project is the completion of nuclear power plants and not a new build project, and thus the WENRA Safety Objectives for new NPPs do not have to be applied.

Moreover, no further information on the protection against a deliberate airplane crash will be provided, because this information is fully classified.

Assessment of the answer

The questions have been answered.

The reply confirmed that the Ukraine regulator still does not require to protect KhNPP 3&4 from an intentional crash of a commercial aircraft. This does not meet the WENRA requirements for new nuclear power plants, but from Ukraine's point of view KhNPP 3&4 is not a new nuclear power plant but an existing one and therefore such protection is not required.

It should be borne in mind that in general an existing sufficient structural protection against external impacts such as a deliberate aircraft crash can be presented to the public. (It has to be noted that KhNPP-3&4 is not protected against an accidental crash of a commercial aircraft because the probability of such a crash is estimated to be very low.)

Existing nuclear power plants continue to operate for several years without protection against the crash of commercial and military aircraft; this poses a dangerous situation

Question 4

- *Have the requirements with respect to the protection against cyberattacks and insiders improved since the survey of the Nuclear Security Index 2018 or is such an increase/update of the requirements planned?*

Answer of the Ukrainian side

A4: "At present, a specialized document on protection against cyber-attacks is being developed and is expected to be officially issued before 2020." (ENERGOATOM AND JSC KIEP 2019a)

During the consultations in Vienna on 13 June 2019, the Ukrainian side explained that an improved protection against insider attacks is not necessary as the concept of physical separation is implemented.

Assessment of the answer

The question has been answered. It is certainly positive that the regulations regarding cyber security will be improved. But also the regulations concerning attacks by so-called insiders (internal perpetrators) need improvement (e.g. by reliability checks). A protection only by spatial separation of the safety systems is not sufficient.

Question 5

- *Against which external attacks must the reactor building, and other safety relevant buildings be designed, especially the already completed building (back-up diesel generator of unit 3)? Is this protection still guaranteed despite adverse ageing effects? On the basis of which studies and conducted in which years can such a statement be made, or will it be made in the future?*

Answer of the Ukrainian side

A5: “The list of design impacts for the unit is given in the reactor section.” (ENERGOATOM AND JSC KIEP 2019a)

Assessment of the answer

The questions have been answered and clarified that terrorist attacks are not specifically addressed.

Question 6

- *Is a peer-review mission of the IAEA International Physical Protection Advisory Service (IPPAS) planned before commissioning of KhNPP-3&4?*

Answer of the Ukrainian side

A6: “Certainly, NAEC Energoatom will be grateful if such mission is carried out before commissioning of the KNPP power units 3 and 4”. (ENERGOATOM AND JSC KIEP 2019a)

During the consultations in Vienna on 13 June 2019, it was added that the nuclear authority would have to invite for such a mission.

Assessment of the answer

The question has been answered. The International Physical Protection Advisory Service (IPPAS) assists States, upon request, in strengthening their national nuclear security regimes, systems and measures. It is recommended to invite this IAEA service.

6.3 Conclusions and final recommendations

The answers during the consultations on the 13 June 2019 in Vienna confirmed that the Ukraine regulator still does not require the protection of KhNPP 3&4 against an intentional crash of a commercial aircraft. This does not meet the WENRA requirements for new nuclear power plants, but from Ukraine's point of view KhNPP 3&4 is not a new nuclear power plant but an existing one and therefore such protection is not required.

Furthermore, it has to note that KhNPP 3&4 is not protected against an accidental crash of a commercial aircraft as the probability of such a crash is estimated to be very low.

It is a positive fact that regulations regarding cyber security will be improved. But the regulations concerning attacks by so-called insiders (internal perpetrators) should be also improved. The International Physical Protection Advisory Service (IPPAS) assists States, upon request, in strengthening their national nuclear security regimes, systems and measures. It is recommended to invite this IAEA service.

Final recommendations

1. It is recommended to apply the requirements of WENRA 2013 (Position 7: Intentional crash of a commercial airplane) for KhNPP-3&4.
2. In light of the special situation in Ukraine, third parties' impacts (terrorist attacks or acts of sabotage of the plant) should be given high priority. Protection against cyber-attacks and insiders should be improved. The IAEA's International Physical Protection Advisory Service (IPPAS) should be used to improve the security.

7 TRANSBOUNDARY IMPACTS

7.1 Summary of the expert statement

Chapter 5.9.3 of ENERGOATOM (2017a, p. 35) summarized the "assessment of the consequences of accidents on the territory of neighbouring countries".

For the simulation of transboundary consequences, three typical **meteorological situations** were chosen with a possible intensive transboundary transfer in the direction of Poland and Belarus. For that purpose, real atmospheric data of three different time periods were used. The data of these scenarios were also modified: it was assumed, while precipitation was absent on the whole territory of Ukraine, precipitation (0.5 mm/h) started after the radioactive cloud is passing the border of Poland or Belarus. (OVOS 2016 p.8f, see also IAS 2011, annex C).

The basic criteria of the radiation limitation of the population in Europe through anthropogenic sources is the limit of the annual individual effective dose at the level of 1 mSv per year. (OVOS 2016, p. 10)

For the evaluation of the **annual individual effective dose**, relevant exposure ways are considered (inhalation, ingestion, radiation from radioactive cloud, radiation from radionuclides deposited on the ground). The assessment of the dose was made for two age groups – adults and 1-2-year-old children. Calculations were made using the set of application programme RadEnvir3.1, which was developed jointly by IAEA and Scientific and Research Institute of the Radiation Protection of the Academy of Technical Science of Ukraine (OVOS 2016, p. 9; see also IAS 2011, annex C).

According to ENERGOATOM (2017a, p. 35) findings of the assessment of the **transboundary impact** indicate that during none of the both accidents the level of the individual annual effective dose for the individuals of the critical group in the neighbouring countries will be exceeded.

The updated EIA document OVOS (2016) used the same approach and results of the transboundary impact assessment as the EIA document OVOS (2011), Energoatom obviously did not conduct a new calculation

The described **approach** to calculate the transboundary impacts is comprehensible**.** The reasons for selecting the meteorological situations used are not explained in detail; thus it is not possible to assess whether worst case meteorological conditions were applied.

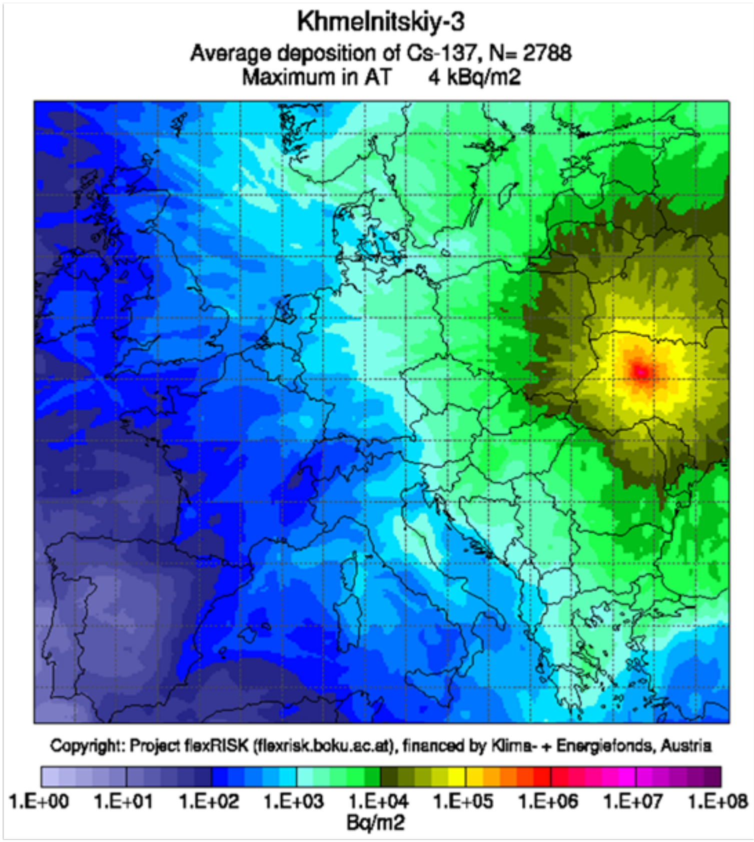
However, in particular the conclusion regarding possible transboundary impacts is not comprehensible because the considered BDBA does not constitute a worst-case accident scenario for KhNPP-3&4 (see chapters "accident analysis"). Because this analysis is lacking, the conclusions on the transboundary impacts is not sufficient.

As the EIA documents do not provide possible consequences of a severe accident with containment failure or containment-bypass, the results of a study performed by the Austrian Institute of Ecology in the framework of the review of the Environmental Impact Assessment (EIA) of the completion of Khmelnitsky 2/Rovno 4 are presented in the Expert Statement. For severe accidents the caesium-137 releases are estimated between 4% and 50% of the total core inventory. To investigate the possible impact following a severe accident at Khmelnitsky-2 (KhNPP-2), a release of 20% of the total core inventory of caesium-137 was assumed (55,000 TBq). The results of the presented calculation indicate that there is the possibility that an accident at the KhNPP would contaminate not only regions in Ukraine, but also several regions in Europe, as in May 1986 after the Chernobyl accident. For the Eastern part of Austria, the calculation resulted in values up to approx. 1,000 kBq/m² contamination with cesium-137 (which is about 5 times the highest values measured in Austria in 1986). (WENISCH et al. 1998)

Additionally, calculations of the flexRISK project were used to estimate the possible impacts of transboundary emission of KhNPP-3&4 (FLEXRISK 2013). The flexRISK project modelled the geographical distribution of severe accident risk arising from nuclear facilities, in particular nuclear power plants in Europe. Using source terms and accident frequencies as input, for about 1,000 meteorological situations the large-scale dispersion of radionuclides in the atmosphere was simulated.

Figure xy illustrates the average deposition of Cs-137 after a severe accident at KhNPP-3 with the Cs-137 release of 74,000 TBq. An accident could result in a considerable contamination of the Austrian territory; the average deposition of Cs-137 in the simulation is between 500- 4,000 Bq/m². Most parts of Austria could show depositions of 800 Bq/m² or more. As within the simulation the average ground depositions of most areas are higher than the threshold for agricultural countermeasures (650 Bq/m²), Austria would be most likely significantly affected from a severe accident at KhNPP-3&4.

Figure 1: Average deposition of Cs--137 after a hypothetical BDBA in KhNPP-3.



Source: http://flexrisk.boku.ac.at/en/evaluationAggUnit.phtml#form umweltbundesamt

The **probability of a severe accident** with a large release (core damage frequency (CDF) and large release frequency (LRF)) may be different at KhNPP-3&4 compared to KhNPP-2. But, reactor core inventory and other reactor characteristics of the reactor types of KhNPP-2 and KhNPP-3&4 that determinate the release of such an accident (source term) are comparable. Thus, the presented results of an accident at KhNPP-2 illustrate the consequences of a potential severe accident at KhNPP-3 or KhNPP-4.

The distance of the KhNPP site to the Austrian border is about 730 km. There are no results presented in the EIA documents for this distance to the KhNPP-3&4.

7.2 Questions, answers and assessments of the answers

Question 1

- *Please provide the quantitative results of the calculated ground deposition of I-131 and Cs-137 for the distance to Austria.*

Answer of the Ukrainian side

No answer has been given. During the consultations on the 13 June in Vienna, it was clarified that these values have not been calculated. The ground contaminations have been calculated only up to a distance of 400 km.

Assessment of the answer

The quantitative results of the calculated ground deposition of I-131 and Cs-137 neither for the distance to Austria nor for any other distance were given.

This information is important for Austria. In case ground contamination would surpass a certain threshold, a set of agricultural intervention measures would be triggered in Austria. The measures include earlier harvesting, closing of greenhouses and covering of plants, putting livestock in stables etc. Austrian authorities defined a threshold for cesium-137 ground deposition of 650 Bq/m² and for iodine-131 ground deposition of 700 Bq/m² (BMLFUW 2014).

Question 2

- *Please explain the reasons for the selection of the meteorological situations in more detail. Have analyses been performed using different meteorological assumptions? Please explain the choice of the emission height. Have simulations with other emissions heights been performed?*

Answer of the Ukrainian side

Comprehensive information has been given about the "Modelling results on the transboundary transfer of the accidental releases at KhNPP 3&4 in (ROMANENKO and KOVALETS 2019). Here is a summary of the information provided:

The influence assessment of the effective release height and release duration and the age group specification for the maximum dose was carried out to determine the conservative calculation conditions

The calculations of the maximum annual effective doses received from cloud, by inhalation, ground deposition, secondary wind blowing and food consumption within the radiuses of 150 to 400 km were carried out. In case of daytime release, the influence of the effective release height at a distance of the transboundary transfer is almost inconsiderable. The effective release height of 300 m, which is a realistic for a rising heat cloud n the event of beyond design basis accidents was used for the calculation.

The calculation based on the meteorological conditions which occurred on 1 June 20018, at the release height of 300 m, release duration of 1 hour, for the population group of 1-year-old children, was carried out to assess the ways of effective radiation dose formation. 99% of the effective dose is formed during the first year after the accident due to food consumption, which consists of the iodine isotopes.

About 4000 calculations were carried out to assess the transboundary influence of the releases from KhNPP.

The minimum distance from the Khmelnitsky NPP to the Austrian border is 730 kilometers. Taking into account the calculations performed in the previous sections, it can be argued that the accidents at KhNPP 3&4 will not exceed the annual dose rate at the border with Austria in excess of 1 mSv with a large margin.

Assessment of the answer

The question has been answered.

The approach to determine the release height and the other parameters for the calculations of the doses are sufficiently explained.

However, an essential factor for the dispersion calculation, the source term, is not sufficiently justified. In this respect, the conclusion that a severe accident in KhNPP 3&4 cannot have an impact on Austria is not justified.

Furthermore, it should be noted that Austria is considered affected when the need for agricultural intervention measures arises. But these values were not provided. (see question 1)

7.3 Conclusions and final recommendation

Comprehensive information is given about the calculation of the transboundary transfer of releases from accidents at KhNPP 3&4.

However, severe accidents with releases considerably higher than assumed in the EIA documents cannot be excluded for the KhNPP-3&4, even if their probability is required to be below a specific value. Such worst-case accidents should be included in the assessment since their effects can be widespread and long-lasting and even countries not directly bordering Ukraine, like Austria, can be affected.

Because of the lack of analysis of the worst-case scenarios, the conclusion of the EIA documents concerning transboundary effects is not appropriate.

The results of the flexRISK project indicated that after a severe accident, the average caesium-137 ground depositions in most areas of the Austrian state territory would be higher than the threshold for agricultural intervention measures (e.g. earlier harvesting, closing of greenhouses). Therefore, Austria would be significantly affected by a severe accident at the KhNPP-3&4.

Final recommendations

1. It is recommended to perform a conservative worst-case release scenario which is based on specific severe accident analyses of the KhNPP-3&4.
2. It is assumed that the dispersion calculations to evaluate possible transboundary consequences of a severe accident will be updated in the framework of the preparation of the Preliminary Safety Analysis Report (PSAR). It would be appreciated if the following PSAR information would be provided to the Austrian side[23]:
    a. Description of the methodology of dispersion calculation and of the calculation of the radiation doses,
    b. Input data used for the dispersion calculation (source terms, emission height and duration, meteorological data) and their justification,
    c. Results of the dispersion calculation in particular of the ground deposition of Cs-137 and I-131 for large distances including the Austrian territory.

[23] During the bilateral consultations, it was agreed to provide relevant parts of the Preliminary Safety Analysis Report as soon as it becomes available.

8 RECOMMENDATIONS

8.1 Overall and procedural aspects of the Environmental Impact Assessment (EIA)

Final recommendation

1. It is recommended that financing issues do not have detrimental impact on nuclear safety and security.

8.2 Spent fuel and radioactive waste

Final recommendation

1. According to the concept of the State Economic Program for the Management of Spent Fuel of Nuclear Power Plants for the period up to 2024, the state program is being set up in line with the requirements of Council Directive 2011/70/EURATOM. It is recommended that the Austrian government follows up on this issue under the pertinent "Bilateral Agreement".

8.3 Reactor type

Final recommendations

1. It is recommended to finish the survey of the conditions of the buildings, structures and equipment before taking any decision regarding the specific project completion. The survey should take into account the protection against external hazards (natural and man-made) according to current international requirements. The prediction should include the expected service life time. It is recommended that the results of the survey be subject to an international review.
2. It is recommended that for the period between the investigation of components and the start of regular AMP, ageing phenomena should be addressed adequately.
3. It is recommended to implement all available technical design improvements of VVER-1000/V320 reactor at KhNPP-3&4.
4. It is recommended to apply the WENRA Safety Objectives for new NPP to assess the nuclear safety of KhNPP-3&4. According to WENRA, this document should be used as a reference for identifying reasonably practicable safety improvements for "deferred plants" such as KhNPP-3&4.
5. It would be welcomed if convincing evidence that every reasonably practicable safety improvement has been made would be made available.
6. At the design stage of the project it should be evaluated by an external review that the NPP will meet current international and European safety standards.

7. It is appreciated that the result of the survey/assessment of the existing structures, buildings and equipment will be provided.[24]
8. The following information concerning the project should be part of the Preliminary Safety Analysis Report that will be provided to the Austrian side[25]:
   a) Information about the applied national requirements and international recommendations
   b) Updated justification on the condition of the existing structures, buildings and equipment
   c) A systematic evaluation of the KhNPP-3&4 design deviations from the current international safety standards and requirement.

8.4 Incidents and accidents without involvement of third parties

Final recommendations

1. It is recommended that for KhNPP-3&4, practical elimination of accident sequences has to be demonstrated with state-of-the-art probabilistic and deterministic methods, fully taking into account the relevant WENRA publications.

2. It is recommended to demonstrate for KhNPP-3&4 that threats from external hazards are either eliminated or minimized as far as reasonably practicable using the method according to the WENRA Safety Objectives for new Nuclear Power Plants (Position 6).

3. Usage of current IAEA and WENRA safety guides and requirements for the evaluation of the external hazards is recommended.

4. It is recommended to address the issue why the inclusion of an in-depth assessment of the impact of extreme external events of natural and man-made nature as well as their combination in the PSAR is not a condition for the approval of the current FS by SNRIU (2017) under the pertinent “Bilateral Agreement”.

5. Providing information at a later stage would be appreciated regarding
   a. additional measures to prevent and mitigate severe accidents that will implemented at KhNPP 3& 4.
   b. measures according to ENSREG Stress Test recommendation at KhNPP 3& 4
   c. the list of the initiating events (external and internal) that will be considered for the accident analyses
   d. the result of the seismic hazard assessment.

[24] During the bilateral consultations, it was agreed to provide the results of the survey.

[25] During the bilateral consultations, it was agreed to provide relevant parts of the Preliminary Safety Analysis Report as soon as it becomes available.

6. The parts of **Preliminary Safety Analysis Report**[26] that will be provided to the Austrian side should include the following information concerning accident analyses and the results of the PSA (Level 1, 2 und 3):
   a. Core damage frequency (CDF) and severe accidents with (early) large releases (L(E)RF)
   b. Contribution of internal events as well as internal and external hazards to CDF and L(E)RF
   c. List of the design basis accidents (DBA) and beyond design basis accidents (BDBA)
   d. Source terms of the most important release categories including releases from the spent fuel pools
   e. Time spans needed to restore the safety functions after the loss of heat removal and/or station-blackout and cliff edge effects
   f. Justification of the BDBA(s) that is/are chosen to calculate possible transboundary consequences
7. The parts of **Preliminary Safety Analysis Report** that will be provided should include the following information concerning site evaluation and external hazards:
   a. Presentation of the results of current studies on natural hazards (in particular earthquakes, floods and extreme weather conditions)
   b. Description of the method used to determine the relevant external hazards
   c. List of external events to be considered (including their justification) and their characteristics
   d. Information on the combination of external events taken into consideration
   e. Data on the required safety margins for the NPP design basis (in particular for earthquakes)
   f. Consideration of multi-unit accidents and accidents in the spent fuel pools.

8.5 Incidents and accidents with involvement of third parties

Final recommendations

1. It is recommended to apply the requirements of WENRA 2013 (Position 7: Intentional crash of a commercial airplane) for KhNPP-3&4.
2. In light of the special situation in Ukraine, third parties' impacts (terrorist attacks or acts of sabotage of the plant) should be given high priority. Protection against cyber-attacks and insiders should be improved. The IAEA's International Physical Protection Advisory Service (IPPAS) should be used to improve the security.

[26] During the bilateral consultations, it was agreed to provide relevant parts of the Preliminary Safety Analysis Report as soon as it becomes available.

8.6 Transboundary impacts

Final recommendations

1. It is recommended to perform a conservative worst-case release scenario which is based on specific severe accident analyses of the KhNPP-3&4.

2. It is assumed that the dispersion calculations to evaluate possible transboundary consequences of a severe accident will be updated in the framework of the preparation of the Preliminary Safety Analysis Report (PSAR). It would be appreciated if the following PSAR information would be provided to the Austrian side[27]:

   a. Description of the methodology of dispersion calculation and of the calculation of the radiation doses,
   b. Input data used for the dispersion calculation (source terms, emission height and duration, meteorological data) and their justification,
   c. Results of the dispersion calculation in particular of the ground deposition of Cs-137 and I-131 for large distances including the Austrian territory.

[27] During the bilateral consultations, it was agreed to provide relevant parts of the Preliminary Safety Analysis Report as soon as it becomes available.

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10 GLOSSARY

AMP .... Ageing Management Programme

BDBA .... Beyond Design Basis Accident

Bq .... Becquerel

C(I)SIP .... Comprehensive (Integrated) Safety Improvement Program

CDF .... Core Damage Frequency

CHF .... Critical Heat Flux

CMU .... Cabinet of Ministers of Ukraine

Cs-137 .... Caesium-137

DBA .... Design Basic Accident

DEC .... Design Extension Conditions

DID .... Defence in Depth

EBRD .... European Bank for Reconstruction and Development

ECCS .... Emergency Core Cooling System

ECMWF .... European Centre for Medium Range Weather Forecasting

ECR .... Emergency Control Room

EHRS .... Emergency Hydrogen Removal System

EIA .... Environmental Impact Assessment

ENSREG .... European Nuclear Safety Regulators Group

ENTSOE-E .... European Network of Transmission System Operators for Electricity

EOP .... Emergency Operating Procedures

ESWS .... Essential Service Water Systems

EU .... European Union

EUR .... European Utility Requirements

FCVS .... Filtered Containment Venting System

FS .... Feasibility Study

g .... GravitationalAcceleration

GRS .... Gesellschaft für Anlagen- und Reaktorsicherheit, Germany

I-131 .... Iodine-131

IAEA .... International Atomic Energy Agency

IAS .... Information and Analytical Survey

IC .... Ionization Chamber

IPPAS .... International Physical Protection Advisory Service

ISLOCA .... Interfacing System Loss of Coolant Accident

IVMR .... In-Vessel Melt Retention

KhNPP .... Khmelnitsky nuclear power plant

LBLOCA .... Large Break Loss of Coolant Accident

LEDI .... Name of a Lagrangian-Eulerian diffusion model

LOCA .... Loss of Coolant Accident

LRF .... Large Release Frequency

MCCI .... Molten core concrete interaction

MCR .... Main Control Room

MDBA .... Maximum Design Basis Accident

MDGS .... Mobile Diesel Generator System

NIS PAR .... (NIS) Passiv Autocatalytic Recombiner

NPP .... Nuclear Power Plant

NRPA .... Norwegian Radiation Protection Authority

NRS .... Nuclear and radiation safety

NTI .... Nuclear Threat Initiative

OBE .... Operating Base Earthquake

PGA .... Peak Ground Acceleration

PSA .... Probabilistic Safety Assessment

PSAR .... Preliminary Safety Analysis Report

PWR .... Pressurized Water Reactor

RCS .... Reactor Coolant System

RHWG .... Reactor Harmonization Working Group

RL .... Reference Level

RPV .... Reactor Pressure Vessel

SAM .... Severe Accident Management

SAMG .... Severe Accident Management Guideline

SBO .... Station Black Out

SC .... Sealed Containment

SDPP .... Standby Diesel Power Plant

SEA .... Strategic Environmental Assessment

SFP .... Spent Fuel Pool

SG .... Steam Generator

SNRIU .... State Nuclear Regulatory Inspectorate of Ukraine

SSC .... Structure, Systems and Components

SSE .... Safe Shutdown Event

TBq .... Tera-Becquerel, E12 Bq

TPR .... Topical Peer Review

UNECE .... United Nations Economic Commission for Europe

VVER .... Water-Water-Power-Reactor, Pressurized Reactor originally developed by the Soviet Union

WENRA .... Western European Nuclear Regulators´ Association