umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

Rivne 1&2 Lifetime Extension
Environmental Impact Assessment

Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

pulswerk
Das Beratungsunternehmen des
Österreichischen Ökologie-Instituts

Final expert statement and report on the bilateral consultations

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RIVNE 1&2 LIFETIME EXTENSION ENVIRONMENTAL IMPACT ASSESSMENT

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Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

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Das Beratungsunternehmen des Österreichischen Ökologie-Instituts

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SUMMARY

Ukraine is conducting an Environmental Impact Assessment (EIA) for the lifetime extension of the reactors Rivne 1&2 under the Espoo Convention. The nuclear power plant Rivne is located near the town of Varash in the Rivne Oblast. At the Rivne site, four reactors are in operation. The VVER-440 reactors Rivne 1&2 are the oldest of these reactors and were connected to the grid in 1980 and 1981, respectively.

Austria has been notified by Ukraine and decided to participate in the EIA. The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Environment Agency Austria to assess the submitted EIA Documents in an expert statement. (UMWELTBUNDESAMT 2021) In this expert statement, open questions and preliminary recommendations were formulated.

In April 2021, the Ukrainian side provided written answers on these questions (ANSWERS 2021). In this final expert statement at hand these answers are assessed and final recommendations given. The objective of the Austrian participation in the EIA procedure is to minimise or even eliminate possible significant adverse impacts on Austria which might result from this project.

Overall and procedural aspects of the Environmental Impact Assessment

Not conducting an EIA for the lifetime extension of Rivne 1&2 is violating the Espoo Convention. The case "EIA/IC/CI/4 Ukraine" has been open since 2011. In its Decision VIII/4e of December 2020 the Meeting of the Parties to the Espoo Convention (MOP) called on the Government of Ukraine to complete the transboundary EIA and revise the final decision on the lifetime extension of Rivne reactors 1&2 taking into due account the outcomes of the environmental impact assessment procedure. The answers provided by the Ukrainian side did not clarify if and how such a revision of the decision on the LTE will be undertaken.

In 1998, a bilateral agreement on information exchange and cooperation in nuclear safety and radiation protection between Austria and Ukraine was set up. Although until today no meetings under this agreement were conducted, it is recommended to discuss the Rivne 1&2 lifetime extension project bilaterally in regular intervals.

Spent fuel and radioactive waste

The EIA Document lacked important information on the management of the spent fuel and radioactive waste from Rivne 1&2. In the answers provided during consultations some of this missing information was given. While storage capacities for the spent fuel and radioactive waste from the lifetime extension are available or will be available in the near future, it is not clear where the HLW

which has to be taken back from Russia after reprocessing will be stored. No information on the final repository of spent fuel and high level waste was given.

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore it will be welcomed if the Ukrainian side provides more information on its national nuclear waste management plan.

Long-term operation of reactor type VVER440

Although ageing of the 40 years old structures, buildings and equipment is a safety issue for Rivne1&2, it was not addressed in the EIA Document. It only referred to "structures, systems and components aging" being a safety factor (SF) within the periodic safety review (PSR). The adverse effect of ageing depends also on the inspection, restoration and protection measures taken. A comprehensive ageing management program (AMP) is necessary to limit ageing-related failures at least to a certain degree. However, information of an ageing management programme (AMP) was also not provided in the EIA Document.

The ANSWERS (2021) provide only general information about the AMP. It is also stated that the existing AMP is sufficient. However, specific results are not provided. Furthermore, the explanations are not consistent with the results of the Topical Peer Review (TPR) “Ageing Management” in the framework of the implementation of the Nuclear Safety Directive 2014/87/EURATOM, carried out in 2017/18. The TPR showed several deviations from the expected level of performance for ageing management that should be reached to ensure consistent and acceptable management of ageing throughout Europe. The results of the TPR and the activities to remedy the weaknesses should be presented in the EIA Document, in particular the very important safety issue of the RPV embrittlement should be discussed. The ANSWERS (2021) provide general information about this issue, but the critical brittle temperature and the safety margins are not provided. Furthermore, it was explained that according to the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) Board decision of 5 September 2019 the first Ukrainian National Action Plan on Ageing Management was approved based on the results of the TPR. SS RNPP has planned the measures necessary to meet the SNRIU requirements.

Although conceptual ageing is also an issue for the Rivne 1&2, the EIA Document did not deal with any of the known safety issues of the VVER-440/V213 reactors. VVER 440/V213 units have several design weaknesses: the reactor building and the spent fuel pool building are relatively vulnerable against external events. The VVER-440 reactors are designed as twin units, sharing many operating systems and safety systems. The sharing of safety systems increases the risk of common-cause failures affecting the safety of both reactors at the same time. One system designed to fulfil functions on more than one safety level cannot be considered state of the art.

This NPP design developed in the 1980s, only partly meets modern design principles such as redundancy, diversity and physical separation of redundant sub-

systems or the preference for passive safety systems. The EIA Document neither provided a description of the safety-relevant systems, nor information about the capacities, redundancies and physical separation.

In December 2010, although safety relevant issues are not completely solved, SNRIU granted 20-year lifetime extensions for Rivne 1&2. The stress tests revealed 2011 that Ukrainian NPPs are compliant only with 172 of the 194 requirements according to the IAEA Design Safety Standards published in 2000[1]. Implementation of necessary improvements is on-going under the Upgrade Package. The completion of the program was postponed several times. Completion is now scheduled for 2023. The ANSWERS (2021) confirmed that the backfitting programmes are still ongoing. Further programmes to meet the current safety standard are not envisaged.

Ukraine is a member of the Western European Nuclear Regulators Association (WENRA). 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. A major update of the RLs was the revision of Issue F "Design Extension of Existing Reactors" introducing the concept of Design Extension Conditions (DEC). The ANSWERS (2021) revealed that the updated WENRA RL published already in 2014 are not included in the Ukrainian legislation, and thus Rivne 1&2 does not have to meet the WENRA RL.

Accident Analyses

Maintaining containment integrity under severe accident conditions is an important issue for accident management. The Rivne 1&2 severe accident management (SAM) strategy will rely on retaining corium inside the pressure vessel (in-vessel retention – IVR). However, these measures are not implemented 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.

A systematic analysis of beyond design basis accidents (BDBA) was not presented in the EIA Document. To calculate the possible (trans-boundary) consequences, it was assumed that the containment integrity will be kept up. This assumption is not justified. The used source term of a beyond design basis accident (BDBA) was chosen on the basis of safety requirements of the European operators for the design of a light water reactors (LWR). However, this limited source term can only be assumed if the plant has been designed or retrofitted

[1] Under the framework of joint IAEA-EC-Ukraine projects a design evaluation was carried out to conduct an overall evaluation of the compliance of the Ukrainian NPPs design with the IAEA Safety Standards “Safety of Nuclear Power Plants: Design (NS-R-1)” published in 2000. Meanwhile, even this IAEA document is outdated; in January 2012 new safety requirements were published by IAEA (2012).

accordingly. This is not the case for Rivne 1&2. The ANSWERS (2021) revealed that a filtered containment venting system will not be implemented.

The accident analyses in the EIA Document should use a possible source term derived from the calculation of the current PSA 2. Even though the probability of severe accidents with an early and/or large release for existing plants is estimated to be very small, the consequences caused by these accidents are serious.

In any case, the EIA Document should contain a comprehensive justification for the source term used. In principle, possible Beyond Design Basis Accidents should be part of the EIA, irrespective of their probability of occurrence.

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 440/V213 reactor type.

The results of the EU stress tests have revealed a lot of shortcomings of the severe accident management (SAM) (i.e. the prevention of severe accidents and the mitigation of its consequences) at the Ukrainian NPPs. 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.

The stress tests showed that after decades of safety programs, Ukrainian reactors remain to be plants posing exceptionally high risk. The continuous upgrading programs did not deliver the promised results. The ENSREG peer review team pointed to one of the main problems, which are characteristic of nuclear safety in the Ukraine: the constant severe delay of the implementation of upgrading measures. According to the ANSWERS (2021), the implementation of the necessary Severe Accident Measures (SAM) will be completed as late as 2023.

The WENRA “Safety Objectives for New Power Reactors” should be used as a reference for identifying reasonably practicable safety improvements for Rivne 1&2. However, the EIA Document did not mention these WENRA safety objectives. The most ambitious WENRA safety objective intends to reduce potential radioactive releases to the environment from accidents with core melt. Accidents with core melt which would lead to early or large releases would have to be practically eliminated. Practical elimination of an accident sequence cannot be claimed solely based on compliance with a general cut-off probabilistic value. Even if the probability of an accident sequence is very low, any additional reasonably practicable design feature, operational measures or accident management procedures to further lower the risk should be implemented. Neither the concept of "practical elimination" of early or large releases nor the WENRA safety objectives are used in the Rivne 1&2 lifetime extension project.

Not even the WENRA RLs for existing NPPs have been used for Rivne 1&2 to meet the agreed safety level in the EU, as these have not yet been adopted into Ukraine's regulatory framework despite the fact that Ukraine is a member of WENRA.

Accidents initiated by natural events and site assessment

The plant safety assessment takes into account the following natural hazards: river flood, extreme precipitation, abnormally low water level (lack of cooling water), tornado, earthquake, high wind, fog, thunderstorm, snowstorm (snow load) and extreme temperature. In addition, karst and suffusion (including human-induced karstification and suffusion) are discussed.

The assessment of natural phenomena that may have adverse effects on the safety of the NPP is restricted to a small number of hazard types. The EIA Document failed to demonstrate that the site assessment identified all natural hazards that apply to the site. A thorough assessment including the steps

- hazard screening and identification of hazard combinations
- hazard assessment
- definition of design basis events
- development of a protection concept
- analysis of design extension conditions

as required by WENRA (2020, Issue T) has not been performed.

Hazard screening and the identification of hazard combinations should start from an exhaustive list of natural hazards (e.g., WENRA 2015; DECKER & BRINKMAN 2017) to demonstrate that all relevant hazards and hazard combinations are addressed.

Hazard severities for occurrence probabilities of 10-4 per year as required by WENRA (2014) have been determined by hazard assessments for several, but not all hazards considered in the EIA Document. The results, however, are not followed up to define design basis events and develop adequate protection concepts in a way that complies with the WENRA Safety Reference Levels for Existing Reactors (2014). This is particularly the case for external flooding by extreme precipitation, low water level (lack of cooling water), high wind, tornado, snow load/snow storm and extreme temperatures. Adequate protection against several hazards is therefore currently not in place. This is most important for:

- Flooding by extreme precipitation for which the current design only protects against events with occurrence probabilities of 10E-1 per year. Events exceeding the current design value are expected to lead to severe impacts on the on-site power system. This occurrence probability exceeds the exceedance frequency of design basis events required by WENRA by a factor of 10E3.
- High wind for which the EIA Document shows that storms with occurrence probabilities of 1.40E-3 can lead to failure of the essential service water system.

We assume that the low robustness of the cooling system against wind loads and other meteorological hazards are important reasons for the high conditional probability of core damage due to failure of the essential service water system. This probability is stated with 6,93E-03. Such a high Core Damage Frequency (CDF) value is unacceptable when compared to regulations and safety

expectations for existing NPPs that are in place in most of the European countries[2].

Karstification and suffusion pose significant threats to the safety of the NPP Rivne by the possible destabilization of the foundation soil of the reactor buildings and containments, buildings that house safety-relevant structures, systems and components (SSC), safety-relevant underground piping and the cooling towers. Information provided by the EIA Document proved that the operation of the NPP leads to the lasting seepage of large amounts of technical water that has the potential to increase karstification and suffusion, and to destabilize foundation soils. Since human-made karstification and suffusion are self-enhancing mechanisms, it may be expected that their safety relevance increases during the future operation of the NPP. According to ANSWERS (2021) karstification and suffusion processes as well as resulting ground settlements are extensively monitored and mitigation measures have been implemented to minimize the infiltration of precipitation and service water.

The available EIA Document provided only insufficient information on the safety margins of the reactors with respect to the different natural hazard types. Design Extension Conditions (DEC) were not analysed. This is contrary to the WENRA requirement that DEC analysis shall be undertaken with the purpose of further improving the safety of existing nuclear power plants and enhancing their capability to withstand more challenging events or conditions than those considered in the design basis. Related requirements and procedures are provided by WENRA (2020) and WENRA (2014). The expert team recommended to extend the efforts with respect to natural hazard analysis and to develop adequate protection concepts for natural hazards in line with the WENRA approach for DEC.

Accidents with involvement of third parties and man-made impacts

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the Rivne NPP. Nevertheless, they were not mentioned in the EIA Document. In comparable EIA documents such events were addressed to some extent. According to the ANSWERS (2021), which provided only general information the capability of the physical protection system to counter the design basis threat is determined in the Nuclear Security Assessment. The corresponding report is prepared and submitted to the supervisory authority. This report is classified as "secret".

Although precautions against sabotage and terror attacks cannot be publicly discussed in detail in the EIA procedure for reasons of confidentiality, the necessary legal requirements should be set out in the EIA Document.

[2] In the majority of member countries of WENRA (Western European Nuclear Regulators Association) and in the Ukraine the Core Damage Frequency (CDF) shall not exceed the value of 10^{-4} per year. Some WENRA countries require CDF≤10^{-5} per year.

Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. In particular, the EIA Document should include detailed information on the requirements for the design against the targeted crash of a commercial aircraft. This topic is of particular importance, because the reactor building of Rivne 1&2 is vulnerable against terror attacks (including airplane crash). That the reactor building cannot withstand the crash of any airplane type was confirmed in the ANSWERS (2021).

A recently released nuclear security assessment (NTI Index 2020) pointed to deficits in the necessary nuclear security requirements in Ukraine. With an overall score of 65 out of 100 points, Ukraine ranks only 29th out of 47 countries, indicating a low level of protection. Deficits were identified in particular in "Insider Threat Prevention" and "Cyber-security". It was recommended in UMWELTBUNDESAMT (2021) to invite an International Physical Protection Advisory Service (IPPAS) of the IAEA that assists states in strengthening their national nuclear security regimes, systems and measures. According to ANSWERS (2021), an IPPAS mission is not planned.

Trans-boundary impacts

The used source term for Cs-137 (30 TBq) of a beyond design basis accident (BDBA) was determined on the basis of the limited value of the release according to the safety requirements of the European operators. The assumption of this relatively moderate source term is not justified. This limited source term can only be used if the plant has been designed or retrofitted accordingly. This is not the case for the Rivne 1&2 NPP. The project flexRISK made an assessment of source terms and identified for Rivne 1&2 a possible source term for Cs-137 of 76,500 TBq. This source term is related to the behaviour of the plant in case of a severe accident and the possible release.

During the consultations, contamination data were provided for the calculated severe accident in dry weather condition. Those data would not lead to the necessity of taking agricultural measures in Austria. However, this is not necessarily the case for wet weather conditions.

Severe accidents with releases considerably higher than assumed in the EIA Document still cannot be excluded for Rivne 1&2.

The results of the flexRISK project indicated that after a severe accident, the average Cs-137 ground depositions at most areas of the Austrian territory could be higher than the threshold for agricultural intervention measures (e.g. earlier harvesting, closing of greenhouses). Therefore, Austria could be significantly affected by a severe accident at Rivne 1&2.

Because no analysis of such worst case scenarios was performed, the conclusion of the EIA Document concerning trans-boundary effects cannot be considered sufficiently proven.

ZUSAMMENFASSUNG

Die Ukraine führt eine Umweltverträglichkeitsprüfung (UVP) für die Lebensdauerverlängerung der Reaktoren Rivne 1&2 gemäß der Espoo-Konvention durch. Das Kernkraftwerk Rivne liegt in der Nähe der Stadt Varash in der Region Rivne. Am Standort Rivne sind vier Reaktoren in Betrieb, wobei die VVER-440 Reaktoren Rivne 1&2 die ältesten sind und in den Jahren 1980 bzw. 1981 in Betrieb genommen wurden.

Nachdem die Republik Österreich von der Ukraine notifiziert wurde, beschloss Österreich sich an der UVP zu beteiligen. Das österreichische Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie beauftragte das Umweltbundesamt mit der Erstellung eines Expert_innengutachtens (UMWELTBUNDESAMT 2021), in welchem die übermittelten UVP-Dokumente bewerten wurden. In diesem Expert_innengutachten wurden offene Fragen und vorläufige Empfehlungen formuliert.

Die ukrainische Seite übermittelte im April 2021 eine schriftliche Fragebeantwortung. (ANSWERS 2021) In dem hier vorliegenden abschließenden Expert_innengutachten werden diese Antworten bewertet und abschließende Empfehlungen formuliert. Das Ziel der österreichischen Beteiligung an dem UVP-Verfahren ist die Minimierung oder sogar Beseitigung möglicher signifikant negativer Auswirkungen auf Österreich, die von diesem Projekt ausgehen könnten.

Allgemeine Aspekte und Verfahrensaspekte der Umweltverträglichkeitsprüfung

Für das Projekt der Lebensdauerverlängerung des KKW Rivne 1&2 wurde zunächst keine UVP durchgeführt, wodurch es zur Verletzung der Vorgaben der Espoo-Konvention kam. Die Beschwerde „EIA/IC/CI/4 Ukraine“ ist seit dem Jahre 2011 offen. Die ESPOO-Konventionsvertragsstaatenkonferenz (MOP) forderte in ihrem Beschluss VIII/4e vom Dezember 2020 die Regierung der Ukraine auf, die grenzüberschreitende UVP abzuschließen und die finale Genehmigung für die Lebensdauerverlängerung von Rivne 1&2 zu revidieren um die Ergebnisse des jetzt laufenden UVP-Verfahrens zu berücksichtigen. Die von der ukrainischen Seite übermittelten Antworten stellten nicht klar, ob und wie diese Revision der Entscheidung für die Lebensdauerverlängerung durchgeführt werden wird.

Die Republik Österreich und die Ukraine haben 1998 ein bilaterales Abkommen betreffend Informationsaustausch und Kooperation im Bereich der nuklearen Sicherheit und des Strahlenschutzes abgeschlossen. Obwohl im Rahmen dieses Abkommens bis heute keine Treffen stattgefunden haben, wird die Empfehlung ausgesprochen, das Lebensdauerverlängerungsprojekt Rivne 1&2 bilateral in regelmäßigen Abständen zu diskutieren.

Abgebrannte Brennelemente und radioaktive Abfälle

In der UVP-Dokumentation fehlten wesentliche Informationen über das Management von abgebrannten Brennelementen und radioaktiven Abfällen aus dem KKW Rivne 1&2. Die Antworten bei den Konsultationen brachten einige der fehlenden Informationen. Während Kapazitäten für die abgebrannten Brennelemente und radioaktiven Abfälle aus der Lebensdauerverlängerung bestehen oder in nächster Zukunft bestehen werden, ist es unklar, wo die hochaktiven Abfälle gelagert werden, die nach der Wiederaufbereitung aus Russland zurückgenommen werden müssen. Es wurden keine Angaben zur Endlagerung von abgebrannten Brennelementen und hochaktivem Abfall gemacht.

Abgebrannte Brennelemente und radioaktiver Abfall können negative Umweltauswirkungen haben, daher wäre es zu begrüßen, wenn die ukrainische Seite weitere Informationen über das nationale Entsorgungsprogramm für Atommüll zur Verfügung stellen würde.

Langzeitbetrieb von Reaktoren des Typs VVER-440

Obwohl die Alterung der 40 Jahre alten Strukturen, Gebäude und Anlagen für Rivne 1&2 sicherheitsrelevant ist, wurde dieser Themenkomplex in der UVP-Dokumentation nicht angesprochen. Diese bezog sich nur auf „Strukturen, Systeme und Komponentenalterung“ als Sicherheitsfaktor im Rahmen der Periodischen Sicherheitsüberprüfung (PSÜ). Die negativen Auswirkungen der Alterung stehen auch in Abhängigkeit zu den durchgeführten Inspektions-, Erneuerungs- und Schutzmaßnahmen. Ein umfassendes Alterungsmanagementprogramm (AMP) ist notwendig, um altersbedingtes Versagen zumindest in einem bestimmten Ausmaß zu beschränken. Allerdings fehlte die Information über das Alterungsmanagementprogramm (AMP) in der UVP-Dokumentation.

Die Antworten (ANSWERS 2021) stellen nur allgemeine Informationen über das Alterungsmanagementprogramm (AMP) zur Verfügung, sowie die Aussage, dass das bestehende AMP ausreichend sei. Konkrete Ergebnisse wurden jedoch nicht vorgelegt. Darüber hinaus stimmen die Erklärungen nicht mit den Resultaten der Topical Peer Review (TPR) aus dem Jahre 2017/2018 mit dem thematischen Schwerpunkt „Alterungsmanagement“ im Rahmen der Umsetzung der Nuklearsicherheitsrichtlinie 2014/87/EURATOM überein. Die TPR zeigte einige Abweichungen vom erwarteten Niveau für die Durchführung des Alterungsmanagements auf, welches im Sinne eines konsistenten und akzeptablen Alterungsmanagements in ganz Europe erzielt werden sollte. Die TPR-Resultate und die Aktivitäten zur Behebung von Schwachstellen sollten in der UVP-Dokumentation präsentiert werden. Das gilt insbesondere für die wesentliche Sicherheitsfrage der Versprödung des Reaktordruckbehälters. Die Antworten (ANSWERS 2021) enthalten allgemeine Angaben zu dieser Frage, doch fehlen die kritische Versprödungstemperatur und die Sicherheitsmargen. Ebenso wurde angeführt, dass laut der Entscheidung des Boards der Staatlichen Nuklearaufsichtsbehörde der Ukraine (SNRIU) vom 5. September 2019 der erste Nationale Aktionsplan zum Alterungsmanagement der Ukraine auf der Basis der TPR-Ergebnisse

verabschiedet wurde. Um die Auflagen von SNRIU zu erfüllen, hat das Management (SS Rivne NPP) des KKW Rivne die entsprechenden Maßnahmen beschlossen.

Obwohl die konzeptuelle Alterung für Rivne 1&2 ebenso ein Problem darstellt, befasste sich die UVP-Dokumentation mit keinem der bekannten Sicherheitsdefizite der VVER-440/213 Reaktoren. VVER-440/213 Reaktoren haben einige Designschwächen: Das Reaktorgebäude und auch das Gebäude für das Abklingbecken für abgebrannte Brennelemente sind gegenüber externen Ereignisse relativ verwundbar. Die VVER-440 Reaktoren sind als Zwillingsanlangen konstruiert, die sich mehrere Betriebs- und Sicherheitssysteme teilen. Die gemeinsame Verwendung erhöht das Risiko eines Versagens aus gemeinsamer Ursache, wodurch die Sicherheit beider Reaktoren gleichzeitig betroffen ist. Darüber hinaus entspricht es nicht dem Stand von Wissenschaft und Technik, wenn ein System Aufgaben für mehrere Sicherheitsebenen übernimmt.

Dieses KKW-Design wurde in den 1980ern entwickelt und entspricht nur teilweise modernen Auslegungsprinzipien wie Redundanz, Diversität und physischer Trennung von redundanten Subsystemen oder der bevorzugten Verwendung von passiven Sicherheitssystemen. Die UVP-Dokumentation enthielt weder eine Beschreibung der sicherheitsrelevanten Systeme noch Informationen über die Kapazitäten, Redundanzen und physische Trennung.

Im Dezember 2010 genehmigte die SNRIU für das KKW Rivne 1&2 eine Lebensdauerverlängerung für 20 Jahre, obwohl die sicherheitsrelevanten Defizite noch nicht vollständig gelöst waren. Der Stresstest kam 2011 zu dem Ergebnis, dass die ukrainischen KKW nur 172 von 194 Anforderung der IAEA Design Safety Standards von 2000[3] erfüllten. Die Umsetzung der notwendigen Verbesserungen ist Teil des noch laufenden Nachrüstungspakets. Die Beendigung dieses Programmes wurde einige Male verschoben und ist nun für 2023 vorgesehen. Die Antworten (ANSWERS 2021) bestätigten, dass das Nachrüstprogramm noch läuft. Keine weiteren Programme zur Erreichung des aktuellen Sicherheitsstandards sind in Planung.

Die Ukraine ist Mitglied in der WENRA – Western European Nuclear Regulators Association. Im Jahre 2014 veröffentlichte die WENRA eine revidierte Version der Safety Reference Levels (RLs) für bestehende Reaktoren, die die Reactor Harmonisation Working Group (RHWG) ausgearbeitet hatte. Das Ziel der Revision war die Berücksichtigung der Erfahrungen, die aus dem Unfall im KKW Fukushima Daiichi gewonnen wurden. Ein wesentliches Update war die Revision des Issue F „Design Extension of Existing Reactors“ durch die Einführung des Auslegungskonzepts der Design Extension Conditions (DEC), der Erweiterten Auslegungsbedingungen. Die Antworten (ANSWERS 2021) zeigten auf, dass die aktualisierte und bereits 2014 veröffentlichten WENRA RL keinen Eingang in die

[3] Im Rahmen eines gemeinsamen IAEO-EK-Ukraine Projekts wurde eine Designevaluierung durchgeführt, um umfassend die Übereinstimmung der ukrainischen KKW-Designs mit den IAEO Safety Standards „Safety of Nuclear Power Plants: Design (NS-R-1)“ aus dem Jahre 2000 zu bewerten. Mittlerweile ist auch dieses IAEO-Dokument veraltet, denn im Jänner 2012 wurden die neuen Sicherheitsanforderungen IAEO (2012) publiziert.

ukrainische Gesetzgebung gefunden hatten und Rivne 1&2 somit diese WENRA RL nicht erfüllen muss.

Unfallanalysen

Der Erhalt der Containment-Integrität unter Bedingungen schwerer Unfälle ist ein wichtiges Thema für das Unfallmanagement. Die Strategie für das Management schwerer Unfälle (SAM) wird vor allem auf das Zurückhalten des Kerns innerhalb des Reaktordruckbehälters setzen (In-Vessel Retention – IVR). Doch diese Maßnahmen sind noch nicht umgesetzt. Selbst wenn diese Einrichtung installiert sein wird, kann es nur zur Reduktion des Risikos von radioaktiven Freisetzungen in den meisten, aber nicht in allen Fällen von schweren Unfallszenarien kommen.

In der UVP-Dokumentation fehlte eine systematische Analyse der auslegungsüberschreitenden Unfälle (BDBA). Für die Berechnung möglicher (grenzüberschreitender) Folgen wurde angenommen, dass die Containment-Integrität erhalten bleiben wird. Diese Annahme ist nicht gerechtfertigt. Der für einen auslegungsüberschreitenden Unfall verwendete Quellterm wurde auf der Grundlage der Sicherheitsanforderungen der europäischen Betreiber von Leichtwasserreaktoren ausgewählt. Doch kann dieser Quellterm nur dann als Annahme verwendet werden, wenn das Kraftwerk dementsprechend ausgelegt oder nachgerüstet wurde. Das ist bei Rivne 1&2 nicht der Fall. Die Antworten (ANSWERS 2021) zeigten auf, dass es zu keiner Implementierung eines Systems zur gefilterten Druckentlastung des Containments kommen wird.

Für die Unfallanalyse in der UVP-Dokumentation sollte ein möglicher Quellterm von der Berechnung der aktuellen PSA 2 abgeleitet werden. Auch wenn die Wahrscheinlichkeit für schwere Unfälle mit einer frühen und/oder großen Freisetzung für bestehende KKW als gering angenommen wird, sind die Folgen dieser Unfälle schwer.

In jedem Fall sollte die UVP-Dokumentation eine nachvollziehbare Begründung für den verwendeten Quellterm enthalten. Prinzipiell sollten mögliche auslegungsüberschreitende Unfälle (BDBA) Teil der UVP sein, ungeachtet ihrer Eintrittswahrscheinlichkeit.

Um die Konsequenzen von BDBAs zu bewerten ist es notwendig, eine Reihe von schweren Unfällen zu analysieren, einschließlich der Unfälle mit Containmentversagen und Containment-Bypass. Diese Arten von schweren Unfällen sind für den Reaktortyp VVER 440/V213 möglich.

Die Resultate der EU-Stresstests haben eine Reihe von Defiziten beim Management schwerer Unfälle (SAM) bei den ukrainischen KKW gezeigt, z.B. bei der Verhinderung von schweren Unfällen und der Verhinderung von deren Folgen. Die Aufsichtsbehörde verlangt einige umfassende Verbesserungen, wobei das ENSREG Peer Review Team weitere Verbesserungsmaßnahmen empfiehlt. Dabei handelt es sich um ein Beispiel für die Kluft zwischen den Sicherheitsstandards und Sicherheitsanforderungen der Ukraine und der EU.

Die Stresstests zeigten, dass nach jahrzehntelangen Sicherheitsprogrammen die KKW auch weiterhin ein ungewöhnlich hohes Risiko darstellen. Die kontinuierlichen Nachrüstprogramme haben nicht die versprochenen Resultate gebracht. Das ENSREG Peer Review Team verwies auf eines der Hauptprobleme, die für die nukleare Sicherheit in der Ukraine charakteristisch sind: die permanente Verschiebung der Umsetzung der Nachrüstmaßnahmen. Laut den Antworten (ANSWERS 2021) werden die notwendigen Severe Accident Measures (SAM) erst im Jahre 2023 umgesetzt sein.

Die WENRA "Safety Objectives for New Power Reactors" sollten als Referenzdokument für die Identifikation der vernünftig umsetzbaren Sicherheitsverbesserungen für Rivne 1&2 dienen. Die UVP-Dokumentation nannte diese WENRA Sicherheitsziele allerdings nicht. Das ehrgeizigste WENRA-Sicherheitsziel beabsichtigt die Reduktion potentieller radioaktiver Freisetzungen in die Umwelt bei Kernschmelzunfällen. Kernschmelzunfälle mit frühen oder großen Freisetzungen wären dann praktisch ausgeschlossen. Der praktische Ausschluss von Unfallabläufen kann nicht nur mit einem allgemeinen probabilistischen Grenzwert bestimmt werden. Selbst wenn die Wahrscheinlichkeit für einen bestimmten Unfallablauf sehr gering ist, sollte ein zusätzliches vernünftig umsetzbares Designelement, eine betriebliche Maßnahme oder ein Unfallmanagementverfahren eingeführt werden, um das Risiko weiter zu reduzieren. Weder das Konzept des „praktischen Ausschlusses" von frühen oder großen Freisetzungen noch die WENRA Sicherheitsziele finden beim Projekt der Lebensdauerverlängerung von Rivne 1&2 Verwendung.

Für Rivne 1&2 wurden nicht einmal die WENRA RL für bestehende KKW angewendet, um das in der EU vereinbarte Sicherheitsniveau zu erreichen, da diese noch nicht Eingang in das ukrainische Regelwerk fanden, obwohl die Ukraine ein WENRA-Mitglied ist.

Unfälle, die durch natürliche Ereignisse initiiert werden, Standortbewertung

Die Sicherheitsbewertung für das KKW betrachtet folgende Naturgefahren: Überschwemmung durch Flusswasser, extremer Niederschlag, außergewöhnlich niedriger Wasserpegel (Mangel an Kühlwasser), Tornado, Erdbeben, Starkwinde, Nebel, Gewitter, Schneesturm (Schneelast) und extreme Temperaturen. Zusätzlich betrachtet wurden Karst und Suffusion (einschließlich menschgemachter Verkarstung und Suffusion).

Die Prüfung von natürlichen Phänomenen, die negative Auswirkungen auf die Sicherheit des KKW haben können, wurde auf eine geringe Anzahl von Gefährdungstypen beschränkt. Die UVP-Dokumentation hat nicht gezeigt, dass die Standortbewertung alle natürlichen Gefährdungen identifiziert hat, die für diesen Standort möglich sind. Eine gründliche Bewertung mit den folgenden Schritten, wie von der WENRA (2020, Issue T) vorgesehen, wurde nicht durchgeführt:

- Gefährdungsscreening und Identifikation von Gefährdungskombinationen
- Gefährdungsbewertung

- Identifikation von Auslegungsstörfällen
- Entwicklung eines Schutzkonzepts
- Analyse von erweiterten Auslegungsbedingungen

Das Gefährdungsscreening und die Identifizierung von Gefährdungskombinationen sollte mit einer vollständigen Liste der natürlichen Gefährdungen begonnen werden (z.B. WENRA 2015; DECKER & BRINKMAN 2017), um nachzuweisen, dass alle relevanten Gefährdungen und Gefährdungskombinationen berücksichtigt wurden.

Die Gefährdungen mit Eintrittswahrscheinlichkeiten von 10-4 pro Jahr, wie von der WENRA (2014) vorgesehen, wurden mit einer Gefährdungsprüfung einiger, aber nicht aller Gefährdungen in der UVP-Dokumentation durchgeführt. Die Ergebnisse wurden allerdings nicht dafür verwendet um Auslegungsstörfälle zu definieren und adäquate Schutzkonzepte zu entwickeln, die den WENRA Safety Reference Levels für bestehende Reaktoren (2014) entsprechen. Das gilt insbesondere für die externe Flutung durch extreme Niederschläge, niedrigen Wasserstand (Mangel an Kühlwasser), Starkwinde, Tornados, Schneelast/Schneesturm und extreme Temperaturen. Ein adäquater Schutz liegt somit zurzeit für einige Gefährdungen nicht vor. Das gilt insbesondere für:

- Überflutung durch extreme Niederschläge, für die die aktuelle Auslegung nur gegen Ereignisse mit einer Eintrittshäufigkeit von 10E-1 pro Jahr ausreicht. Bei Ereignissen, die den aktuellen Auslegungswert überschreiten, sind schwere Auswirkungen auf das Standortstromversorgungssystem zu erwarten. Diese probabilistische Eintrittshäufigkeit überschreitet die Häufigkeit für Auslegungsstörfälle, wie sie von der WENRA gefordert wird, um einen Faktor von 10E3.
- Starkwind, der laut UVP-Dokumentation bei Stürmen mit einer Eintrittswahrscheinlichkeit von 1,40E-3 zum Versagen des wichtigen Speisewassersystems führen kann.

Es ist davon auszugehen, dass die geringe Widerstandsfähigkeit des Kühlsystems gegen Windlasten und andere meteorologische Gefährdungen wesentliche Gründe für die hohe Eintrittswahrscheinlichkeit für Kernschmelzen in Folge eines Verlusts des essentiellen Speisewassersystems darstellt. Die Wahrscheinlichkeit wird mit 6,93E-03 angeführt. Ein so hoher Wert für die Kernschmelzhäufigkeit (CDF) ist nicht akzeptabel, wie der Vergleich mit den Regeln und Sicherheitsanforderungen an bestehende KKW zeigt, die im Großteil der Länder Europas[4] herrschen.

Die Verkarstung und Suffusion stellen bedeutende Gefährdungen der Sicherheit des KKW Rivne durch die mögliche Destabilisierung des Fundamentbodens unter dem Reaktorgebäude, dem Containment und den Gebäuden dar, die die sicherheitsrelevanten Strukturen, Systeme und Komponenten (SSC) beherbergen,

[4] Im Großteil der Mitgliedsstaaten der WENRA (Western European Nuclear Regulators Association) und der Ukraine sollte die Kernschmelzhäufigkeit (CDF) den Wert 10^{-4}pro Jahr nicht überschreiten. Einige WENRA-Länder verlangen CDF≤10^{-5} pro Jahr.

wie auch der sicherheitsrelevanten unterirdischen Rohrleitungen und der Kühltürme. Die Information in der UVP-Dokumentation zeigten, dass der Betrieb des KKW zu einer anhaltenden Versickerung von großen Mengen an technischem Wasser führt, welches das Potential für eine Verstärkung der Verkarstung und Suffusion hat und zu einer Destabilisierung der Fundamentböden führen kann. Da die menschgemachte Verkarstung und Suffusion selbstverstärkende Mechanismen sind, ist davon auszugehen, dass deren Sicherheitsrelevanz im künftigen KKW-Betrieb ansteigen wird. Laut den Antworten (ANSWERS 2021) werden die Verkarstungs- und Suffusionsprozesse wie auch die resultierenden Bodensenkungen umfassend überwacht, auch wurden Mitigationsmaßnahmen umgesetzt, um die Infiltrierung von Niederschlags- und Gebrauchswasser zu minimieren.

Die vorliegende UVP-Dokumentation bot nur unzureichende Informationen über die Sicherheitsreserven der Reaktoren für die verschiedenen natürlichen Gefährdungsarten. Die erweiterten Auslegungsbedingungen (DEC) wurden nicht analysiert. Das widerspricht den WENRA-Anforderungen wonach die DEC-Analyse zur weiteren Verbesserung der Sicherheit bestehender KKW und der Erhöhung deren Fähigkeit dient, Ereignisse oder Bedingungen zu bewältigen, die massiver sind als in der Auslegung vorgesehen. Die Dokumente WENRA (2020) und WENRA (2014) stellen die damit zusammenhängenden Anforderungen und Vorgangsweisen dar. Das Expert_innenteam empfiehlt die Anstrengungen im Bereich der Analyse der natürlichen Gefährdungen auszuweiten und entsprechende Schutzkonzepte für die natürlichen Gefährdungen entsprechend den WENRA-Vorschriften für DEC zu entwickeln.

Unfälle mit Beteiligung Dritter und durch Aktivitäten des Menschen verursachte Auswirkungen

Terrorangriffe und Sabotageakte können schwere Auswirkungen auf Nuklearanlagen haben und zu schweren Unfällen führen – auch beim KKW Rivne. Dennoch wurden diese in der UVP-Dokumentation nicht erwähnt. In vergleichbaren UVP-Dokumentationen wurden diese Ereignisse bis zu einem gewissen Umfang angesprochen. Die Antworten (ANSWERS 2021) stellen nur allgemeine Angaben zur Verfügung. Die Fähigkeit des physischen Schutzsystems die Auslegungsbedrohungen abzuwehren ist durch die Nukleare Sicherungsbewertung bestimmt. Der entsprechende Bericht ist fertiggestellt und der Aufsichtsbehörde übermittelt worden. Dieser Bericht wurde als geheim eingestuft.

Wenn auch vorbeugende Maßnahmen gegen Sabotage und Terrorangriffe nicht öffentlich im Detail im UVP-Verfahren aufgrund der Vertraulichkeit diskutiert werden können, sollten doch die gesetzlichen Anforderungen in der UVP-Dokumentation dargelegt werden.

Aufgrund der gravierenden Folgen möglicher Angriffe ist die Information zur Problematik von Terrorangriffen sehr wichtig. Die UVP-Dokumentation sollte detaillierte Informationen über die Auslegungsanforderungen für den gezielten Absturz von Verkehrsflugzeugen anführen. Dieses Thema ist besonders wichtig,

da das Reaktorgebäude des KKW Rivne 1&2 gegenüber Terrorangriffen (einschließlich Flugzeugabstürzen) verwundbar ist. Im Dokument ANSWERS (2021) wird bestätigt, dass das Reaktorgebäude keinem Absturz eines Flugzeugs gleich welchen Typs standhalten würde.

Die jüngste Bewertung der nuklearen Sicherung (NTI Index 2020) zeigt Defizite der notwendigen Sicherungsanforderungen in der Ukraine auf. Mit einer Gesamtbewertung von 65 von 100 Punkten wurde die Ukraine nur auf Platz 29 von 47 Ländern eingereiht, was auf ein sehr geringes Schutzausmaß deutet. Insbesondere für „Insider Threat Prevention" und „Cybersecurity" wurden Defizite sichtbar. In der Fachstellungnahme (UMWELTBUNDESAMT 2021) wurde empfohlen, den International Physical Protection Advisory Service (IPPAS) der IAEO einzuladen, der die Staaten bei der Stärkung ihrer nationalen Regelungen, Systeme und Maßnahmen zur nuklearen Sicherung unterstützt. Laut den Antworten (ANSWERS 2021) ist keine IPPAS Mission geplant.

Grenzüberschreitende Folgen

Der verwendete Quellterm für Cäsium 137 (30 TBq) für einen auslegungsüberschreitenden Unfall (BDBA) wurde auf der Grundlage des beschränkten Freisetzungswerts festgelegt, der für die Sicherheitsanforderungen der europäischen Betreiber gilt. Diesen relativ moderaten Quellterm heranzuziehen ist nicht gerechtfertigt. Dieser beschränkte Wert kann nur verwendet werden, wenn das KKW entsprechend ausgelegt oder nachgerüstet wurde. Das ist für das KKW Rvne 1&2 nicht der Fall. Das Projekt flexRISK führte eine Bewertung der Quellterme durch und bestimmte für Rivne 1&2 einen möglichen Quellterm für Cs-137 von 76 500 TBq. Dieser Quellterm bezieht sich auf das Verhalten des KKW bei einem schweren Unfall und der möglichen Freisetzungen.

Während der Konsultationen wurden Kontaminationsdaten für den berechneten schweren Unfall unter trockenen Wetterbedingungen übermittelt. Keine landwirtschaftlichen Maßnahmen müssten bei dieser Datenlage in Österreich eingeleitet werden. Allerdings ist das nicht notwendigerweise auch der Fall bei nassen Wettersituationen.

Schwere Unfälle mit Freisetzungen, die deutlich über den in der UVP-Dokumentation abgeschätzten liegen, können für Rivne 1&2 nicht ausgeschlossen werden.

Die Resultate des flexRISK Projekts zeigten, dass nach einem schweren Unfall die durchschnittlichen Bodendepositionen von Cs-137 in den meisten Regionen Österreich den Schwellenwert für landwirtschaftliche Interventionsmaßnahmen (z.B. vorgezogene Ernte, Schließen von Glashäusern) überschreiten könnten. Daher könnte Österreich von einem schweren Unfall im KKW Rivne 1&2 signifikant betroffen sein.

Da die Analyse für solche Worst-Case Szenarien nicht durchgeführt wurde, sind die Schlussfolgerungen der UVP-Dokumentation zu grenzüberschreitenden Auswirkungen nicht ausreichend nachgewiesen.

1 INTRODUCTION

The nuclear power plant Rivne is located near the town of Varash in the Rivne Oblast, Ukraine. At the Rivne site, four reactors are in operation. Rivne1&2are the oldest of these reactors, they were connected to the grid in 1980 and 1981, respectively. While Rivne 1&2 are VVER-440/213 reactors, Rivne 3&4 are VVER-1000/320 with grid connection in 1986 and 2004.

The NPP is owned by the State Enterprise "National Nuclear Energy Generating Company Energoatom", in short Energoatom.

For the lifetime extension of Rivne 1&2, the Ukrainian side is conducting an Environmental Impact Assessment (EIA) under the Espoo Convention. Austria has been notified by Ukraine and is participating in the EIA.

The competent EIA authority in Ukraine is the Ministry of Environmental Protection and Natural Resources, the project developer is Energoatom.

The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Environment Agency Austria to provide an expert statement assessing the submitted EIA Documents. (UMWELTBUNDESAMT 2021a) In this expert statement, open questions and preliminary recommendations were formulated.

In April 2021, the Ukrainian side provided written answers on these questions (ANSWERS 2021). In this final expert statement at hand these answers are assessed and final recommendations are given.

The objective of the Austrian participation in the EIA procedure is to minimise or even eliminate possible significant adverse impacts on Austria which might result from this project.

2 OVERALL AND PROCEDURAL ASPECTS OF THE ENVIRONMENTAL IMPACT ASSESSMENT

2.1 Short Summary of the Expert Statement

The original license has been issued for 30 years and was prolonged in 2010 until December 2030. The project of the lifetime extension of Rivne 1&2 is violating the Espoo Convention because the Environmental Impact Assessment has not been conducted in 2010. The "EIA/IC/CI/4 Ukraine" case under the Espoo Convention started in 2011 and is still open. In December 2020, the Meeting of the Parties to the Espoo Convention asked Ukraine to revise its final decision on the lifetime extension of Rivne 1&2, taking due account of the outcomes of the EIA procedure.

This Espoo procedure shows that it is not clear if and how the results of the ongoing EIA procedure will be taken into account by the Ukrainian side. Furthermore, the next steps of the licensing procedure are not clear.

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 was not sufficient.

2.2 Questions, answers and assessment of the answers

Question AU1

How will the results of the EIA be taken into account?

Written answer by the Ukrainian side

The results of the SS "Rivne NPP" environmental impact assessment will be accounted for in accordance with requirements of the Law of Ukraine "On environmental impact assessrnent", namely requirements of the Article 11.

The SS RNPP EIA was performed (as specified in the Notification of the planned activities) as for an economic player that operates nuclear units.

To identify, collect and account for proposals of the public regarding the SS RNPP planned activities the Ministry of Environmental Protection of Ukraine arranged the public hearings at the regional centers of Khmelnytskyy, Rivne, Zhytomyr, Ternopil, Volyn, Lviv, Ivano-Frankivsk, Vinnytsya regions and in Kyiv between July 1 and July 11, 2019. According to the national legislation public discussion of the EIA report in Ukraine was completed on 31 July 2019.

The Ministry of Environmental Protection of Ukraine provided the involved parties with the "SS "Rivne NPP" EJA report' in June2019 asking to start its discussions.

Assessment of the answer

Article 11 of the Ukrainian Law "On environmental impact assessment" stipulates that the project developer submits the EIA Report, the report on public consultations and the EIA conclusion to a public authority/local self-governance authority and seeks this authority's permit. According to the EIA law, this decision will establish parameters and conditions for carrying out the project and will be taken in the form of a permit or other act of the public authority/local self-governance authority pursuant to the procedure established by the legislation for the relevant decisions. (EIA LAW 2017, Art. 11)

The Ukrainian side has not explained when the EIA will be finished and when the EIA conclusion will be submitted to the responsible authority.

The Meeting of the Parties to the Espoo Convention (MOP) requested in its Decision VIII/4e of Dec 2020 that the Government of Ukraine completes the trans-boundary EIA; it also reaffirmed its earlier decision:

- *"(ii) Revising the final decision on the lifetime extension of reactors 1 and 2 of the Rivne nuclear power plant, taking due account of the outcomes of the environmental impact assessment procedure, including the environmental impact assessment documentation and comments received from the affected Parties, further to article 6 of the Convention;*
- *(iii) Providing the revised final decision to the affected Parties, along with the reasons and considerations on which it was based, as set out in article 6 (2) of the Convention;"*(UNECE 2020, p. 15f.)

The Ukrainian side did not inform how these requirements of the Espoo MOP will be fulfilled once the trans-boundary EIA will be completed and the EIA conclusion issued.

Therefore it remains unclear how the EIA results will be taken into account.

Question AU2

What are the further steps in the licensing procedure?

Written answer by the Ukrainian side

SS Rivne NPP of the SS NNEGC "Energoatom" is the economic operator working in the area of nuclear energy utilization. Activities in the area of nuclear energy utilization are subject to licensing according to the Laws of Ukraine, decisions of the Cabinet of Ministers of Ukraine, and regulatory documents.

Based on requirements of the Article 8 of the Law of Ukraine "On licensing activities in the area of nuclear energy utilization" the operator of SS RNPP units based on the submitted applications, following the comprehensive safety assessment of the nuclear facility, demonstration of ability to implement all safety assurance measures have received the license for activities related to the given phase of nuclear facility's lifetime, namely operation of nuclear facilities.

According to the Article 12 of the Law of Ukraine "On licensing activities in the area of nuclear energy utilization" SS RNPP of the SS NNEGC "Energoatom" to obtain the license for operation of nuclear facilities had submitted applications to the national nuclear and radiation safety regulatory authority.

The applications were supplemented with the copies of the properly certified statutory documents, the documents attesting the safety level of nuclear facilities, as well as the documents that confirm the applicant's ability to adhere to the requirements related to performance of the applied activities, and established nuclear and radiation safety norms and rules.

The list of the documents submitted with the application for license as well as requirements to their format and content are defined by the nuclear and radiation safety regulatory authority (SNRIU). Completeness and reliability of information contained in the submitted documents was verified by the nuclear and radiation safety regulatory authority through the state expert review of nuclear and radiation safety and inspection. Nuclear and radiation safety of RNPP nuclear facilities operation was confirmed, and this fact was documented in the results of the SNRIU Board activities and public hearings; required regulatory documents were prepared and required licenses were obtained for the period justified in the safety review documentation.

Lifetime extension of the SS RNPP units as well as prolongation of the licenses' validity period were carried out by the economic operator in accordance with the Law of Ukraine "On the procedure of making decision as for siting, designing and construction of nuclear facilities and installations dedicated for radioactive waste management of national significance". The Article 6 of this law envisages that decision on lifetime extension of operating nuclear facilities and installations dedicated for radioactive waste management of national significance us made by the national nuclear and radiation safety regulatory authority based on the conclusion of the state expert review of the nuclear and radiation safety level by amendment of the license for nuclear facility operation.

The licenses were amended following the procedure identical as the one for obtaining the license. To amend the license the activities envisaged by the nuclear and radiation safety codes and standards in force in Ukraine have been completed:

- Three years before the design lifetime expiration the operator developed the programs determining the scope, procedure, and deadlines for implementation of corresponding organizational and engineered measures aimed at units preparation for long-term operation. These programs and periodical safety review reports were submitted to the SNRIU. Based on the safety review results the regulatory authority determined compliance

with the target safety criteria for operating NPP units, and defined the period, modes, and conditions of the units further operation;

- periodical safety review of the units was completed. Conclusion of the state expert review of nuclear and radiation safety confirmed justification of the proposed period of further units operation that was the basis to make decision as for amendment of the licenses for nuclear facilities operation.

Thus, SS RNPP as the economic operator in the area of nuclear energy utilization had completed all licensing procedures. Safety of the activities was confirmed. Necessary licenses were obtained (amended) according to the procedure established by the Ukrainian legislation. There are no other procedures and steps in the licensing process for the economic operator in the area of nuclear energy utilization. In the future the licensing procedures envisaged by the legislation, regulations, nuclear safety codes and standards in force in Ukraine will be followed as well.

Assessment of the answer

The Ukrainian side explained in its answer the steps of the licensing procedure.

According to the answer, the operator has completed all licensing procedures and the licensing process does not foresee any further procedure.

No information has been provided at which step in this process the results of the EIA will be taken into account.

2.3 Conclusions and final recommendations

Not conducting an EIA for the lifetime extension of Rivne 1&2 is violating the Espoo Convention. The case "EIA/IC/CI/4 Ukraine" is open since 2011. The Meeting of the Parties to the Espoo Convention (MOP) requested in its Decision VIII/4e of Dec 2020 that the Government of Ukraine completes the transboundary EIA and revises the final decision on the lifetime extension of Rivne reactors 1&2 taking due account of the outcomes of the environmental impact assessment procedure.

The answers provided by the Ukrainian side did not clarify if and how such a revision of the decision on the LTE will be undertaken.

In 1998, a bilateral agreement on information exchange and cooperation in nuclear safety and radiation protection (Federal Law Gazette, BGBL 1998) between Austria and Ukraine was set up. Although until today no meetings under this agreement were conducted, it is recommended to discuss the Rivne 1&2 lifetime extension project bilaterally in regular intervals.

Final recommendations

1. Ukraine should reach full compliance with the Espoo Convention, especially with Decision VIII/4e taken by the Meeting of the Parties in December 2020.
2. Ukraine should provide adequate information how the future results of the EIA procedure will be used to revise the licensing procedure.
3. Alternatives to the lifetime extensions and the no-action alternative should be assessed in every EIA procedure for NPP lifetime extension.
4. It is recommended to enable public participation in environmental assessments of nuclear projects according to the requirements of the Espoo Convention at a time when all options are still open.

3 SPENT FUEL AND RADIOACTIVE WASTE

3.1 Short Summary of the Expert Statement

The EIA Document lacked important information on the management of the spent fuel and radioactive waste from Rivne 1&2. The expected inventory of spent fuel and radioactive waste resulting from the lifetime extension was not given.

Information on the status of the central interim storage where the spent fuel from Rivne 1&2 shall be stored (CSFSF) was lacking. No information on the final repository of spent fuel and high level waste, including the vitrified HLW resulting from reprocessing in Mayak/Russian Federation, was given.

It would be welcomed if the Ukrainian side provided more information on its national nuclear waste management plan, because spent fuel and radioactive waste can cause adverse environmental impacts.

3.2 Questions, answers and assessment of the answers

Question AU3

What is the expected inventory of spent fuel and radioactive waste from the lifetime extension of Rivne 1&2?

Written answer by the Ukrainian side

The spent nuclear fuel management technology was developed during the VVER plant designing and it envisages periodical shipment of spent nuclear fuel (SNF) to Russian Federation, its reprocessing with uranium (plutonium) segregation, and conditioning of the generated high-level waste (HLW) to the form appropriate for further storage. According to the current SNF shipment contracts it is envisaged that the HLW generated during the SNF reprocessing will be returned to Ukraine. After the units 1&2 lifetime extension in2010 the spent fuel was shipped to RF for reprocessing in the contracted volumes.

The total expected amount of spent nuclear fuel from lifetime extension of units 1&2 till 2030 is 3055 spent nuclear fuel assemblies.

The expected SRW volume from lifetime extension of units 1&2 is about 2400 m3, expected LRW volume — about 2500 m3. Available free volumes of RAW storage facilities are sufficient for waste storage during the long-term operation of the units.

Assessment of the answer

The question has been answered partially. However, information on the HLW inventory returning from Russia after reprocessing is missing.

Question AU4

What is the status of the central interim storage facility for spent fuel (CSFSF)?

Written answer by the Ukrainian side

In 2005 the SE NNEGC "Energoatom' and Holtec International (USA) signed the contract for designing and construction of the centralized spent fuel storage facility (CSFSF). In February 2009 the Cabinet of Ministers of Ukraine approved the design estimates for the CSFSF by its decision No. 131-r. In 2012 the Parliament of Ukraine adopted the Law No. 4384-VI "On spent nuclear fuel management regarding siting, designing, and construction of the centralized storage facility for spent nuclear fuel from VVER reactors of Ukrainian nuclear power plants".

As of beginning of2021, construction of the main facilities of the CSFSF first phase is completed. in 2021 it is planned to complete non-designing activities at equipment of RNPP units 1&2 and to obtain authorizations for the first SNF batch shipment to the CSFSF.

Information on the SNF volumes and storage period at the CSFSF is provided below.

Design capacity, spent fuel assemblies - 16529

including from:
VVER-l000 reactors— 12010
VVER-440 reactors —4519

Design capacity of the first phase, spent fuel assemblies – 3616

including from:
VVER-l 000 reactors — 2511
VVER-440 reactors — 1105
CSFSF design lifetime — 100 years.

Assessment of the answer

The construction of the centralized spent fuel storage facility (CSFSF) is ongoing, the main buildings are already completed. The authorization for the first spent fuel shipment to the CSFSF is planned for 2021. The question on the status of CSFSF has been answered.

Question AU5

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

Written answer by the Ukrainian side

International cooperation in part of the RAW final disposal is implemented on the permanent basis within the projects under the Instrument for Nuclear Safety Cooperation (INSC).

International cooperation is planned in the area of studying the international experience of SNF final disposal. The CSFSF design lifetime provides sufficient time and possibilities to study international experience and to make decision as for the SNF final disposal.

Assessment of the answer

The question concerning cooperation in research and knowledge exchange has been answered.

Information about a possible cooperation in a multinational repository is lacking and should be given in future bilateral contacts between the Ukrainian and the Austrian side.

Question AU6

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 the lifetime extension and decommissioning of Rivne 1&2?

Written answer by the Ukrainian side

The RAW interim storage facilities are sufficient for long-term operation of units 1&2.

According to the Law of Ukraine "On radioactive waste management" radioactive waste disposal is carried out exclusively by the specialist companies for radioactive waste management provided availability of the corresponding license granted in accordance with the established procedure, and at the specially dedicated radioactive waste storage facilities.

Construction of the RAW final disposal facilities is carried out by the specialist companies in accordance with the Law of Ukraine" On the State targeted envi-

ronmental program of radioactive waste management" and decision of the Cabinet of Ministers of Ukraine No. 990 dated 19 August 2009 "On approval of the Strategy for radioactive waste management in Ukraine".

Assessment of the answer

The question has been answered partially. In a presentation at an IAEA conference the information was provided that products from reprocessing will be returned to Ukraine after 2022. (YATSENKO 2019) Missing in the answers of the Ukrainian side is information on capacities for the storage for this HLW returning from Russia.

Also missing is information on available capacities for the decommissioning waste of Rivne 1&2.

Question AU7

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

Written answer by the Ukrainian side

In case of force-majeure situation and unavailability of the centralized spent fuel storage facility (CSFSF), the spent nuclear fuel management strategy developed during the VVER units designing phase envisages periodical SNF shipment to the RF for reprocessing and conditioning of the generated high level waste into form suitable for further storage. The CSFSF design lifetime provides sufficient time and possibilities to study international experience and to make decision as for final disposal of the SNF stored at the CSFSF.

Assessment of the answer

During the EIA procedure of Khmelnitsky 3&4 the Ukrainian side informed about two possible options – in addition to the transport to Russia – in case the necessary disposal capacities will not be ready in time. The first option was reprocessing in La Hague as a cooperation between Energoatom and the French Orano had been developed and has already been signed in 2019. The second option was the lifetime extension of the CSFSDF. (UMWELTBUNDESAMT 2019)

Information should be provided to clarify whether the cooperation with France is still an option, whether ageing management for the CSFSF is foreseen for a period beyond 100 years.

3.3 Conclusions and final recommendations

The EIA Document lacked important information on the management of the spent fuel and radioactive waste from Rivne 1&2. In the answers provided during consultations some of this missing information was given. While storage capacities for the spent fuel and radioactive waste from the lifetime extension are available or will be available in near future, it is not clear where the high level waste that will be returned from Russia after reprocessing will be stored. No information on the final repository of spent fuel and high level waste was given.

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore it is welcomed if the Ukrainian side provides more information on its national nuclear waste management plan.

Final recommendations

To demonstrate the safe management of nuclear waste detailed information on the inventory and on the status of interim storages and final disposals should be provided; also alternative nuclear waste management solutions if these facilities will not be operable in time.

4 LONG-TERM OPERATION OF REACTOR TYPE VVER 440

4.1 Short Summary of the Expert Statement

Although ageing of the 40 years old structures, buildings and equipment is a safety issue for the Rivne 1&2, it was not addressed in the EIA Report. It only refers to "Structures, systems and components aging" being a safety factor (SF) within the periodic safety review (PSR). The adverse effect of ageing depends also on the inspection, restoration and protection measures taken. A comprehensive ageing management program (AMP) is necessary to limit ageing-related failures at least to a certain degree. However, information of an ageing management programme (AMP) was not provided in the EIA Report.

Ukraine participated in the Topical Peer Review (TPR) “Ageing Management” in the framework of the implementation of the Nuclear Safety Directive 2014/87/EURATOM, carried out in 2017/18. Several “areas for improvement” were identified, i.e. deviation of the TPR expected level of performance for ageing management that should be reached to ensure consistent and acceptable management of ageing throughout Europe. The results of the TPR and the activities to remedy the weaknesses should be presented in the EIA Report, in particular the very important safety issue of the RPV embrittlement should be discussed.

Although conceptual ageing is also an issue for the Rivne 1&2, the EIA Documentation did not discuss any of the known safety issues of the VVER-440/V213 reactors. VVER 440/V213 units have several design weaknesses: the reactor building and the spent fuel pool building are relatively vulnerable against external events. VVER-440 reactors are designed as twin units, sharing many operating systems and safety systems. The sharing of safety systems increases the risk of common-cause failures affecting the safety of both reactors at the same time.

This NPP design was developed in the 1980s. It only partly meets modern design principles such as redundancy, diversity and physical separation of redundant subsystems or the preference for passive safety systems. The EIA Document neither provided a description of the safety-relevant systems, nor information about the capacities, redundancies and physical separation.

In December 2010, although safety relevant issues are not completely solved, the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) granted 20-year lifetime extensions for Rivne 1&2. The stress tests revealed 2011 that Ukrainian NPPs are compliant only with 172 of the 194 requirements according to the

IAEA Design Safety Standards published in 2000.[5] Implementation of necessary improvements is on-going under the Upgrade Package. This includes the Comprehensive (Integrated) Safety Improvement Program(C(I)SIP). The completion of the program was postponed several times. Completion is now scheduled for 2023.

Ukraine is a member of the Western European Nuclear Regulators Association's (WENRA). 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. A major update of the RLs was the revision of Issue F "Design Extension of Existing Reactors" introducing the concept of Design Extension Conditions (DEC). However, it has to be noted that Ukraine has not implemented 88 RL of the 342 as of 1 January 2019.

4.2 Questions, answers and assessment of the answers

Question AU8

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 Directive 2014/87/EURATOM?

Written answer by the Ukrainian side

The RNPP approaches to development and organization of lifetime management activities do not contradict to the provisions set forth in the Article 8e of Directive 2014/87/EURATOM.

According to requirements of the national regulations, the Operator reviews the AMP based on results of its effectiveness assessment (if necessary) but at least during each periodical safety review of the unit (i.e. every 10 years) or on demand of the nuclear and radiation safety regulatory authority.

In fact, the actual RNPP AMP for units 1&2 is revised and updated at least once a year depending on operating experience, results of the completed ageing management activities, equipment modernization, and SNRIU requests. All changes to the AMP undergo the nuclear and radiation safety review and are

[5] Under the framework of joint IAEA-EC-Ukraine projects a design evaluation was carried out to conduct an overall evaluation of the compliance of the Ukrainian NPPs design with the IAEA Safety Standards "Safety of Nuclear Power Plants: Design" (NS-R-1) published in 2000.Meanwhile, even this IAEA document is outdated; in January 2012 new safety requirements were published by IAEA (2012).

agreed with the regulator. The AMP for units 1&2 is the integrated program that was developed and agreed with the regulator with account for the nuclear safety codes and standards in force in Ukraine and the IAEA recommendations.

Assessment of the answer

The question is not answered directly. It is explained that the RNPP AMP for units 1&2 is revised and updated at least once a year depending on operating experience, results of the completed ageing management activities, equipment modernization, and SNRIU requests. The AMP for Rivne1&2 was developed and agreed with the regulator taking into account the nuclear safety codes and standards in force in Ukraine and the IAEA recommendations. No clear mention was made that the results of the TPR will be considered. However, it is understood from answer AU11 that at least the recommendations for ageing management of the RPV are taken into account.

Question AU9

What are the specific findings of the ageing management programme for Rivne 1&2?

Written answer by the Ukrainian side

Positive results of technical condition evaluation for critical elements and structures (E&S) confirm effectiveness of the existing ageing management system. Effectiveness of the E&S ageing management activities is confirmed by the following facts:

- no unit unplanned down time due to component failures caused by ageing;
- no deviations of operational parameters of the unit components subject to ageing management set forth in the operational documentation;
- no changes in the outage and maintenance frequency.

Evaluation of effectiveness of the AMP for units 1 &2 is performed based on 9 attributes with account for international experience.

Conclusions on effectiveness of RNPP AMP implementation:

- AMP for units 1&2 covers all E&S that must be included into the program according to the scoping methodology according to the regulatory documentation. For all E&S included into the AMP the ageing effects are identified and degradation mechanisms are determined. Ageing effects and degradation mechanisms are listed for all elements and structures included into the AMP lists.
- SS RNPP ageing management activities are aimed at restraining/mitigation of elements and structures degradation caused by ageing. Preventive

measures include adherence to the water chemistry norms according to the requirements Set forth in the regulatory documents.

- Identification of the ageing effects precedes achievement of the E&S limit state. For this purpose, the technical condition parameters are monitored using appropriate methods and techniques. Inspection frequency and representative samples have been identified and justified. These activities are based on performance of the in-Service metal inspection according to the established frequency and scope. Ageing effects for buildings and structures are detected during surveys and technical inspection of civil structures.
- The current technical condition evaluation results are compared against the previous results to determine the degradation rate. Information on completed inspections is registered in the technical data sheets (passports) of the corresponding equipment and pipelines. Comparative analysis of the actual and previous inspection results is performed.
- Activities (operation, maintenance, replacement, and implementation of organizational and engineered measures) are carried out that allow mitigating further degradation after the ageing effects are identified and degradation mechanisms are determined. Here, the technical condition parameters are still within the acceptance criteria.
- Acceptance criteria used to determine necessity of corrective actions ensure the E&S performing the assigned functions during the service life. Acceptance criteria are developed based on the nuclear and radiation safety codes and standards.
- Actions to be taken when acceptance criteria are not met have been identified. They are described in detail in the consolidated ageing management schedules. Corrective actions are aimed at elimination of the causes and timely prevention of degradation redevelopment as well as retaining/mitigating E&S degradation caused by ageing.
- SS RNPP determined the procedure of operating experience use with establishment of accumulation and analysis System elements, their interfaces, and functions of SS RNPP departments within activities related to use of the operating experience. The OE activities are based on systematic search, selection, and analysis of the available operating experience with its further implementation by development, incorporation, and evaluation of corrective actions' efficiency (effectiveness).
- The SS RNPP quality assurance system ensures the AMP implementation and maintaining it up-to-date.

To ensure effective ageing management of elements and structures SS RNPP uses a Set of automated information Systems that accumulate and store information containing the design data, manufacturing data, Operation and maintenance history, inspection and R&D results.

Assessment of the answer

The question has been answered to some extent. The answer describes the general AMP approach for Rivne and concluded that the existing AMP is appropriate, as there have been no unplanned shutdowns, for example. However, specific results are not provided. Furthermore, the explanations are not consistent with the results of the TPR. The TPR showed several deviations from the expected level of performance for ageing management which should be achieved in order to ensure a consistent and acceptable ageing management throughout Europe.

Question AU10

What are the results of Safety Factor (SF) 4 (structures, systems and components ageing) of the last periodic safety review?

Written answer by the Ukrainian side

Results obtained for the SF-4

On the basis of AMP evaluation criteria and based on ageing management analysis the following may be concluded:

- SS RNPP management team exercises continuous monitoring of the ageing management activities documentation process. Within the existing IMS, ageing management is organized as a systematic process. Within the process the parties have been identified, and responsibilities for work execution within the ageing management process are determined for each party. Within the SS RNPP organizational structure there is a department coordinating the matters related to ageing management;
- SS RNPP has developed, implemented, and maintains up-to-date the AMP for units 1&2. With account for accumulated experience, the AMPs were defined for each element included into the AMP list, and ageing effects and ageing mechanisms (including the dominant ones) were identified;

According to AMP for units I&2 the ageing management activities include:

- understanding of ageing phenomenon;
- ageing control;
- mitigation of ageing effects;

Understanding of ageing phenomenon is the basis for effective control and mitigation of ageing effects.

To understand ageing impact, the degradation mechanisms and consequences are studied during Operation through inspections and testing (including non-destructive examination):

- ageing monitoring is carried out through in-service inspection and testing, surveys (technical examinations carried out according to the schedules developed by departments owning the equipment), equipment maintenance performed according to the technical specifications and instructions in force at SS RNPP;
- mitigation of ageing effects includes the actions limiting degradation after its identification, namely: actions during Operation, maintenance or equipment replacement that mitigate the identified ageing effects and/or degradation of a structure/element. Actions aimed at mitigation of ageing effects include:
  - maintenance of the structure or element including repair and periodical replacement of components (parts, assemblies);
  - practical activities aimed at minimization of the rate of degradation caused by a structure or element ageing;
  - possible changes in the design and materials of the structure or element to reduce their degradation;
- periodical evaluation of the ageing management effectiveness is carried out to improve the overall AMP and ageing management programs for individual structures and elements. Analysis of the ageing management activities compliance with nine attributes performed in 2018 confirmed effectiveness of SS RNPP ageing management activities;
- evaluation of the actual condition of the AMP elements is carried out with the frequency defined by the operational and maintenance documentation. Before each outage of units 1&2 the working program of in-service metal inspection and an additional in-service metal inspection program for equipment and pipelines are developed that account for requests from the departments compiled based on operating experience. The scope and acceptance criteria for in-service inspection are defined by the regulatory documents;
- the protocols, reports, and conclusions prepared based on the metal inspection results all defects are recorded that exceed the minimum recorded level with specification of their size and location. Information on completed inspection is recorded to the technical data sheets of the corresponding equipment and pipelines;
- monitoring of the ageing effects as well as determination of the actual technical condition of the AMP elements is performed by equipment examination. Demonstration of ageing mechanisms such as stress corrosion cracking, local corrosion, corrosion fatigue, erosion corrosion, etc. is detected using non-destructive examination methods. During execution of the planned activities on technical condition evaluation within the on-going maintenance activities additional examination is carried out for compo-

nents with previously identified defects or subject to preventive maintenance works. Such approach allows evaluating effectiveness of the implemented measures;

- applied at SS RNPP monitoring and diagnostics means allow the component condition monitoring, and the established frequency and scope of testing, examination, in-service inspection, and maintenance allow keeping equipment in operable condition with account for the unit safe Operation limits and conditions;
- monitoring of ageing management activities implementation is carried out by the departments owing the equipment as well as within self-assessment of the ageing management activities. Annually a report is prepared aimed at analysis of the SS RNPP performance effectiveness in part of implementation of technical and operational measures to keep degradation of the AMP elements within the acceptable limits. Effectiveness analysis is aimed at elimination of deficiencies and improvement of the ageing management System at SS RNPP units.
- Accounting for the obtained results of technical condition prediction, and with account for ageing of elements that Limit the unit service life, availability of an effective ageing management program for SS RNPP units l&2 and implementation of the measures developed based on the safety review results, safe operation of equipment and structures is possible during the long-term Operation period till the next periodical safety review.
- As for the comments related to ageing of the structures, Systems and components, it should be noted that the periodical safety review report, SF-4 “Ageing of structures, Systems, and components“, Chapter 5 ‘Analysis of ageing effects for civil structures“ considers the following buildings and structures:
  - reactor building;
  - clvii structures of the reactor pit;
  - civil structures of the spent fuel pond;
  - electrical equipment rack;
  - civil structures of the overhead pass between the reactor building and auxiliary building No. 1;
  - civil structures of the turbine hall;
  - civil structures of the auxiliary building of units l&2;
  - civil structures of the DG Station and diesel fuel storage.

Survey, renovation, protection, monitoring and ageing effects mitigation measures, corrective actions for equipment, buildings and structures are included into the AMP for units 1&2. The regulator oversees implementation of such measures.

Assessment of the answer

The question has not been answered: Comprehensive information is given on ageing management program for the Rivne 1&2, however, the results from the review of the AMP in the framework of the most recent PSR has not been made available.

Question AU11

What are the results of the embrittlement of the reactor pressure vessels (RPVs)?

Written answer by the Ukrainian side

Radiation embrittlement is the main process that limits the service life of reactor pressure vessels (RPV) made of ferrite steel1 5X2MDA. Weld joint No. 4 located across the core is the most dangerous RPV element from the standpoint of brittle fracture resistance that determines the radiation service life of the whole RPV. To restore mechanical properties of the RPV weld joint No. 4it was annealed at unit 1 to reduce its critical brittle temperature. Analysis results for the weld joint No. 4 brittle fracture resistance confirmed that criteria of the RPV brittle fracture resistance are met till the end of operational period of 60 years (2040).

Annealing was not performed at unit 2. Analysis results for the weld joint No. 4 brittle fracture resistance confirmed that criteria of the RPV brittle fracture resistance are met till the end of operational period of 60 years (2041).

Radiation embrittlement is not a cause of cracking but it reduces metal resistance to development of crack that evolved in result of fatigue, stress corrosion or during the RPV manufacturing. The following measures were implemented to ensure the RPV brittle fracture resistance:

- use of fuel loads with reduced neutron leakage;
- primary circuit cold overpressure protection;
- ECCS water heat up to above 55°C that assists to reduction of thermal impacts onto the RPV cylinder part in emergency situations;
- interlocks for reactor protection against reactor cooldown in case of accidents with secondary steam lines rupture.

Besides, responding to the comments on participation of Ukraine in the Topical expert review (TER) “Ageing management“ within implementation of the Directive 2014/87/EURATOM on nuclear safety that was performed in 2017-2018, it should be noted that:

- according to the Decision of the SNRIU Board No. 9 dated 05.09.2019 made based on results of the WENRA National ageing management report

the following document was approved: /ENSREG: The first topical peer review. National ageing management action plan (Ukraine));

- to fulfill requirements of the SNRIU (the letter dated 09.10.2019) SS RNPP has planned the corresponding actions.

Assessment of the answer

The question has been answered to some extent, but only general information has been provided. The critical brittle temperature and the safety margins have not been reported. Concerning this issue information was only provided on the RPV weld joint No. 4 having been annealed at unit 1 to reduce its critical brittle temperature; analysis results confirmed that criteria of the RPV brittle fracture resistance are met until the end of operational period of 60 years (2040). Annealing was not performed at unit 2, because analysis results confirmed that criteria of the RPV brittle fracture resistance are met until the end of the 60-year operational period (2041).

Also, the measures to ensure the RPV brittle fracture resistance are listed.

Furthermore, it was explained that according to the SNRIU Board decision of 5 September 2019 the first Ukrainian National Action Plan on Ageing Management of was approved based on the results of the TPR. SS RNPP has planned the measures necessary to meet the SNRIU requirements.

The Topical Peer Review criticized that comprehensive Non-destructive examination (NDE) was not performed in the base material of the beltline region in order to detect defects. Additionally, it is criticized that fatigue analyses have not taken into account the environmental effect of the coolant. (ENSREG 2018)

Question AU12

Is the preparation of a systematic evaluation of the Rivne 1&2 design deviations from the current international safety standards and requirements envisaged?

Written answer by the Ukrainian side

Pursuant to section 3 [22.1.133.OB.03.07.03. "Rivne NPP. Unit 1. Safety analysis report. Additional materials on safety assessment. Volume 7. Analysis of design solutions and performance indicators. Deterministic assessment of safety level. Part 3. Analysis of deviations from requirements in force", 2019] all measures under the Safety enhancement concept for operating NPP units were included into the Consolidated safety enhancement program (CSEP, 2007). The CSEP was aimed at:

- Elimination of the operating NPP units' design deviations from the acting national safety codes and/or reduction of such deviations' safety impact by implementation of compensatory measures as well as recommendations

of the IAEA and other international organizations as for safety enhancement of Ukrainian NPPs.

- Definition of the scope of works in the area of safety enhancement required for development of long-term investment programs for each unit.

For further implementation of the safety enhancement measures at Ukrainian NPP units, the "Comprehensive (consolidated) safety enhancement program for Ukrainian NPP units" was adopted in 2010 within the National long-term strategy of safety enhancement and fulfillment of the Ukraine's international obligations.

With new codes and standards coming into effect, the lists of deviations from the safety codes' requirements were compiled. SS Rivne NPP continuously deals with development and implementation of safety enhancement measures including the ones for elimination of deviations from the safety codes and standards. The measures from the "Implementation schedule of the Comprehensive (consolidated) safety enhancement program for Ukrainian NPP units" are included into the implementation schedules for RNPP units 1&2.

The approach to classification of deviations from safety standards is similar to the IAEA principles proposed during development of the IAEA off-budget project in the document IAEA-EBP-VVER-03.

Pursuant to section 3 item 3.1 [22.l.133.ZPPB.06. Rivne NPP. Unit 1. Periodical safety review report. Volume 6. Chapter 6.Comprehensive safety analysis", 2020] implementation of the safety enhancement measures according to the "Implementation schedule of the Comprehensive (consolidated) safety enhancement program for V-213 RF" will cover the defense-in-depth improvement measures determined based on the results of safety assessments, implementation of the IAEA experts' recommendations on unit design safety enhancement, and recommendations of the IAEA and RISKAUDIT experts' recommendations on elimination of safety issues and majority of deviations.

Safe operation of the reactor facilities in compliance with international requirements was confirmed by the OSART and WANO missions reviewing compliance of operational safety level against international requirements.

SS Rivne NPP periodically receives the operational reviews, technical support missions, seminars, workshops under the auspices of the IAEA and WANO with involvement of experts from other Ukrainian NPPs and international experts. in general, both according to the SF-9 review results, and according to external independent reviews' results in this area, the SS RNPP pursuit towards improvement of the operating experience accumulation, analysis and use system to achieve full compliance with the success and quality criteria defined by the national and international requirements to this factor was confirmed.

SS Rivne NPP has implemented and uses the IMS that ensures continuous performance assessment aimed at continuous improvement at all management levels. The RNPP IMS is certified by the TÜV NORD CERT for compliance with international standards ISO900 1:2015, ISO 14001:2015 and BS OHSAS 18001:2007. Self-assessment of the IMS is carried out on the permanent basis.

Safe Operation of the reactor facilities in compliance with international requirements was confirmed by the OSART and WANO missions reviewing compliance of operational safety level against international requirements.

Assessment of the answer

The question has been answered. The answer confirms that the backfitting programmes are many years behind. According to the information provided, the 2019 Safety Analysis Report (SAR) contains an analysis of the design solutions, including an analysis of deviations from the applicable requirements. However, it is explained that the safety improvement concept measures have already been included in the 2007 consolidated safety improvement programme. For further implementation of the safety improvement measures, the "Comprehensive (Consolidated) Safety Improvement Programme for Ukrainian NPP Units" was adopted in 2010. The measures are included in the implementation plans for RNPP 1&2.

Further information stated that the IAEA OSART mission confirmed the safe operation of the plant, however, the last OSART mission took place in 2008.

Question AU13

Which safety systems and Severe Accident Management (SAM) systems are shared between the units?

Written answer by the Ukrainian side

The NPP design is based on the defense-in-depth concept ensuring prevention of:

- failure of physical barriers intactness;
- physical barriers failure in case of considered initiating events;
- physical barriers failure resulting from failure of other barriers;
- common cause failure of physical barriers.

Safety Systems and components are designed with account for the following principles:

- redundancy;
- diversity;
- physical Separation;
- single failure.

The NPP design defines and the SAR justifies engineered measures to ensure preservation of water inventory sufficient for emergency cooldown of the reactor facility in case of external hazards. The essential service water System design (a normal Operation system that combines the functions of supporting

safety system) complies with the above requirements of the codes and standards except for the shared water reservoirs of units 1&2 containing network water in part of the redundancy principle.

Assessment of the answer

The question has been answered. The essential service water system, which also provides safety functions, has a common water reservoir for both units. Furthermore, this system has duties in more than one safety level this approach is not state of the art.

Question AU14

To which extent were and will international documents (IAEA, WENRA) be applied in a binding manner for the lifetime extension?

Written answer by the Ukrainian side

In organization of works on lifetime extension and long-term Operation SS RNPP follows the national codes and standards as well as the branch documents of the SS NNEGC 'Energoatom' that were developed with account for recommendations of the following IAEA documents:

1. IAEA. Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL), IAEA Safety Reports Series No. 82, Vienna 2015
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants, Specific Safety Guide No. SSG-48, IAEA, Vienna 2018
3. IAEA-TECDOC- 1557 Assessment and Management of Ageing of Major NPP Components Important to Safety - PWR Pressure Vessel Internals, IAEA, Vienna 2007
4. IAEA-TECDOC-1556 Assessment and Management of Ageing of Major NPP Components Important to Safety - PWR Vessels, IAEA, Vienna 2008
5. Unified Procedure for Lifetime Assessment of Components and Piping in VVER NPPs "VERLIFE", version, 2008
6. IGALL Database (/gnssn.iaea.org/) - AMR tables, a collection of AMPs, a collection of TLAAs

Assessment of the answer

The question has been answered. The answer made clear that the Rivne 1&2 lifetime extension project is in line with national regulations and standards as

well as NNEGC 'Energoatom' documents developed taking into account the recommendations of IAEA documents. The WENRA publications are not mentioned, i.e. not taken into account for the LTE. Furthermore, one of the IAEA documents listed is outdated because a revision was published last year.[6]

Question AU15

When will the WENRA RL be fully implemented in the Ukrainian regulations? Is the application of the RL binding?

Written answer by the Ukrainian side
This question is not under control of the SS NNEGC "Energoatom".

Assessment of the answer
The question cannot be answered by SS NNEGC "Energoatom" as the regulatory authority is responsible for incorporating the WENRA RL into the rules and regulations. However, the updated WENRA RL were already published in 2014.

Question AU16

When will be conducted a review on whether the Rivne 1&2 meets the WENRA RL requirements?

Written answer by the Ukrainian side
Review of SS RNPP units 1&2 compliance with the WENRA RL may be conducted after incorporation of such requirements into the Ukrainian codes and standards.

Assessment of the answer
The question has been answered. However, it is not known when the WENRA RL will be transposed into the Ukrainian legislation. .

[6] IAEA. Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL), IAEA Safety Reports Series No. 82 (Rev. 1), Vienna 2020

4.3 Conclusions and final recommendations

Although ageing of the 40 years old structures, buildings and equipment is a safety issue for Rivne 1&2, it was not addressed in the EIA Document. It only refers to "Structures, systems and components aging" being a safety factor (SF) within the periodic safety review (PSR). A comprehensive ageing management program (AMP) is necessary to limit ageing-related failures at least to a certain degree. However, information of an AMP was also not provided in the EIA Document.

The ANSWERS (2021) provide only general information about the AMP. It is also stated that the existing AMP is sufficient. However, specific results are not provided. Furthermore, the explanations are not consistent with the results of the Topical Peer Review (TPR) “Ageing Management” in the framework of the implementation of the Nuclear Safety Directive 2014/87/EURATOM, carried out in 2017/18. The TPR showed several deviations from the expected level of performance for ageing management, which should be achieved in order to ensure a consistent and acceptable ageing management throughout Europe.

The results of the TPR and the activities to remedy the weaknesses should be presented in the EIA Document in particular the very important safety issue of the RPV embrittlement should be discussed. The ANSWERS (2021) provide general information about this issue but the critical brittle temperature and the safety margins are not provided.

Furthermore, it was explained that according to the SNRIU Board decision of 5 September 2019 the first Ukrainian National Action Plan on Ageing Management of was approved based on the results of the TPR. SS RNPP has planned the measures necessary to meet the SNRIU requirements.

Although conceptual ageing is also an issue for Rivne 1&2, the EIA Document did not deal with any of the known safety issues of the VVER-440/V213 reactors. VVER 440/V213 units have several design weaknesses: the reactor building and the spent fuel pool building are relatively vulnerable against external events. VVER-440 reactors are designed as twin units. The essential service water system, which also provides safety functions, has a common water reservoir for both units. The sharing of safety systems increases the risk of common-cause failures affecting the safety of both reactors at the same time. Furthermore, this system has duties in more than one safety level this approach is not state of the art.

The stress tests revealed 2011 that Ukrainian NPPs are compliant only with 172 of the 194 requirements according to the IAEA Design Safety Standards published in 2000. Implementation of necessary improvements is on-going under the Upgrade Package. The completion of the program was postponed several times. Completion is now scheduled for 2023. The ANSWERS (2021) confirms that the backfitting programmes are still ongoing. Further programmes to meet the current safety standard are not envisaged.

Ukraine is a member of WENRA. 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. A major update of the RLs was the revision of Issue F "Design Extension of Existing Reactors" introducing the concept of Design Extension Conditions (DEC). The ANSWERS (2021) reveals that the updated WENRA RL published already in 2014 are not included in the Ukrainian legislation and thus Rivne 1&2 does not have to be in line with the WENRA RL.

Final recommendations

1. Considering the fact that Ukraine has been a member of WENRA since 2015, it is recommended that the WENRA requirements be implemented in the national regulations.
2. It is recommended to implement all available design improvements of VVER-440/V213 reactor at the Rivne 1&2. This should be done by comparing the design with current safety requirements first.
3. It is recommended to compare the design and features of the Rivne 1&2 with all requirements of the WENRA Reference Levels (RL), in particular of the RL F. In case of deviations, the reasons for this should be explained.
4. It is recommended to provide additional information on:
   a. detailed descriptions of the safety systems, including information on requirements for the important safety-relevant systems and components. Furthermore, detailed description of the measures taken to control severe accidents or to mitigate their consequences.
   b. information about the applied national requirements and international recommendations.
   c. comprehensive presentation and overall assessment of all deviations from the current state-of-the-art of science and technology. This presentation should include:
      - All deviations from the modern requirements for redundancy, diversity and independence of the safety levels.
      - Incompleteness of the database and plant documentation used.
      - Presentation of all safety assessments or parameter definitions by personal expert assessments (“engineering judgement”).
      - Presentation of the general approach in dealing with uncertainties and non-knowledge and its effects on risk.
      - Deviations from the state-of-the-art of science and technology with regard to the detection methods used, the technical estimates and calculation procedures.
      - Safety margins available for the individual safety-relevant components and their respective ageing related changes compared to the original condition.
   d. Information about the ageing management program including:

- The national action plan relating to the Topical Peer Review (TPR) “Ageing Management” under the Nuclear Safety Directive 2014/87/EURATOM and its progress.
- The very important safety issue of the ageing of the RPVs (embrittlement), including definition and justification of appropriate safety margins.

5 ACCIDENT ANALYSES

5.1 Short Summary of the Expert Statement

Maintaining containment integrity under severe accident conditions is an important issue for accident management. The Rivne 1&2 severe accident management (SAM) strategy will rely on retaining corium inside the pressure vessel (in-vessel retention - IVR). However, these measures are not implemented 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.

A systematic analysis of beyond design basis accidents (BDBA) was not presented in the EIA Document. To calculate the possible (trans-boundary) consequences, it was assumed that the containment integrity will be kept up. This assumption is not justified. The used source term of a beyond design basis accident (BDBA) was chosen on the basis of safety requirements of the European operators for the design of a light water reactors (LWR). However, this limited source term can only be assumed if the plant has been designed or retrofitted accordingly. This is not the case for the Rivne 1&2.

The accident analyses in the EIA Report should use a possible source term derived from the calculation of the current PSA 2. Even though the probability of severe accidents with an early and/or large release for existing plants is estimated to be very small, the consequences caused by these accidents are very serious.

In any case, the EIA Report should contain a comprehensible justification for the source term used. In principle, possible Beyond Design Basis Accidents should be part of the EIA, irrespective of their probability of occurrence.

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 440/V213 reactor type.

The results of the EU stress tests have revealed a lot of shortcomings of the severe accident management (SAM) (i.e. the prevention of severe accidents and the mitigation of its consequences) at the Ukrainian NPPs. 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.

The stress tests showed that after decades of safety programs, Ukrainian reactors remain to be plants posing exceptionally high risk. The continuous upgrading programs did not deliver the promised results. The ENSREG peer review team pointed to one of the main problems, which are characteristic of nuclear safety in the Ukraine: the constant severe delay of the implementation of upgrading measures.

The WENRA "Safety Objectives for New Power Reactors" should be used as a reference for identifying reasonably practicable safety improvements for the Rivne 1&2. However, the EIA Document did not mention these WENRA safety objectives although Ukraine is a member of WENRA. The most ambitious WENRA safety objective intends to reduce potential radioactive releases to the environment from accidents with core melt. Accidents with core melt which would lead to early or large releases would have to be practically eliminated. Practical elimination of an accident sequence cannot be claimed solely based on compliance with a general cut-off probabilistic value. Even if the probability of an accident sequence is very low, any additional reasonably practicable design features, operational measures or accident management procedures to lower the risk further should be implemented. The concept of "practical elimination" of early or large releases was not mentioned for Rivne NPP in the EIA Document.

5.2 Questions, answers and assessment of the answers

Question AU17

What are the source terms of the calculated BDBA in the PSA 2 including releases from the spent fuel pools?

Written answer by the Ukrainian side

Calculation results for individual isotopes releases in case of BDBA at the reactor and spent fuel pond are provided in the following documents:

- 22.1.133.OB.04.06.04. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. Annex VI. Calculations and analytical justification of accident process behavior. Book 4. Severe accident analysis for the reactor facility. 2020.
- 3813 l0.203.003.OTO1-04 (2-RUTA-AO-RAES). Rivne NPP. Unit 2. Development of analytical justification of the severe accident management strategies and SAMG development for RNPP unit 2. Phase 3. Analytical justification of the severe accident management guideline (SAMG) for RNPP unit 2. 2015.

Assessment of the answer

The question is not answered. It mentions that a safety analysis report including a PSA exists but neither the report nor the results are provided.

Question AU18

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

Written answer by the Ukrainian side

Implementation of the filtered venting System was not considered in the modernization projects for VVER-440 units.

Assessment of the answer

The question is answered. The information given in the answer is very interesting as it states that a filtered venting system is not considered in the modernisation project. The planned forced containment system is apparently an unfiltered pressure relief system.

Question AU19

What is the currently valid time schedule for the implementation of all required SAM features for the Rivne 1&2?

Written answer by the Ukrainian side

The following actions have been completed for RNPP units l&2:

1. Makeup lines from the mobile pumping units in case of long-term station blackout for:
   - spent fuel storage pond;
   - additional SG feedwater system tanks;
   - group A service water consumers in case of the spray ponds dewatering.
2. Electrical power supply restoration for the 0.4 kV safety trains under the long-term station blackout conditions using the mobile diesel generator.
3. Hydrogen concentration monitoring system in the SG compartment, RCP compartment, and PRZ compartment.
4. Emergency and post-accident monitoring system in case of long-term Station blackout.
5. Analysis of possibility of the corium in-vessel retention Strategy implementation.

The following measures are going on:

- Reactor pressure vessel (RPV) external cooling (deadline — 2022);

- System of hydrogen concentration reduction inside the containment for beyond design basis accidents (deadline — 2023);
- Forced containment venting system (deadline — 2023).

Assessment of the answer
The question is answered. The measures are planned to be finished in 2023. The most important measures to cope at least to some extent with a severe accident are not implemented yet.

Question AU20

What are the parameters of the maximum aircraft crash (plane mass and speed) the buildings of the Rivne 1&2 can withstand?

Written answer by the Ukrainian side
In the PSA it is conservatively assumed that a crash of any plane or helicopter onto the buildings of RNPP units 1 &2 would result in damage of such buildings. In such case the summary frequency of an aircraft crash at the reactor building of the unit is 3.11E-07 per year [22.1.133.OB.04.10.Rev.1. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. Annex X. Externalhazards.2020].

Assessment of the answer
The question is not answered. It is only stated which report contains this information.

Question AU21

What is the technical justification of the BDBA that is chosen to calculate possible trans-boundary consequences?

Written answer by the Ukrainian side

When determining the radionuclide release during the beyond design basis accident (BDBA), the limit value of Cs-137 release into the environment at the level of 30 TBq was taken as the basis, in accordance with the safety requirements of European operating organizations for designs of nuclear power plant with light-water reactors. The Cs-137 isotope was chosen because of its dominant importance for long-term environmental contamination, as well as its effect on the health consequences.

Other isotopes in the form of aerosols (that is, all radioactive decay products, except for noble gases and gaseous isotopes of iodine) are released into the environment in proportion to this value, even if these isotopes are released into the atmosphere.

For noble gases and gaseous forms of iodine, the activity of release was calculated at the level of 0.5% of all activity in the containment per day. The total release activity over the entire release period was conservatively set at level of 7-times release activity during the first day.

The height of release is conservatively considered as near-surface, which corresponds to the predicted release routes in case of serious accidents due to leakage of containment.

Into the general list of radionuclides that can enter the environment, in addition to the isotopes taken as an example, other radioisotopes from the same group are added, and they are represented in a common term in the same ratio as in the aggregate of decay products in the reactor core, relative to isotope taken as an example.

When calculating the dose of the proposed source member, it is recommended to take into account the release of individual radioisotopes, in accordance with a time interval of linear duration from 0 to 24 hours after the accident, which is a conservative approach compared with the considered release duration of 7 days.

Table. 3.5 (Book 7, "Transboundary environmental impact of production activities") provides the parameters for the release of radionuclides during the maximum design basis accident. The duration of this accident is assumed to be 60 minutes. All other accidents leading to lower releases of radionuclides are not considered.

Table 1 (3.5): Activity of radionuclides releases during the maximum design basis accident (MDBA) at RNPP, Bq2

Radionuclide	***Half life***	***Release at MDBA, Bq***
Kr-88	2.84 years	2.00E+13
Sr-90	29.1 years	3.10E+11
Ru-103	39.6 years	4.50E+12
Ru-106	1.01 years	6.60E+11
I-131	8.04 days	4.98E+12
I-132	2.3 years	2.70E+12
I-133	20.8 years	4.00E+12
I-135	6.61 years	2.30E+12
Cs-134	2.06 years	7.80E+11
Cs-137	30.0 years	5.00E+11
La-140	1.68 days	8.40E+12
Ce-141	35.2 days	1.40E+13
Ce-144	284 days	8.60E+12

The main radionuclides and their release during the beyond design basis accident are given in table. 3.6. (Book 7 "Transboundary environmental impact of production activities").

Also, the contribution of Xe-135, Xe-137 was calculated and shown, and the corresponding conclusions were drawn.

The expected effective doses for the population after MDBA and BDBA are small compared to the natural radiation background. According to the report of the UN Scientific Committee on the effects of atomic radiation presented to the UN General Assembly for 1993, the annual effective dose from natural sources of radiation in areas with normal radiation background is 2.4 mSv, that is, over 50 years, this dose will be 120 mSv. And during BDBA the expected dose over 50 years is less than 13 mSv for all countries.

Table 3 (3.6): Activity of radionuclides releases during the beyond design basis accident at RNPP, Bq

Radionuclide	Release, TBq	Radionuclide	Release, TBq
Xe-133	3,50E+05	Cs-136	1.50E+01
Kr-85	2.10E+03	Te-131m	2.00E+01
Kr-85m	5.30E+04	Te-129m	8.00E+00
Kr-87	1.10E+05	Te-132	2.00E+02
Kr-88	1.40E+05	Sb-127	1.60E+01
Xe-131m	2.10E+03	Sb-129	4.60E+01
Xe-133m	1.10E+04	Sr-90	5.00E+00
Xe-135	1.10E+05	Sr-89	6.00E+01
Xe-135m	7.70E+04	Sr-91	7.50E+01
Xe-138	3.20E+05	Ru-103	3.00E+00
I-131	1.00E+03	Mo-99	4.00E+00
I-132	1.50E+03	La-140	5.00E+00
I-133	2.10E+03	Y-91	4.00E+00
I-134	2.30E+03	Ce-141	4.00E+00
I-135	2.00E+03	Ce-144	3.00E+00
Cs-137	3.00E+01	Np-239	4.80E+01
Cs-134	6.00E+01	Ba-140	1.00E+02

The relative contribution of various nuclides to the expected effective dose at a distance of 340 km from the RNPP during BDBA is shown in the diagram below.

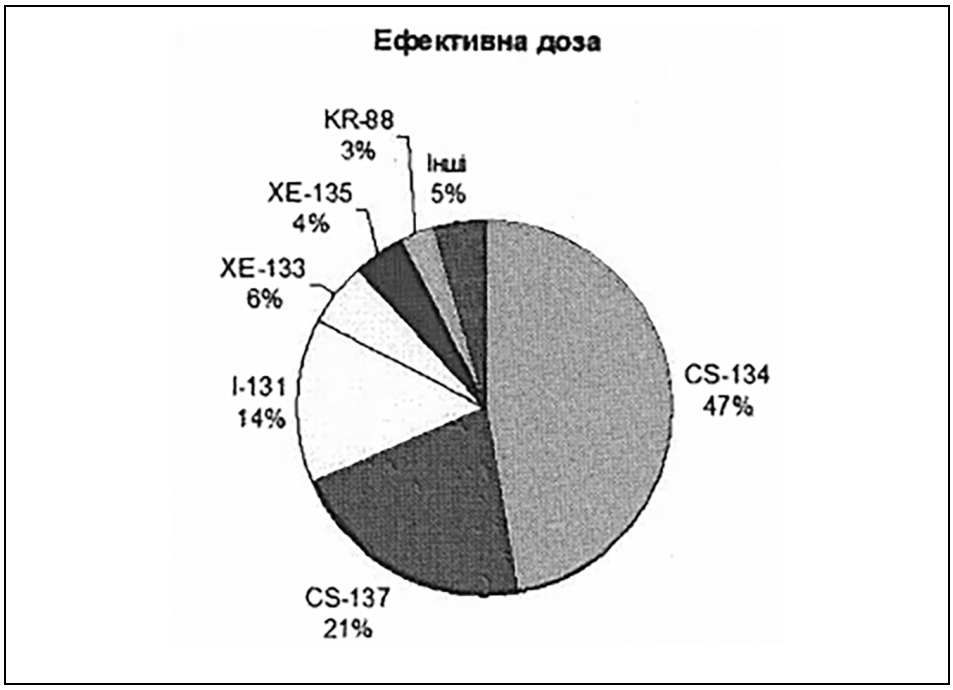

Figure 1: Relative contribution of various nuclides to the expected effective dose at 340 km distance during BDBA

As follows from the data on the diagram, the largest contributions are made by cesium isotopes: 134Cs - 47% and 137Cs - 21%. Inert gases: 133Xe, l35Xe and 88Kr also make a noticeable contribution to the total effective dose. The total contribution of the remaining 29 nuclides during BDBA is less than 5%.

Assessment of the answer

The question is only answered partly. The question aims in particular to the technical justification of the Cs-137 source term (30 TBq). It is confirmed in the ANSWERS (2021) that the limit value of the Cs-137 release was taken as the basis, in accordance with the safety requirements of European operators for the design of a light water reactors but without technical justification for Rivne 1,2. As already explained in UMWELTBUNDESAMT (2021), this assumption is not justified.

5.3 Conclusions and final recommendations

Maintaining containment integrity under severe accident conditions is an important issue for accident management. The Rivne 1&2 severe accident management (SAM) strategy will rely on retaining corium inside the pressure vessel (in-vessel retention - IVR). However, these measures are not implemented 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. The ANSWERS (2021) revealed that a filtered containment venting system will not be implemented.

A systematic analysis of beyond design basis accidents (BDBA) was not presented in the EIA Document. To calculate the possible (trans-boundary) consequences, it was assumed that the containment integrity will be maintained. This assumption is not justified. The used source term of a beyond design basis accident (BDBA) was chosen on the basis of safety requirements of the European operators for the design of a light water reactors (LWR). However, this limited source term can only be assumed if the plant has been designed or retrofitted accordingly. This is not the case for Rivne 1&2.

The accident analyses in the EIA Document should use a possible source term derived from the calculation of the current PSA 2. Even though the probability of severe accidents with an early and/or large release for existing plants is estimated to be very small, the consequences caused by these accidents are very serious. In principle, possible Beyond Design Basis Accidents should be part of the EIA, irrespective of their probability of occurrence.

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 440/V213 reactor type.

The results of the EU stress tests have revealed a lot of shortcomings of the severe accident management (SAM) (i.e. the prevention of severe accidents and the mitigation of its consequences) at the Ukrainian NPPs. 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.

The stress tests showed that after decades of safety programs, Ukrainian reactors remain to be plants posing exceptionally high risk. The continuous upgrading programs did not deliver the promised results. The ENSREG peer review team pointed to one of the main problems, which are characteristic of nuclear safety in the Ukraine: the constant severe delay of the implementation of upgrading measures. According to the ANSWERS (2021), the implementation of the necessary Severe Accident Measures (SAM) will be only ready in 2023.

Bearing in mind that Ukraine is a member of WENRA the WENRA “Safety Objectives for New Power Reactors” should be used as a reference for identifying reasonably practicable safety improvements for Rivne 1&2. The most ambitious WENRA safety objective intends to reduce potential radioactive releases to the environment from accidents with core melt. Accidents with core melt which would lead to early or large releases would have to be practically eliminated. Even if the probability of an accident sequence is very low, any additional reasonably practicable design features, operational measures or accident management procedures to further lower the risk should be implemented. Neither the concept of "practical elimination" of early or large releases nor the WENRA safety objectives are used in the Rivne 1&2 life extension project.

Not even the WENRA RLs for existing NPPs have been used in the lifetime extension project to meet the agreed safety level in the EU, as these have not yet been adopted into Ukraine's regulatory framework.

Final recommendations

1. It is recommended to use the WENRA Safety Objectives for new NPP to identify reasonably practicable safety improvements for Rivne 1&2. It is recommended to use the concept of practical elimination for this approach.
2. It is recommended to provide the following information concerning accident analyses and the results of the PSA (Level 1, 2 und 3):
   a. Core damage frequency (CDF) and large (early) releases frequency (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 beyond design basis accidents (BDBAs)
   d. Source terms of the BDBAs including releases from the spent fuel pools
   e. Time spans to restore the safety functions after the loss of heat removal and/or station-blackout and cliff edge effects.

6 ACCIDENTS INITIATED BY NATURAL EVENTS AND SITE ASSESSMENT

6.1 Short Summary of the Expert Statement

The assessment of natural phenomena that may have adverse effects on the safety of Rivne NPP is restricted to a rather small number of hazard types. The EIA Document fails to demonstrate that the site assessment considered all natural hazards that apply to the site.

The expert team recommended the use of a generic list of natural hazards as a start for hazard screening and the identification of relevant hazard combinations (e.g., WENRA 2015; DECKER & BRINKMAN 2017) to demonstrate that all relevant hazards and hazard combinations are addressed.

Hazard severities for occurrence probabilities of 10-4 per year have been determined for several, but not all hazards considered in the EIA Document. These results, however, are not followed-up to define design basis events and develop adequate protection concepts in a strict way. This is particularly the case for external flooding by extreme precipitation, drought/lack of cooling water, high wind, tornado, snow load/snow storm and extreme temperatures.

Adequate protection against several hazards is currently not in place. This is most important for:

- flooding by extreme precipitation for which the current design only protects against events with occurrence probabilities of 10-1 per year;
- high wind for which the EIA Document shows that storms with occurrence probabilities of 1.40E-3 can lead to failure of the essential service water system;

We assume that the low withstand of the cooling system against wind loads and other meteorological hazards are important factors for the high CDF value[7] described in the EIA Document ("The conditional probability of core damage due to the failure of the essential service water system is 6,93E-03").Such a high CDF value seems unacceptable when compared to regulations and safety expectations for existing NPPs that are in place in most of the WENRA countries.

Karstification and suffusion pose significant threats to the safety of the NPP Rivne by the possible destabilization of the foundation soil of the reactor buildings and containments, buildings that house safety-relevant SSCs, safety-relevant underground piping and the cooling towers. Information provided by the EIA Document proves that the operation of the NPP leads to the lasting seepage of large amounts of technical water that has the potential to increase karstifica-

[7] In the majority of WENRA countries and in the Ukraine the Core Damage Frequency (CDF) shall not exceed the value of 10^{-4} per year. Some WENRA countries require CDF≤10^{-5} per year.

tion and suffusion, and to destabilize foundation soils. Human-made karstification and suffusion are slow but self-enhancing. Both processes were set off by the start-up of the NPP in the 1970ies. The experts expect that the intensity of the erosion of the foundation soil increases with time, and that the safety relevance of karstification and suffusion will increase during the continued operation of the NPP.

Design Extension Conditions (DEC) are not analysed in the available EIA Document. This is in violation of the WENRA requirement that DEC analysis shall be undertaken with the purpose of further improving the safety of existing nuclear power plants and enhancing their capability to withstand more challenging events or conditions than those considered in the design basis. Related requirements and procedures are provided by WENRA (2020) and WENRA (2014). The experts recommended extending the efforts with respect to natural hazard analysis and develop adequate protection concepts for natural hazards in line with the WENRA DEC approach.

6.2 Questions, answers and assessment of the answers

Preliminary remark of the Ukrainian side on chapter 6

General Information regarding analysis of the accident caused by natural events and site assessment

As the EIA report was prepared in 2018, it used the actual results of the probabilistic safety assessment (PSA) for RNPP units l&2 as of 3l.03.2014. Within the current periodical safety review for units 1&2 the PSA and SF-6,7 of the periodical safety review reports were updated as of 01.07.2018. The updated materials contain a much wider list of external hazards that were subject to safety impact review, and account for upgrading measures implemented at units 1&2 as of 01.07.2018, including the measures developed based on the lessons learnt from the Fukushima accident.

Documents:

1. 22.1.133.OB.04.10.Rev.l. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. Annex X. External hazards. 2020.
2. 22.1 133.OB.12.03.Rev.l. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. PSA update report.2020.#
3. 22.l.133.OPPI3.02.03. Rivne NPP. Unit 1. Periodical safety review report, Safety factor 7. Chapter 2. Unit safety analysis. PART 3. Analysis of safety impact from internal and external events. 2020

Assessment of the preliminary remark

The experts appreciate the clarification of the currentness of the data provided in EIA Report Book 1 (2018). It is, however, not understood why the documentation for the Environmental Impact Assessment (EIA) for the lifetime extension of the reactors Rivne 1&2 under the Espoo Convention are seemingly based outdated documents. The cited documents are not available to the expert team. It is therefore not possible to judge whether or not a comprehensive hazard assessment including all steps required by WENRA (2020, Issue T) has been performed.

Question AU22

Why has flooding due to extreme precipitation been excluded from the further consideration of natural hazards?

Written answer by the Ukrainian side

Floods caused by extreme precipitations have been analyzed in the PSA. Based on the analysis results it was defined that heavy rains may result in malfunction of the open switchyard equipment and other normal power supply system equipment that may cause initiating events of the group "Loss of all 6 kV house loads power supply buses" that is considered in the Level 1 PSA for internal initiating events. This group covers, in particular, events associated with the loss of external (open switchyard and the grid) and internal power supply sources of the unit. In IE frequency determination for the Level 1 PSA for internal events based on statistics of actual operational occurrences various initiators were accounted for including the IE caused by external factors. The IE group "Loss of all 6 kV houseloads power supply buses' frequency for RNPP units 1&2 is 3.29E-02 per year, and conditional core damage probability (CCDF) for these IE is 3,86T-06 that proves high potential of the units to achieve safe state in case of such IE occurrence.

Documents:

1. 22.l.133.OB.04.l0.Rev.1. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. Annex X. External hazards. 2020.
2. 22.1.133.OB.12.03.Rev.l. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. PSA update report. 2020.

Assessment of the answer

The answer clarifies that some aspects of flooding by extreme precipitation have been considered in the safety demonstration. It remains, however, unclear if also other possible effects such as the flooding of subsurface rooms housing

SSCs important to safety or water ingress via roofs or openings of buildings have been analysed in detail.

Question AU23

The probability of the water level of the River Styr to drop below the critical value of 158.80 m in case of drought is stated with 0.3% per year. Would the dropping of the water level even lower result in the full unavailability of cooling water from the River Styr?

Written answer by the Ukrainian side

Abnormal water level reduction in the River Styr does not pose danger for NPP structures and components. The impact of abnormal river water level drop onto the pumping Station of makeup water cannot cause an initiating event in accordance with the approach adopted in the probabilistic risk assessment. In case of abnormal water level drop in the River Styr, failure of the pumping Station of makeup water, and impossibility to make up the circulating water system the units will be shut down in a planned manner.

SS RNPP has developed and applies the "Guideline on prevention of operational occurrences at SS RNPP in case of water level drop in the in the River Styr". The document defines several scenarios of human actions depending on the criteria (up to units disconnection from the grid and brining reactors to the Cold Shutdown state that is a standard mode of normal Operation).

Assessment of the answer

The answer clarifies that operating procedures are in place to mitigate the consequences of a possible loss of makeup water from the River Styr.

Question AU24

Are the water reserves at the primary and secondary circuits of the VVER units large enough to cool all four reactors after shutdown from full power and maintain cooling until a safe state is reached in cases when no cooling water is available from River Styr?

Written answer by the Ukrainian side

In case of complete loss of water supply from the Styr (failure of the makeup water system) is considered within the probabilistic safety assessment and additional targeted safety review for Rivne NPP units. A failure of the makeup water system may result in termination of water supply from the essential and non-essential service water systems. In such case the units must be shut down and heat removal would be arranged using the stationary systems. Water from the cooling towers' bowl, supply and discharge channels of the circulation water system may be used as an additional source to ensure water supply to essential loads of the primary and secondary circuits that are involved into normal operation and remain in operation to cope with emergency situations. The circulation water system inventory is sufficient to maintain the RNPP units in safe state for 27 days.

In extreme situations it is envisaged to supply cooling water of drinking water quality from two independent water intakes.

1. 1. 22.I.133.OB.04.I0.Rev.I. Rivne NPP. Unit 1. Safety analysis report. Probabilistic safety assessment. Annex X. External hazards.2020.
2. 2. OTsPB-0.4 1.002.02. Additional targeted safety review for RNPP units with account for the lessons learnt from the Fukushima accident. Chapter 2. Extemal hazards assessment. 2012.

Assessment of the answer

The answer confirms that the water reserves in place are sufficient to mitigate the consequences of a loss of makeup water from the River Styr and maintain the plant in a safe shutdown state for a sufficiently long enough time.

Question AU25

Is it intended to equip the Rivne NPP with a second, independent cooling water supply such as ground water wells to ensure the availability of cooling water/essential service water in case of low river water levels and drought?

Written answer by the Ukrainian side

Complete loss of water supply from the River Styr (failure of the makeup water system) is considered within the probabilistic risk assessment and additional targeted safety re-assessment for RNPP units. A failure of the makeup water system may result in termination of water supply from the normal and essential service water systems. In such case the units must be shut down, and residual heat removal will be arranged using the stationary systems. Water from the cooling towers' bowls as well as from the inflow and outflow channels of the circulating water system may be used an additional source of water to supply essential loads of the primary and secondary circuits involved into normal Operation and remaining in Operation during mitigation of emergency situations. The circulating water system's inventory is sufficient to keep the RNPP units safe for 27 days.

In extreme situations there is a possibility of drinking-water quality cooling water supply from two independent underground water intake wells.

Assessment of the answer

The answer confirms that water reserves in place are sufficient to mitigate the consequences of a loss of makeup water from the River Styr and maintain the plant in a safe shutdown state for a sufficiently long time.

Question AU26

With respect to snow loads the EIA REPORT BOOK 1 (2018, p. 109) refers to a "current normative document" that sets the normative values of the snow load for the Rivne region to 1,400 Pa. This value is above the original design. What are the consequences of this discrepancy between the status as-built and the current requirements for buildings housing safety-relevant SSCs of the Rivne reactors?

Written answer by the Ukrainian side

Verification calculations of civil structures of the buildings and facilities housing the safety-related systems for resistance to loads and impacts regulated by the acting Ukrainian regulations in the area of construction were performed during the lifetime extension ofunits1&2.

The snow load of 1400 Pa (for Rivne region) was accounted for according to the acting Ukrainian construction norms in the verification calculations for civil structures of units 1 &2.

According to results of the performed verification calculations, safety and reliability of civil structures is ensured from the standpoint of load bearing capacity and strain capacity during the long-term Operation in all operational modes including the most unfavourable external impacts.

Thus, discrepancy between the as-built and current requirements for buildings and structures does not impact reliable operation of the buildings housing the safety-related equipment.

Assessment of the answer

The answer of the Ukrainian side asserts that the civil structures of the Rivne NPP have the capacity to withstand the normative values of the snow load for the Rivne region, i.e., 1,400 Pa.

Question AU27

Terminology used for the description of seismic hazards in the EIA REPORT BOOK 3 VOL 3 (2018, p. 718ff) appears unclear. The experts had to assume that the "design basis earthquake (DBE)", also termed "Project Earthquake (PE)", refers to SL-1 as used by IAEA (2010) and the "safe shutdown earthquake (SSE)", also termed "maximum estimated earthquake (MEE)", refers to SL-2 (IAEA, 2010) or the Design Basis Earthquake (WENRA, 2014a; 2015). Also they assumed further that terms like "5 point", "6 point", "magnitude 5", "magnitude 6" refer to intensity (MSK-64 scale) instead of magnitude. Is this correct?

Written answer by the Ukrainian side

The maximum estimated earthquake (MEE) — an earthquake with the maximum expected intensity at the NPP site with occurrence frequency per 10000 years (NP 306.2.208-2016).

Project earthquake (PE) - an earthquake with expected intensity at the NPP site with occurrence frequency per 100 years for operating NPP units and once every 1000 years for new NPP units (NP 306.2.208-2016).

According to the document "Designing and qualification of seismic resistant structures of nuclear power plants. Guideline NS-G1.6", the LS- 1 refers to the project earthquake, and SL-2 refers to the maximum estimated earthquake.

The terms "5 points", "6 points", "magnitude 5", and "magnitude 6" refer to intensity according to the MSK-64 scale.

Actually, the terms «design basis earthquake» and «project earthquake» are equivalent (SL-1). The same refers to the terms «safe shutdown earthquake» and «maximum estimated earthquake» (SL-2). Different terminology is the result of incorrect translation into English. The terms "magnitude 5", "magnitude 6" actually refer to the earthquake intensity 5 and 6 according to MSK-64.

Assessment of the answer

The Ukrainian side clarifies the terminological issue of seismic safety levels and the use of the terms earthquake magnitude vs. terminology exhaustively.

Question AU28

EIA includes contradicting information about the recurrence interval of "maximum estimated earthquake" (also termed "safe shutdown earthquake") with I=6. Both, values of 5,000 and 10,000 years are stated as recurrence intervals. The experts ask for the clarification of this contradiction.

Written answer by the Ukrainian side

The recurrence value of 5000 years for the safe shutdown earthquake is erroneous. An earthquake of the maximum expected intensity is assumed as the "maximum estimated earthquake" at the NPP site with recurrence of 10000 years. For RNPP site such an earthquake is 1=6 earthquake that is confirmed by the studies [Rivne NPP. Unit 4. Technical report on results of additional seismic hazard studies. 2001].

Assessment of the answer

The Ukrainian answer fully clarifies the subject.

Question AU29

It appears that I=VI MSK64 is associated with Peak Ground Acceleration (PGA) of 0.05g. What is the basis for such a correlation between macro-seismic intensity and ground acceleration?

Written answer by the Ukrainian side

According to the acting Ukrainian construction norms Rivne NPP is related to the territory for which the maximum estimated earthquake intensity is 6 per MSK-64 that corresponds to the plant design value.

The peak ground acceleration (PGA) of0.05g corresponds to the intensity 6 per MSK-64.

Assessment of the answer

The answer does not clarify the question. Empirical correlations between intensity and peak ground acceleration (PGA) are generally characterized by large uncertainties. The empirical correlation by Trifuniak and Brady[8] (1975; 1976) suggests that intensity 6 correlates to a PGA of about 0.08 g. The experts assume that the value of 0.05 g stated in the Ukrainian reply derives from Russian normative documents, possibly NP-031-02 which correlates intensity 6 MSK with a PGA of 0.5 g.

The experts note that seismic hazard assessments based on intensity do not correspond to the current state of science and technology. State of the art probabilistic seismic hazard assessment should be based on (moment) magnitude. It is recommended to update the hazard assessment according to the actual WENRA regulations and guidelines (WENRA, 2016; 2020).

Question AU30

The IEA document mentions additional seismic hazard assessments that were performed in the late 1990ies and early 2000nds. These, however, are not further explained in the EIA Document. The experts ask to provide those references and results of these investigations for the Rivne NPP site.

Written answer by the Ukrainian side

The last comprehensive seismic safety studies of SS RNPP site territory were performed in 1999-2001.

In course of additional examination of the SS RNPP site seismic safety the experts of the Geophysics Institute of the National Academy of Science of Ukraine performed the seismic hazard assessment using deterministic approach and probabilistic assessment based on the lineament-domain approach.

These, however, are not based on calculation results for seismic impact characteristics for SS RNPP site according to the traditional deterministic method the seismic impact intensity for PE equals to 5, and for MEE equals to 6 according to MSK-64.

[8] log PGAv = - 0.18 + 0.30 I_0 (cm/s²) (vertical component of ground acceleration)
log PGAh = 0.014 + 0.30 I_0 (cm/s²) (horizontal component of ground acceleration)

Assessment of the answer

The question is not answered.

The Ukrainian side confirms the existence of seismic hazard assessments that were performed in 1999-2001. Information about the results of these studies, however, is not provided. It remains unclear whether or not the studies confirm the original seismic design base basis values.

On the background that (a) the original, intensity-based seismic hazard assessment for Rivne NPP does not conform with the current state of science and technology (see Question AU29), and (b) the advance of science and technology since the last seismic hazard assessment in 2001, the expert team suggests to consider performing a new full-scope seismic hazard assessment for the Rivne site.

The suggestion conforms with the WENRA Safety Reference Levels, Issue P, Periodic Safety Reviews (PSR), Reference Level 2.2 (h) that requires reviews of the site-specific hazard assessment in the course of PSR. In addition, WENRA (2016), Chapter 07 particularly suggests regular reviews of the site specific seismic hazard.

Question AU31

Karstification and suffusion are listed as hazardous phenomena destabilizing the soil under the NPP site, also under the reactor buildings. According to the EIA Report Book 3 Volume 3, (2018, p.721-722) the foundations for unit 4 are laid on piles reaching below the karstified layer into basalt. Are the foundations of the other reactor units constructed in the same way? Are the concrete injections sufficient to stabilize fundaments of the other blocks? How is the stability of foundations secured for other buildings housing safety-relevant equipment and safety-relevant underground piping?

Written answer by the Ukrainian side

There are four units in Operation at the RNPP site. Essential structures of unit 4 are built on the piles reaching into basalt, i.e. passing through the layers subject to karstification impact, thus ensuring their reliable Operation.

Resistance of the rest of buildings and structures of unit 4 and buildings and structures of units 1,2, 3 is improved owing to cementation of the chalk layer and basalt contact area. Simultaneously with cementation reinforcement of

soils was done using the well-and-injection tubes passing through the chalk layer.

Technical report "Comprehensive analysis of geophysical, hydrogeological, and geodetic survey with account for engineering and geological sile conditions and man-caused impact onto the geological environment between 20/0 and 2018, and prediction of the SSRNPP buildings' and structures' settlement and careen till 2030" was developed in 2019.

Conclusions of the above Technical Report specify, in particular:

- Settlement and careen of all facilities located at the SS RNPP site arc within the allowed values and do not impact safe operation of buildings and structures.
- Cementation of the chalk layer besides prevention of the possible suffusion processes assisted improvement of the strain capacity of the soil foundation that, actually, can explain absence of significant settlement of buildings and structures that were observed in2010-2018.
- When defining effectiveness of chalk layer cementation in the foundation of buildings and structures located within the SS RNPP site, possibility of additional settlement and careen deformations development due to rheological processes in the loaded soil mass, determines necessity of continuous geodetic monitoring of buildings and structures to detect unpredicted deformations in the soil foundations.
- Providing non-excess of the bad carrying capacity of the cemented soil foundation by current loads, activation and development of negative deformation processes should not be expected at such areas till 2030.

For anthropogenic safety assurance the SS RNPP performs continuous condition monitoring of soils, buildings and structures of units 1÷4 and of the rest of the site:

- hydrogeological monitoring of the ground waters (monitoring of the underground water level and temperature, its chemical composition) at 193 hydrogeological monitoring wells;
- monitoring of soil humidity and density under the foundations of buildings and structures using radioisotopic logging at 193 geophysical wells;
- monitoring of buildings and structures settlement and careen using 3288 settlement marks;
- inspection of buildings and structures;
- monthly survey of the plant site for suffusion and karst occurrences.

Currently the site geological environment is balanced, corresponds to geotechnical properties of the soils at the foundations of buildings and structures, and ensures reliable Operation of buildings and structures.

Over the last 39 years of SS RNPP site observations there were no cases of identified suffusion and karst development at the ground surface.

Assessment of the answer

The answer provides comprehensive information on the technical measures in place to avoid ground settlement by karstification and suffusion.

Question AU32

How is sewage water removed from the site? Is it secured that concentrated seepage of sewage water from surface runoffs and/or direct infiltration of sewage water does not lead to extended man-made karstification and suffusion?

Written answer by the Ukrainian side

The SS RNPP site design envisages the site improvement measures including:

- vertical planning and water removal lines that ensure prompt collection and removal of rainwater and surface water to the rainwater concentrated seepage of sewage system;
- paving next to buildings and structures including extended asphalting and paving of territory around the cooling towers.

The existing rainwater sewage system and treatment facilities cope with rainwater removal from the SS RNPP site. There is no water stagnation observed at the territory. Thus, there is no significant surface water impact onto activation of suffusion and karstification processes.

Assessment of the answer

The answer provides sufficient information on site improvement measures that are envisaged to reduce the infiltration of precipitation and lessen the contribution of surface water to ongoing karstification and suffusion processes.

Question AU33

The formation of a "ground water dome" at the site proves the continued outflow of large amounts of water from the hydro-engineering installations. How is it secured that these outflows do not destabilize the foundation soil by increased karstification and suffusion? Are the cooling towers, cooling water channels and pipes, which are supposed to be the sources of infiltrating water, subjected to a monitoring program to secure their stability? Are those structures made of watertight concrete or lined with other impermeable materials? What are the measures envisaged to reduce or prevent the infiltration of technical water and reduce karstification / suffusion processes?

Written answer by the Ukrainian side

12.1. Before construction had started, the natural groundwater ridge was located at the site territory in the area of outflow channel of unit 4 and cooling towers 5&6 with the absolute ridge elevation 178,60 m. Over the SS RNPP operation period some migration of the ridge top was observed between units 1 &2 and 4. As of 31.12.2020 the groundwater level exceeds the natural level by 1,97 m.

Additional engineering and research studies performed in 2008-2019 have not identified notable changes in hydrogeological environment and geotechnical properties of soils.

Cementation of the chalk layer and basalt contact area was performed under the units' buildings and structures. At the same time the soils were reinforced with well-and-injection tubes passing through the chalk layer. There were no cases of suffusion and karstification identified at the mentioned territory over the whole plant operation period.

12.2. To ensure stable operation of hydraulic facilities the quarterly condition monitoring of the hydraulic facilities' civil structures is carried out according to the approved schedule.

Pursuant to operational documentation, hydraulic facilities surveys are performed every 15 days, and extraordinary surveys are performed following the extreme meteorological events (heavy snowfalls, heavy rains, strong wind, hurricane).

Once every 5 years the industry-wide commission performs the streamlined survey of hydraulic facilities and reviews the oversight arrangements within the scope of requirements of the branch regulations.

Civil structures of hydraulic facilities are made of B8 watertight concrete.

The following measures preventing the service water infiltration into the ground have been implemented during the hydraulic facilities construction:

- hydraulic insulation of facilities according to the design documentation;
- paving around the facilities;
- - vertical planning of the territory and arrangement of necessary services ensuring prompt collection and removal of rainwater and surface water to the rainwater sewage system.

12.3. The following measures preventing the service water infiltration into the ground have been implemented over the hydraulic facilities operation period:

- 1983 draining of all hydraulic facilities with further application of asphalt-bituminous hydraulic insulation and its protection with the concrete and gunned-concrete layer;
- 2003+2007repair of the damaged and destroyed surfaces of the concrete and hydraulic insulation layer (spray ponds of units 1+4; bowls of cooling towers 1&2; open outflow channel of units 1&2 with overflow device; closed outflow channels of units 1, 2, 3; channels of the cooling towers 1&2. Intake basins of unit pumping station BNS-1; breast wall of unit pumping station BNS-1).

Assessment of the answer

The answer provides additional information about the measures to minimize the infiltration of cooling water into the soil below the cooling towers. The question is sufficiently answered.

6.3 Conclusions and final recommendations

The assessment of natural phenomena that may have adverse effects on the safety of Rivne NPP is restricted to a rather small number of hazard types. The EIA Document fails to demonstrate that the site assessment considered all natural hazards that apply to the site. With respect to the comprehensiveness of natural hazard assessment ANSWERS (2021) explains that the EIA Report was prepared in 2018 and is not based on the latest data. It states that the EIA Report does not contain information and data obtained during the current periodical safety review (PSR) for units 1&2 and new probabilistic safety assessments (PSA). It continues by saying that the corresponding documents contain a much wider list of external hazards that were subject to the safety assessment and account for upgrading measures implemented at units 1&2 in 2018. However, detailed information is not provided, and the cited PSR and PSA documents are not available to the expert team.

For the experts it is incomprehensible why the documentation for the Environmental Impact Assessment (EIA) for the lifetime extension of the reactors Rivne 1&2 under the Espoo Convention does not consider the latest PSR and PSA results. It is therefore not possible to judge whether a comprehensive hazard assessment including the steps

- hazard screening including the identification of hazard combinations
- hazard assessment
- definition of a design basis
- development of a protection concept
- analysis of design extension conditions

as required by WENRA (2020, Issue T) has been performed or not.

The expert team recommends demonstrating that all relevant hazards and hazard combinations are addressed by comparing the list of considered hazards with the generic list of natural hazards and hazard combinations (e.g., WENRA, 2015; DECKER & BRINKMAN 2017)

Hazard severities for occurrence probabilities of 10-4 per year have been determined for several, but not all hazards considered in the EIA Document. These results, however, are not followed-up to define design basis events and develop adequate protection concepts in a strict way. This is particularly the case for external flooding by extreme precipitation, drought/lack of cooling water, high wind, tornado, snow load/snow storm and extreme temperatures.

Adequate protection against several hazards is currently not in place. This is most important for:

- flooding by extreme precipitation for which the current design only protects against events with occurrence probabilities of 10-1 per year;
- high wind for which the EIA Document shows that storms with occurrence probabilities of 1.40E-3 can lead to failure of the essential service water system.

We assume that the low withstand of the cooling system against wind loads and other meteorological hazards are important factors for the high CDF value[9] described in the EIA Document ("The conditional probability of core damage due to the failure of the essential service water system is 6,93E-03").Such a high CDF value seems unacceptable when compared to regulations and safety expectations for existing NPPs that are in place in most of the WENRA countries.

Karstification and suffusion pose significant threats to the safety of the NPP Rivne by the possible destabilization of the foundation soil of the reactor buildings and containments, buildings that house safety-relevant SSCs, safety-relevant underground piping and the cooling towers. Information provided by the EIA Document proves that the operation of the NPP leads to the lasting seepage

[9] In the majority of WENRA countries and in the Ukraine the Core Damage Frequency (CDF) shall not exceed the value of 10^{-4} per year. Some WENRA countries require CDF≤10^{-5} per year.

of large amounts of technical water that has the potential to increase karstification and suffusion, and to destabilize foundation soils. According to ANSWERS (2021) these processes are extensively monitored and mitigation measures have been implemented to minimize the infiltration of precipitation and service water.

Human-made karstification and suffusion are slow but self-enhancing. Both processes were set off by the start-up of the NPP in the 1970ies. The experts expect that the intensity of the erosion of the foundation soil increases with time, and that the safety relevance of karstification and suffusion will increase during the continued operation of the NPP.

Design Extension Conditions (DEC) are not analysed in the available EIA Document. This is in violation of the WENRA requirement that DEC analysis shall be undertaken with the purpose of further improving the safety of existing nuclear power plants and enhancing their capability to withstand more challenging events or conditions than those considered in the design basis. Related requirements and procedures are provided by WENRA (2020) and WENRA (2014). The experts recommended extending the efforts with respect to natural hazard analysis and develop adequate protection concepts for natural hazards in line with the WENRA DEC approach.

Final recommendations

1. The list of natural hazards assessed in the EIA Report Book 1 (2018) is not complete. ANSWERS (2021) informs that additional hazards were considered in the last periodic safety review. The expert team recommends checking the completeness of the considered hazards by comparing it with the "Non-exhaustive List of Natural Hazard Types" (WENRA, 2015). Comparison should ensure that all site-specific hazards are addressed.
2. Natural hazard assessment does not address hazard combinations as required by WENRA (2020) and further explained by WENRA (2015). The expert team recommended the use of a hazard correlation chart (e.g., Decker & Brinkman, 2017) as a starting point to ensure that all relevant combinations are addressed.
3. The expert team recommends the selection of design basis parameters from design basis events with occurrence probabilities of 10-4 per year for all natural hazards that apply to the site and use the derived parameters to develop adequate protection concepts. This is particularly important for, but should not be limited to the following hazards: high wind, external flooding by extreme precipitation, snow storm and snow load.
4. The expert team recommends the upgrade of the protection against wind loads to ensure that SSCs important to safety and buildings that house SSCs important to safety withstand wind speeds with occurrence probabilities of 10-4 per year.
5. The expert team recommends the upgrade of the capacity of the sewer systems to ensure that precipitation intensities with occurrence probabilities of

10-4 per year do not lead to (a) water ingress into buildings that house SSCs important to safety (b) flooding of the basement of such buildings.

6. The expert team recommends the re-evaluation of the occurrence probability of extreme precipitation that leads to the flooding of the site and compare the results to the capacity of the sewer system. These evaluations should consider the possible contribution of thaw water and combinations of thawing and rain. The precipitation intensity corresponding to the occurrence probability of 10-4 per year should be taken as the design basis for the capacity of the sewer system (IAEA, WENRA), and the sewer systems for individual buildings and the site as a whole should be upgraded accordingly.
7. The expert team recommends to additionally monitor the sources of technical water infiltrating into the karstified aquifer in the foundation soil of the Rivne NPP site (e.g., from cooling towers and connected water channels) and to prevent further infiltration by adequate measures. The recommended action should prevent the continued degradation of the foundation soil by man-made karstification and suffusion.
8. The expert team recommends the implementation of automatically initiated active safety measures that trigger power reduction or shutdown upon the exceedance of pre-set temperature limits for maximum and minimum air and/or cooling water temperatures. As a minimum administrative measures should be developed to respond to hazardous temperature extremes. The protection concept should take into account the advantage that both extremely high and low temperatures are predictable hazards and progress slowly.
9. The expert team recommends an update of the current seismic design basis to the value of 0.1g to fulfil the minimum requirements of WENRA Safety Reference Level T 4.2 (WENRA 2020).
10. The expert team recommends to use the procedures for the life time extension of Rivne NPP for a periodic review of the site-specific seismic hazard as recommended by WENRA (2016, p. 25). This review should take advantage of the rapid development of science and technology in the fields of geology, seismology and paleo-seismology that were achieved in the last decades and include targeted assessments of the major faults closest to the site. Up-to-date fault investigations include, for instance, reflection seismic and paleo-seismological techniques.
11. The expert team recommends to apply the WENRA approach of analysing Design Extension Conditions (DEC) for natural hazards and updates of the protection concepts against natural hazards. DEC are not analysed in the available EIA Document. This is a violation of the WENRA requirement that DEC analysis shall be undertaken with the purpose of further improving the safety of existing nuclear power plants and enhancing their capability to withstand more challenging events or conditions than those considered in the design basis.

7 ACCIDENTS WITH INVOLVEMENT OF THIRD PARTIES AND MAN-MADE IMPACTS

7.1 Short Summary of the Expert Statement

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the Rivne NPP. Nevertheless, they were not mentioned in the EIA Document for the Rivne NPP. In comparable EIA documents such events were addressed to some extent.

Although precautions against sabotage and terror attacks cannot be publicly discussed in detail in the EIA procedure for reasons of confidentiality, the necessary legal requirements should be set out in the EIA Document.

Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. In particular, the EIA Document should include detailed information on the requirements for the design against the targeted crash of a commercial aircraft. This topic is of particular importance, because the reactor building of Rivne 1&2 is vulnerable against terror attacks (including airplane crash).

A recently released nuclear security assessment (NTI Index 2020) pointed to deficits in the necessary nuclear security requirements in Ukraine. With an overall score of 65 out of 100 points, Ukraine ranks only 29th out of 47 countries, indicating a low level of protection. Deficits were identified in particular in "Insider Threat Prevention" and "Cyber-security". It was recommended in UMWELTBUNDESAMT (2021) to invite an International Physical Protection Advisory Service (IPPAS) of the IAEA that assists states in strengthening their national nuclear security regimes, systems and measures.

7.2 Questions, answers and assessment of the answers

Question AU34

What are the requirements with respect to the planned NPP design against the deliberate crash of a commercial aircraft?

Question AU35

Against which external attacks must the reactor building and other safety relevant buildings be designed? Is this protection still guaranteed despite adverse ageing effects?

Written answer by the Ukrainian side

lt is conservatively accepted within the framework of the PSA that the crash of any aircraft or helicopter on the buildings of RNPP units 1, 2 leads to destruction of these buildings. The total frequency of aircraft crashes on the reactor building is 3,11 E-07 l/year [22.1.133.OB.04.10.Rev.1. Rivne NPP. Unit 1. Safety Analysis Report. Probabilistic safety analysis. Annex X. External hazards.2020].

External and internal threats to nuclear facilities and nuclear materials that should be taken into account during the designing of the reactor building and other in Ukraine» (Design Basis Threat) approved by the Decree of the President of Ukraine No. 97-4T/2019 dated 03 .04.2019 (classified as "secret"). The design basis threat was determined based on the assessment of threats and in accordance with the Law of Ukraine" On physical protection of nuclear facilities, nuclear materials, radioactive waste, other ionizing radiation sources".

The physical protection system ensures counteraction to external and internal threats to nuclear facilities and nuclear materials. The ability of the physical protection system to counter the design basis threat including the threat caused by ageing degradation of equipment and engineering controls is determined during the vulnerability assessment of nuclear facilities and nuclear materials (Nuclear Security Assessment). Based on the results of the vulnerability assessment the corresponding report is prepared and submitted to the regulatory authority in accordance with the procedure established by the SNRIU. This report is classified as "secret" and covers the risk mitigation measures.

Assessment of the answer

The questions are only partially answered. It is explained that the PSA conservatively assumes that the reactor building will be destroyed in the event of a crash of any type of aircraft or helicopter. However, the probability of such a crash is

considered being very low. This is incomprehensible, since no probability can be determined for the intentional crash of an aircraft. For safety reasons, a probability of 1 must rather be assumed. Furthermore, some general information is provided: The physical protection system is designed to provide protection against external and internal threats. The capability of the physical protection system to counter the design basis threat (also taking into account ageing effects) is determined in the Nuclear Security Assessment. Based on the results of this assessment, the corresponding report is prepared and submitted to the supervisory authority. However, this report is classified as "secret".

Question AU36

Is a peer-review mission of the IAEA International Physical Protection Advisory Service (IPPAS) planned?

Written answer by the Ukrainian side
SS RNPP of the SE «NNEGC «Energoatom» does not have information about the planned peer review missions of the IAEA International Physical Protection Advisory Service (IPPAS).

Assessment of the answer
The question is answered. An IPPAS mission is not planned.

7.3 Conclusions and final recommendations

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also at the Rivne NPP. Nevertheless, they were not mentioned in the EIA Document for the Rivne NPP. In comparable EIA Document such events were addressed to some extent. In the ANSWERS (2021) only some general information is provided: The capability of the physical protection system to counter the design basis threat is determined in the Nuclear Security Assessment. The corresponding report is prepared and submitted to the supervisory authority. However, this report is classified as "secret".

Although precautions against sabotage and terror attacks cannot be publicly discussed in detail in the EIA procedure for reasons of confidentiality, the necessary legal requirements should be set out in the EIA Document.

Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. In particular, the EIA Document should include detailed information on the requirements for the design against the targeted crash of a commercial aircraft. This topic is of particular importance, because the reactor building of Rivne 1&2 is vulnerable against

terror attacks (including airplane crash). In the ANSWERS (2021) it is confirmed that the reactor building cannot withstand any crash of an airplane.

A recent assessment of nuclear security (NTI Index 2020) points to deficits of the nuclear security requirements in Ukraine. With an overall score of 65 out of 100 points, Ukraine ranks only 29th out of 47 countries, indicating a low level of protection. Deficits can be seen in particular in "Insider Threat Prevention" and "Cybersecurity". It was recommended in UMWELTBUNDESAMT (2021) to invite an International Physical Protection Advisory Service (IPPAS) of the IAEA that assisted states, in strengthening their national nuclear security regimes, systems and measures. According to ANSWERS (2021), an IPPAS mission is not planned.

Final recommendations

In light of the special situation in Ukraine, the impact caused by third parties (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.

8 TRANS-BOUNDARY IMPACTS

8.1 Short Summary of the Expert Statement

The used source term for Cs-137 (30 TBq) of a beyond design basis accident (BDBA) was determined on the basis of the limited value of the release according to the safety requirements of the European operators. The assumption of this relatively moderate source term is not justified. This limited source term can only be used if the plant has been designed or retrofitted accordingly. This is not the case for the Rivne 1&2 NPP. The project flexRISK made an assessment of source terms and identified for Rivne 1 and 2 a possible source term for Cs-137 of 76,500 TBq. This source term is related to the behaviour of the plant in case of a severe accident and the possible release.

Severe accidents with releases considerably higher than assumed in the EIA Document therefore cannot be excluded for Rivne 1&2. 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 Document concerning trans-boundary effects could not be considered sufficiently proven.

The results of the flexRISK project indicated that after a severe accident, the average Cs-137 ground depositions in most areas of the Austrian territory could be higher than the threshold for agricultural intervention measures (e.g. earlier harvesting, closing of greenhouses). Therefore, Austria could be significantly affected by a severe accident at Rivne 1&2.

8.2 Questions, answers and assessment of the answers

Question AU37

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

Written answer by the Ukrainian side

The calculations were performed using the European decision support system JRODOS. When analyzing the emission source of 30 TBq Cs-137 for a beyond design basis accident (BDBA), depending on the wind speed the density of ground deposition of radionuclides at the borderline of Austria was:

Wind speed, m/s	Cs-137, Bq/m2	I-131, Bq/m2
1	27.0	0.6
3	18.0	21.4
5	10.4	27.3
10	4.5	20.6

Based on a conservative approach, the density of ground deposition ofl-131 and Cs-137 will be 27 Bq/m2.

Note: The following parameters were used for calculation: emission duration - 24 hours; atmospheric stability category - "D", without precipitation; wind direction - 70°; activity ofCs-137 - 30 TBq, 1-131 - 30 TBq; effective emission height - 100 m; diffusion model" Dipcot";

Assessment of the answer

The question has been answered partly, the inquired contamination data have been provided, but only for dry weather conditions. These results show that in case of such an accident no agricultural measures have to start in Austria. However, it is not clear if this would also be the case when other parameters would have been used, especially if precipitation was included.

Besides, for a severe accident with a higher release adverse significant impacts on Austria still cannot be excluded.

8.3 Conclusions and final recommendations

For the calculated severe accident in dry weather condition no agricultural measures would have to be introduced in Austria. However, this is not necessarily the case for wet weather conditions.

The expert statement (UMWELTBUNDESAMT 2021) included an extensive discussion showing that a higher source term cannot be excluded. The experts still recommend performing a dispersion calculation using a source term that is based on specific severe accident analyses of the Rivne1&2.

Final recommendations

1. Performing a dispersion calculation using a source term that is based on specific severe accident analyses of the Rivne1&2 is recommended.

9 SUMMARY OF FINAL RECOMMENDATIONS

9.1 Overall and procedural aspects of the Environmental Impact Assessment

Final recommendations

1. Ukraine should reach full compliance with the Espoo Convention, especially with Decision VIII/4e taken by the Meeting of the Parties in December 2020.
2. Ukraine should provide adequate information how the future results of the EIA procedure will be used to revise the licensing procedure.
3. Alternatives to the lifetime extensions and the no-action alternative should be assessed in every EIA procedure for NPP lifetime extension.
4. It is recommended to enable public participation in environmental assessments of nuclear projects according to the requirements of the Espoo Convention at a time when all options are still open.

9.2 Spent fuel and radioactive waste

Final recommendations

1. To demonstrate the safe management of nuclear waste detailed information on the inventory and on the status of interim storages and final disposals should be provided; also alternative nuclear waste management solutions if these facilities will not be operable in time.

9.3 Long-term operation of reactor type VVER440

Final recommendations

1. Considering the fact that Ukraine has been a member of WENRA since 2015, it is recommended that the WENRA requirements be implemented in the national regulations.
2. It is recommended to implement all available design improvements of VVER-440/V213 reactor at the Rivne 1&2. This should be done by comparing the design with current safety requirements first.
3. It is recommended to compare the design and features of the Rivne 1&2 with all requirements of the WENRA Reference Levels (RL), in particular of the RL F. In case of deviations, the reasons for this should be explained.
4. It is recommended to provide additional information on:

a. detailed descriptions of the safety systems, including information on requirements for the important safety-relevant systems and components. Furthermore, detailed description of the measures taken to control severe accidents or to mitigate their consequences.
b. information about the applied national requirements and international recommendations.
c. comprehensive presentation and overall assessment of all deviations from the current state-of-the-art of science and technology. This presentation should include:
   - All deviations from the modern requirements for redundancy, diversity and independence of the safety levels.
   - Incompleteness of the database and plant documentation used.
   - Presentation of all safety assessments or parameter definitions by personal expert assessments ("engineering judgement").
   - Presentation of the general approach in dealing with uncertainties and non-knowledge and its effects on risk.
   - Deviations from the state-of-the-art of science and technology with regard to the detection methods used, the technical estimates and calculation procedures.
   - Safety margins available for the individual safety-relevant components and their respective ageing related changes compared to the original condition.
d. Information about the ageing management program including:
   - The national action plan relating to the Topical Peer Review (TPR) "Ageing Management" under the Nuclear Safety Directive 2014/87/EURATOM and its progress.
   - The very important safety issue of the ageing of the RPVs (embrittlement), including definition and justification of appropriate safety margins.

9.4 Accident Analyses

Final recommendations

1. It is recommended to use the WENRA Safety Objectives for new NPP to identify reasonably practicable safety improvements for Rivne 1&2. It is recommended to use the concept of practical elimination for this approach.
2. It is recommended to provide the following information concerning accident analyses and the results of the PSA (Level 1, 2 und 3):
   a. Core damage frequency (CDF) and large (early) releases frequency (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 beyond design basis accidents (BDBAs)
d. Source terms of the BDBAs including releases from the spent fuel pools
e. Time spans to restore the safety functions after the loss of heat removal and/or station-blackout and cliff edge effects.

9.5 Accidents initiated by natural events and site assessment

Final recommendations

1. The list of natural hazards assessed in the EIA Report Book 1 (2018) is not complete. ANSWERS (2021) informs that additional hazards were considered in the last periodic safety review. The expert team recommends checking the completeness of the considered hazards by comparing it with the "Non-exhaustive List of Natural Hazard Types" (WENRA, 2015). Comparison should ensure that all site-specific hazards are addressed.
2. Natural hazard assessment does not address hazard combinations as required by WENRA (2020) and further explained by WENRA (2015). The expert team recommended the use of a hazard correlation chart (e.g., Decker & Brinkman, 2017) as a starting point to ensure that all relevant combinations are addressed.
3. The expert team recommends the selection of design basis parameters from design basis events with occurrence probabilities of 10-4 per year for all natural hazards that apply to the site and use the derived parameters to develop adequate protection concepts. This is particularly important for, but should not be limited to the following hazards: high wind, external flooding by extreme precipitation, snow storm and snow load.
4. The expert team recommends the upgrade of the protection against wind loads to ensure that SSCs important to safety and buildings that house SSCs important to safety withstand wind speeds with occurrence probabilities of 10-4 per year.
5. The expert team recommends the upgrade of the capacity of the sewer systems to ensure that precipitation intensities with occurrence probabilities of 10-4 per year do not lead to (a) water ingress into buildings that house SSCs important to safety (b) flooding of the basement of such buildings.
6. The expert team recommends the re-evaluation of the occurrence probability of extreme precipitation that leads to the flooding of the site and compare the results to the capacity of the sewer system. These evaluations should consider the possible contribution of thaw water and combinations of thawing and rain. The precipitation intensity corresponding to the occurrence probability of 10-4 per year should be taken as the design basis for the

capacity of the sewer system (IAEA, WENRA), and the sewer systems for individual buildings and the site as a whole should be upgraded accordingly.

7. The expert team recommends to additionally monitor the sources of technical water infiltrating into the karstified aquifer in the foundation soil of the Rivne NPP site (e.g., from cooling towers and connected water channels) and to prevent further infiltration by adequate measures. The recommended action should prevent the continued degradation of the foundation soil by man-made karstification and suffusion.
8. The expert team recommends the implementation of automatically initiated active safety measures that trigger power reduction or shutdown upon the exceedance of pre-set temperature limits for maximum and minimum air and/or cooling water temperatures. As a minimum administrative measures should be developed to respond to hazardous temperature extremes. The protection concept should take into account the advantage that both extremely high and low temperatures are predictable hazards and progress slowly.
9. The expert team recommends an update of the current seismic design basis to the value of 0.1g to fulfil the minimum requirements of WENRA Safety Reference Level T 4.2 (WENRA, 2020).
10. The expert team recommends to use the procedures for the life time extension of Rivne NPP for a periodic review of the site-specific seismic hazard as recommended by WENRA (2016, p. 25). This review should take advantage of the rapid development of science and technology in the fields of geology, seismology and paleo-seismology that were achieved in the last decades and include targeted assessments of the major faults closest to the site. Up-to-date fault investigations include, for instance, reflection seismic and paleo-seismological techniques.
11. The expert team recommends to apply the WENRA approach of analysing Design Extension Conditions (DEC) for natural hazards and updates of the protection concepts against natural hazards. DEC are not analysed in the available EIA Document. This is a violation of the WENRA requirement that DEC analysis shall be undertaken with the purpose of further improving the safety of existing nuclear power plants and enhancing their capability to withstand more challenging events or conditions than those considered in the design basis.

9.6 Accidents with involvement of third parties and man-made impacts

Final recommendations

1. In light of the special situation in Ukraine, the impact caused by third parties (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.

9.7 Trans-boundary impacts

Final recommendations

1. Performing a dispersion calculation using a source term that is based on specific severe accident analyses of the Rivne1&2 is recommended.

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10 GLOSSARY

AAMS.....Automated Ageing Management System

AM .....Ageing Management

AMP.....Ageing Management Programme

BDBA.....Beyond Design Basis Accident

Bq .....Becquerel

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

CDF.....Core Damage Frequency

CRWP.....Complex for radioactive waste processing

CSFSF.....Centralized spent fuel storage facility (interim storage for spent fuel)

Cs-137 .....Caesium-137

DBA .....Design Basic Accident

DEC.....Design Extension Conditions

EBRD .....European Bank for Reconstruction and Development

EC.....European Commission

ECR .....Emergency Control Room

EIA .....Environmental Impact Assessment

ENSREG .....European Nuclear Safety Regulators Group

EOP.....Emergency Operating Procedures

EU .....European Union

EUR.....European Utility Requirements

g.....Gravitational Acceleration

I&C.....Instrumentation and Control

I-131 .....Iodine-131

IAEA.....International Atomic Energy Agency

IPPAS.....International Physical Protection Advisory Service

IVMR.....In-Vessel Melt Retention

IVR .....In-Vessel Retention

LOCA .....Loss of Coolant Accident

LRF.....Large Release Frequency

LTO .....Long-Term Operation

LWR .....Light Water Reactor

MCR.....Main Control Room

MDBA.....Maximum Design Basis Accident

MDGPU.....Mobile Diesel Generators and Pumping Unit

NAcP .....National Action Plan

NDE .....Non-Destructive Examination

NDI .....Nondestructive Inspection

NPP.....Nuclear Power Plant

NTI .....Nuclear Threat Initiative

OBE.....Operating Base Earthquake

OZ.....Observation Zone (30km)

PGA.....Peak Ground Acceleration

PSA .....Probabilistic Safety Assessment

PSR .....Preliminary Safety Report

PWR.....Pressurized Water Reactor

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

SE NNEGC .....State Enterprise National Nuclear Generating Company

SEA .....Strategic Environmental Assessment

SF.....Safety Factors

SFP.....Spent Fuel Pool

SG .....Steam Generator

SNRIU .....State Nuclear Regulatory Inspectorate of Ukraine

SPZ.....Sanitary Protection Zone (2.5km)

SS Rivne NPP .....Separate subdivision “Rivne nuclear power plant”

SSC .....Structure, Systems and Components

SSE.....Safe Shutdown Event

TBq .....Tera-Becquerel, E12 Bq

TCA .....Technical Condition Assessment

TLAA ..... Time Limited Ageing Analysis

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

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