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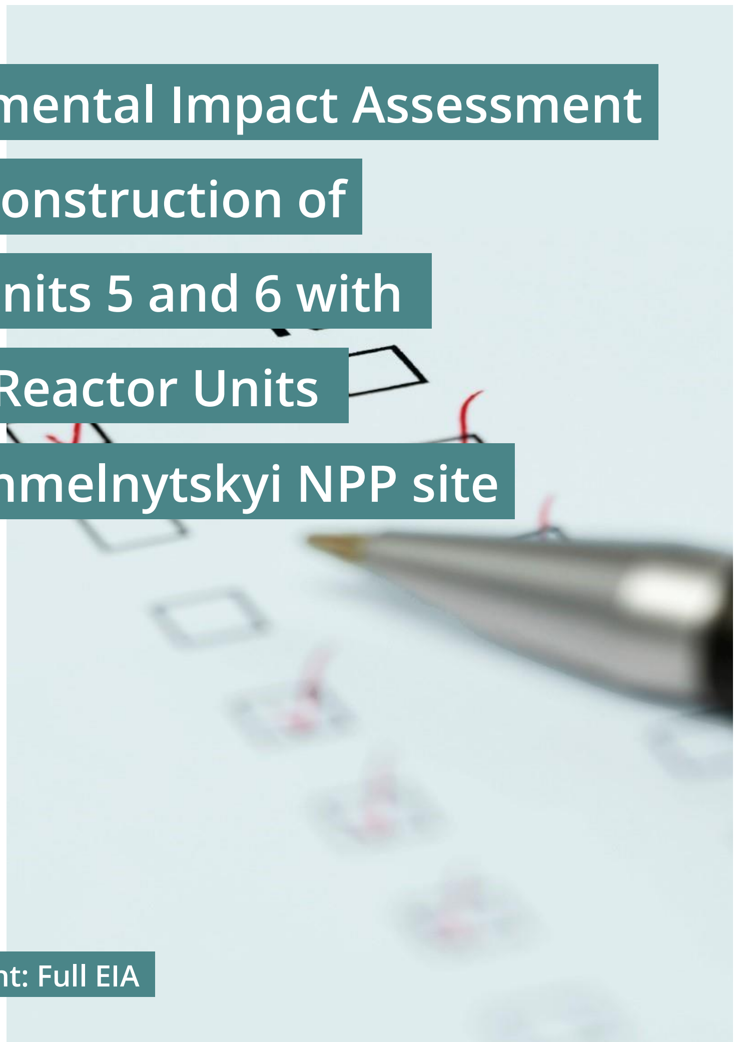

Environmental Impact Assessment for the construction of Power Units 5 and 6 with AP1000 Reactor Units at the Khmelnytskyi NPP site

Project element: Full EIA

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Project element: Full EIA

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INHALTSVERZEICHNIS

1 EXECUTIVE SUMMARY

Ukraine has notified Austria about the Environment Impact Assessment (EIA) procedure under the Espoo Convention for the project “CONSTRUCTION OF POWER UNITS 5 AND 6 WITH AP1000 REACTOR UNITS AT THE KHMELNYTSKYI NPP SITE”. Austria, having interest in possible impact to Austrian territory from radioactive releases from Ukraine’s NPPs is participating in the transboundary EIAs process with Ukraine.

The Federal Ministry of Agriculture and Forestry, Climate and Environmental Protection, Regions and Water Management commissioned the Federal Environment Agency to prepare an expert opinion on the submitted documents. The Environment Agency commissioned a team led by ENCO to elaborate an expert statement concerning the EIA report. For the expert statement, the EIA report has been evaluated in detail, including other publicly available documents that offer insight into the subject matter.

Ukraine’s “Energy strategy up to 2050” mandates continued reliance on nuclear power. It also requires that the units that would be decommissioned post-2025 and would need to be replaced with new units. The AP1000, for which in 2022 an agreement was signed between Westinghouse Electric Corporation (WEC) and Energoatom, are envisaged as the initial western designed units to replace existing ones.

Ukraine’s Law "On Environmental Impact Assessment" from 2017 specifically requires that the environmental impact assessment needs to be undertaken for various categories of facilities to be constructed, NPPs among them. As the construction KhNPP Units 5 and 6 may have a significant impact on the environment, the EIAR has been developed.

The AP 1000 is a Generation III NPP design that has been licensed by the US NRC and by the Chinese NNSA. Despite lots of difficulties in construction and related cost overruns, two AP1000 are in operation in the US and four more in China.

The Khmelnytskyi site was established as a nuclear site in the 1980’s, with unit 1 in operation since 1987 and unit 2 since 2004. units 3 and 4 are planned, but construction was stopped in the 1990’s. Units 1 to 4 are WWER 1000. AP1000 are planned as units 5 and 6 at the Khmelnytskyi site.

The EIA process for the Khmelnytskyi NPP units 5 and 6 follows the requirements for an EIA under the Espoo convention. The sources for some information and analyses for the EIA was (one of) the feasibility studies for the KhNPP units 3 and 4 that were completed a decade or more ago. Therefore, some information might not be up to date. In particular, the uncertainty regarding the future of the units 3 and 4 is an issue, as the environmental impact of the site would be different with 4 or 6 units operating simultaneously.

The fact that the EIAR does not discuss any alternatives to the construction of the NPPs at the Khmelnytskyi (or some other) site(s) could be seen as a deficiency. Even though the EIAR follows the "National energy strategy" that requires replacement of nuclear units with new ones, a complete EIAR would need to look into other possible alternatives. Also, the EIAR does not clarify as to why the Khmelnytskyi site, which was originally envisaged for 4 units, was chosen to host the AP1000 as units 5 and 6, as those might be better suited to be built at some other nuclear site.

The site characteristics, in particular the external hazards, are described in the EIAR. However, the EIA document does not contain sufficient information on most of the relevant external hazards. The discussion is often limited to very brief information, which is sometimes (e.g., extreme weather and floods) assessed to "have never occurred in the lifetime of the KhNPP". This is a far too short period for external hazards that could jeopardize the safety of the plant. Lack of information in the EIAR raises considerable doubts as to the extent to which a site-specific hazard analysis has been carried out that would be appropriate for the planning of a new-built NPP. The EIAR fails to demonstrate that the available site assessment considered all natural and man-made hazards and all hazard combinations relevant to the site.

The EIAR addresses the long-term climate change only superficially. There is no assessment of the possible effects of global warming on the local conditions, from temperature and draughts to extreme weather and precipitation. The EIAR does not address any assessment of potential additional costs associated with adapting to climate risks—such as structural reinforcements, protective barriers, or upgrades to water drainage infrastructure. To fully meet the standards of an EIA for nuclear facilities in Europe today, the EIAR section should be expanded with concrete calculations, climate risk assessments, and cost evaluations of potential climate-related challenges.

The EIAR states that the AP 1000 units to be the constructed at the KhNPP will comply with current regulations in Ukraine, including radiological protection and radiation safety of personnel and the public. The Ukrainian regulations have been aligned with WENRA requirements comparable to the level in some other EU countries. Nevertheless, the AP1000 is developed against the US NRC safety criteria. To what extent US NRC criteria are comparable to applicable EU standards is not discussed and presented in the EIAR. Such a comparison should be made to assess the regulatory framework relevant for this project. The EIAR does not discuss the adjustments of the generic AP 1000 design that would be needed for Ukraine and for the KhNPP site in particular.

The contribution of external events for KhNPP units 5 and 6 to the core damage frequency (CDF) have not been determined as the site has not yet been sufficiently analyzed. The EIAR lacks information on the results of probabilistic safety analyses (PSA) on large (early) release (L(E)RF) frequencies by release category. A possible release from the spent fuel pool, which can contribute to the frequency of a severe accident, is also not discussed. In order to be able to assess the possible impact on Austria in a comprehensible manner, an EIAR should provide a range of additional information on the PSA Levels 1 and 2 including the probability for CDF and LERF, as well as the contributions of internal and external events to CDF and LERF.

The accident sequences considered with the design extension condition (DEC) that could cause transboundary impact to Austria, are not adequately described. In particular, the source term that has been used in the transboundary impact assessment appears to be limited to more "benign" DEC sequences. There seems to be some inconsistency in the values used for the DBA and DEC conditions, as for certain radionuclides, the release during DBA might be higher than for DEC. The JRODOS dispersion models using an actual historic weather and a generic release category for a 1000 MW PWR determined that Austrian territory would be affected to a level that emergency protective measures might be required.

The EIAR mentioned that the Ukraine regulatory framework is being adjusted with modern international standards and EU requirements, but does not dwell any further on the compatibility of the AP 1000 design with Ukrainian regulations. This is an important issue because in some cases the generic AP 1000 design or the one of Vogtle, the reference for the Kh NPP units 5 and 6, might need to be adjusted to accommodate for specific regulatory requirements. Specific challenges in this respect might include emergency planning zones, extensive use of probabilistic justification in the design of the AP 1000, where Ukrainian regulation relies on deterministic safety analyses, lack of regulatory framework for passive safety features, etc.

Finally there is no information in the EIAR regarding the further processing (i.e beyond the KhNPP site) and disposal for radioactive waste generated by KhNPP units 5 and 6. The requirements for an EIA for a nuclear plant is that the full cycle of planned safe disposal of radioactive waste is included.

As not all information that are relevant and necessary for understanding the environmental impact of the KhNPP units 5 and 6 project have been provided in the EIAR, it is recommended that the bilateral consultation, which is envisaged in the Espoo convention, is used as a forum to exchange pertinent information. Reflecting on the findings in this Expert statement and expanded with the additional information from the bilaterial consultation will serve as the basis for recommendations.

2 ZUSAMMENFASSUNG

Die Ukraine hat Österreich über das Umweltverträglichkeitsprüfungsverfahren (UVP) gemäß dem Espoo-Übereinkommen für das Projekt „BAU DER REAKTORBLÖCKE 5 UND 6 MIT AP1000-REAKTOREN AM STANDORT DES KERNKRAFTWERKS CHMELNYTSKYJ“ informiert. Österreich beteiligt sich am grenzüberschreitenden UVP-Verfahren mit der Ukraine, da potentielle Auswirkungen radioaktiver Freisetzungen aus ukrainischen Kernkraftwerken unter Unfallbedingungen auf sein Hoheitsgebiet nicht ausgeschlossen werden können

Das Bundesministerium für Land- und Forstwirtschaft, Klima- und Umweltschutz, Regionen und Wasserwirtschaft hat das Umweltbundesamt mit der Erstellung eines Gutachtens zu den vorgelegten Unterlagen beauftragt. Das Umweltbundesamt hat ein Team unter der Leitung von ENCO mit der Ausarbeitung einer Fachstellungnahme zum UVP-Bericht beauftragt. Für die Fachstellungnahme wurde der UVP-Bericht eingehend geprüft, einschließlich anderer öffentlich zugänglicher Dokumente.

Die „Energiestrategie bis 2050” der Ukraine sieht eine weitere Nutzung der Kernenergie vor. Außerdem sollen die nach 2025 stillgelegten Blöcke durch neue Blöcke ersetzt werden. Die AP1000-Reaktoren, für die 2022 eine Vereinbarung zwischen Westinghouse Electric Corporation (WEC) und Energoatom unterzeichnet wurde, sind als erste westlich konzipierte Blöcke zum Ersatz der bestehenden Blöcke vorgesehen.

Das ukrainische Gesetz „Über die Umweltverträglichkeitsprüfung” aus dem Jahr 2017 schreibt ausdrücklich vor, dass für verschiedene Kategorien von zu errichtenden Anlagen, darunter auch Kernkraftwerke, eine Umweltverträglichkeitsprüfung durchgeführt werden muss. Da der Bau der Blöcke 5 und 6 des Kernkraftwerks Chmelnitzkyj erhebliche Auswirkungen auf die Umwelt haben kann, wurde der UVP-Bericht entwickelt.

Der AP 1000 ist ein Kernkraftwerksdesign der Generation III, das von der US-amerikanischen NRC und der chinesischen NNSA zugelassen wurde. Trotz zahlreicher Schwierigkeiten beim Bau und damit verbundenen Kostenüberschreitungen sind zwei AP1000 in den USA und vier weitere in China in Betrieb.

Der Standort Chmelnyzkyj wurde in den 1980er Jahren als Kernkraftwerksstandort eingerichtet, wobei Block 1 seit 1987 und Block 2 seit 2004 in Betrieb ist. Die Blöcke 3 und 4 sind geplant, aber der Bau wurde in den 1990er Jahren eingestellt. Die Blöcke 1 bis 4 sind WWER 1000 Reaktoren. Als Blöcke 5 und 6 am Standort Chmelnyzkyj sind AP1000-Reaktoren geplant.

Das UVP-Verfahren für die Blöcke 5 und 6 des Kernkraftwerks Chmelnyzkyj entspricht den Anforderungen einer Umweltverträglichkeitsprüfung gemäß der Espoo-Konvention. Die Quellen für einige Informationen und Analysen für die UVP waren (eine der) Machbarkeitsstudien für die Blöcke 3 und 4 des Kernkraftwerks Chmelnyzkyj, die vor einem Jahrzehnt oder mehr abgeschlossen wurden. Daher sind einige Informationen möglicherweise nicht mehr aktuell. Insbesondere die Ungewissheit über die Zukunft der Blöcke 3 und 4 ist ein Problem, da die Umweltauswirkungen des Standorts bei gleichzeitigem Betrieb von 4 oder 6 Blöcken unterschiedlich wären.

Die Tatsache, dass der UVP-Bericht keine Alternativen zum Bau der Kernkraftwerke am Standort Chmelnyzkyj (oder an anderen Standorten) erörtert, könnte als Mangel angesehen werden. Auch wenn der UVP-Bericht der „Nationalen Energiestrategie" folgt, die den Ersatz von Kernkraftwerken durch neue Anlagen vorsieht, müsste ein vollständiger UVP-Bericht auch andere mögliche Alternativen prüfen. Außerdem wird im UVP-Bericht nicht erläutert, warum der Standort Chmelnyzkyj, der ursprünglich für vier Blöcke vorgesehen war, für die Blöcke 5 und 6 des Typs AP1000 ausgewählt wurde, da diese möglicherweise besser für den Bau an einem anderen Kernkraftwerksstandort geeignet wären.

Die Standortmerkmale, insbesondere die externen Gefahren, werden im UVP-Bericht beschrieben. Das UVP-Dokument enthält jedoch keine ausreichenden Informationen zu den meisten relevanten externen Gefahren. Die Erörterung beschränkt sich oft auf sehr kurze Informationen, die manchmal (z. B. extreme Wetterereignisse und Überschwemmungen) als „in der Betriebsdauer des Kernkraftwerks Chmelnyzkyj noch nie aufgetreten" bewertet werden. Dies ist ein viel zu kurzer Zeitraum für die Bewertung externe Gefahren, die die Sicherheit der Anlage gefährden könnten. Die fehlenden Informationen im UVP-Bericht lassen erhebliche Zweifel daran aufkommen, inwieweit eine standortspezifische Gefahrenanalyse durchgeführt wurde, die für die Planung eines neu zu bauenden Kernkraftwerks angemessen wäre. Der UVP-Bericht kann nicht nachweisen, dass die verfügbare Standortbewertung alle für den Standort relevanten natürlichen und vom Menschen verursachten Gefahren sowie alle Gefahrenkombinationen berücksichtigt hat.

Der UVP-Bericht geht nur oberflächlich auf den langfristigen Klimawandel ein. Es gibt keine Bewertung der möglichen Auswirkungen der globalen Erwärmung auf die lokalen Bedingungen, von Temperatur und Trockenheit bis hin zu extremen Wetterereignissen und Niederschlägen. Der UVP-Bericht enthält keine Bewertung der potenziellen zusätzlichen Kosten, die mit der Anpassung an Klimarisiken verbunden sind, wie z. B. bauliche Verstärkungen, Schutzbarrieren oder die Modernisierung der Entwässerungsinfrastruktur. Um die Standards einer Umweltverträglichkeitsprüfung für kerntechnische Anlagen in Europa heute vollständig zu erfüllen, sollte der Teil des UVP-Berichts - um konkrete Berechnungen, Klimarisikobewertungen und Kostenbewertungen potenzieller klimabedingter Herausforderungen erweitert werden.

Der UVP-Bericht besagt, dass die AP 1000-Blöcke, die im Kernkraftwerk Chmelnytzkyj gebaut werden sollen, den geltenden Vorschriften in der Ukraine entsprechen werden, einschließlich bzgl. Strahlenschutz- und Strahlensicherheit für das Personal und die Bevölkerung. Die ukrainischen Vorschriften wurden an die WENRA-Anforderungen, vergleichbar mit denen einiger anderer EU-Länder, angepasst. Dennoch wurde der AP1000 nach den Sicherheitskriterien der US-amerikanischen NRC entwickelt. Inwieweit die Kriterien der US-amerikanischen NRC mit den geltenden EU-Normen vergleichbar sind, wird im UVP-Bericht nicht erörtert und dargelegt. Ein solcher Vergleich sollte durchgeführt werden, um den für dieses Projekt relevanten Rechtsrahmen zu bewerten. Der UVP-Bericht geht nicht auf die Anpassungen des generischen AP-1000-Entwurfs ein, die für die Ukraine und insbesondere für den Standort des Kernkraftwerks Chmelnyzkyj erforderlich wären.

Der Beitrag externer Ereignisse zur Kernschadenshäufigkeit (CDF) für die Blöcke 5 und 6 des Kernkraftwerks Chmelnytzkyj wurde nicht ermittelt, da der Standort noch nicht ausreichend analysiert wurde. Der UVP-Bericht enthält keine Informationen zu den Ergebnissen probabilistischer Sicherheitsanalysen (PSA) zur Häufigkeit großer (früher) Freisetzungen (L(E)RF) nach Freisetzungskategorien. Eine mögliche Freisetzung aus dem Lagerbecken für abgebrannte Brennelemente, die zur Häufigkeit eines schweren Unfalls beitragen kann, wird ebenfalls nicht erörtert. Um die möglichen Auswirkungen auf Österreich in einer nachvollziehbaren Weise beurteilen zu können, sollte der UVP-Bericht eine Reihe zusätzlicher Informationen zu den PSA-Level 1 und 2 enthalten, einschließlich der Wahrscheinlichkeit für CDF und LERF sowie der Beiträge interner und externer Ereignisse zu CDF und LERF.

Die Unfallsequenzen, die unter Berücksichtigung der Auslegungserweiterungsbedingung (DEC) berücksichtigt wurden und grenzüberschreitende Auswirkungen auf Österreich haben könnten, sind nicht ausreichend beschrieben. Insbesondere scheint der in der Bewertung der grenzüberschreitenden Auswirkungen verwendete Quellterm auf „harmlosere" DEC-Sequenzen beschränkt zu sein. Es scheint eine gewisse Inkonsistenz bei den für die DBA- und DEC-Bedingungen verwendeten Werten zu bestehen, da für bestimmte Radionuklide die Freisetzung während der DBA höher sein könnte als für die DEC. Die JRODOS-Ausbreitungsmodelle, die tatsächliche historische Wetterdaten und eine generische Freisetzungskategorie für einen 1000-MW-PWR verwenden, ergaben, dass das österreichische Staatsgebiet in einem Ausmaß betroffen wäre, dass Notfallschutzmaßnahmen erforderlich sein könnten.

Im UVP-Bericht wird erwähnt, dass der ukrainische Rechtsrahmen an moderne internationale Standards und EU-Anforderungen angepasst wird, jedoch wird nicht näher auf die Vereinbarkeit des AP 1000-Entwurfs mit den ukrainischen Vorschriften eingegangen. Dies ist ein wichtiger Punkt, da in einigen Fällen der generische AP 1000-Entwurf oder der Entwurf von Vogtle, der als Referenz für die Blöcke 5 und 6 des Kernkraftwerks Chmelnytzkyj dient, möglicherweise angepasst werden muss, um spezifischen regulatorischen Anforderungen gerecht zu werden. Spezifische Herausforderungen in dieser Hinsicht könnten Notfallplanungszonen, die umfassende Verwendung probabilistischer Nachweise bei der Auslegung des AP 1000, während die ukrainischen Vorschriften auf deterministischen Sicherheitsanalysen beruhen, das Fehlen eines Regelungsrahmens für passive Sicherheitsmerkmale usw. sein.

Schließlich enthält der UVP-Bericht keine Informationen über die weitere Behandlung (d. h. über den Standort des Kernkraftwerks Chmelnytzkyj hinaus) und die Entsorgung der radioaktiven Abfälle aus den Blöcken 5 und 6 des Kernkraftwerks Chmelnytzkyj. Die Anforderungen an eine Umweltverträglichkeitsprüfung für ein Kernkraftwerk sehen vor, dass der gesamte Zyklus der geplanten sicheren Entsorgung radioaktiver Abfälle einbezogen wird.

Da nicht alle Informationen, die für das Verständnis der Umweltauswirkungen des Projekts „KhNPP-Blöcke 5 und 6“ relevant und notwendig sind, im UVP-Bericht bereitgestellt wurden, wird empfohlen, die in der Espoo-Konvention vorgesehene bilaterale Konsultation als Forum für den Austausch relevanter Informationen zu nutzen. Die Ergebnisse dieser Expertenstellungnahme werden zusammen mit den zusätzlichen Informationen aus der bilateralen Konsultation als Grundlage für Empfehlungen dienen.

3 INTRODUCTION AND OVERVIEW

Ukraine's strategic decision, anchored in the national energy planning, is to remain the user of nuclear power. The "Energy strategy up to 2050" requires that that the units that would be decommissioned post 2025 and would need to be replaced with new units. Furthermore, the Ukrainian national strategy is to discontinue all of the commercial relations, and in particular energy reliance on Russia. In the nuclear sector, this has already been the case, with maintenance and supplies of spare parts being provided by Ukrainian and Western companies. The fuel supply for all Ukrainian NPPs is being provided by Westinghouse.

The Federal Ministry of Agriculture and Forestry, Climate and Environmental Protection, Regions and Water Management commissioned the Federal Environment Agency to prepare an expert opinion on the submitted documents. The Environment Agency commissioned a team led by ENCO to elaborate an expert statement concerning the EIAR. The objective of Austria's participation in the EIA procedure is to minimise or prevent possible significant adverse effects of the project on Austria. For the expert statement, the EIAR has been evaluated in detail, including other publicly available documents that offer insight into the subject matter.

Khmelnytskyi NPP is an operating nuclear site in Western Ukraine. The construction of unit 1, a WWER 1000 reactor, started in 1981. The unit 1 became operational in 1987. Unit 2 followed with a 2 year gap, but the construction stopped in 1990. Supported by the EBRD loans (R4K2 arrangement), unit 2 was finally completed in 2004. Both units remain in stable operation, achieving a lead factor in excess of 80%. The construction of units 3 and 4 also started in the Soviet era, but were abandoned in the 1990's. Currently, there are plans being made to complete those units using the equipment from the cancelled WWER 1000 Belene project in Bulgaria.

Due to the recent decision of the Bulgarian government not so sell equipment from the WWER1000 project at Belene to Ukraine the future of the K3&4 project seems to be uncertain. Nevertheless the EIAR should address the issue whether or not there will be 4 or 6 reactors on site. Especially accident conditions, which could lead to releases a several reactors on site, has to be discussed in the EIAR,

The AP1000 are planned as units 5 and 6 at the Khmelnytskyi site. As per the EIAR, those units are planned on the land that belongs to the KhNPP, which is said to be big enough to accommodate all 6 units. Also the KhNPP cooling pond is, as could be concluded from the EIAR, big enough to supply water to all 6 units.

The AP1000 is a two-loop pressurized water reactor (PWR) that uses a simplified, innovative and effective approach to safety. The units are "compact" ones, deploy passive safety systems to increase safety and are designed for modular construction. There are 6 operating AP 1000 units, 2 in USA and 4 in China.

The AP1000 project at Vogtle faced a lot of difficulties, time delays and cost overruns. The EIAR should discuss how obstacles, which faced the Vogtle project, as well as the VC Summers project faced, and how similar circumstances can be assured to be avoided in Ukraine.

The AP 1000 has been licensed by the US NRC and by the Chinese NNSA. The AP 1000 is being considered in several EU MS, with Poland and Bulgaria already selected the model and other countries, including the Netherlands, Sweden and Slovenia considering it.

As KhNPP is an NPP operating site since the 1980's, a lot of data exists on all aspects of the environment, including meteorological data, air, surface and underground water monitoring, soil sampling, overview on flora and fauna as well as impact on operation of the NPP units 1 and 2 on the people and environment. Furthermore, the feasibility studies for the units 3 and 4 generated specific (modern) models that were used in the EIA to assess the impact of units 5 and 6. The description, including safety justification for the AP 1000 is duly reproduced in the EIAR.

Among the assessments presented in the EIAR are the description of monitoring of groundwater, based on monitoring points that were installed in 1986. The discussion on the dispersion of soil contaminants that partially relies on experience and observations from the Chernobyl exclusion zone is remarkable. On the other hand, the EIAR fails to present the actual data on, e.g. extreme weather, tornadoes, or flooding and seismic events, only concluding that "those have not been observed on the site". There is no discussion on the impact of eventual climate change that is of very high relevance for the NPP units that would likely remain in operation at the beginning of the 22nd century.

In terms of locating the units at the KhNPP site, it looks like the area (space) needed for the AP 1000 quantified with "57 ha" is smaller than some other studies considered. Even more so is the total construction area of 100 Ha. The estimate of only 2880 temporary construction workers on the site appears low as compared with other studies.

Finally, the EIAR does not at all discuss the adjustments of the design that might be needed from a standard AP 1000 or reference plant which is Vogtle NPP in Georgia, to accommodate for the construction of an AP 1000 as KhNPP 5&6. It looks like that there might be some inconsistencies in the EIAR in terms of the source term in case of a severe accident (DEC A and B), e.g. in tables 5.30 and 8.2. There is very little information as to how specific source terms have been generated in terms of actual accident sequence(s) and release paths without proving the basic assumptions that are underpinning each of those.

While discussing the EP&R concept for the KhNPP site as a whole, the EIAR fails to discuss any impact from the units under construction on the operating units (and vice versa), nor even mentioned a possibility of multiple units on the site being simultaneously affected by, e.g. external impact of man-made or natural hazards. This could be seen as a deficiency, as the impact on the people and the environment might be underestimated.

While the EIAR claims that the AP1000 safety approach has been specifically designed to maximise the plant robustness against catastrophic events resulting in extensive loss of infrastructure, making it robust against external events, this has not been justified with any specific studies or evidence.

Further findings of the review by the experts are provided in each of the thematic sections of this report. In each section, the assessment is provided and followed by clarifying questions that are expected to be answered in the consultation process.

4 PROCEDURAL ASPECTS OF THE EIA

The EIA process of the Khmelnytskyi NPP units 5 and 6 does follow the process as per the Espoo convention. The EIAR should give reference to the determination of the scope of it, been determined by the relevant environmental authority, due to the related scoping decision.

The version of the EIAR that has been reviewed contains in the Annex A comments raised by different stakeholders during public consultations e.g. the Polish government and its Atomic Commission, as well as from several Ukrainian municipalities. EIAR responses these comments in part, but with general statements rather with calculated data. All of the comments have been replied to, though in many cases the reply just points to a section of the EIAR where such information could be found. In the view of the experts, the sections referred to do not provide sufficient information to address the questions raised in full. An improvement in the response to the questions raised by, in particular, international parties would add to the quality of the EIA.

The comments regarding construction activities, radioactive and non-radioactive emissions and discharges, waste management, and impacts on public health are, at least partially, addressed. However, several significant concerns remain unanswered.

The assessment provides limited justification through analysis of project alternatives, particularly in relation to energy demand, the integration of renewable energy sources, and comparative environmental impacts. Cumulative impacts are insufficiently studied. Socio-economic impacts are acknowledged but not quantitatively assessed.

Where the above criteria are covered only in part or not at all, there is a requirement for further consideration, which might be concluded through a Feasibility Study Report, Design Safety Analysis, or a detailed Site Selection Report.

Maybe the biggest deficiency in a procedural sense (i.e., in addition to the Strategic Environmental Assessment not being available) is that there is no clear timeframe for the implementation of the project. Furthermore, there is also no clear timeline or even a decision whether the units 3 and 4 would be constructed or not. The environmental impact of having 2 or 4 units under construction, as well as in particular the transboundary impact with 4 or 6 units in operation at the Khmelnytskyi site might be different than determined in the EIAR that is available now.

The Espoo convention foresee that after the consultation with the wider public bilateral consultations between the environment authorities concerned can take place. During these bilateral consultations open questions, related to the EIAR, as well a draft decision of the relevant environmental authority can be discussed. Related to these bilateral consultations following issues, recommendations, request for further information are listed below.

Issues to be discussed during consultation

1. While it is understood that the EIA has been initiated in anticipation of the KhNPP units 5 and 6 being constructed, lack of clarify on the schedule of implementation is a deficiency. It is obvious that the longer it takes to construct those units, the larger the difference between the findings of this EIA and the real situation might be. This might require an upgrade of the EIAR when the final decision is taken for beginning the construction.

2. The uncertainty regarding units 3 and 4 is another issue that does not contribute to the precision of the EIA for KhNPP units 5 and 6. As the possible construction of units 3 and 4 will impact both the construction and operation of units 5 and 6, some clarity in this respect in the EIAR would add to the usefulness of the study in determining the overall environmental impact, including transboundary impact.

5 ALTERNATIVES

The EIAR does not discuss any alternatives to the construction of the NPPs at the Khmelnytskyi (or some other) site. In this respect, the EIAR reflects the Energy strategy, which commits Ukraine to use of nuclear power and envisages the replacement capacity for nuclear units that are to reach the end of the lifetime after 2025.

The EIAR would benefit by containing an evaluation of other possible sources that could be used instead of nuclear power. As the Strategic EIA is not available, one would expect such an evaluation to be provided in the main EIAR.

The justification for the selection of the AP1000 design is assessed to be ensuring nuclear and radiation safety of the population and environmental protection according to the current legislation. This could be assessed as appropriate because it is clearly that the AP1000 units are superior from the safety perspective to existing WWER 1000 designs. Although the operational efficiency is the responsibility of the operator, the increased efficiency of power generation at the AP 1000 as compared with the WWER 1000 would be in less maintenance activities, due to its simplified design. With all other things being equal, this would lead to higher availability.

The justification for the construction of new units at the Khmelnytskyi site is found in the fact that "the most acceptable option for the deployment of new facilities is to build them at the sites of operating NPPs". This is correct because then new units would be using the infrastructure that already exists (with some modifications as needed).

The EIAR does not really clarify as two why the Khmelnytskyi site was chosen, except indicating that the site area is large enough (147 Ha) for adding two more units to the 4 units that were originally envisaged for the Khmelnytskyi site. In this, the EIAR uses certain values for the land needed for siting the AP1000 units, as 45 Ha for 2 units with cooling tower and 100 Ha for the construction. The experts believe that this is a smaller area then used in the planning for AP1000 in some other countries.

The EIA assessment to suggest that there are no major changes needed in the on-site facilities, apart from building additional roads and eventually channels for cooling water, etc. From the information available, this cannot be independently corroborated.

Issues to be discussed during consultation

1. Despite the fact that the Ukrainian energy strategy calls for the continued use of nuclear power and for replacement of units that reach the limits of their lifetime after 2025, the experts believe that a discussion of possible alternatives, considering energy conversation, penetration of renewables but also hydro potential would be a useful addition to the EIAR.

2. More detailed graphics on the layout, where one could see the position of all 6 units as well as new infrastructure that would be needed for units 5 and 6 would be useful.
3. The experts would suggest double checking the area available vs. area needed for 1 AP 1000 in construction and in operation.

6 SITING ISSUES INCLUDING EXTERNAL HAZARDS

KhNPP units 5 and 6 are to be built adjacent to the operating units 1 and 2 and units 3 and 4 that are (somehow) under construction. The site is, as per the EIAR, large enough to accommodate for the construction and operation of the units 5 and 6.

The units are to be cooled by the natural draft cooling tower, with the KhNPP cooling pond being a source of water intake for the condenser cooling system and the other process system needs. The water discharges are outed into the cooling pond as well.Each of the units, i.e. 5 and 6, has a fully separate water supply system.

The natural site conditions of KhNPP are only cursory described in EIAR-. Accordingly, the KhNPP site is located in the central Ukraine on the Volyn-Podolia terrane of the Ukrainian Shield in a distance of ca. 180 km from the Carpathian Mountains. The geological substratum of the site consists of Archean-Middle Proterozoic metamorphic basement rocks, overlying Upper Proterozoic-Palaeozoic sediments and Miocene (Sarmatian) clastic deposits. The Palaeozoic succession is dissected by faults of different orientation and age. The topographic location of the NPP construction site is in the Malopilska lowland, on the first floodplain terrace of the Horyn and Hnylyi Rih rivers which provide service water to the existing NPPs.

External hazards that apply to the site are described in chapter 3.8 of EIAR. The report contains the following information:

Tornado: the KhNPP site is said to be located in a tornado-prone area. According to catalogues of tornadoes registered in the USSR and the Ukraine, no tornadoes were registered directly within the KhNPP site area.

Earthquake: EIAR (104) states a “design basis earthquake[1]” value of 5 points[2], a “maximum credible earthquake[3]” value of 6 points[4], and a Peak Ground Acceleration (PGA) of PGA = 0.1 determined by deterministic analysis of the KhNPP site[5]. Further details on seismic hazards such as the type and results of seismic hazard assessments performed for the site are not provided.

Fire (smoke): No information is included in addition to the hazard types.

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[1] Here interpreted as Operation Base Earthquake or SL-1 as defined by IAEA (2010)

[2] The notion is interpreted to indicate intensity I = 5 of the MSK-64 intensity scale used in Eastern Central Europe and the former USSR

[3] Interpreted as design basis earthquake or SL-2; IAEA 2010

[4] Interpreted as intensity I = 6 of the MSK-64 intensity scale

[5] PGA = 0.1 g corresponds to the minimum requirements of WENRA (2021; Safety Reference Level TU 4.2) and the minimum value recommended by IAEA (2010; 2022).

Meteorological hazards: EIAR (p. 103-104) identifies the following hydro-meteorological processes and phenomena which could occur at the KhNPP site:

- heavy rains (rainfall of at least 50 mm within 12 hours or less);
- large hail (diameter of at least 20 mm);
- wind with a speed of at least 25 m/s, hurricanes, squalls and tornadoes;
- dust storm
- heavy fog (visibility less than 100 meters);
- severe snowstorms (with a wind speed of at least 15 m/s)
- snowfall (precipitation of at least 20 mm in 12 hours or less)
- heavy ice (diameter of deposits not less than 20 mm)

For most of the listed meteorological hazards EIAR states that "during the plant operation [of the existing NPP units, i.e., since the 1980ies], natural meteorological events that occurred in the areas, adjacent to the plant … did not create any emergencies at KhNPP". Neither values related to hazard severities (e.g., maximum recorded wind speeds, pressure difference by tornado, precipitation intensity, snow load etc.) nor to the related event frequencies are stated.

Availability and the temperature of the **water in the cooling pond:** it looks like that the original cooing pond has been designed to support the operation of 4 units, rather than 6 that would be operating in a case that the units 3 and 4 and the 5 and 6 would be constructed at the Khmelnytskyi site. The EIAR quotes some previous assessment where with the simultaneous operation of 4 units the temperature of the water in the pond is to reach almost 35 degrees C. This assessment does not cover the impact of global warming that is expected to, in the case of those regions of Ukraine, add to the ambient temperature and increase the droughts, both being directly relevant for the availability of the water in the cooling pond. Even though the condenser cooling for units 5 and 6 is envisaged to use the cooling towers, the availability and temperature of water in the pond might have negative impact on the cooling of the plant's consenter but possibly also on the cooling of safety system, that are being supplied by an open loop from the lake. All this raise the question regarding the appropriateness of the selection of Khmelnytskyi site for additional AP 1000 units.

River flood: The NPP construction site is located in the Malopilska lowland at a reservoir damming the Horyn and Hnylyi Rih rivers. The reservoir provides service water to the existing units and is foreseen to also service the new blocks. The site is located on the upstream side of the reservoir dam. Flood protection includes the possibility to drain the reservoir in cases of extreme floods that coincide with periods of full reservoir filling. EIAR-does not provide numerical data on the elevation of the site platform above the water levels of the dammed lake and the rivers feeding into the reservoir. There is also no information on the heights of recorded river floods. References to hazard assessments with respect to river flooding are not provided either.

Toxic and corrosive emissions into the atmosphere: Emissions may be caused by a number of industrial enterprises located in the area around KhNPP. It is stated that pollutants may result from technological processes or fuel combustion without providing further detail.

Chapter 8.2 of EIAR (p. 234-237) informs about the results of a Probabilistic Safety Assessment (PSA) performed for the AP 1000 of the new power units. The PSA apparently only accounts for internal initial events (EIAR p. 234) and explicitly excludes events initiated by earthquake, fires and flooding. It remains open if the exclusion of fire only applies to external fire or also pertains to internal fires. The EIAR document, however, states that conservative limit estimates of fires and floods show that the reactor Core Damage Frequencies (CDF) due to these events are small compared to CDF due to events related to power line accidents and outage.

Discussion

External hazards have the potential to initiate severe accidents with large releases into the atmosphere. In the case of a severe accident at the new KhNPP, Austrian territory could be affected although the distance of the planned new KhNPP from Austria is larger than about 750 km. A sound consideration of all possible initiating events that can lead to accidents with significant releases is therefore important within the framework of the transboundary EIA procedure. This applies in particular to severe accidents with early or large releases, unless these can be practically eliminated (see below).

The safety expectations for new NPPs are higher than those for existing plants. WENRA (2013) in line with Nuclear Safety Directive of the European Union (Council Directive 2014/87/Euratom) stipulates that for new NPPs “accidents with core melt which would lead to early or large releases have to be practically eliminated”. The Vienna Declaration on Nuclear Safety (IAEA 2015) formulates the same objective for new NPPs, although without reference to the notion of practical elimination (Principle 1 of the Declaration). In this context, the possibility of certain conditions occurring is considered to have been practically eliminated if it is physically impossible for the conditions to occur or if the conditions can be considered with a high degree of confidence to be extremely unlikely to arise (WENRA, 2019). IAEA provides literally the same definition. No consensual definition of the term “extremely unlikely” exists so far. However, European convergence towards a probabilistic target value in the order of 10^{-6} (or lower) for the early or large release frequency by “extreme unlikeliness” is observed.

WENRA further specifies, “For that reason [i.e., to avoid accidents with core melt which would lead to early or large releases], rare and severe external hazards, which may be additional to the general design basis, unless screened out (…), need to be taken into account in the overall safety analysis.” It is further said that “Rare and severe external hazards are additional to the general design basis, and represent more challenging or less frequent events. This is a similar situation to that between Design Basis Conditions (DBC) and Design Extension Conditions (DEC); they need to be considered in the design but the analysis could be realistic rather than conservative.”

These safety expectations require a broad and extensive consideration of external hazards in the plant design and the consideration of events with occurrence probabilities well below 10^{-4} per year in the safety demonstration. Accordingly, natural and human-induced events with occurrence probabilities well below the design basis value (10^{-4} per year as required by WENRA 2021) need to be considered in order to evaluate if sufficient protection is in place to practically eliminate early or large releases. Taking probabilistic target values of 10^{-6} per year for the practical elimination of early or large releases[6] requires to demonstrate that, for different hazard types, events with occurrence probabilities in the range of 10^{-7} per year (e.g., earthquake, river flooding, storm) do not lead to early or large releases.

The available EIA document does not contain sufficient information on external hazards but is limited to very brief mentions of some selected natural hazards (tornado, earthquake, some meteorological hazards, river floods, fire) and a single human-made hazard (toxic and corrosive emissions into the atmosphere). Other natural[7] and human-made[8] hazards that must be expected to apply to the site are not identified.

Lack of information in the EIAR raises considerable doubts as to the extent to which a site-specific hazard analysis has been carried out that would be appropriate for the planning of a new-built NPP. The EIAR fails to demonstrate that the available site assessment considered all natural hazards and all hazard combinations relevant to the site and that all of these phenomena were subjected to detailed hazard analysis. A thorough consideration of external hazards including the steps:

- hazard screening including the identification of hazard combinations;
- hazard assessment;
- definition design basis parameters for hazards that apply to the site;
- analysis of design extension conditions;
- development of adequate protection.

as required by WENRA is not demonstrated (WENRA 2020a; 2020b; 2020c; 2020d; 2021, Issue TU)[9]. EIAR refrains from providing data on hazard severity and the frequency of hazardous events. Instead, the document lists brief summaries of operational experience with some hazards that were acquired in the past about 40 years. Information on how and up to which severities external hazards are considered in the AP1000 design are fully missing.

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[6] E.g., Sweden: "Extremely unlikely" has been interpreted to indicate a limit between 10^{-6} and 10^{-7} per year.

[7] E.g., extreme air and cooling water temperatures, drought, icing, lightning

[8] E.g., external explosion, airplane crash, off-site grid instability

[9] It must be noted that the cited WENRA regulations and guidance apply to existing nuclear power plants and are to be understood as minimum requirements for new-built plants.

With respect to earthquakes, it is noted that the KhNPP site-specific "maximum credible earthquake3" of Intensity I = 6[10] equals the strongest recorded ground shaking in the respective part of the Ukraine. I = 6 conforms to the local intensity recorded for the 1802 (M ≈ 7.9) and 1977 (M = 7.5) Vrancea earthquakes. The level of the "maximum credible earthquake" value therefore denotes the maximum observed local intensity rather than a design basis earthquake for which WENRA requires an occurrence probability of less than 10^{-4}/year. WENRA (2021) also stipulates that "The design basis events shall be compared to relevant historical data to verify that historical extreme events are enveloped by the design basis with a sufficient margin." (WENRA, 2021, Safety Reference Level TU4.3). The experts conclude that a state-of-the-art site-specific probabilistic seismic hazard analysis has apparently not been performed. A review of the site-specific seismic hazard is regarded necessary in spite of the fact that Khmelnytskyi is located on the tectonically "stable" Ukrainian Shield which is generally characterized by low seismicity.

Issues to be discussed during consultation

1. Which types of hazards and hazard combinations that apply to the Khmelnytskyi site have been considered in the site evaluation/characterization so far?

2. Have an updated hazard assessments been performed for the hazards considered, or do the design basis parameters currently in use (e.g., for earthquake) rely on hazard assessments performed for the existing KhNPP units?

3. Do Ukrainian regulations for new-built NPPs require the practical elimination of accidents with core melt which would lead to early or large releases? If so: What are the probabilistic target values to demonstrate practical elimination by extreme unlikeliness?

[10] In Eastern Central Europe and the former Soviet UInion I=VI MSK64 is frequently associated with a Peak Ground Acceleration (PGA) of 0.05g (ENSREG 2012, p. 5)

7 CONSTRUCTABILITY OF THE UNITS 5 AND 6

The section of the EIAR dedicated to climate conditions at the site, contains only a general description of the regional weather. It lacks key technical details and quantitative indicators necessary to properly assess site safety and long-term suitability.

The EIAR mentions that snow cover is present in the winter season; however, it does not provide any numerical data on maximum snow depth or snow loads, which are essential for the structural design of buildings. This is a significant shortcoming because without such data, it is impossible to evaluate whether the infrastructure, specifically safety related buildings, can withstand extreme weather conditions.

The report also notes that snowmelt may place additional pressure on the drainage system, but it includes no analysis or calculation of the system's effectiveness. There is no modelling of surface runoff or flood risk assessment, which creates uncertainty regarding the potential impact of heavy rainfall or rapid snowmelt.

Furthermore, the issue of long-term climate change is addressed only superficially. The EIAR fails to analyze how global warming might affect local temperatures, wind patterns, precipitation, or the frequency of extreme weather events in the future. Such analysis is critical for determining the site's resilience over the long term (30–60 years or more).

In addition, the report does not include any assessment of potential additional costs associated with adapting to climate risks—such as structural reinforcements, protective barriers, or upgrades to water drainage infrastructure.

In short, while the EIAR identifies some climate factors, it lacks detailed data, risk assessments, and cost estimates. To fully meet the standards, the EIAR section should be expanded with concrete calculations, climate risk assessments, and cost evaluations of potential climate-related challenges.

Issues to be discussed during consultation:

Sufficient information about climate related issues should be made available during the bilateral consultations.

8 AP 1000 DESIGN AND ITS COMPLIANCE WITH THE EU STANDARDS

8.1 AP 1000 design for KhNPP

The EIAR establishes that AP 1000 units to be the constructed at the KhNPP will comply with the current regulations on environmental protection against radioactive releases in Ukraine, as well as radiological protection and radiation safety of personnel and the public.

The radiation safety regulation requires that the individual dose levels and/or the number of exposed persons shall be as low as reasonably achievable including economic and social factors. The numerical values of the dose limits in Ukraine are in line with the EU and international norms.

The EIAR states that the "the Level 3 analysis[11] shows that the risk to the public is small and within acceptable limits". This statement is not supported with any reference, nor further information are provided as to on which basis the Level 3 PSA analysis has been developed, whether the specific population in the vicinity of KhNPP and wider has been considered, which methodology was used and which severe accident's end state was used in the Level 3 impact modelling (e.g. DEC A or B, or just DBA, without external events, as mentioned earlier in the report) criteria have been referred to when stating that the "impact is within the acceptable limits"

According to the EIAR, the AP1000 is a proven Generation III+ reactor with passive safety systems, modular standard design, high availability and load monitoring capability licensed by the U.S. Nuclear Regulatory Commission (NRC).

To what extent US NRC criteria are comparable to applicable EU standards is not discussed and presented in the EIAR. Such a comparison should be made available to be able to assess the regulatory framework relevant for this project.

EIAR Chapter 7.1 describes the technical solutions to prevent accidents. It is explained that to reduce the probability of deviations from normal operation that could lead to emergency situations, non-safety-related active systems are provided. These highly reliable active systems are the first level of protection against more likely events, as they are automatically activated and prevent unnecessary operation of passive systems important for safety.

To mitigate design basis accidents, the AP1000 plant is equipped with passive safety features as a second level of protection. The passive safety systems do not require operator actions or AC power. These systems use only natural forces, such as gravity, natural circulation, and compressed gas to make the systems work. Simple valves actuate passive safety systems automatically.

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[11] The EIAR doesn't explicitly refer to the Level 3 PSA, but is read as such by the authors of the expert statement.

EIAR chapter 8.1 states that the AP1000's approach to safety has been specifically designed to maximize the nuclear power plant's resistance to disaster events that result in major infrastructure damage and total loss of power from a common cause, both on and off-site.

Ukraine has 15 reactors generating half its electricity at four existing nuclear sites. The country has plans for nine Westinghouse AP1000 units, including at the existing nuclear plants of Khmelnytskyi, Rivne and South Ukraine. (WNN 2024b) The unit 5 at the Khmelnytskyi NPP will be the first of a planned fleet of AP1000 reactors in Ukraine.

The EIAR also mentions the six AP1000 reactors currently in operation. However, it does not point out that several AP1000 projects have been abandoned for different reasons.

According to the EIAR, the facilities of KhNPP units 5 and 6 are based on the design configuration of the reference NPP. that is the Vogtle NPP units 3 &4 in the United States.

It is mentioned that the design of the AP1000 unit was developed in accordance with the requirements internationally recognized standards (ASTME, ASME, etc.) and the design in accordance with the requirements of international institutions (IAEA, EUR and WENRA). It is not clear from the EIAR to what extent the international documents (IAEA, EUR, WENRA) are to be considered in a binding form for the project. It is worth mentioning that the IAEA and WENRA documents basically only represent recommendations, and the EUR documents are not official standards either.

Particularly in view of the situation in Ukraine, the resistance of the outer structure of the reactor building is of great importance. According to the EIAR, an accident scenario of crash of a large passenger aircraft similar to a Boeing 777/Boeing 737 with full fuel tanks of the KhNPP units 5 and 6 is partially considered. It is explained that accident scenarios are considered in the Preliminary Safety Analysis Report (PSAR).

The EIAR does not explain whether the FSAR for KhNPP units 5 and 6 has been developed (the above quoted statement does not indicate which " PSAR" is meant) available and if yes, if it is available to the affected public within and outside Ukraine, as required by the Article 9 (3) of the Aarhus Convention. In a case the PSAR has not yet been developed, all the specific of the Khmelnytskyi site, including all the external hazards, also with the consideration of the climate change, but also the interaction and possible interference among all units of the site needs to be covered within the PSAR, which is then to be used as the basis for the issuance of the construction license for AP100 as KhNPP units 5 and 6.

The EIAR refers many times to the passive safety systems of the AP 1000. The safety of the AP1000 reactor is based primarily on passive safety systems. There are a number of fundamental questions regarding the passive safety systems. These concern the ability and reliability of a passive system to guarantee the safety function with the expected performance.
The WENRA Reactor Harmonization Working Group has addressed the question

of new safety approaches for passive safety systems. A 2018 report provides an overview of some of the key features of passive systems and emphasizes the potential need to provide specific evidence to the regulatory authorities. (WENRA 2018)

The EIAR does not provide any information to the ageing management program. It is stated that the ageing management program will be implemented at the design stage. Since the planned nuclear power plant is to have an operating life of at least 60 years, it is important to be able to assess whether adequate ageing management is in place to compensate for possible negative long-term aspects.

Issues to be discussed during consultation

1. Is a special version of the AP1000 reactor being built for Ukraine? What changes are being made compared to the reference plant at the Vogtle NPP?
2. Can you please explain the function of the passive containment cooling system (PXS) of the AP1000? Is there any action by the personnel needed to activate any of the passive systems?
3. When the PSAR will be ready, if not yet available. How the concerned public will get access to the PSAR, to assess if and how the assumptions presented in the EIAR are met.

8.2 Accidents affecting AP 1000 at KhNPP

Chapter 8.2 of the EIAR introduces the findings of the probabilistic safety analysis (PSA). It is explained that the PSA for AP1000 reactor units was performed in accordance with ASME/ANSI standards approved by the NRC. The PSA results indicate that the AP1000 design meets the higher expectations and goals for the next generation of passive pressurized water reactors (PWRs).

The nuclear fuel damage frequency in the core (CDF) and maximum accidental release frequency[12] (LRF) for internal events during power operation (excluding seismic events, fires, and floods) are 3,94E-07 per reactor year and 3,83E-08 per reactor year respectively. It is pointed out that these frequencies are at least two orders of magnitude lower than for typically operated pressurized water reactors. The risk reduction is attributed to many plant design features, with the dominant reduction coming from highly reliable and redundant passive safety systems that address both reactor operation and shutdown risks.

[12] Note: In the EIA-REPORT 2025 the abbreviation used is MARF.

The PSA´s results in accordance with the AP1000 Design Control Document for units 5 and 6, namely the core damage frequency and the frequency of accidental releases, are presented in the following table. In addition, for comparison, the table shows the assessment of the fulfillment of the safety criteria for KhNPP units 1 and 2.

Table 1: Results of probabilistic risk assessment of AP1000 (EIAR, table 8.1)

	CDF per reactor year	**LRF per reactor year**
unit No. 5 (AP 1000)	3,94E-07	3,83E-08
unit No. 6 (AP 1000)	3,94E-07	3,83E-08
unit No. 1 (WWER -1000)	4,08E-06	1,62E-06
unit No. 2 (WWER -1000)	4,12E-06	9,10E-07

Based on the summary results of the PSA of the AP1000 unit, it is concluded that the CDF and the LRF of the AP1000 unit meet the safety criteria for NPP units by the Basic Safety Principles for Nuclear Power Plants, (according to NP 306.2.245-2024, such criteria should not exceed 1E-6 per reactor year (CDF) and 1E-7 per reactor year (LRF).

EIAR Chapter 8.3 discusses the accident scenarios. It is explained that based on the results of the analysis of relevant accidents, it was determined that the most serious radiological consequences arising from a loss of coolant accident (Loss of Coolant Accident - LOCA). Even though the analysis of the AP1000 core during a LOCA shows that the integrity of the core is preserved, it is assumed that major core degradation and melting occurred to assess the radiological consequences of the accident.

The EIAR explains: Design extension conditions are conditions caused by initial events not considered as part of a design basis accident, in particular, the expected probability of occurrence of which is lower than that taken into account for design basis accidents, or the course (development) of which is accompanied by additional failures of safety systems or human errors compared to design basis accidents. Radiation accidents of this category result in the release of radioactive substances into the environment and contamination of the natural environment. The degree of contamination of the territory adjacent to the plant depends primarily on the amount of radionuclides released into the environment and the nature of their dispersion in the atmosphere. Unfavorable weather conditions are those under which there is minimal dispersion of radioactive substances in the atmosphere. Under such conditions, contamination of a small area with very large density gradients occurs.

In the case of an accident, the following radioactive mixture of fission products is released into the environment: radioactive noble gases, radioisotopes of iodine, Cs-137, Sr-90. At further stages of the accident, long-lived radionuclides

Cs-137 and Sr-90 will play a leading role in the product contamination. The value of the total release corresponding to the design extension conditions is given in the following table.

Table 2: Expected total release of radionuclide composition to the environment under the design extension conditions at the AP1000 power unit (Bq) (EIAR Table 8.2)

Nuclide	0-2 hours	2-8 hours	8-24 hours	24-96 hours	96-720 hours	Total
Cs-137	3.03E+12	8.13E+12	5.07E+11	2.59E+09	2.40E+10	1,17E+13
I-131	3.34E+13	9.27E+13	9.50E+12	6.24E+12	1.87E+13	1,61E+14
Te-131m	7.48E+11	2.32E+12	1.26E+11	2.22E+08	7.40E+07	3,19E+12
Sr-90	1.37E+11	4.51E+11	2.82E+10	1.48E+08	1.33E+09	6,18E+11
Ru-103	2.96E+11	9.71E+11	6.03E+10	2.96E+08	2.15E+09	1,33E+12
La-140	2.84E+10	8.94E+10	5.03E+09	1.48E+07	3.70E+06	1,23E+11
Ce-141	6.54E+10	2.14E+11	1.33E+10	7.03E+07	4.48E+08	2,93E+11
Ba-140	2.76E+12	9.01E+12	5.54E+11	2.96E+09	1.15E+10	1,23E+13

In case of design basis accidents, the public exposure doses on the boundary and beyond should not exceed the values of unconditional justification levels given in NRBU-97, namely a) an effective dose of 10 mSv for children and 20 mSv for adults respectively.[13] The modeling of release propagation from KhNPP units 5-6 was performed for the design basis LOCA scenario. The calculations of contamination parameters and radiation doses were performed for stationary meteorological conditions at points on the plume axis with a step of 50 m up to a maximum distance of 3000 m from the source.

The EIAR explains that calculations of contamination characteristics and radiation doses were performed for stationary meteorological conditions at points on the plume axis with a step of 100 m up to a maximum distance of 30 km from the source. Effective doses to the public were calculated for different age groups. In accordance with the Ukrainian requirements[14], the results presented in the EIAR were obtained by modeling the distribution of radionuclides in the atmosphere with a value of the wet removal constant = 2 h-1, which corresponds to the intensity of rainfall J = 21.4 mm h-1.

The results show even with a beyond design basis accident sequence (design extension conditions) at the AP1000 unit, the limit to the effective dose to the

[13] In the EIA-REPORT (2024) also the thyroid dose: (children - 100 mSv; adults - 300 mSv) and skin dose: (children - 300 mSv; adults - 500 mSv) are mentioned.

[14] NP 306.2.173-2011. Requirements for determining the size and boundaries of the SA of a nuclear power plant.

public (50 mSv) for will not be reached. This applies to all considered meteorological conditions and for all age groups at distances of more than 3500 m from the release source.

The EIAR provides the values for the core damage frequencies (CDF) and the large release frequencies i.e. the CDF= 3.94E-07 per reactor year and LRF=3.83E-08 per reactor year. [Note: The EIAR for the planned AP1000 in Poland gives the generic data for PSA from Westinghouse for the AP1000, which are higher (CDF = 8.4E0-7 per reactor year and a LRF of 7.4E-8 per reactor year). At the same time, the values from the preliminary safety report for the AP1000 at the Vogtle site are also mentioned (CDF = 2.41E-7 per reactor year; LRF = 1.95E-8 per reactor year), which are lower.]

The contribution of external events for KhNPP units 5 and 6, to the core damage frequencies (CDF) have not been determined as the site has not yet been sufficiently analyzed. The EIAR lacks information on the results of probabilistic safety analyses (PSA) on large (early) release (L(E)RF) frequencies by release category. A possible release from the spent fuel pool, which can contribute to the frequency of a severe accident, is also not discussed.

In order to be able to assess the possible impact on Austria in a comprehensible manner, an EIAR should provide a range of information on the PSA Levels 1 and 2:

- The probability distribution (quantiles) probabilities/frequencies for core damage (CDF) and severe accidents with large releases (LRF) should be given, also information on early large releases (LERF)
- The contributions of internal and external events to CDF and LRF as far as this is possible at the current stage of the project.
- Further source terms for the most important release categories or for releases from the spent fuel pool should be provided.

The dispersion calculations and the determination of the radiation doses for incidents and accidents are presented in a comprehensible manner, but not all the information is provided:

- The methods and programs chosen for the dispersion calculations are mentioned;
- the input parameters used in the dispersion calculation (source term, release height and duration, meteorological data) and their justification are stated in a sufficiently comprehensible manner;
- the probability distribution of the results is not mentioned, only the calculated mean values are given;
- the results of the dispersion calculations are not given in the form of soil contamination (in particular of the nuclide Cs-137).

Practical elimination of severe accidents

One of the most important safety requirements for new-generation nuclear power plants is the requirement to practically eliminate core melt accidents that could lead to early failure of the containment or to very large releases of radioactive substances into the environment.

Internationally, it is expected that large or early releases can be practically eliminated with new reactors. The European Union's 2014 amendment to the Nuclear Safety Directive requires that new nuclear facilities be designed with the aim of preventing accidents and, in the event of an accident, mitigating their consequences, as well as avoiding early releases and large releases of radioactive material. (EU 2014).

According to the IAEA (2012), a situation is *practically eliminated* if it is either physically impossible for it to occur or can be regarded as extremely improbable with a high degree of confidence. The term “extremely improbable” is not defined in more detail by the IAEA, nor is there currently any internationally generally accepted numerical definition. The same applies to the meaning of the phrase “high degree of confidence”. For example, whether the 95 % or 99 % quantile corresponds to the required high degree of confidence is not internationally defined.

For the frequencies of core damage and large releases (CDF and LRF), values are often given that represent the median of the calculated probability distribution. This means that there is a 50 % probability that the corresponding frequency will be lower or higher than this value, so the value does not correspond to a high degree of confidence.

The WENRA (Western European Nuclear Regulators Association) report on the safety of new NPP designs also states that accidents involving core meltdown, which would lead to early or large releases, must be practically eliminated. The report goes on to say: “*For accidents involving core meltdown that are not practically eliminated, design precautions must be taken so that only limited protective measures for the population are required in terms of space and time and sufficient time is available for the implementation of these measures.*” (WENRA 2013)

WENRA refers to the above-mentioned IAEA definition, but did not feel obliged to provide a quantitative definition of what is meant by “practically eliminated”. However, a WENRA report published in 2019 provides a common understanding of the approach to demonstrating the avoidance of early and large releases using the concept of practical elimination. (WENRA 2019)

According to WENRA (2019), the demonstration of practical elimination must be based on the two pillars of deterministic and probabilistic consideration. For the deterministic part of the demonstration, practical elimination should be based primarily on design provisions, supported by operating provisions. For the probabilistic part of the demonstration, the practical elimination of a scenario can be considered successful if a target value is achieved.

There are various types of scenarios to which the concept of practical elimination can be applied. To get an overview of all relevant cases, it makes sense to classify the scenarios into three types:

- Type I - scenarios with a triggering event that directly leads to severe fuel damage and early failure of the containment function.
- Type II - severe accident scenarios with phenomena that cause early failure of the containment function.
- Type III - severe accident scenarios that lead to late failure of the containment function.

All WENRA countries apply the concept of practical elimination to Type I and Type II scenarios; some countries also apply it to Type III scenarios. (WENRA 2019)

It is not stated in the EIAR that the safety analyses for the AP1000 nuclear power plant, in particular the probabilistic safety assessments (PSAs), have shown that accident scenarios that could lead to early and large releases of radioactive material into the environment are "practically eliminated".

The EIAR does not mention the concept of practical elimination of accident sequences that could lead to an early and/or large release of radioactive material into the environment. It is therefore not known what requirements exist in Ukraine with regard to the concept of demonstrating practical elimination.

Beyond design basis accidents and source terms

A beyond design basis accident that belongs to the design extension condition (DEC) and that could cause transboundary impacts is assessed in the EIAR but the accident sequence selection is not adequately described. Other potentially possible accidents with higher releases can only be practically ruled out once a deterministic and probabilistic analysis has been carried out to prove that they can be practically eliminated.

To calculate the possible transboundary impact, for the accident scenario considered in the EIAR, a source term for the important radionuclides Cs-137 of 11,7 TBq and I-131 of 161 TBq was used. It is not explained which accident sequences with possibly significantly higher source terms from the safety reports were not considered in the EIAR.

In the event of a severe accident with large releases into the atmosphere, the territory of Austria may be affected. A detailed consideration of a covering accident in the EIAR is therefore particularly important. In principle, possible beyond-design-basis accidents should therefore be presented in the EIAR, regardless of their frequency of occurrence.

Issues to be discussed during consultation

1. What is the technical justification for the beyond design accident selected for the calculation of possible (transboundary) effects?

2. Can the probability distributions (quantiles) for the frequencies for core damage (CDF) and severe accidents with large releases (LRF) be specified? What probabilities were determined for early large releases (LERF) in the generic PSA?

3. What are the source terms for the beyond design basis accidents calculated in PSA Level 2 for the other release categories, and what probabilities were calculated for them?

4. According to Ukrainian regulations, is the application of the concept of practical elimination for large and early releases required in the event of a severe accident? Should proof of practical exclusion be provided in Ukraine in accordance with WENRA 2019? Does this also apply to accident scenarios involving late containment failure (accident type III)? Has a target value for probabilistic proof already been defined?

9 UKRAINE REGULATORY REQUIREMENTS AND COMPLIANCE WITH WENRA SRLS

The EIAR does not discuss the Ukraine regulatory framework in any level of details. The EIAR mentioned that the Ukraine regulatory framework is being adjusted with the modern international standards and EU requirements but does not dwell any further on the compatibility of the AP 1000 design with Ukraine regulations. This is an important issue because in some cases the generic AP 1000 design or the one of Vogtle, the reference for the KhNPP units 5 and 6 might need to be adjusted to accommodate for specific requirements. This is the case in Poland and would be also the case for an AP 1000 is to be constructed in the UK.

The original Soviet era regulatory framework for nuclear power plants was based on a technology-oriented approach with rigid and inflexible conditions. Since the early years of independence, Ukraine has been working to improve its legal and regulatory framework in the field of nuclear and radiation safety (NRS). One of the key directions of this improvement is the harmonization of national regulatory requirements with the recommendations of EU and international organizations and associations in the field of nuclear energy use.

In the framework of the overall EU accession process, Ukraine undertakes to harmonize its nuclear legislation with the EU Acquis. This harmonization process was started shortly after signature of the EU-Ukraine Association Agreement back in 2014 based on self-assessment implemented by relevant Ukrainian government organizations and their TSOs.

The Ukraine's key legal and regulatory documents relevant for the construction and operation of NPPs include:

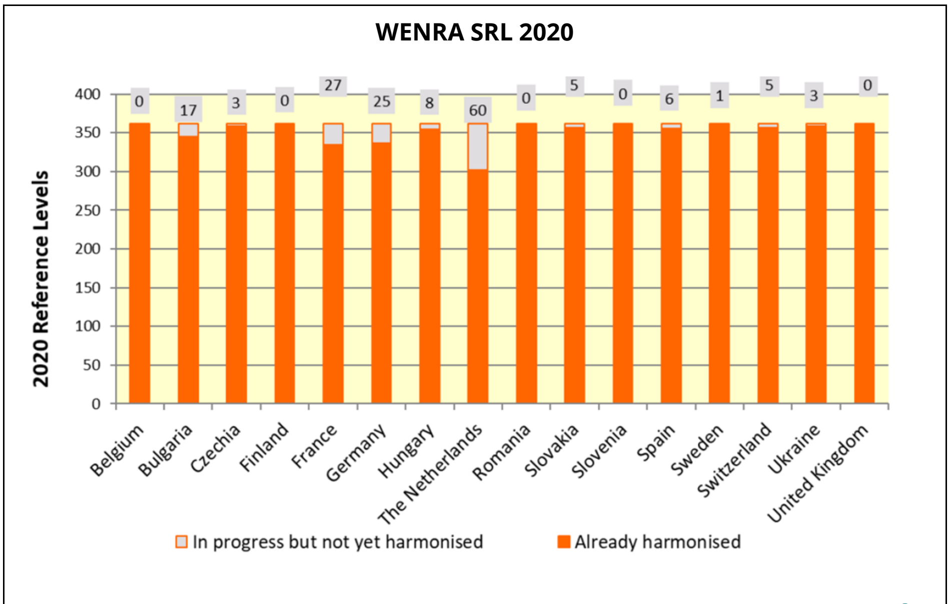
- Law of Ukraine No. 39 On the Use of Nuclear Energy and Radiation Safety
- Law of Ukraine No. 15 On the Protection of Humans from Ionizing Radiation
- Law of Ukraine No. 1370-XIV On Licensing Activities in the Field of Nuclear Energy Use
- Law of Ukraine No. 255 On the Management of Radioactive Waste
- Law of Ukraine No. 1868-IV On the Regulation of Issues Related to Nuclear Safety
- Law of Ukraine dated No. 4384-VI On the Management of Spent Nuclear Fuel Regarding the Location, Design, and Construction of a Centralized Spent Nuclear Fuel Storage Facility for VVER Type Reactors of Domestic Nuclear Power Plants
- Law of Ukraine dated No. 2573-IX on the Public health system
- Law of Ukraine No. 2861-IV On the Procedure for Decision-Making on the Location, Design, and Construction of Nuclear Installations and Facilities Intended for Radioactive Waste Management of National Importance
- Law of Ukraine No. 1264 On the Protection of the Environment

- Law of Ukraine No. 2059 On Environmental Impact Assessment
- Law of Ukraine, 2015 No. 124 On Technical Regulations and Compliance Assessment
- General Safety Provisions for Nuclear Power Plants (NP 306.2.141-2008);
- Requirements for Nuclear Safety of Reactor Installations (NP 306.2.205-2013);
- A wide range of technical norms, rules, and standards issued by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU).

The State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) participate in WENRA activities, of which Ukraine became a member in 2015. As part of this cooperation, Ukraine is harmonizing its national rules and regulations in the field of NRS with WENRA's reference levels, particularly through self-assessment and the elimination of identified gaps.

Following the first self-assessment in 2013 and its subsequent peer review, a harmonization plan was developed and has been gradually implemented. Further self-assessments and peer reviews have confirmed good progress in aligning the national legal and regulatory framework with European standards. In particular, the WENRA Report "Preliminary status of the Implementation of the 2020 Safety Reference Levels in National Regulatory Frameworks as of 1 January 2025" reported quite high compliance of Ukraine to WENRA SRL 2020 (see Figure 1).

Figure 1: WENRA SRL 2020



Quelle: Umweltbundesamt

Currently, Ukraine's legislation in the field of nuclear and radiation safety covers all aspects relevant to the regulation of safety in the operation of nuclear installations. It should be noted that some issues related to the design, construction, operation, and environmental protection in the operation of NPPs fall under the jurisdiction of other regulatory bodies, such as public health and hygiene, environmental safety, architecture, and urban planning, etc. Those might or might not be aligned with relevant EU standards.

Although Ukraine in general comply with EU nuclear Acquis, planed construction of a US designed reactor in Ukraine might still face regulatory challenges. Those might include:

- The emergency planning zones might not be fully aligned with the IAEA emergency planning zone concepts and requirements;
- Current Ukrainian regulations heavily rely on deterministic safety analysis. While this remains a foundational approach, it may not sufficiently accommodate the probabilistic safety methods integral to modern reactor designs such as the AP1000, possibly requiring different safety justifications;
- The AP1000's reliance on passive safety features is not fully reflected in Ukraine's existing regulatory framework, which remains oriented toward active safety systems. This misalignment may complicate the licensing;
- The technical guidance for fuel qualification processes for a novel type of fuel, and related regulatory approval is needed;
- Existing regulations lack specific provisions graded approach during the decommissioning of nuclear installations, despite this being a requirement in higher-level decommissioning policy documents.
- Ukraine lacks established practices for pre-licensing project assessments. There is no formal mechanism for certifying standardized reactor designs.

Issues to be discussed during consultation

1. The EIAR shall address the impact of specific challenges related to the licensing of AP1000 in Ukraine

2. The EIAR shall address or at least comment on the gaps between Ukrainian safety philosophy and that applied in Generation III+ Western reactors

3. The EIAR shall address the deviation in Ukraine regulatory framework to that of WENRA SRL and Safety objectives for new reactors, as far as those might affect the licensing process of AP 1000.

10 POTENTIAL AND ACTUAL IMPACT OF THE RUSSIAN AGGRESSION ON THE CONSTRUCTION AND OPERATION OF AP 1000

The EIAR does not assess any impact of the on-going Russian aggression on the possibility to construct the AP 1000 at Khmelnytskyi site. This is in a way understandable, because the construction in conditions as those are now would be subject to multiple challenges and possibly inviting a military attack to the site.

In the current situation the construction of KhNPP units 5 and 6 would be facing multiple challenges, from possibilities of transporting heavy components to obtaining services and supplies from various companies (that are listed in the EIAR but that might or not exist anymore or might have changed their scope of work).

There might be further challenges in the availability of the workforce, in particular for the construction.

There might be range of legal issues related with the construction of the plant, from export to insurance and the liability issues that might be related with the equipment to be supplied to Ukraine.

In terms of the operation of AP 1000 units at Khmelnytskyi site, given Energoatom experience in operating NPPs, availability of well experienced operators and support staff (who would, as the EIAR states, need to be retained for the AP 1000 technology), there should not be expected problems in that regard. Nevertheless, staring up and operating new nuclear units, under the continuing threat of military attacks would be a big challenge.

Issues to be discussed during consultation

1. The EIAR should update the part of the report that present possible supplies for services and equipment, to reflect their current status and availability to provide expected services or supplies
2. The EIAR could discuss potential challenges to construction of new NPP in the view of on-going Russian aggression.

11 TRANSBOUNDARY IMPACT

The EIAR in its section 5.3.8 discusses the transboundary impact of the potential release from the KhNPP units 5 and 6. The transboundary impact is driven by two important elements one being the meteorological conditions and another being the source term including the duration and the height of the release.

In terms of meteorological conditions, the EIAR states that the "the most reasonable approach to selecting meteorological scenarios [...] is not co construct an artificial "ultra conservative scenario, rather to use the real data of atmospheric characteristic measurements". The EIAR further states that a "conservative meteorological forecast based on the results of long-term observations of the meteorological post of the KhNPP". On that basis, the weather data with the wind speed of 1, 2, 3, 5, 10 m/s was selected, with atmospheric stability category D. It is not entirely clear how the variable wind speed was used in the JRODOS calculation. Furthermore, the wind direction looks like to be set on the vector to assure the most direct impact on the neighboring countries.

The release height used is 72,5 meters with likely corresponds to the stack release. The duration of the release taken into the account is not entirely clear as the table 5.26 provides 5 different time spans. Furthermore, the table 5.26 indicates that the values are for the emissions of radionuclides for the " maximum design basis accident". The experts believe that for the transboundary impact, the maximum severe accidents (so DEC B) is to be used, as it has been used in numerous EIAR studies in the EU. Another potential misunderstanding comes from the fact that the Table 5.30 provided " The expected release of activity into the environment in case of beyond design basis accident", where e.g. the value for I 131 seems to be lower for BDBA than for the DBA.

The results for the analyses are presented in maps, one for each country concerned that indicates the potential transboundary impact for each of them. As there is no legend provided, it is hard to understand what is the level of impact that those maps are showing. Judging from the color codes, the doses in some "hot spots" in the neighboring countries might be only one order of magnitude lower than in the edge of the emergency planning zone of the KhNPP.

Austria is not a neighboring country to Ukraine and therefore the impact on the Austrian territory has not been assessed nor presented. The experts believe that the impact in terms of the doses to the population would be (very) small, though the impact in the term for the deposition on the ground, which would trigger the protective actions in Austria is possible, as shown on the maps below.

The source term use in the calculation of the experts is for a PWR of 1000 MW, for a hypothetical accident involving loss of coolant, with integrity not compromised, and no core melt. The release started one hour after the reactor shut down. Such a source term is generally a DBA source term, meaning that it could be 1 or 2 order of magnitude lower than a limiting DEC B accidents, which associated bypass or a beach of the containment. Higher source term with all other things being equal, will lead to a higher deposition rate.

The source term used and compared with the source term used in the EIAR is provided in the table below.

Table 3: Source term used in JRODOS calculation and comparison with EIAR

Nuclide	**Activity (Bq)** **A typical PWR 1000 MW, DBA**	**Activity (Bq)** **EIAR for KhNPP AP 1000 (EIAR Table 5.30)**
Cs-137	1.20E+14	1,17E+13
I -131	1.40E+15	1,61E+14
La-140	9.10E+11	1,23E+11
Ru-103	4.80E+12	1,33E+12
Sr- 90	9.10E+11	6,18E+11
Te-131m	-	3,19E+12
Xe-133	4.00E+16	2,86E+16
Xe-133m	-	2,85E+14

Deposition of the radioactive material released during an accident depends on a number of factors: characteristics of a release, meteorological conditions, deposition surface and others. For this task, meteorological conditions for period 28 August – 1 September 2024, which led to transport of a radioactive plume over Austrian territory, were chosen.

Local Scale Model Chain (LSMC), a short-range atmospheric dispersion model in JRODOS, was used for atmospheric dispersion modelling. The actual weather as occurred on 28th August 2024 is used. This weather had a prevailing westerly wind. Release duration of 96 hours was postulated.

Table 4: Basic parameters for JRODOS

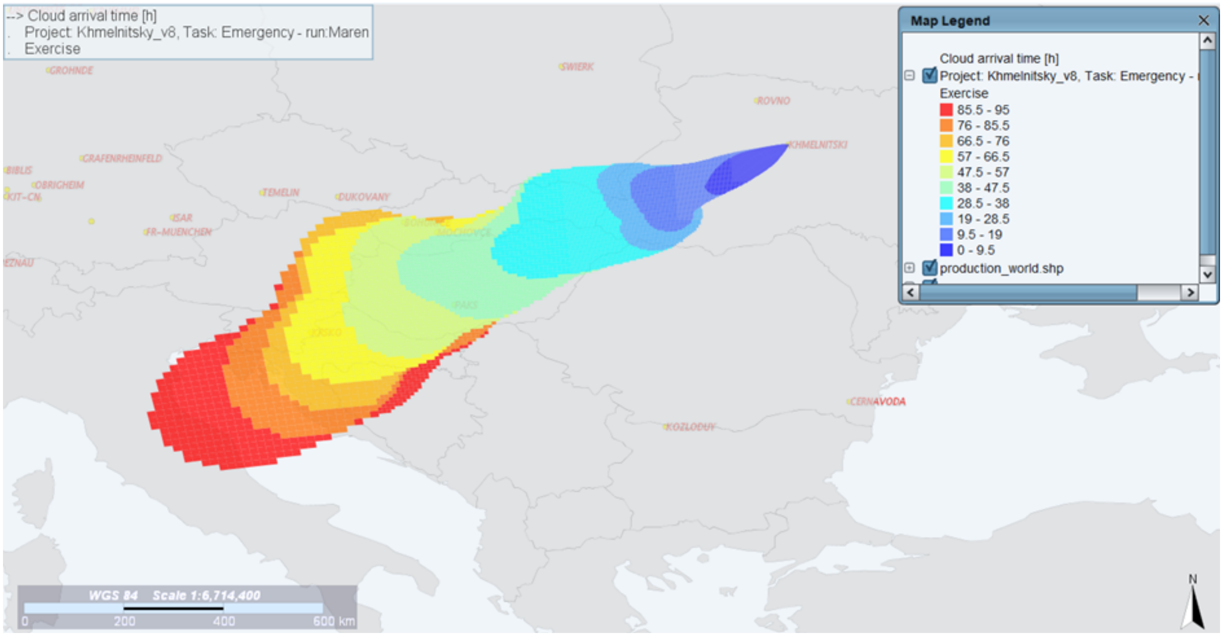
Location:	Khmelnytskyi, Ukraine
Release start:	28 August 2024, 02:00 UTC
Release end:	28 August 2024, 14:00 UTC
Prognosis duration:	96 hours

Presented here are the results of a calculation that onfirmed possibility of ground contamination in Austria from a release in Khmelnytskyi.

Information on cloud arrival time (Fig. 1) tells when the cloud is expected to arrive to the affected country. In the case presented here, it takes around 50 hours for cloud to reach the Austrian territory. As it heavily depends on the weather, cloud arrival time may be significantly different for different meteorological conditions.

Figure 2: Cloud arrival time

Cloud arrival time

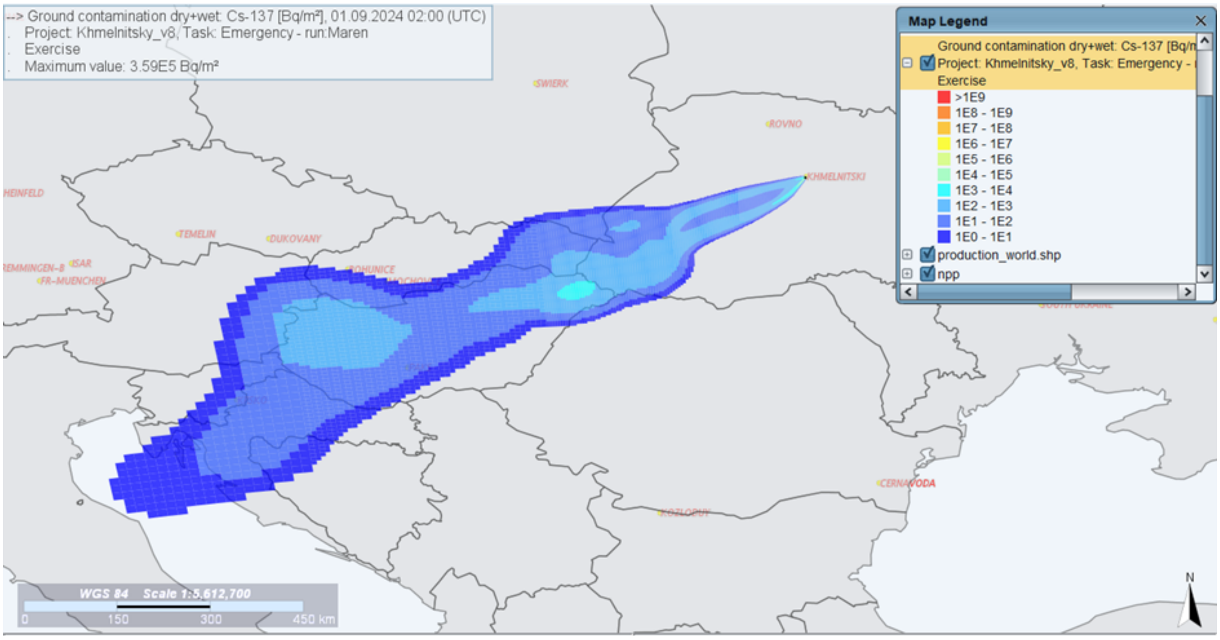


Quelle: Umweltbundesamt

umweltbundesamt

Figure 3: Ground contamination with Cs-137 from the release case in Khmelnytskyi

Cloud arrival time



Quelle: Umweltbundesamt

Results of JRODOS calculation presented in Figure 3, show that there is a possibility of contamination in Austria with the maximum calculated value between 1E+2 and 1E+3 Bq/m2, triggering the protective actions in Austria.

Issues to be discussed during consultation

1. Could you please explain the selection of the source term used in your transboundary calculation. Why do you select the source term that apparently does not correspond to a most severe possible release
2. The weather used for the dispersion and the way it is defined is, in the view of the experts not appropriate for the dispersion analyses over longer distances (it might be appropriate for the emergency planning zone around KhNPP). It is suggested that the JRODOS dispersion calculation is repeated with the actual weather that would show the impact to the potentially affected countries, not just population doses than the deposits on the ground.

12 RADIOACTIVE WASTE GENERATED

The EIAR described the general principles of generation of radiative waste at ANPP 1000 KhNPPs units 5 and 6. It specifies that solid, liquid and gaseous wastes will be generated and identify the sources of waste as:

- NPP equipment and systems containing gaseous, liquid, and solid media.
- maintenance, small leaks, and fugitive coolant leaks.
- auxiliary equipment, balance of plant containing radioactive media or that is contaminated.

The EIAR states that the AP1000 units are designed to contain radioactive waste treatment and management system, which will also for processing the radioactive waste generation from plant operation. The EIAR also mentions that there is a possibility for engaging mobile processing systems, that are known to be used at other WEC plants. The AP is designed to minimise total radioactive waste volumes compared to reactors of previous generations.

While the gaseous radioactive waste and some of the liquid waste is expected to be released (after certain decay period), the main waste stream from the operational NPP that needs to be processed and disposed is the solid radioactive waste. For the AP 1000, the most important (in terms of the activity) waste comes from spent ion exchange resins and spent filter cartridges. Specialized systems are in place to adequately process such waste.

The KhNPP operator, Energoatom, is said to be implementing a project for the construction of the KhNPP Radioactive Waste Processing Complex (RWPC). This is expected to serve the waste processing needs of operating units 1 and 2, and units 3,4 5 and 6 when operational, as well as for the decommissioning waste from the units. The RWPC is expected to prepare processed waste for further shipment to specialized enterprises for disposal following the waste acceptance criteria as defined from the disposal facility. It is not entirely clear whether the AP 1000 would then be constructed without the waste processing facility that is a part of a generic design. The EIAR indicates that the construction of the RWPS at the KhNPP site will ensure increasing the level of personnel protection, the public and the environment from negative radiation impact.

The EIAR does not give any indication as to where and how the radioactive waste generated by the KhNPP units 5 and 6 will be disposed in the long term. While it is known that Ukraine is developing the disposal facility for the radioactive waste (located in the Chernobyl exclusion zone) EIAR does not mention whether this would be used and whether the AP 1000 waste would be compatible with the waste acceptance criteria of the disposal facility.

It is to be expected that the spent nuclear fuel, once it leaves the cooling point at each unit, will be stored in the dry store. Ukrainian NPPs including KhNPP are using Holtec dry storage container. It is reasonable to assume that the same arrangement will be used for KhNPP units 5 and 6. Still the EIAR does not contain any discussion on the environmental impact beyond storage period, i.e. what will happen with the spent nuclear fuel in the long term.

Issues to be discussed during consultation

1. Could you please provide the information on the plans and arrangements in Ukraine for the final disposal of radioactive waste from KhNPP units 5 and 6

2. Could you please provide the information on the plans regarding the on-site storage of the spent nuclear fuel, as well as current consideration in Ukraine for the long term management and disposal of SNF/high level radioactive waste.

13 GLOSSARY

AP1000 .... WEC Pressurized water reactor

Bq .... Becquerel

CDF .... Core damage frequency

DBA .... Design Basis Accident

DEC .... design extension condition

EBRD .... European Bank for Reconstruction and Development

EIA .... Environmental impact assessment

EU .... European Union

IAEA .... International Atomic Energy Agency

JRODOS .... Java based Real-time On-line DecisiOn Support

KhNPP .... Khmelnytskyi NPP

LERF .... Large early release fraction

LILW .... Low- and Intermediate Level radioactive Waste

LSMC .... Local Scale Model Chain

MW .... Megawatt

MWe .... Megawatt electric

MWth .... Megawatt thermal

NPP .... Nuclear power plant

NRC .... U.S. Nuclear Regulatory Commission

NRS .... nuclear and radiation safety

PSA .... Probabilistic Safety Assessment

PSR .... Periodic safety review

PWR .... Pressurized water reactor

R4K2 .... R4/K2 Khmelnytsky unit 2 Rovno unit4

RWPC .... Radioactive Waste Processing Complex

SNF .... Spent nuclear fuel

SSC .... System Structures & Components

TBq .... Terabecquerel

WENRA .... Western European Nuclear Regulators‘ Association

WWER 1000 .... Soviet designed reactor unit

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ANNEX 1: OVERVIEW OF THE AP 1000 TECHNOLOGY

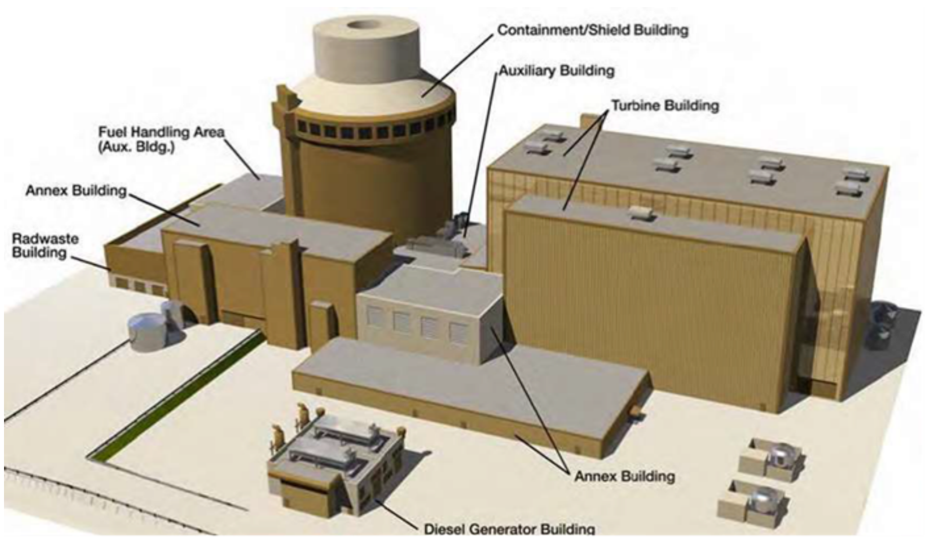
In chapter 1.4.2 of the EIAR some technological characteristics of the AP1000 plant are provided. It is explained that the AP1000 is a two-loop pressurized water reactor (PWR) that uses a simplified, innovative and efficient approach to safety. The AP1000 design provides high safety, economic competitiveness, and improved and more efficient operation. The advantage of AP1000 reactors is a very high installed capacity utilization rate of 93% and an extended fuel cycle of 18 months. The AP1000 design offers clear advantages, including high safety, economic competitiveness, and improved and more efficient operation.

The AP1000 power unit site consists of five main building structures (see Figure 4):

- nuclear island (containment, shield building and auxiliary building);
- turbine island;
- radioactive waste management building;
- diesel generator building;
- annex building.

Figure 4: AP1000 power unit (EIA-REPORT 2024)

AP1000 power unit

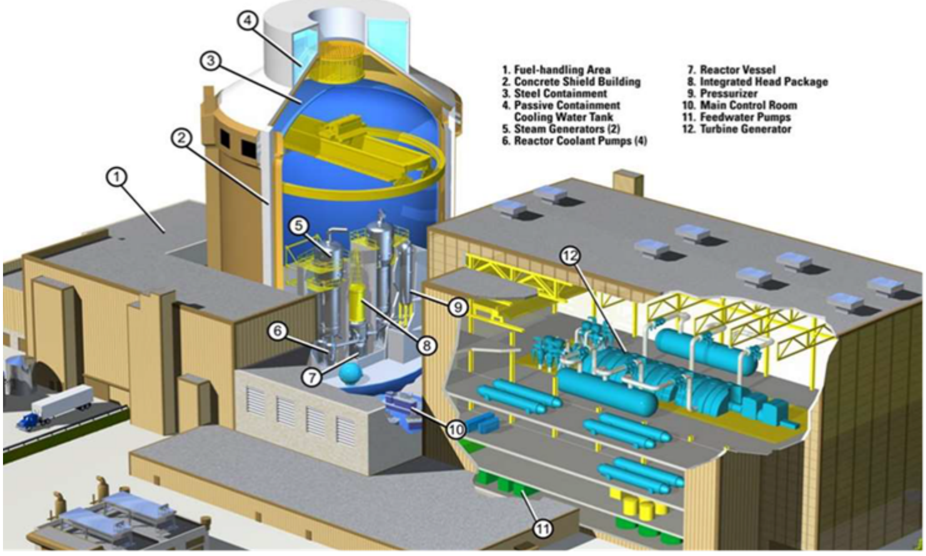


Quelle: Umweltbundesamt

The layout of the main facilities and components of the AP1000 power unit is shown in Figure 5.

Figure 5: The layout of the AP1000 unit main facilities and components (EIA-REPORT 2024)

Layout of the AP1000 unit main facilities and components



Quelle: Umweltbundesamt umweltbundesamt

The reactor coolant system (RCS) consists of

- Reactor;
- Steam Generator;
- Pressurizer;
- Main Coolant Pumps;
- Primary Coolant Pipelines.

The AP1000 RCS is designed to circulate the coolant to transfer heat generated in the reactor core to the secondary side. The RCS consists of two heat transfer circuits, each with a steam generator, two reactor coolant pumps (RCPs), a single hot leg and two cold legs, for circulating reactor coolant between the reactor and the steam generators. In addition, the system includes a pressurizer, interconnecting piping, and valves and instrumentation necessary for operational control and safeguards actuation. All system equipment is located in the reactor containment.

The RCS performs and/or supports the following safety-related functions:

- Reactor coolant pressure boundary (RCPB) serves as a pressure boundary for containing the reactor coolant, soluble boron, limiting radiation releases (by limiting coolant leakage) to the containment and between the primary and non-radioactive secondary circuit except for plant conditions that postulate a failure of the RCPB.
- The RCS provides the coolant circulation and decay heat removal required during the transition from forced circulation to natural circulation. The RCS, in conjunction with the reactor system (RXS), and the passive/active

core cooling systems (PXS) contain the soluble neutron poison, which supplements the negative reactivity inserted by the control rods to provide the reactor shutdown subcriticality margin.

- The RCS supplies the signals required by the Protection and Safety Monitoring System (PMS) to provide automatic reactor trip and actuation of the passive safety systems.
- The automatic depressurization system (ADS) function is to automatically depressurize the RCS so that the Passive Core Cooling System can adequately cool the core during small-break loss of coolant accidents (LOCAs). (Any of the six ADS 1-3 subsystem flow paths in the RCS provides a manually opened vent path large enough, 27.8 cm2 to relieve water from the RCS to prevent reactor vessel low temperature over-pressurization in the event that the RNS relief valves are not operable when the reactor coolant is less than 135°C.
- An emergency letdown system allows to control pressurizer level during accident events associated with an increase in pressurizer water level.
- The RCS provides the capability to vent non-condensable gases that might collect in the pressurizer and reactor vessel head in order to support core cooling capability in accident scenarios.
- The RCS provides the capability to depressurize the system to an extent necessary to support the Passive Core Cooling System (PXS) during a non-design basis external event.

The reactor coolant loop has connections to the Passive Residual Heat Removal Heat Exchanger, which is part of the PXS. This connection, along with the two core makeup tanks results in three safety related, natural circulation flow paths to the reactor core through the RCS loop piping and PXS components.

Natural circulation would be expected to continue through until plant or equipment conditions change (such as depletion of safety-related batteries) and require actuation of the ADS valves and transition from natural circulation core cooling to safety injection and containment sump recirculation core cooling.

The **nuclear island systems** of the AP1000 unit include the following:

1) Reactor coolant system (RCS)

2) Nuclear island process systems:

- Chemical and Volume Control System (CVS)
- Primary Sampling System (PSS)
- Radio-chemistry Laboratory System (RLS)
- Spent Fuel Pool Cooling System (SFS)
- Normal Residual Heat Removal System (RNS)
- Containment Leak Rate Test System (VUS)
- Steam Generator Blowdown System (BDS)
- Component Cooling Water System (CCS)
- Service Water System (SWS)

- Special Process Heat Tracing System (EHS)

3) Safety systems
- Passive Containment Cooling System (PCS)
- Passive Core Cooling System (PXS)
- Containment Hydrogen Control System (VLS)
- Emergency Habitability System (VES)
- Containment Isolation System (CNS)
- Spent fuel pool cooling system (SFS)

4) Protection and Safety Monitoring System (PMS)

5) Class 1E DC system (IDS)

The main characteristics of the AP1000 power unit are shown in the following table.

Table 5: Main characteristics of the AP1000 power unit

Rated electric power	1117 - 1145 MW (the value is variable for each site, depending on the turbine unit used, cooling configuration, planned load, etc.)
Design operating lifetime of the power unit	60 years
Rated thermal power	3400 MW
Operating pressure in the reactor unit RU	15,51 MPa
Hot loop temperature	321,11 °C
Calculated pressure in the steam generator	8,27 MPa
Temperature of the main feedwater	226,67 °C
The number of fuel assemblies (FA) per unit	157
Core height	4,267 mm
Fuel assembly (FA) array	17 x 17

The AP1000 was designed with passive safety systems to eliminate reliance on additional support systems, thereby creating a safer design and more independent:

1. In the case of a power outage, critical structures, systems, and components (SSCs) automatically achieve a fail-safe configuration without the need for operator action or AC/DC power.

2. The AP1000's passive approach to safety reduces the importance of the AC power supply and cooling by providing long recovery periods from events, that would result in a prolonged plant outage and/or prolonged loss of connection to the final heat sink.

3. The SSCs critical to bringing the reactor to a safe shutdown state are protected within a steel containment and surrounded by a robust reinforced concrete composite shield. The reactor building is designed following the latest US NRC, EUR, and WENRA regulations to withstand commercial aircraft impact.

It is also explained that the facilities of KhNPP units 5 and 6 are based on the design configuration of the reference NPP that is the Vogtle NPP with two AP1000 units 3 &4 in the United States. The AP1000 technology is the only Generation III+ reactor technology that has received a license for construction and operation from the U.S. NRC.

In the U.S., Vogtle 4 starts commercial operation in April 2024, following Vogtle 3 which entered commercial operation in July 2023. Construction of the two AP1000 reactors began in 2013. This is a period of 10 and 11 years from construction start to commissioning. After Westinghouse's bankruptcy, Southern Nuclear and Georgia Power took over project management for the construction of the units in 2017. In February 2022, it was announced that the units' startup would be further delayed because the inspection reports for much of the materials and equipment for unit 3 were incomplete or missing. (WNN 2022a, c, 2024a)

In 2017, the insolvency of Westinghouse significantly affected the prospects for the construction of further AP1000 units. The construction of two units at the V.C. Summer nuclear power plant in the United States was cancelled[15], as were the plans at the Moorside nuclear power plant in the United Kingdom. (NUKLERIA 2018)

On June 21, 2018, the first AP1000 reactor in the Chinese nuclear power plant Sanmen went critical for the first time. The first criticality marks the end of more than nine years of construction, which was marked by numerous delays. (NUKLERIA 2018) For example, fuel loading at the Sanmen nuclear power plant had been delayed due to “safety concerns”, the China Daily reported on 12 February, 2018. Sanmen 1 was initially expected to begin operation in 2014. (NEI 2018a) It was originally planned to take just over four years to build. In 2014, first-of-a-kind engineering issues related to the reactor coolant pumps and squib valves for the Chinese AP1000 have been resolved, according to Westinghouse. Some reactor coolant pumps had passed factory tests, and others had not. (NEI 2014a) In 2018/2019, in total four AP1000 started operation Haiyang-1 and -2, as well as Sanmen-1 and -2.

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[15] The project to build two Westinghouse AP1000 reactors at the US Summer NPP was over 64% complete, Scana subsidiary South Carolina Electricity & Gas (SCG&E) said on 8 May 2017. (NEI 2017a)

Westinghouse won the 2006 tender for the construction of up to six units at the Sanmen NPP site and also won the tender for six units at the Haiyang NPP. In connection with this, Westinghouse had agreed to a technology transfer to the China State Nuclear Power Technology Company (SNPTC). The Chinese company is licensed to build the AP1000 under license from Westinghouse but is not allowed to market it abroad. The Chinese version of the AP1000, with 50 Hz pumps, localized automation, etc., is called the CAP1000 (China Advanced Passive 1000). China is allowed to build the CAP1000 itself for a license fee.[16]

The construction of the first two 1250 MWe CAP1000 reactors at the Lianjiang site was approved by China's State Council in September 2022. Lianjiang unit 1 is expected to be completed and put into operation in 2028. (WNN 2025a) Until now, nine CAP1000 started construction[17], nine more CAP1000 are planned. However, according to WNA (2025a), it is likely that some planned and proposed CAP1000 units will be displaced by the Chinese reactor type Hualong One.

In November 2022, the Polish government selected the AP1000 reactor technology for construction at the Lubiatowo-Kopalino site. Poland's first AP1000 reactor is intended to enter commercial operation in 2033. (WNN 2024d) Westinghouse's AP1000 has been selected as the technology for two proposed new units at Kozloduy NPP. The aim is for unit 7 at Kozloduy - to be operational in 2035 and unit 8 in 2037. (WNN 2025b) Plans for the construction of AP1000 also exist in some other European countries (e.g. Czech Republic)

[16] However, a contractual blocking clause sets a maximum output limit of 1,350 MW for all modified reactor designs. This motivated China to develop the 1,400 MW CAP1400.

[17] Haiyang-3 and -4, Lianjiang-1 and -2, Sanmen-3 and-4, and Xudapu-1 and-2, Lufeng-1

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