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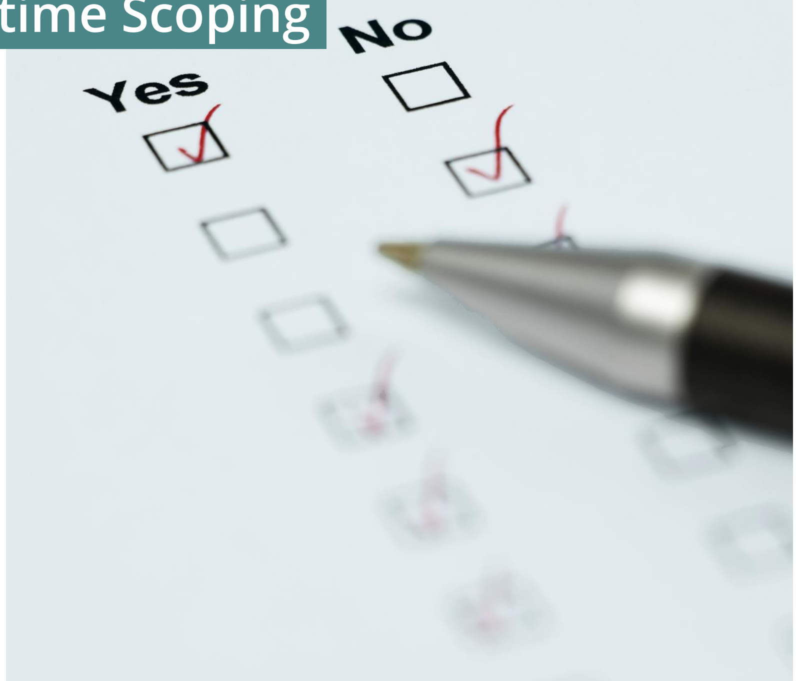
Environmental Impact Assessment NPP Paks 1-4, 2nd extension of the Lifetime Scoping



Bundesministerium
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ENVIRONMENTAL IMPACT ASSESSMENT NPP PAKS 1-4, 2ND EXTENSION OF THE LIFETIME - SCOPING

Paks NPP Subsequent Service Life Extension

Bojan Tomic
Ioana Popa
Oana Velicu
Kurt Decker
Lukas Moschen
Gabriele Mraz

REPORT
REP-0949

VIENNA 2024

Project Manager Franz Meister

Authors Oana Velicu (Enconet Consulting Ges.m.b.H.), Chapters 1, 2
Gabriele Mraz, pulswerk (BIEGE Nuklearexpertise), Chapter 6
Kurt Decker (BIEGE Nuklearexpertise), Chapters 4, 6
Lukas Moschen, Ebner ZT (BIEGE Nuklearexpertise), Chapter 4
Bojan Tomic (Enconet Consulting Ges.m.b.H.), Chapters 5, 7
Ioana Popa (Enconet Consulting Ges.m.b.H.), Chapter 3

Layout Felix Eisenmenger

Title photograph © iStockphoto.com/imagestock

Contracting authority Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK)

Publications For further information about the publications of the Umweltbundesamt please go to: https://www.umweltbundesamt.at/

Imprint

Owner and Editor: Umweltbundesamt GmbH
Spittelauer Laende 5, 1090 Vienna/Austria

This publication is only available in electronic format at https://www.umweltbundesamt.at/.

ISBN 978-3-99004-795-8

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EXECUTIVE SUMMARY

Four units of the WWER 440-213 type that are currently in operation at Paks site were commissioned between 1982 and 1987. Having a design life of 30 years, the lifetime extension process has been implemented and units obtained licences for the extended lifetime. The current operating license for the units expires between 2032 and 2037.

The construction of the Paks II, a two-unit WWER 1200 plant has been initiated recently. The Hungarian national energy policy envisaged that the four units of the Paks I plant would be gradually shut down as two new Paks II units are coming into operation. Due to the long delays, Paks II units will not becoming operational before mid or late 2030ties. Given that the Paks units provide 40% of Hungary's electricity supply, the second lifetime extension of the Paks I units is therefore becoming essential for the Hungarian energy supply.

In 2022 the operator of the Paks units, MVM Paks Nuclear Power Plant Ltd. initiated the project “Subsequent Service Life Extension”, which is to include an environmental impact assessment and the consultations on the environmental permitting. Further to that, the project is to complete a detailed assessment of the condition of the plant's SSCs including the adequacy of current ageing management programs to mitigate the impacts of ageing. The material examination and the analysis concluded that, for the expected lifetime of 70 years none of the main (non-replaceable, like RPV or SGs) components would reach their actual end of life. The plant’s staff also concluded that the replaceable and/or refubishable components could be maintained up to the end of the lifetime of the units through the implementation of ageing management programs. The actual approval for the extension beyond the current 50 years requires the approval by the nuclear regulator HAEA, which would be issued upon the HAEA being satisfied that a robust safety case exists for the Paks I units. Per EU legislation, the EIA is another element of the lifetime extension that needs to be implemented.

In order to establish Austrian position on the Paks I lifetime extension EIA, UBA, the coordinator of Austria’s participation, is undertaking a study to assess the challenges facing Paks I facilities during the second lifetime extension. The outcome of the study is this “expert statement”, which is to inform the counterparts on the Austrian position regarding the items that need to be addressed in the future environmental impact assessment report. The aim is to define the requirements that are, from the Austrian perspective, necessary to be taken into account in the environmental impact assessment in order to be able to assess the impact of the second lifetime extension of the Paks I units onto the environment and in particular on the population of Austria.

Austria participates in the EIA process for Paks I second lifetime extension, by undertaking a review of the “MVM 2024 Preliminary Consultation Document”, which is to define the scope of the future EIA. The outcome of the review that covered areas from procedural aspect over safety enhancements, simulations operation of Paks I and II, seismic risk, environmental risks to the ageing man-

agement including the recommendation for the content of the EIA is documented in this report. The recommendations provided are expected to be addressed when the EIA for the second life extension of Paks I units is being developed.

In relation with the procedural aspect, it is recognised that the EIA will be developed and the public consultation completed prior to both the PSR and necessary studies to estimate the remaining lifetime of SSC and establish relevant ageing management programs will be completed. This creates a situation that the public will not have necessary information and will not be able to assess the safety level that will be maintained during the second lifetime extension.

In terms of safety enhancements, while recognising that Paks I units have been subject to multiple safety improvements programs from AGNES in nine-teen nineties to most recent Post Fukushima Stress test action plan, it is recognised that other similar plants implemented additional safety measures that might be add to the safety level or Paks I units. Furthermore, given that the lifetime extension will see the Paks I units operating post-2050, it is reasonable to consider that the safety requirements in line to those for new reactors, e.g. as defined by the Hungarian Nuclear safety code as well as in the WENRA Safety Objectives for New Nuclear Power Plants should also be applied to Paks I units for the period of extended lifetime. Consequently a recommendation that key elements of safety justification for the second lifetime ex-tension are thoroughly reviewed against the safety requirements as defined in the Hungarian Nuclear safety code as well as in the WENRA objectives for new reactors has been established.

With the construction of Paks II units and extension of the lifetime of Paks I units, there will be simultaneous operation of up to 6 nuclear units at Paks site. The Preliminary consultation document (MVM 2024) does not say any-thing about possible interactions between multiple units at the site, including any planned assessment in relation with external impact. In particular, there is no discussion in relation with the man-made event that could possibly be critical when considering the risks to the environment and population. Recommendations has been provided to assure that relevant aspect of multi units operation from the assessment of man-made external events, over combination of events and assessment of the cliff edge effects for multiple units to establishing an enveloping radiological release source term are ad-dressed in the EIA.

MVM (2024) claims that re-assessment or revision of seismic hazards is not necessary in the framework of LTE and EIA. The approach not to review seismic hazards disagrees with international practice and WENRA requirements, and it is contrary to the objective of the Article 8a of the Directive 2014/87/EURATOM which requires consideration of seismic safety in the EIA process.

The EIA Scoping Document does not discuss any seismic analysis, evaluation strategies, and design checks concerning seismic safety for the extended lifetime. It is mandatory that SSCs designed and seismically retrofitted are checked in agreement with technical specifications provided in codes and guidelines. While site-specific seismic hazard is only one aspect of seismic safety, it is the seismic response of the SSC that is of major relevance as it governs the failure probability. Hence, comprehensive seismic structural assessment, analysis, and, if found necessary, retrofitting of SSC is mandatory for the lifetime extension Therefore it is recommended that detailed information on the seismic assessment, design and retrofit is to be provided in the EIA.

In terms of the ageing management of Paks I units, the MVM 2024 rightly points out that the 60 years lifetime of Gen II nuclear plants is a norm at pre-sent, and that some reactor units are receiving permissions to extend the life-time to 80 years. This however is not necessarily applicable to Paks I units, which, with the lifetime of 70 years, would exceed the lifetime of any other WWER 440 units. While current ageing management program for Paks I was subject to multiple international assessments and found to be exemplary, for the second lifetime extension, comprehensive ageing management pro-grams and processes need to be developed. Of particular relevance is the identification of possible additional or different (and indeed accelerated) degradation mechanism that the SSCs might be subject to in period between 50 to 70 years of operation. Furthermore, it looks that little attention is being paid to the structures, which might be expected to become critical for the long lifetime and may seriously undermine safety of the Paks I units.

In order to assure that adequate safety level is maintained all the way to the end of the second extended lifetime of Paks I, a series of recommendation has been provided, from provision of details on any design changes that are necessary over identification of new or different degradation mechanisms and assurance of integrity and functionality of the structures to dealing with obsolesce of equipment for 70 years of operation. Finally, it is essential that the EIA provides the CDF, LERF and/or other metrics for the status at the end of the second extended lifetime for Paks I units.

When deciding on the lifetime extension of existing nuclear power plants, it must be considered that the spectrum of hazards that might impact safety may change during the period of extended operation. This applies in particular to the risk posed by extreme weather events and expected effects of climate change. It is recommended that the EIA documents how hazards and hazard combinations applies to the Paks site. The EIA should describe how Design Extension Conditions (DEC) are analysed in the LTE process in accordance with WENRA Issues T6 and TU6. The EIA Report is expected to show how the overall goal formulated by WENRA, i.e., to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents, will be achieved in the LTE process.

ZUSAMMENFASSUNG

Am Standort Paks laufen aktuell vier Anlagen des Typs WWER 440-213, welche zwischen 1982 und 1987 in Betrieb genommen wurden. Die Blöcke hatten ursprünglich eine geplante Laufzeit von 30 Jahren. Um die Laufzeit zu verlängern, wurde bereits in der Vergangenheit ein Prozess zur Laufzeitverlängerung umgesetzt und die Anlagen erhielten Genehmigungen für die verlängerte Laufzeit. Die aktuelle Betriebsgenehmigung für die Anlagen läuft zwischen 2032 und 2037 aus.

Der Bau von Paks II, einem Kraftwerk mit zwei WWER 1200-Blöcken, wurde vor kurzem begonnen. Die nationale Energiepolitik Ungarns sah vor, dass die vier Blöcke des Kraftwerks Paks I schrittweise abgeschaltet werden, während zwei neue Paks II-Einheiten in Betrieb gehen. Aufgrund langer Verzögerungen werden die Paks II-Blöcke nicht vor Mitte oder Ende der 2030er Jahre in Betrieb gehen. Da die Paks-Böcke 40 % der ungarischen Stromversorgung abdecken, wird eine zweite Laufzeitverlängerung der Paks I-Blöcke für die ungarische Energieversorgung erforderlich.

Im Jahr 2022 leitete der Betreiber, MVM Paks Nuclear Power Plant Ltd., das Projekt „Subsequent Service Life Extension“ ein, welches eine Umweltverträglichkeitsprüfung und Konsultationen zur Umweltgenehmigung umfassen soll. Darüber hinaus soll das Projekt eine detaillierte Bewertung des Zustands der SSCs des Kraftwerks durchführen, einschließlich der Angemessenheit der aktuellen Alterungsmanagementprogramme zur Minderung der Auswirkungen der Alterung. Die Materialuntersuchung und die Analyse ergaben, dass während der erwarteten Laufzeit von 70 Jahren keine der Hauptkomponenten (nicht austauschbar, wie RPV (Reaktordruckbehälter) oder SGs (Dampferzeuger) ihr tatsächliches Lebensdauerende erreichen würde. Das Personal des Kraftwerks kam außerdem zu dem Schluss, dass die austauschbaren und/oder überholbaren Komponenten durch die Umsetzung von Alterungsmanagementprogrammen bis zum Ende der Laufzeit der Blöcke instandgehalten werden könnten. Die tatsächliche Genehmigung für die Verlängerung über die derzeitigen 50 Jahre hinaus erfordert eine Genehmigung der Atomaufsichtsbehörde HAEA, welche erteilt würde, wenn die HAEA davon überzeugt ist, dass für die Paks I-Blöcke ein robuster Sicherheitsnachweis vorliegt. Gemäß der EU-Gesetzgebung ist für die Laufzeitverlängerung eine UVP durchzuführen.

Um die österreichische Position zur Umweltverträglichkeitsprüfung für die Laufzeitverlängerung von Paks I festzulegen, führt das Umweltbundesamt, das die österreichische Beteiligung koordiniert, eine Studie durch, um jene Herausforderungen zu bewerten, denen sich die Anlagen von Paks I während der zweiten Laufzeitverlängerung gegenübersehen. Das Ergebnis der Studie ist diese „Fachstellungnahme“, welche Ungarn über die österreichische Position hinsichtlich der Punkte informieren soll, die im künftigen Umweltverträglichkeitsbericht behandelt werden müssen. Ziel ist es, die Anforderungen zu definieren, die aus österreichischer Sicht bei der Umweltverträglichkeitsprüfung berücksichtigt wer-

den müssen, um die Auswirkungen der zweiten Laufzeitverlängerung der Anlagen von Paks I auf die Umwelt und insbesondere auf die Bevölkerung Österreichs bewerten zu können.

Österreich beteiligt sich am UVP-Prozess für die zweite Laufzeitverlängerung von Paks I, indem es eine Prüfung des „MVM 2024 Preliminary Consultation Document" durchführt, das den Umfang der zukünftigen UVP festlegen soll. Das Ergebnis der österreichischen Prüfung, das die Bereiche von Verfahrensaspekten über Sicherheitsverbesserungen, gleichzeitigen Betrieb von Paks I und II, Erdbebenrisiken, Umweltrisiken bis hin zum Alterungsmanagement abdeckte, einschließlich der Empfehlung für den Inhalt der UVP, ist in diesem Bericht dokumentiert. Es wird erwartet, dass die Empfehlungen bei der Ausarbeitung der Umweltverträglichkeitsprüfung für die zweite Verlängerung der Laufzeit der Paks-I-Blöcke berücksichtigt werden.

In Bezug auf den Verfahrensaspekt wird festgestellt, dass die UVP entwickelt und die öffentliche Konsultation abgeschlossen wird, bevor sowohl der PSR als auch die erforderlichen Studien zur Abschätzung der verbleibenden Lebensdauer von SSC und zur Festlegung relevanter Alterungsmanagementprogramme beendet sind. Dies führt dazu, dass die Öffentlichkeit nicht über die erforderlichen Informationen verfügt, um das Sicherheitsniveau beurteilen zu können, welches während der zweiten Laufzeitverlängerung aufrechterhalten werden soll.

Was die Sicherheitsverbesserungen angeht, ist anzuerkennen, dass die Paks I Blöcke zahlreichen Sicherheitsverbesserungsprogrammen unterzogen wurden, von AGNES in den 1990er Jahren bis zum jüngsten Aktionsplan für den Stresstest nach Fukushima. Es ist jedoch auch festzuhalten, dass andere, ähnliche Anlagen zusätzliche Sicherheitsmaßnahmen umgesetzt haben, die das Sicherheitsniveau der Paks I Blöcke erhöhen könnten. Da die Paks I Blöcke aufgrund der Laufzeitverlängerung auch nach 2050 in Betrieb sein werden, sollten für die Dauer der verlängerten Laufzeit auch auf die Paks I Blöcke dieselben Sicherheitsanforderungen wie für neue Reaktoren angewendet werden sollten, z. B. wie sie in den ungarischen Nuklearsicherheitsvorschriften sowie in den WENRA-Sicherheitszielen für neue Kernkraftwerke definiert sind. Folglich wurde die Empfehlung ausgesprochen, wesentliche Elemente der Nachweise der Sicherheit für die zweite Laufzeitverlängerung anhand der Sicherheitsanforderungen gründlich zu überprüfen, die in den ungarischen Nuklearsicherheitsvorschriften und in den WENRA-Zielen für neue Reaktoren definiert sind.

Mit dem Bau der Paks-II-Blöcke und der Laufzeitverlängerung der Paks-I-Blöcke werden am Standort Paks bis zu sechs Blöcke gleichzeitig betrieben. Das vorläufige Konsultationsdokument (MVM 2024) enthält keine Aussagen über mögliche Wechselwirkungen zwischen mehreren Blöcken am Standort, auch nicht über eine geplante Bewertung in Bezug auf externe Auswirkungen. Insbesondere gibt es keine Diskussion in Bezug auf vom Menschen verursachte Ereignisse, die bei der Betrachtung der Risiken für die Umwelt und die Bevölkerung möglicherweise entscheidend sein können. Es wurden Empfehlungen abgegeben, um sicherzustellen, dass relevante Aspekte des Betriebs mehrerer Blöcke, von der

Bewertung vom Menschen verursachter externer Ereignisse über die Kombination von Ereignissen und die Bewertung der Cliff-Edge-Effekte für mehrere Blöcke bis hin zur Festlegung eines umfassenden radiologischen Freisetzungsquellterms, in der Umweltverträglichkeitsprüfung behandelt werden.

MVM (2024) behauptet, dass eine Neubewertung oder Überarbeitung der Erdbebengefährdung im Rahmen von Laufzeitverlängerung und UVP nicht erforderlich ist. Der Ansatz, Erdbebengefährdungen nicht zu überprüfen, steht im Widerspruch zur internationalen Praxis und den WENRA-Anforderungen und widerspricht dem Ziel des Artikels 8a der Richtlinie 2014/87/EURATOM, welcher eine Berücksichtigung der Erdbebensicherheit im UVP-Prozess vorschreibt.

Das UVP Scoping Dokument behandelt keine Erdbebenanalysen, Bewertungsstrategien und Designprüfungen in Bezug auf die Erdbebensicherheit für die verlängerte Laufzeit. Es ist zwingend erforderlich, dass SSCs, die für Erdbebensicherheit entworfen und nachgerüstet werden, in Übereinstimmung mit den in Vorschriften und Richtlinien enthaltenen technischen Spezifikationen geprüft werden. Während die standortspezifische Erdbebengefährdung nur einen Aspekt der Erdbebensicherheit darstellt, ist das seismische Verhalten der SSC von größter Bedeutung, da sie die Ausfallwahrscheinlichkeit bestimmt. Daher sind umfassende seismische Strukturbewertungen und Analysen, sowie falls erforderlich, Nachrüstung von SSC für die Laufzeitverlängerung zwingend erforderlich. Daher wird empfohlen, in der Umweltverträglichkeitsprüfung detaillierte Informationen zur Erdbebenbewertung, zur Auslegung und zur Nachrüstung bereitzustellen.

In Bezug auf das Alterungsmanagement der Paks I-Blöcke weist das MVM 2024 zu Recht darauf hin, dass eine Laufzeit von 60 Jahren für Kernkraftwerke der zweiten Generation derzeit die Norm ist und dass einige Reaktorblöcke Genehmigungen für eine Laufzeitverlängerung auf 80 Jahre erhalten. Dies gilt jedoch nicht unbedingt für die Paks I-Blöcke, die mit einer Laufzeit von 70 Jahren die aller anderen WWER 440-Blöcke übertreffen würden. Während das derzeitige Alterungsmanagementprogramm für Paks I mehreren internationalen Bewertungen unterzogen und als vorbildlich befunden wurde, müssen für die zweite Laufzeitverlängerung umfassende Alterungsmanagementprogramme und -prozesse entwickelt werden. Von besonderer Bedeutung ist die Identifizierung möglicher zusätzlicher oder anderer (und tatsächlich beschleunigter) Degradationsmechanismen, denen die SSCs in einem Zeitraum zwischen 50 und 70 Betriebsjahren unterliegen könnten. Darüber hinaus scheint diesen Strukturen wenig Aufmerksamkeit geschenkt zu werden. obwohl diese im Zuge einer voraussichtlich langen Laufzeit Probleme bereiten und die Sicherheit der Paks I-Blöcke ernsthaft gefährden könnten.

Um sicherzustellen, dass bis zum Ende der zweiten verlängerten Laufzeit von Paks I ein angemessenes Sicherheitsniveau aufrechterhalten wird, werden eine Reihe von Empfehlungen gegeben, von der Bereitstellung von Details zu allen erforderlichen Designänderungen über die Identifizierung neuer oder anderer Degradationsmechanismen und die Gewährleistung der Integrität und Funktionalität der Strukturen bis hin zum Umgang mit der Alterung der Ausrüstung nach 70 Betriebsjahren. Weiters ist es wichtig, dass in der UVP die CDF, LERF und/oder andere Messgrößen für den Status am Ende der zweiten verlängerten Laufzeit der Paks I-Blöcke zur Verfügung gestellt werden.

Bei Entscheidungen über die Laufzeitverlängerung bestehender Kernkraftwerke muss berücksichtigt werden, dass sich das Spektrum der Gefahren, die die Sicherheit beeinträchtigen könnten, während der verlängerten Laufzeit ändern kann. Dies gilt insbesondere für das Risiko durch extreme Wetterereignisse und erwartete Auswirkungen des Klimawandels. Es wird empfohlen, dass die UVP dokumentiert, wie sich Gefahren und Kombinationen von Gefahren auf den Standort Paks auswirken. Die UVP sollte beschreiben, wie die Design Extension Conditions (DEC) im Laufzeitverlängerungsprozess gemäß den WENRA-Leitlinien T6 und TU6 analysiert werden. Der UVP-Bericht soll zeigen, wie das von WENRA formulierte Gesamtziel, d. h. die Ermittlung vernünftigerweise durchführbarer Verbesserungen zur Erhöhung der Robustheit und Belastbarkeit einer Anlage, die zur Verhinderung schwerer Unfälle umgesetzt werden können, im Laufzeitverlängerungsprozess erreicht wird.

VEZETŐI ÖSSZEFOGLALÓ

A paksi telephelyen jelenleg üzemelő WWER 440-213 típusú négy blokkot 1982 és 1987 között helyezték üzembe. A 30 éves tervezési élettartammal megtörtént az üzemidő-hosszabbítás, és a meghosszabbított üzemidőre engedélyt kaptak a blokkok. A blokkok jelenlegi működési engedélye 2032 és 2037 között jár le.

A közelmúltban megkezdődött a Paks II, egy kétblokkos WWER 1200-as üzem építése. A magyar nemzeti energiapolitika a két új Paks II. blokk üzembe helyezésével a Paks I. erőmű négy blokkjának fokozatos leállítását irányozta elő. Azonban a hosszú késések miatt a Paks II. blokkok csak a 2030-as évek közepe vagy vége előtt lesznek üzembe helyezve. Tekintettel arra, hogy a paksi blokkok adják Magyarország villamosenergia-ellátásának 40 százalékát, a Paks I. blokkok második üzemidő-hosszabbítása ezért elengedhetetlen a magyar energiaellátás számára.

A paksi blokkok üzemeltetője, az MVM Paksi Atomerőmű Zrt. 2022-ben kezdeményezte a „Következő üzemidő-hosszabbítás" projektet, amely környezeti hatásvizsgálatot (KHV) és a környezetvédelmi engedélyezési egyeztetéseket foglalja magában. Ezen túlmenően a projekt célja az erőmű RRE-k részletes állapotfelmérése, beleértve a jelenlegi öregedéskezelési programok megfelelőségét az öregedés hatásainak mérséklésére. Az anyagvizsgálatok és az elemzések arra a következtetésre jutottak, hogy a várható 70 éves üzemidő alatt egyik nem-cserélhető (például reaktortartály vagy gőzfejlesztő) főberendezés sem érné el tényleges élettartamát. Az üzem szakemberei arra a következtetésre jutottak, hogy a cserélhető és/vagy felújítható berendezések az öregedéskezelési programok végrehajtásával a berendezések élettartamának végéig karbantarthatók. A jelenlegi 50 éven túli meghosszabbítás tényleges engedélyezéséhez az OAH nukleáris biztonsági hatóság engedélye szükséges, amelyet akkor adnának ki, ha az OAH meggyőződött arról, hogy a Paks I. blokkokra vonatkozóan szilárd biztonsági elemzés áll rendelkezésre. Az uniós jogszabályok értelmében a KHV az üzemidő-hosszabbítás másik eleme, amelyet végre kell hajtani.

A Paks I. üzemidő-hosszabbítással kapcsolatos osztrák álláspont kialakítása érdekében az UBA, Ausztria részvételének koordinátora tanulmányt készít a Paks I. erőmű előtt álló kihívások felmérésére a második üzemidő-hosszabbítás során. A tanulmány eredménye ez a „szakértői nyilatkozat", amelynek célja, hogy tájékoztassa a partnereket az osztrák álláspontról a jövőbeni környezeti hatástanulmányban tárgyalandó tételekkel kapcsolatban. A cél azoknak a követelményeknek a meghatározása, amelyeket osztrák szemszögből figyelembe kell venni a környezeti hatásvizsgálat során, hogy értékelni lehessen a Paks I blokkok második üzemidő-hosszabbításának a környezetre és különös tekintettel Ausztria lakosságára gyakorolt hatását.

Ausztria részt vesz a Paks I. második üzemidő-hosszabbításának KHV-folyamatában az „MVM 2024. évi előzetes konzultációs dokumentum" felülvizsgálatával, amelynek célja a jövőbeni KHV terjedelmének a meghatározása. A felülvizsgálat eredményeit, amelyek kiterjednek a biztonságnövelés, a Paks I. és

II. üzemeltetésének szimulációjának, a szeizmikus kockázat és az öregedéskezelés környezeti kockázatainak a témáira, valamint a KHV tartalmára vonatkozó ajánlásokat is, ebben a jelentésben dokumentáltuk. A bemutatott ajánlásokat várhatóan figyelembe veszik a Paks I. blokkok második üzemidő-hosszabbítására vonatkozó KHV kidolgozásakor.

Az eljárással kapcsolatban ismert tény, hogy a KHV kidolgozására és a nyilvános konzultációra az Időszakos Biztonsági Felülvizsgálat, valamint a rendszerek és rendszerelemek (RRE) hátralévő élettartamának becsléséhez és a vonatkozó öregedéskezelési programok kidolgozásához szükséges tanulmányok kidolgozása előtt kerül sor. Ez azt a helyzetet teremti meg, hogy a nyilvánosság nem fogja tudni a szükséges információt a második üzemidő-hosszabbítás során fenntartott biztonsági szint felméréséhez.

Ami a biztonságnövelést illeti, jóllehet elismerjük, hogy a Paks I-es blokkokon az AGNES-től a kilencvenes évektől a legutóbbi, fukusimai stressztesztet követő akciótervig több biztonsági fejlesztési program is el lett végezve, látjuk, hogy más hasonló üzemek további biztonsági intézkedéseket hajtottak végre, amelyek a Paks I. blokkok biztonsági szintjét tovább növelhetik. Továbbá, tekintettel arra, hogy az üzemidő-hosszabbítása a Paks I. blokkokat 2050 után is üzemelteti, indokolt megfontolni, hogy az új reaktorokra vonatkozó biztonsági követelményeket, összhangban pl. A Nukleáris Biztonsági Szabályzatban, valamint a WENRA Új Atomerőművek Biztonsági Céljaiban meghatározottak szerint, a Paks I. blokkokra is alkalmazni kell a meghosszabbított élettartamra. Következésképpen ajánlás született arra vonatkozóan, hogy a második üzemidő-hosszabbítás biztonsági megalapozásának kulcsfontosságú elemeit alaposan vizsgálják felül a Nukleáris Biztonsági Szabályzatban, valamint az új reaktorokra vonatkozó WENRA-célokban meghatározott biztonsági követelményekkel szemben.

A Paks II. blokkok megépítésével és a Paks I. blokkok élettartamának meghosszabbításával a paksi telephelyen akár 6 nukleáris blokk is üzemel majd egyidejűleg. Az előzetes konzultációs dokumentum (MVM 2024) semmit nem mond a telephelyen lévő több blokkok közötti lehetséges kölcsönhatásokról, beleértve a külső hatásokkal kapcsolatos tervezett értékelésről sem. Nincs információ az ember által előidézett veszélyekkel kapcsolatban, amely kritikus lehet a környezetet és a lakosságot érintő kockázatok mérlegelése során. Javaslatok kerültek megfogalmazásra annak biztosítására, hogy a több blokkos üzemelés aspektusai foglalkozzanak a KHV-ben az ember által előidézett külső veszélyek értékelésétől, az események kombinálásán és a több blokkok szakadékszél effektus hatásainak értékelésén át a radiológiai kibocsátási forrástagok burkoló meghatározásáig.

Az MVM (2024) azt állítja, hogy az üzemidő-hosszabbítás és a KHV keretében nem szükséges a szeizmikus veszélyek újraértékelése vagy felülvizsgálata. A szeizmikus veszélyek felülvizsgálatának mellőzése nem egyezik a nemzetközi gyakorlattal és a WENRA követelményeivel, és ellentétes a 2014/87/EURATOM irányelv 8a. cikkének céljával, amely előírja a szeizmikus biztonság figyelembevételét a KHV-folyamat során.

A KHV terjedelmére vonatkozó dokumentum nem tárgyalja a meghosszabbított üzemidőre vonatkozó szeizmikus elemzéseket, értékelési stratégiákat és tervezési ellenőrzéseket. A tervezett és utólag szeizmikusan feljavított RRE-ket kötelező ellenőrizni a kódokban és irányelvekben megadott műszaki előírásokkal összhangban. Míg a helyspecifikus szeizmikus veszély csak az egyik aspektusa a szeizmikus biztonságnak, az RRE-k szeizmikus reakciója az, amely a fő jelentőséggel bír, mivel ez határozza meg a meghibásodás valószínűségét. Ezért az RRE-k átfogó szeizmikus szerkezeti felmérése, elemzése és szükség esetén utólagos feljavítása kötelező az üzemidő-hosszabbítás érdekében. Ezért ajánlatos a KHV-ban részletes információkat megadni a szeizmikus felmérésről, tervezésről és utólagos feljavításról.

A Paks I blokkok öregedéskezelésével kapcsolatban az MVM 2024 helyesen mutat rá arra, hogy a Gen II atomerőművek 60 éves élettartama jelenleg normának számít, és egyes reaktorblokkok kapnak engedélyt az üzemidő-hosszabbításra az erőmű 80 éves koráig. Ez azonban nem feltétlenül vonatkozik a Paks I blokkokra, amelyek 70 éves üzemidejükkel meghaladnák bármely más WWER 440 blokk üzemidejét. Míg Paks I jelenlegi öregedéskezelési programja több nemzetközi értékelésen esett át, és példaértékűnek bizonyult, addig a második üzemidő-hosszabbításhoz átfogó öregedéskezelési programokat és folyamatokat ki kell dolgozni. Ez különösen fontos az esetleges további vagy eltérő (és valójában felgyorsuló) degradációs mechanizmusok azonosítására, amelyeknek az RRE-k 50–70 éves üzemeltetési periódusban ki lehetnek téve. Továbbá úgy tűnik, hogy kevés figyelmet fordítanak azokra a szerkezetekre, amelyek várhatóan kritikussá válhatnak a hosszú élettartam szempontjából, és súlyosan alááshatják a Paks I blokkok biztonságát.

Annak érdekében, hogy a Paks I második meghosszabbított üzemidejének végéig a megfelelő biztonsági szint fennmaradjon, egy sor ajánlást fogalmaztunk meg, kezdve az esetlegesen szükséges átalakítások részleteiről, az új vagy más típusú degradációs mechanizmusok azonosításán, valamint a szerkezetek integritásának és működőképességének biztosításán át a berendezések 70 éves működés alatti elavulásának a kezeléséig. Végül elengedhetetlen, hogy a KHV során meghatározzák a CDF, LERF és/vagy egyéb mérőszámokat a Paks I blokkok második üzemidő-hosszabbításának végén fennálló állapothoz.

A meglévő atomerőművek üzemidejének meghosszabbításáról való döntésnél figyelembe kell venni, hogy a biztonságot esetlegesen befolyásoló veszélyek spektruma a hosszabb üzemidő alatt változhat. Ez különösen vonatkozik a szélsőséges időjárási viszonyok és az éghajlatváltozás várható hatásai által jelentett kockázatokra. Javasoljuk, hogy a KHV dokumentálja, hogy a veszélyek és veszélykombinációk hogyan vonatkoznak a paksi telephelyre. A KHV-nak le kell írnia, hogy a tervezési alap kiterjesztéséhez tartozó állapotokat (TAK) hogyan elemzik az üzemidő-hosszabbítás folyamatban a WENRA T6 és TU6 kérdéseivel összhangban. Elvárható a KHV-jelentéstől, hogy bemutassa, hogyan valósul meg az üzemidő-hosszabbítás folyamatban a WENRA által megfogalmazott átfogó cél, azaz egy erőmű robusztusságának és ellenálló képességének növelését szolgáló, észszerűen megvalósítható fejlesztések azonosítása a súlyos balesetek megelőzése érdekében.

1 INTRODUCTION AND OVERVIEW

The operating Paks Nuclear Power Plant (Paks I) consists of four units of the WWER 440-213 type. Construction of the units 1 and 4 began between 1974 and 1979, and those entered the commercial operation between 1982 and 1987, respectively, with the nominal power level of was 440 MWe. Between 2005 and 2009 all units were uprated, allowing the increase of the nominal power to 500 MWe each. The design lifetime of WWER 440-213 type units was originally set at 30 years. After comprehensive ageing analysis and ageing management activities were carried out, a 20-year lifetime extension was granted for all four units between 2012 and 2017. The current operating license for the units therefore expires between 2032 and 2037.

All Paks I units have an adequate safety record and a particularly high availability factor. Paks I units have been subjected to various national assessments, including the Periodic safety reviews (PSR-two were carried out) and the EU post-Fukushima Stress test. In terms of safety, the most notable incident was the nuclear fuel failure in the cleaning device in the spent fuel pool of Paks Unit 2 in 2003, which represented the highest iodine release from a nuclear power plant in Europe after the Windscale accident in the UK.

At the Paks site on the bank of Danube in Hungary, the construction of the Paks II, a two unit WWER 1200 plant has been initiated recently. While a restricted construction license was issued already in 2022, the “unrestricted” license, which allows the owner of Paks II to start pouring nuclear safety relevant concrete, was only issued in November 2024. The Hungarian national energy policy envisaged that the four units of the Paks I plant would be gradually shut down as two new Paks II units are coming into operation. In accordance with original plans, two units of Paks II were expected to come on line by about 2032. Due to the long delays, the Paks II units will certainly not becoming operational before mid or late 2030ties. Given that the Paks units provide 40% of Hungary's electricity supply, the second lifetime extension of the Paks I units is therefore becoming essential for the Hungarian energy supply. It has to be noted that Hungary currently imports on average 25% of its electricity consumption, and on days when there is no wind energy available often even much more.

In order to assure the energy supply for the country, an action plan was initiated in 2019 to explore a possibility of a second lifetime extension of Paks I units. In this regard, a study assessing the legal, technical, and economic feasibility of such a life extension was conducted in 2020. In 2022 the operator of the Paks units, MVM Paks Nuclear Power Plant Ltd. initiated the project “Subsequent Service Life Extension”, which is to include an environmental impact assessment and the consultations on the environmental permitting. Further to that, the project is to complete a detailed assessment of the condition of the plant's SSCs including the adequacy of current ageing management programs to mitigate the impacts of ageing. The Project is to, where necessary, develop additional ageing management programs to assure safe operation throughout the extended lifetime.

Reflecting the results of the Project and its underlying studies, a program for the second extension of the lifetime of the Paks I units will be prepared. Subsequently, the licensing process to obtain the license for the extended lifetime will be initiated.

The material examination and the analysis concluded that, for the expected lifetime of 70 years (30 original designed plus two 20-years extension) none of the main (non-replaceable, like RPV or SGs) components will reach their actual end of life. The plant's staff also concluded that the replaceable and/or refurbishable components could be maintained up to the end of the lifetime of the units through the implementation of ageing management programs. In the view of the plants' staff, this establishes the basis for a preparation of the extension of the lifetime of the Paks I units to a total lifetime of 70 years.

The actual approval for the extension beyond the current 50 years requires the approval by the nuclear regulator HAEA, which would be issued upon the HAEA being satisfied that a robust safety case exists for the Paks I units. Although not required by Hungarian legislation, the Government of Hungary informed the Parliament on the expected second lifetime extension of the Paks I units.

Table 1: Planned duration of the subsequent service life extension

Nuclear plant unit / system	Commissioning date	End of 50-year service life / start of 20-year subsequent life extension	Planned end of 20-year subsequent service life extension
Unit 1	14.12.1982	14.12.2032	31.12.2052
Unit 2	26.08.1984	26.08.2034	31.12.2054
Unit 3	15.09.1986	15.09.2036	31.12.2056
Unit 4	09.08.1987	09.08.2037	31.12.2057

As required by Article 41 of Euratom Treaty, the European Commission Directorate-General for Energy Unit ENER D.2 was, in October 2023, officially notified of the expected second extension of the lifetime of the Paks units. In accordance with the prevailing legislation in Hungary and in the EU, for a lifetime extension of operating NPPs, an environmental impact assessment is required. Obtaining the environmental license is also a condition for the HAEA issuing the operating permit for the period beyond the (current) lifetime of 50 years.

As required by the environmental legislation within the EU and in particular by the Espoo convention, the initiation of a project, which needs an environmental impact assessment, shall establish a process to review and obtain comments from countries that could be affected by the project. In this respect, the Paks NPP operator is initiating a consultation process on both licensing and environmental impacts, to prepare the ground for the second lifetime extension of the Paks units.

In order to establish Austrian position on the Paks I lifetime extension EIA, UBA, the coordinator of Austria's participation, is undertaking a study to assess the challenges facing Paks I facilities during the second lifetime extension. The outcome of the study is this "expert statement", which is to inform the counterparts on the Austrian position regarding the items that need to be addressed in the future environmental impact assessment report. The aim is to define the requirements that are, from the Austrian perspective, necessary to be taken into account in the environmental impact assessment in order to be able to assess the impact of the second lifetime extension of the Paks I units onto the environment and in particular on the population of Austria.

In order to establish such a requirement, the Austrian team reviewed the "Preliminary consultation document on the Paks Nuclear Power Plant Subsequent Service Life Extension" which was prepared by the MVM Paks Nuclear Power Plant Ltd. in September 2024 and made available to the Austria. Furthermore, in the course of the study, various other sources of information, from the National action plan to the Post-Fukushima Stress test report and the National action plan for the Topical peer review on Ageing to various technical and Paks site related documents were reviewed.

The view of the experts engaged in the review process are summarised in this report, along with a list required information and analysis to be undertaken and documented in the EIA Report to be prepared at next stage of the EIA procedure. In this, the emphasis is to be able to critically assess a possible impact on the population and environment in Austria, with the specific goal to minimise or even eliminate any possible adverse impact on Austria that might occur due to the implementation of the second lifetime extension of the Paks I units.

The procedural aspects and schedule of EIA

At present, the EIA Scoping procedure takes place. In the next step, an Environmental Impact Report will be developed and discussed in a public manner with the Hungarian public as well with participating states and their public. Beside the EIA, several other processes necessary for the second life time extension of Paks I will have to be performed by MAV and approved by nuclear regulatory authority.

Regarding the processes that are relevant for the safety justification, the following are of special interest:

- The periodic safety review for each of the four units of Paks I
- The Time Limited Aging Analysis which, together with a Long-term life cycle management and a resulting Reconstruction program, leads to a License Renewal Application Report.

The timeline of the EIA and mentioned processes differ. The outcomes of the safety justifications generated by those processes might not available at the time of the development of the EIA report. This leads to the question, how the public could get proper insights regarding the safety level of Paks I units for the second extension of the lifetime, which would either not available by the time the EIA is finalized and/or will be subject to a licensing procedure only after the public consultations on the EIA will be finished.

Recommendation

The EIA report should provide detailed information on the scope and the schedules of relevant licensing processes at the level of the nuclear regulatory authority, including the timeline for the development of relevant safety justification. It should describe, which information, mainly plant specific technical data – at the date of the publication of the EIA Report - are assumptions and which data are based on the results of the analyses undertaken (including the date of its elaboration)

The EIA report should describe how the public will be informed after the EIA procedure in Hungary and abroad are completed, but also on the review and approval for the second lifetime extension at the nuclear regulatory authority. With respect to these, the results of the PSR for each unit of Paks I as well as the results of the lifetime estimates for all safety relevant SCC are of special interest.

2 SAFETY ENHANCEMENT REQUIREMENTS FOR PAKS 1-4

All nuclear plants are being periodically modified and modernised, with the main purpose to increase the safety level to the requirements set by the national regulators. In some cases, the requirements for the safety improvements are stemming from incidents and accidents that are safety relevant, and require particular features to enhance plants' resistance to such events. Examples of major events that lead to safety modifications across a fleet of NPPs are the TMI core melt event in the USA in 1979 and – more recently, the Fukushima accident in 2011. For the latter, and in particular in the EU, a highly comprehensive Post-Fukushima Stress test has been implemented, where for each NPP in the EU a series of safety improvements were proposed. Those were then revised and in some case appended by the national regulators, and then reviewed by the EU level "peer review process". Upon the completion of the peer review, each country developed a National action plan, the implementation of which has been followed until completion by ENSREG.

In terms of the safety improvements of the Paks I units, after 1990 it was found that Soviet designed nuclear plants are having deficiencies to the international standards that were in effect at that time. In order to address those deficiencies and to bring the Paks I units to the international safety standards and requirements, a comprehensive safety re-evaluation, including subsequent improvements, was initiated (and implemented) at the Paks I. First, ANGES project was implemented between 1991 and 1994. In following years, other safety improvement projects were implemented including the Safety enhancement program (1996-2002), the Seismic risk assessment and reconstruction (1993-2002), and the severe accident management (2008-2014) program.

The post-Fukushima Stress test established additional safety requirements, mainly related with externally-initiated events, including seismic, flooding and severe weather. Furthermore, the Stress test looked into the resilience as relevant for the loss of power and the loss of ultimate heat sink, as well as the preparedness to cope with severe accidents.

The Paks I units were thoroughly analysed within the Stress test, which was then reviewed by the EU peer review team. On the basis of the outcome, and reflecting the additional requirements from the regulator HAEA, the National action plan was developed, with a total of 51 safety enhancement items to be implemented. The improvements ranged from administrative (procedures) over organisational (emergency planning) to hardware (from mobile Diesels and various pumps to implementation of the in-vessel retention-cooling). The HAEA report to ENSREG in 2022 confirms that all of the safety measures that were planned for the Paks I units were implemented at the time of reporting.

While the safety improvement measures that were implemented were comprehensive, in comparison with some other comparable plants, those were more focused on the mobile equipment and procedures. Other plants put more emphasis on the hardware features, which might be better suited for the response for e.g., loss of ultimate heat sink.

Examples of the safety improvements that were made at other plants, but were not implemented in the same way at the Paks I units include:

- Implementation of another emergency feedwater pump to enable more reliable heat removal on the secondary side;
- Implementation of measures to extend the battery discharge time (at Paks, the emphasis is on recharging the batteries using mobile DGs);
- Alternative fuel filling arrangements for the DG (at Paks, the focus is on maintain the DG tanks full);
- Alternative methods of monitoring of the key technological parameters to enable optimal accident management;
- Provision for alternative heat removal from key safety equipment, including the I&C during the SBO (when the HVAC system might not be operational when the electricity is supplied from mobile DGs);
- Implementation of an alternate ultimate heat sink by means of mechanical draft cooling towers (Paks relies on the availability of water in various channels leading to Danube);
- Alternative mobile devices for alternative fluid supply for heat removal;
- Increase in the capacity for hydrogen removal to cover the full spectrum of beyond design basis accidents (Paks does not have PARS for BDBA);
- Verification of the correctness of the functioning of the SSCs during the BDBA conditions, and confirmation that the SAMGs assumptions on equipment are correct (not clear whether Paks has done similar);
- Alternative supply of power for selected valves from mobile power sources (Paks has mobile DGs that are supplying selected pumps and/or bus bars but not individual valves).

Conclusions and the requirements for the EIA Report

While Paks I units completed all of the safety improvements as per the National action plan, it has been recognised that some other comparable plants went even further in introducing safety enhancements. While this might not be that critical with the expected end of the lifetime in less than 10 years, it is not so when the end of the lifetime is to be extended for an additional 20 years.

Given that the lifetime extension will see the Paks I units operating post-2050, it is reasonable to consider that the safety requirements in line to those for new reactors, e.g. as defined by the Hungarian Nuclear safety code as well as in the WENRA Safety Objectives for New Nuclear Power Plants should also be applied to Paks I units for the period of extended lifetime. Furthermore, considering the length of the remaining lifetime, if extended for the second time, it is reasonable to expect that the new, possibly stringent regulation may be published before the end of the lifetime, which might also apply to the Paks I units.

It is therefore recommended that the key elements of safety justification for the second lifetime extension are thoroughly reviewed against the safety requirements as defined in the Hungarian Nuclear safety code as well as in the WENRA objectives for new reactors. The result of such an investigation should be reported in the EIA, together with the listing of safety measures the implementation of which is a necessity for the continued operation of Paks I units for the duration of the extended lifetime.

3 SIMULTANEOUS OPERATION AND INTERACTIONS OF UNITS OF PAKS I UND PAKS II

Treatment in the EIA program

The "Preliminary consultation document for the Paks Nuclear Power Plant Subsequent Service Life Extension" (MVM 2024) recognises that the Paks site, where currently the Paks I units 1-4 are operating, is also to house the Paks II, two units WWER 1200 plant, the construction of which has started. Paks site also houses the interim store for the spent nuclear fuel, as well as other radioactive waste management facilities. The Preliminary consultation document states that "in addition to the independent examination of the impacts of the Paks Nuclear Power Plant, it is also necessary to assess the cumulative impacts arising from the joint operation of six units (four existing units of the Paks Nuclear Power Plant and two new units of Paks II."[1]

The Preliminary consultation document (MVM 2024) describes expected environmental impacts of Paks II. The licensing documentation of Paks II states that the plant is designed to a constraint that the impacts of radioactive emissions into the environment and on the public will not exceed public dose constraints during continuous normal operation of the units and "expected operational events"[2]. The dose calculations were performed for the operational impacts of Paks II, which concluded that "the results are entirely similar to the normal operational emissions of the Paks I units". It is further stated that the impact of normal operation of Paks II, considering airborne and liquid discharges, will be significantly lower than the dose constraint of 90 µSv/year.

The Preliminary consultation document (MVM 2024) concludes that that the "combined normal operational activities of the Paks I and Paks II are expected to result in negligible environmental radiological exposure".

The Preliminary consultation document (MVM 2024) also describes the interim storage facility for the spent fuel that is in operation at the Paks site, which is planned to be in operation for the next 50 years. The SNF storage is a dry type, where fuel elements are positioned into vertical storage tubes that are stored into vaults surrounded by reinforced concrete walls said to be almost 2 meters tick. The heat is removed by a natural circulation of air. In 2023, there were 10.567 spent fuel assemblies stored in the interim storage facility. The approved storage capacity of the interim store was set to include all fuel elements used at Paks I units up to the end of the first extension of the lifetime, i.e., 50 years of operation. This leads to a total storage capacity of 17.743 assemblies.

[1] MVM 2024 Pg 19 of 213

[2] MVM 2024 Pg. 94 of 213

The Preliminary consultation document (MVM 2024) does not describe in any detail possible interaction or safety impact between Paks I or II units and the Interim spent nuclear fuel storage facility.

Discussion

The Preliminary consultation document (MVM 2024), as described above, considers that there will be other units operating at the Paks site, i.e. additional to the Paks I units. However, it seems to limit the consideration of the multiple units operating at the site to the releases that are expected in normal operation and „expected operational events". In terms of the impact of normal operation, that is correct. A well operated nuclear plant would have normal operational releases that are only a fraction of the usual operational limits set by the regulator, thus contributing very little to the actual radioactive doses to the surrounding population.

The Preliminary consultation document (MVM 2024) also states that the dose constrains would not be exceeded with units experiencing „expected operational events". The problem is that it remains undefined what are the "expected operational events". Are those all design basis events (i.e., including the most critical DBA, like full guillotine break of the RCS piping) or only some of the DBA events, i.e. expected transients?

The Preliminary consultation document (MVM 2024) does not say anything about possible interactions between multiple units at the site, including any planned assessment in relation with external impact. In particular, there is no discussion in relation with the man-made event that could possibly be critical when considering the risks to the environment and population.

The importance of external hazards cannot be underestimated for the individual units, and it is even more so when there are multiple units at one site. As the Fukushima event has empirically shown, if there are multiple units at a site several of those might be affected by the same event. Therefore, external events, both natural and man-made (including, e.g. transportation on the Danube or malevolent impacts) need to be thoroughly analysed, including a scenario where multiple units are affected. The interim spent fuel store located at the Paks site needs to be addressed in this regard as well. Such an assessment and the consequences identified need to be thoroughly described in the EIA.

While it is expected that there are no common systems supporting the units of Paks I and 2, from the layout it is obvious that the water intake structure (for cooling) is a common one. Natural or man-made events could jeopardise the water intake, which is also used for the ultimate heat sink (at least to a certain extent) thus affecting all units. Effects of such events need to be assessed. Further, plant specific challenges including, e.g. the turbine missiles (the containments of Units 1-4 are within the 25 degree range of the Turbine of the units 5-6, which is a limit requiring assessment per US NRC Regulatory Guide RG 1.115) need to be addressed as well.

Requirements for the EIA Report

The EIA Report should contain the following information on possible interactions among multiple units, including assessment of external impacts affecting all the units at the site (as well as the SNF interim store):

- Assessment of the severe weather conditions, including the Danube River/flooding while considering the effects of climate change;
- A summary of outcomes of the assessment of man-made external events like aircraft crashes, terrorism or sabotages, including insider events and terrorist attack;
- Assessment of a combination of external events, including consideration of interactions among multiple units on the site;
- Assessment of the cliff edge effects for individual and multiple unit;
- Investigation into interaction among the plants, including effects like turbine missiles;
- Thorough analysis of the possible events affecting multiple units on the site, with a view on establishing an enveloping radiological release source term.
- Assessment of the effects on the operation and safe shutdown of other units in a case where one or more units at the site have released radioactivity into the environment, making site access and/or communication difficult or impossible.

4 SEISMIC RISKS OF THE SITE

Treatment in the EIA Scoping Document

In chapter 1 of the EIA Scoping Document (MVM 2024) the seismic safety program is mentioned in which approximately 4,000 tons of steel structures were installed as reinforcement. Therefore, according to MVM (2024), the NPP meets the requirements of the 2000s. Seismic risk assessment and reconstruction has been conducted between 1993-2002.

Focus of Chapter 2 is on lifetime extension (LTE) and the NPP site, with attention on seismic hazard in section 2.1.6 (while hazard combinations have been addressed in section 2.1.5). The Scoping Document declares that based on the current state of knowledge risks due to seismic events do not differ from those considered in the safety analyses of the NPP. In this section the wording "risk" refers to earthquakes, earthquake-induced surface displacements, and soil liquefaction. With respect to the geological and tectonic site characteristics MVM (2024) refers to the geological site investigation program performed for the siting of Paks II. Accordingly, the Dunaszentgyörgy-Harta fault zone, *"representing the most intense neotectonic activity in the area"*, passes under the site. According to MVM (2024) the fault cannot be classified as capable according to Hungarian nuclear regulations (NSC 7.3.1.0900), and the IAEA definition of capable faults. MVM (2024) claims that soil liquefaction observed in the loose sediments in research trenches and in the wider surroundings of the site could result from Pleistocene paleoearthquakes with magnitudes M=4-5. Calculations of the surface displacement hazard caused by seismic fault slip in and around the site stated with a frequency of 10^{-7}/year. It is concluded that the Paks NPP is adequately protected against these risks. No future changes are expected that would significantly alter the risks and consequences.

Subsection "Earthquake hazard and soil liquefaction" of section 2.1.6 describes that the mean annual frequency (MAF) of an exceedance of a "safety earthquake" is 10^{-4}, which finally yields to the corresponding free-field acceleration of 0.26 g extracted from PSHA 2016 performed for the siting of Paks II. Moreover, it is stated that global soil liquefaction does not need to be considered at that MAF. Local soil liquefaction is expected only at the north-west corner of the reactor building with a displacement magnitude of 5.08 cm, which is not regarded relevant for risk assessment. Possible effects of soil liquefaction caused by earthquakes with exceedance probabilities below 10^{-4} per year and PGA>0.26 g are not described.

Subsection "Investigation of the geological, tectonic, seismological and geotechnical characteristics of the site" of section 6.1 explains that the site characteristics are based on approximately 50 years of investigation. The seismic displacement hazard has been computed based on the calculations and publications after the completion of the Paks II Geological Research Program – the seismic hazard with a mean annual frequency of 10^{-4} does not change, since there is no modification of the parameters of the seismic model required. Hence, it is stated that the quantification of the impact of the updated seismic hazard on the EIA is not justified.

MVM 2024 (p. 70) summarizes the safety requirements for the different operational states of the NPP referring to HAEA Decree 1/2022. (IV. 29.) on nuclear safety requirements for nuclear facilities, as well as in the Nuclear Safety Code (NSC). Requirements for the core damage frequency (CDF) are stated as follows: *"Taking into account all design operating conditions and assumed initial events, except sabotage, the frequency of core damage leading to a severe accidental release shall not exceed 10^{-4}/year."* Requirements for the Large or Early Release Frequency (LERF) are stated as: *"The summed frequency of severe accident event chains with large or early releases, aggregated for all initiating operating conditions and effects – **excluding** sabotage and **earthquakes** – must not exceed 10^{-5}/year, but should be approached as closely as possible to 10^{-6}/year with all reasonable modifications and interventions."* Compliance with the acceptance criteria for the design basis and design basis extension operational states is said to be demonstrated by Probabilistic Safety Analysis (PSA). PSA is further used to ensure that adequate margins are available to avoid cliff-edge effects. PSA results such as the contribution of earthquake to Core Damage Frequency (CDF) and Large or Early Release Frequency (LERF) are not provided.

Discussion

The EIA Scoping Document gives a brief overview of the work and research conducted concerning the topic "earthquake engineering and seismology" within the Paks I LTE. Regarding the quality of the document focusing on seismic analysis it needs to be emphasized that no information is provided to understand how the authors draw their conclusions. In particular, there are no references to national and international accepted codes, guidelines, literature research papers, etc.

Regarding seismotectonic hazards, MVM (2024) claims that the outcome from seismic hazard analysis in 2016 (performed in the course of the site characterization for the new NPP Paks II) yields that no modification of the site-specific seismic hazard (quantified by PGA = 0.26 g at a MAF of 10^{-4}) is required, and subsequently, there is no need to quantify the impact on the EIA.

For the NPP under scrutiny, the design base earthquake of PGA_H = 0.25 g and PGA_V = 0.20 g for the occurrence probability of 10^{-4}/year originally was established in 1996 (UMWELTBUNDESAMT 2012). Those values seem very similar to the seismic design basis value PGA = 0.26 g for the occurrence probability 10^{-4} per year stated by MVM (2024)[3]. MVM (2024, p. 169) therefore concludes that a recalculation of the seismic hazard associated with the development of the environmental impact assessment is not justified. The EIA Scoping Document states that *"It has been confirmed that the new data do not change the model parameters used for the calculation of the hazard (PSHA) and thus the hazard results, especially*

[3] The EIA Scoping Document does not make clear if the value refers to peak ground acceleration or peak horizontal ground acceleration.

for the UHRS (Uniform Hazard Response Spectra) with a frequency of 10^{-4}/year." The EIA Scoping Document does not provide data to support this conclusion. MVM (2024) neither provides information on the design basis values (PGA, Uniform Hazard Spectra) currently in force for the NPP Paks, nor on the hazard assessment that was used to define these design basis requirements. MVM Paks NPP's conclusion that seismic hazards in the LTE process do not need to be revised is incomprehensible for several reasons:

1. A comparison of the hazard results solely based on PGA values is insufficient because it does not provide information on spectral accelerations (UHRS) which are input parameters for assessing the seismic robustness of SSCs important to safety. Comparisons of the UHRS that are applied as the current design basis parameters to the existing NPP and the UHRS values obtained from site assessment for Paks II are not provided in the EIA Scoping Document.
2. It must be noted that input data and model assumptions for PSHAs changed repeatedly since 1996. The PSHA 1996 which established the design basis value of PGA_H = 0.25 g and PGA_V = 0.20 g was described by KATONA (2012; see discussion in UMWELTBUNDESAMT 2012). Accordingly, the PSHA uses a logic tree in which a 10% probability was assigned to local active fault sources whereas a 90% probability was attributed to seismotectonic scenarios without active faults. The cited hazard model was prepared at a time when the Dunaszentgyörgy-Harta fault zone was not regarded active. The site assessment program for Paks II, however, proved the tectonic activity of the Dunaszentgyörgy-Harta fault zone. MVM (2024) honours this fact stating that the fault *"represent*[s] *the most intense neotectonic activity in the area"* and passes directly below the site. Assigning only 10% probability to active fault sources in the PSHA model described by KATONA (2012) therefore cannot be defended and the logic tree underlying the PSHA must be modified in order to account for this finding. The PSHA performed for the Paks II site characterization notably neither contains fault sources nor a logic tree that accounts for active faults.
3. Rejecting a re-assessment of the seismic hazard in the LTE process is not in line with WENRA requirements. In European countries, LTE is typically linked to Periodic Safety Reviews (PSR) and the achievement of pre-defined safety goals (e.g. France). Requirements for PSR and safety expectations for the design basis and DEC assessments are provided by WENRA (2021) in the Issues P, Periodic Safety Review, E, Design Basis and F, Design Extension Conditions. Reference Level P2.2 contains an enumerative list of safety factors to be covered notably including hazard analysis. For earthquake, hazard reviews should account, inter alia, for novel data on seismic sources, newly discovered active or capable faults, and site effects (WENRA 2020b). This seems particularly relevant with respect to the now accepted activity of the Dunaszentgyörgy-Harta fault zone running below the NPP. Seismic hazard assessment should therefore particularly include the Dunaszentgyörgy-Harta fault zone as a fault source and account for near fault effects on long period ground motion with very short duration

(0.5-5 s) (forward directivity and fling-step ground motion observed from velocity pulses recorded in time histories) (WENRA 2020b).

Potential accidents and severe accidents initiated by earthquake have significant impacts on the environment. Consideration of seismic safety in the EIA process is consequently regarded mandatory.

With respect to seismic engineering, no seismic and/or structural analysis and/or structural design performed by seismic consultants throughout or before the LTE process are mentioned, with exception of the mitigation that 4,000 tons of structural steel has been used for "upgrading" the structure to the safety level of the 2000s. This leads to the conclusion that the EIA Scoping Document leaves it unclear in which depth the "seismic risk assessment and reconstruction between 1993 and 2002" (as mentioned in MVM 2024, section 1.1) involves seismic analysis and design.

It is evident from codes and guidelines (IAEA 2014, IAEA 2021 and IAEA 2024) that a seismic analysis is mandatory for classification, design, and evaluation of seismic safety of both (a) the load bearing structure and (b) the nuclear installations. From the preliminary consultation document there is no evidence that seismic safety of any load bearing structure, substructures, system or component (SSC) has been quantified at any stage of the lifetime of Paks I.

With respect to the general safety expectations, MVM 2024 (p. 70) states that *"taking into account all design operating conditions and assumed initial events, except sabotage, the frequency of core damage leading to a severe accidental release shall not exceed 10^{-4}/year."* This statement is clearly not in line with the WENRA (2021) Safety Reference Levels for Existing Reactors. WENRA (2014, Issue T5.; 2021, Issue TU5.) requires existing reactors being protected from design basis events. During design basis accidents, protection shall be sufficiently reliable to conservatively ensure that the plant is able to fulfil the fundamental safety functions. This is to be achieved by applying reasonable conservatism providing safety margins in the design (WENRA 2014; 2021, Issue E8.). Reactivity control is among the fundamental safety functions. Core damage in the design basis range is consequently not admissible.

The EIA Scoping Document does not include detailed information on expectations or requirements on safety margins beyond the design basis and the assessment of Design Extension Conditions (DEC). The only relevant information concerns the LERF which must not exceed 10^{-5}/year according to Hungarian regulations. The value is calculated summing frequencies of severe accident event chains of all initiating operating conditions and effects, notably **excluding earthquakes** (MVM 2024 p. 70). It is concluded that the Large or Early Release Frequency **including** events initiated by earthquake is larger than 10^{-5}/year. The approach to exclude a certain hazard type from the calculation of LERF is not in line with international practice and WENRA requirements for PSA. MVM (2024) neither specifies the contribution of earthquake / seismotectonic hazards to LERF nor to CDF. The exempt of events initiated by earthquake from LERF calculation, however, suggests that the contribution is significant.

Assessments of Design Extension Conditions (DEC) shall consider phenomena more severe than the design basis events as stipulated in Issue T6. and TU6. of the WENRA Reference Levels, respectively (WENRA 2014; 2021). WENRA requires identifying and assessing the effects of events not covered by the design basis to identify reasonably practicable improvements and to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents. The same is required by Council Directive 2014/87/EURATOM Article 8a lit. (b)[4]. MVM (2024) does not provide information on how such reasonably practicable improvements shall be identified and implemented.

Conclusions and requirements for the EIA Report

Regarding seismic hazard, the EIA Scoping Document only contains superficial information on seismic hazards and exclusively refers to results of the site characterization program for the new NPP Paks II. Information on the seismic design basis of the existing NPP are missing. MVM (2024), however, claims that re-assessment or revision of seismic hazards are not necessary as *"new data do not change the model parameters used for the calculation of the hazard (PSHA)".*

The approach not to review seismic hazards is not in line with international practice and WENRA requirements. LTE in European countries (e.g., France, Belgium) is typically linked to a Periodic Safety Review (PSR). WENRA Reference Levels (WENRA 2021) and applicable WENRA guidance (WENRA 2020a, 2020b) clearly require hazard reviews, re-assessments of the design bases for external hazards and adequate assessments of design extension conditions (DEC). These assessments need to be part of the EIA and LTE process. DEC analysis considers phenomena more severe than the design basis events (WENRA 2014; 2021) to identify reasonably practicable improvements and to increase the robustness and resilience of the NPP with the aim to prevent severe accidents. The same is required by Council Directive 2014/87/EURATOM Article 8a lit. (b).

Regarding seismic engineering: The EIA Scoping Document has not discussed any design checks concerning seismic safety of the NPP in the LTE process. All SSCs designed and seismically retrofitted require by all needs seismic checks in agreement with technical specifications provided in codes and guidelines (IAEA 2014, IAEA 2021, IAEA 2024).

In the EIA Scoping Document, seismic safety is only discussed in the context of seismic hazard and only a single quantity of the entire UHS is mentioned in the

[4] Council Directive 2014/87/EURATOM Article 8a: "…Member States shall ensure that the national nuclear safety framework requires that nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding: (a) early radioactive releases that would require off-site emergency measures but with insufficient time to implement them; (b) large radioactive releases that would require protective measures that could not be limited in area or time. …. Member States shall ensure that the national framework requires that the objective set out … is used as a reference for the timely implementation of reasonably practicable safety improvements to existing nuclear installations, including in the framework of the periodic safety reviews …".

report (PGA = 0.26 g). Site-specific seismic hazard, however, is only one aspect of seismic safety. The seismic response of SSCs important to safety, their fragility and failure probability are not addressed in the EIA Scoping Document. Hence, comprehensive seismic structural assessment, analysis, and design of the existing NPP are mandatory to be included in the LTE process.

Multi hazard assessment in combination with seismic hazard is only briefly addressed in the EIA Scoping Document. While the non-causal combination of earthquake ground shaking with extreme (high or low) temperature is taken into account, the consequential hazard combination earthquake induced internal fire is not, although it is a rather likely hazard combination (e.g., the accident in the Kashiwazaki-Kariwa NPP, IAEA 2007). This aspect should be covered in the EIA.

Requirements

Regarding seismic hazard, the following requirements apply to the EIA Report. The report is expected to include:

- A description of the current design basis requirements for all seismotectonic hazards applicable to the site (vibratory ground motion, soil liquefaction, surface displacement) and all relevant hazard combinations, including earthquake-induced fire.
- A comprehensive schedule and timeline for reviewing seismotectonic hazards in the framework of the LTE process to accord with WENRA requirements and guidance. Hazard reviews should notably account for advances of science and technology, and new information, and consider conducting independent hazard assessments involving different groups of experts and considering all relevant interpretations (WENRA 2020b).
- A comprehensive description of the safety requirements and safety targets that must be achieved in the LTE process. According to MVM (2024)
    a. "the frequency of core damage [CDF] leading to a severe accidental release shall not exceed 10^{-4}/year" and
    b. LERF must not exceed 10^{-5}/year, calculated for all severe accident event chains excluding earthquakes.

  The stated value for CDF is not in line with WENRA requirements. The approach to calculate LERF exempting earthquake is not in line with international practice.
- A comprehensive description how Design Extension Conditions (DEC) shall be analysed in the LTE process in accordance with Issues T6. and TU6. of the WENRA Reference Levels (WENRA 2014; 2021). The EIA Report is expected to show how the overall goal formulated by WENRA, i.e., to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents, will be achieved in the LTE process. Reasonably practicable improvements with the aim to prevent severe accidents are notably also required by Council Directive 2014/87/EURATOM Article 8a lit. (b).

With respect to seismic engineering: The EIA report requires the documentation of the seismic design and performance (e.g. evaluation of failure probabilities, seismic safety margins) of the NPP in full agreement with accepted codes/guidelines (IAEA 2014, IAEA 2021, IAEA 2024) of all load bearing elements, systems, and components.

The EIA Report should cover not only comprehensive information of analysis results concerning seismology and earthquake engineering but also:

- seismic qualification certificates of materials (e.g. structural concrete, structural steel, fastening systems, etc.),
- seismic qualification certificates of structure, systems, and components (e.g. provide seismic qualification certificates of the equipment),
- comprehensive documentation regarding seismic retrofit and detailing of interfaces between e.g. equipment and the load bearing structure,
- comprehensive information of the PSHA such as the entire UHS, and seismic hazard disaggregation to visualize the influence of magnitude and distance to the total seismic hazard.
- framework and methodology to perform seismic risk assessment and computation of seismic safety margins,
- assessment of multi-hazard scenarios (e.g. fire after earthquake etc. should be covered).

5 AGEING MANAGEMENT FOR UNITS 1-4

The Preliminary consultation document (MVM 2024) introduced the ageing management at the Paks I units. The basic premise of the ageing management program that is said to be enabling an economical – and presumably safe – lifetime extension is in the fact that the material inspection, analysis, and results of maintenance activities have confirmed that the most critical equipment (e.g., reactor vessels, steam generators, etc.), the replacement of which would not be feasible technically or economically, would not be necessary for the second lifetime extension of 20 years. The Preliminary consultation document (MVM 2024) does not offer any evidence in that regard, e.g. the nil ductility temperature for the 4 RPVs at the end of the (extended) lifetime or other parameters of relevance. The Preliminary consultation document (MVM 2024) does not specify which inspections, material analyses or maintenance activities have been conducted to lead to such a conclusion. There is some comfort in the fact that the in-service inspection complies with the requirements of the ASME Boiler & Pressure Vessel Code, Section XI: In service Inspection of Nuclear Power Plant Components, the 2001 version of which has been published as a Hungarian standard (MSZ 27011). While it could be assumed that the compliance with the ASME Section IX would ascertain that the In-service inspection is proper, in particular in relation with the RPV, as RPV samples are no longer available, some uncertainty regarding the compliance with the standard remains.

What is somewhat surprising in relation with the discussion regarding "non-replaceable" equipment is that there is no mention of the structures that are supporting plant's equipment and the containment (incl. the barbotage tower) function of which is to protect the RCS and limit the release of radioactivity in a case of an accident. Knowing that the structures of a WWER 440 were designed for a lifetime of 30 years, and considering that the quality of work during construction in nineteen seventies and eighties was not at the highest level it is reasonable to question the capabilities of structures to withstand a lifetime of 70 years without being compromised by normal usage and even more in severe disturbances, e.g. caused by an internal initiators (e.g., large LOCA) or external hazard (e.g., seismic event).

Apart from concluding that those non-replaceable components will support the lifetime of 70 years, the Preliminary consultation document (MVM 2024) concludes that all replaceable and refurbishable components would be maintained within the ageing management programs all the way until the end of the extended service life of the plant, i.e. 70 years. In itself, this is not an unreasonable assumption. Paks I units are known to have a diligent ageing management program that is implemented through a specifically designed ageing management procedure devoted to assuring the functionality of all equipment. Nevertheless, the Preliminary consultation document (MVM 2024) offers precious little insight as to how the ageing management program and processes would need to evolve when the lifetime is extended to more than double the original design lifetime of the plant.

The Preliminary consultation document (MVM 2024) states that achieving the goals of aging management of equipment that is replaceable and refurbishable, various activities including condition-maintenance, medium-term and annual maintenance programs, as well as the preventive maintenance, testing, and supervision programs would need to be developed to ensure that systems, structures and components maintain characteristics that meet design requirements. For Paks I, ageing management program has been developed and is in function. The basis for the ageing management program is the identification of the degradation mechanisms for safety-critical equipment. However, the ageing management program that is designed to assure that the equipment is operational for 50 years, does not necessarily mean that for the period of 70 years there would not be additional degradation and/or even a cliff edge effects that may challenge the operability of the equipment.

The Preliminary consultation document (MVM 2024) mentions the „The medium-term major repair plan", though it is not clear whether this plan covers the existing operating life or it would be applicable to the second lifetime extension. The plan identifies the tasks that could affect major repair plans in terms of duration, resource allocation, or special requirements, including:

- Maintenance programs for equipment groups and individual pieces of equipment that define the maintenance tasks to be performed and their scheduling during a specific period;
- Monitoring programs for individual systems, equipment groups, and individual pieces of equipment, which include technical and structural preparation of the plant's systems, structures and components;
- Recording of failures occurring during operation and associated technical decisions, specifying necessary interventions and execution conditions.

For the implementation of the ageing management program, expected ageing processes and their effects on safety-critical equipment were identified and assessed. On this basis, the evolution of ageing processes was estimated. This in turn determines the inspection cycle to assure that the safety (and operational) functions of the equipment is preserved throughout the lifetime. The Preliminary consultation document (MVM 2024) indicates various repairs and replacements that are necessary, though it is not entirely clear whether those are indeed to be competed for the second lifetime extension for 20 years or still to be addressed in the current extended lifetime.

Specific processes and activities include:

- Renovation and reinforcement of operational main buildings, auxiliary buildings, diesel engine rooms, health and laboratory buildings, hot water channels, and other facilities;
- Replacement of reactor internal equipment, pumps, heat exchangers, valves, compressors and filters and renovations related to the spent fuel pool and transfer pool;
- Replacement of telecommunications system components due to obsolescence of hardware and software and technological changes;

- Partial or full renovation of radiation monitoring systems, including replacement of sensors and computers due to obsolescence;
- Replacement and renovation of control system equipment, with a full renovation anticipated considering the extended operational lifetime. The replacement of turbine performance control system components is currently difficult, with maintenance needs increasing, requiring full reconstruction. Control equipment and tools installed in water intake facilities are mostly original, with increasing maintenance needs, necessitating full reconstruction;
- Renovation of radioactive waste qualification system components, including complete renovation of the gamma-spectrometry measurement system, as the system units become irreparably obsolete approximately every 15 years;
- Periodic renovation of the radioactive waste compaction press and cementation equipment due to wear. This includes modification of 60Co removal and complex dismantling equipment and operational safety upgrades;
- Renovation of fire alarm system components, including replacement of fire alarm and suppression control system elements, due to technical amortization and parts supply issues;
- Evaluation of replacement for high-pressure emergency cooling system pumps due to potential failure modes in the pump construction and frequent maintenance needs (or alternatively, retrofit of the pumps and renovation of the hydraulic part);
- Reconstruction of the hermetic carbon steel plate lining, including repairs of defects found during hermetic space integrity work (hermetic space monitoring and repair program), with reconstruction work possible during long-term major outages;
- Replacement of fans due to expiration of their operational lifetime;
- Replacement of liquid nitrogen storage tanks and evaporators;
- Replacement of high-pressure nitrogen generators due to discontinued parts supply;
- Replacement of diesel generator engines in units 1-2, with the development of a long-term strategy for the emergency diesel generators considering full or partial replacement options;
- Replacement of external operational distribution network transformer stations due to limited parts supply and increasing maintenance needs;
- Replacement of steam generator blow-off system components due to increasing failure frequency;
- Renovation of electrical, building systems, water units, sewage lift stations;
- Replacement of chemical sampling system components, including chemical analysers and ion chromatographs.
- Renovation, reconstruction, and replacement of lifting equipment, lighting fixtures, and electric motors.

This looks like a comprehensive list of repairs and replacements to be undertaken. Nevertheless, there is no way to determine whether this is mere a consideration or this list was developed based on a thorough and complete assessment of the degradation mechanisms for all of the safety relevant SSC in the Paks I units, in particular considering the degradation mechanisms that would affect the equipment for the 70 years lifetime.

Discussion

The Preliminary consultation document (MVM 2024) rightly points out that the 60 years lifetime of Gen II nuclear plants is a norm at present, and that some reactor units (in the US) are receiving permissions to extend the lifetime to 80 years. Nevertheless, it has to be recognised that it is not fully appropriate to draw parallels between the WWER 440 units and some other Gen II units, particularly those of western design. There are lots of differences in the design and construction between units, to be able to draw the conclusion that if some other units have been extended their lifetime to 80 years, other could also do so. This is particularly relevant as for the WWER 440 units in their country of origin – Russia, where all the design knowledge is concentrated, the regulators have been more careful in extending the lifetime, i.e. opting to add 10 years at a time, and not going beyond 60 years (which is already doubling the design lifetime).

On the positive side, Paks I ageing management program has been internationally evaluated and found to be exemplary. In total, 7 pre-SALTO and full scope SALTO missions visited Paks NPP to evaluate the ageing management program and procedures. The recommendations provided by those missions have all been implemented, as confirmed by the follow-up missions. Paks NPP is a very active member of IGALL enabling the plant to use broad international experience to improve the ageing management.

In terms of the results of the TPR, only a few issues have been raised of Hungary. In the National action plan of the 1st TPR, all of the specific and a number of generic issues have been addressed and justified. In the end, only two items remained to be implemented at the Paks I units. Those were:

- appropriate techniques to detect degradation of inaccessible cables
- Inspection of safety related pipework penetrations through concrete structures are part of ageing management programs

On the negative side, the Preliminary consultation document is not really precise as to what has been done and what is only planned. In terms of activities listed, it remains unclear whether (some of) those are to be implemented within the current extended lifetime or are conditions for the second extension. Furthermore, there is no clarity as to the extent of assessments undertaken to plan for the update of the ageing management procedure for the second extension. It is mentioned that the program will benefit from the implementation of the existing ageing management program and build upon the inspection findings (which would reveal degradations). Still, there is no clarity on how would other degradation mechanisms that have not been observed during the original design lifetime and the initial lifetime extension be identified. There is no information provided on the methods to assess and identify potential cliff edges that might affect safety of the SSC. Finally and likely the most important deficiency seems to be a lack of clarity regarding ageing management of civil structures including containment and major supports.

The Preliminary consultation document does not discuss the regulatory requirements for the second life extension, which might be in place already or might be imposed in the future. As discussed previously, with the second extension, Paks I units will still be in operation in 2050, meaning that (some of) the requirements for new NPPs might (would need to) apply. Maintaining the units through the ageing management just to assure that the SSC does not deteriorate (significantly) might not be enough.

The safety requirements for nuclear reactors today establish much stricter criteria as to what is a required safety level, in particular related with severe accidents and DEC conditions that might lead to radioactive releases. From the perspective of Austria, severe accidents, leading to off-site releases and transboundary impacts are the most important issues to be addressed. Simply assuring that the safety of the plant remains "as designed" (in nineteen sixties) until the end of 70 years of lifetime is not enough. When a plant is in operation for 70 years, it is logical to expect that such a plant would need to have the safety level that is comparable to plants that are built to current safety requirements and standards.

Regardless of comprehensiveness of the ageing management program, that might be an unreachable goal. This might particularly apply to the structures that are in most cases difficult to refurbish. The Preliminary consultation document does not indicate whether there might be regulatory requirements is this respect in Hungary, nor whether the Paks I units would, with the ageing management in place, be able to achieve (or at least approach) such a goal.

The lifetime extension of the Paks I units would need to adhere to any regulatory requirements established by the HAEA. This will require both a thorough assessments and refurbishments that are likely to go beyond those listed in the Preliminary consultation document, in particular if adherence to the Hungarian Nuclear safety code is requested. It is very important that the approach, but also results of safety assessments are provided in the EIA, to enable an evaluation of the impact to the environment. From Austrian perspective, a thorough analysis of severe accidents and associated radiological impact beyond the 30 km extent mentioned in the Preliminary consultation documents' is an essential requirement for the EIA. In line with current practice in the EU (for the EIAs for life extension of NPPs), a radiological impact for an enveloping severe accident scenario on the population within 1000 km distance from the plant needs to be provided.

Even if the equipment is well maintained, some equipment (and possibly structures as well, including in particular the cables) would be coming to the end of their useful lifetime, no longer assuring the safety functions those are designated to support. There would be equipment that, due to ageing processes, might no longer be fit for purpose. Such equipment would need to be replaced. Due to obsolesce, there is an increased challenge that specific pieces of equipment or spare parts would not be available. In such cases, a redesign with dedicated analysis (including safety analysis) would be necessary as the replacement would not anymore be like-for-like. This might require selection of different equipment, redesign of systems and structures, detailed safety assessments/justification to be performed, and appropriate regulatory approval through the licensing process to be obtained. All of these are raising challenges, which are increasingly complex as the lifetime is extended further. Information and justification how to cope with such emerging challenges while maintaining high level of safety as required by Hungarian Nuclear safety code needs to be described in the EIA report.

Requirements for the EIA Report

Regarding the ageing management program, the following issues should be presented in the EIA Report:

- The concept of how the Paks I units operator MVM plans to deal with the ageing management, including schedule of activities and their interaction;
- The EIA Report should detail any design changes that are necessary to enable the second lifetime extension;
- The EIA report shall detail the investigations that are planned to identify potentially different degradation mechanisms that might become relevant for the operation between 50 and 70 years ;
- The EIA has to provide a detailed explanation on the assurance of integrity and functionality of the major (and minor) structures that are either safety related (containment , various buildings and structures) of Paks I units, until the end of the second extended lifetime;
- Plans for dealing with (increased) obsolesce of equipment for 70 years of operation;
- The relation of the ageing management program with the forthcoming PSR that will be implemented within the currently licensed extended lifetime;
- The EIA report shall address the concept how the safety level for the extended lifetime corresponds with the safety objectives set for new reactors;
- The EIA shall provide the CDF, LERF and/or other available metrics and estimates for the
    a. end of currently licensed lifetime and
    b. end of the second extended lifetime, which is now sought.

6 ENVIRONMENTAL IMPACTS ON PAKS I AND PAKS 2

Treatment in the EIA Scoping Document

Chapter 5.2. of MVM (2024, p. 109ff.) informs about climate conditions exposure and sensitivity to climate change. The average annual air temperature at Paks between 1981 and 2010 was 10.7°C, and from 1991-2020 it increased to 11.1°C., same as for the period 1983-2023. The number of heatwave days and hot days also increased. No trends in changes of annual precipitation were observed, neither in average nor in total. The wind direction frequency and atmospheric stability categories are described, the annual average wind speed increased.

Results from two climate change scenarios were used to predict climate changes. (MVM 2024, p. 110f.) Scenario RCP4.5 is described as more optimistic due to successful emission reduction efforts, while scenario RCP8.5 is the most pessimistic. The span of predicted temperature rise in these two scenarios lies between 1.5-5.3°C in Hungary by the end of the century; precipitation might change between -5 and 24%.

The data used for projecting climate change impacts are model-based. The Hungarian FORESEE database is used, with supplements from the IPCC interactive Atlas. The FORESEE results predict a faster increase in air temperature that IPCC Atlas. It is expected that the number of days with heavy rainfall (exceeding 30 mm) until 2060 will remain roughly the same, about 2 days/year, while there is a small increase in days with extremely heavy rainfall. Days with wind gusts might stay about the same. In addition, estimates for low and high mean water levels are given, the high levels are predicted to increase and the low levels to decrease. A study from 2016 on the Danube water system is also used for predictions. The results of the studies regarding the discharge and water level predictions are going to be revised and updated if needed in the following study program. (MVM 2024, p. 114)

For prediction of changes in the Danube water temperature a study from 2013 was used for the EIA of Paks II. This study had assessed a highest annual maximum of 25.4°C with a 1% exceedance probability (MVM 2024, p. 114). The EIA Scoping Document mentions that between 2018 and 2024 observations of exceedance above 25°C of the Danube water temperature occurred, and that this might be an increasing trend. Strong turbulent fluctuations in water temperature can be detected near the discharge of the warmed cooling water returned into the Danube. At low water discharge (800 m^3/s) and hot water input of 100 m^3/s, the cooling rate is reduced (to 2.5°C) due to the low water level and the low velocity in the plume. New model studies will be performed to determine the relevant hydro-meteorological conditions. (MVM 2024, p. 116)

The highest measured water temperature in the period before the construction of the nuclear power plant was 25.2°C on 8th August 1971. Since then, the Danube water temperature has continued to rise, with the current peak measured in 2018, when the annual maximum base temperature of the Danube was 27.03°C (MVM 2024, p. 126f.)

The available data indicate that the Danube water temperature is increasing in the long term due to climate change, with a clear increase in the number of days per year with water temperatures exceeding 25°C. Still however, warming does not pose safety issues according to the EIA Scoping Document. Moreover, the Paks II development would reduce the efficiency of the mixing with the undisturbed waters of the Danube at the Paks Nuclear Power Plant's discharge point, and thus the temperature decreases up to the reference section. In order to prevent exceeding the temperature limits, to the necessary degree, the power output of the nuclear power plant units can be decreased. Another option is to explore technical solutions to increase the efficiency of mixing. (MVM 2024, p. 132)

A new heat load model will be created and be used to refine the extension of effected areas by heated cooling water discharge. (MVM 2024, p. 133)

In chapter 5.2.3 the impacts of the NPP's heat load are discussed. It is indicated that the surrounding ecosystems have had to adept to far greater differences in both climatic and weather terms for their survival than the warm water impact detected by measurements and modelling. Regarding the independent operation of the Paks I NPP, no changes in the meso-climate characteristics resulting from the Danube heat load during the extended service life of the plant are anticipated based on currently available information. (MVM 2024, p. 118)

The climatic effects resulting from the heat load on the Danube due to the return of heated cooling water from the parallel operation of two NPP will likely continue to be detectable locally at the power plant site and in the immediate vicinity of the warm water channels. However, no meso-climatic changes are expected to result from this, even with the doubled amount of heated cooling water being returned. The detectability of the impact is likely to remain small, similar to the current state. (MVM 2024, p. 118)

During the screening phase, the following climate change impacts were found to be relevant for the site's climate exposure assessment, with low expected current and future impacts. (MVM 2024, p. 121f.)

Based on the examination following the criteria outlined in the Climate Resilience Guidelines:

- expected change in the average annual temperature (slow increase),
- expected change in summer average temperature,
- expected change in the number of hot days,
- increase in the number of heatwave days.
- decrease in the water flow of Danube River due to the increased length of dry periods in the catchment area.
- increase in the temperature of Danube River.

The assessments conducted as part of the screening phase showed that none of the expected impacts had high consequences, and therefore, no further detailed climate adaptation analysis was required.

On the other hand, economic consequences could occur based on these expected changes. The EIA Scoping Document recommends that it might be advisable to prepare for managing extreme situations beyond the climate adaptation study's acceptance criteria if it is economically justified and technically feasible. (MVM 2024, p.122)

Chapter 6.2 (MVM 2024, p. 170-172) of the EIA Scoping Document provides information on the assessment of meteorological hazards in the context of climate change. Accordingly, a climate characteristics review study program is set out to assess the current and projected future climate of the area around Paks NPP. The program supplements and updates the climate characterisation previously carried out in the framework of the environmental and site licensing of Paks II. The program shall characterize extreme weather events corresponding to a probability of 10^{-4}/year as required for existing nuclear installations. MVM (2024) explicitly mentions storm, extreme precipitation, extreme temperature, the Danube's upstream water temperature, discharge and water level, and the hazard combination heat wave and drought as phenomena to be analysed. The results of the study program are scheduled to model the expected trends of meteorological hazards due to climate change for the period of the LTE.

Chapter 2.1.5 of MVM (2024) provides some additional information on hazard combinations taken into account in the site assessment stating that the following combinations were analysed in detail:

- external hazards from human activities in extreme meteorological conditions,
- high wind and extreme precipitation and lightning (storm),
- high wind and extreme snow,
- extremely high air temperature and high cooling water temperature,
- extremely low air temperature and surface ice (and icing and snow),
- simultaneous accidents in multiple industrial facilities nearby (e.g. due to earthquakes),
- occurrence of an earthquake when the ambient temperature is extremely high or extremely low,
- combinations of hydrological hazards,
- combinations of potential hazards in the field of geosciences.

The EIA Scoping Document concludes that the Paks NPP is adequately protected against the impacts of the hazard combinations specified in the design basis. Available forecasts did not indicate any future changes that would significantly alter the consequences. Consequently, combinations of external hazards would not pose a risk to the plant during the extended operational period to a degree that would significantly affect its environment. (MVM 2024, p. 45)

Discussion

The EIA Scoping Document informs that a program has been set up to assess meteorological hazards that apply to the site and forecast changes of hazard severities due to climate change. The program supplements and updates the results of the site characterization of Paks II (completed in 2016) by the time series of meteorological data obtained since 2016. The aim is to define design basis events corresponding to a probability of 10^{-4}/year.

The contents of MVM (2024) do not allow judging the comprehensiveness of the studies. It is, however, noted that relevant hazards such as river flooding and tornado are not addressed in the document. It also remains unclear if the program is also scheduled to assess the probability and severity of events that exceed the design basis.

Consideration of phenomena more severe than the design basis events are required by the Issues F (SRL F5.1) and TU (SRLs TU6) of the WENRA Safety Reference Levels (WENRA 2021) and associated Guidance Documents (WENRA 2020c, 2020d). Such events and phenomena are summarized under Design Extension Conditions (DEC). The Reference Levels require identifying and assessing the effects of events not covered by the design basis. Analyses shall include the assessment of hazard severity as a function of the related occurrence probability (when practicable) along with the impact of such events on the plant. The overall goal is to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents.

Increases in thermal load from heated cooling water discharge into the Danube, especially in a parallel operation of Paks I and II, are discussed at large in the EIA Scoping Document. The highest temperature in the Danube was reported to be 27.03°C (MVM 2024, p. 126f.). In the heatwave of 2018, the Hungarian NGO Energiaklub conducted independent measures of the Danube water temperature at the Paks site and found temperatures upstream from the NPP of 25-26 °C; downstream, however, the temperature rose to above 30 °C at several points. For the MVM Paks NPP, the cut-off was at this time 30 °C. Shortly after Energiaklub published these findings and an accompanying video, MVM Paks Nuclear Power Plant Ltd, published its official water temperature data. On the day Energiaklub had measured over 30 °C, the official thermometer measured 28.42 °C. The NPP registered the highest water temperature, 29.88 °C, at the beginning of August 2018. This is only 0.12 °C lower than the temperature at which the NPP must be shutdown to protect life in the river. (MÁTYÁS and MRAZ 2021)

These discrepancies need to be clarified. What was the highest temperature measured at the Paks water canal outlet by MVM? On how many days have the measurements shown a temperature of 30°C or above? Where are the water measurement data published?

In the summer of 2024, the Hungarian government issued a decree to bypass the legal temperature limits set for the Danube River downstream of Hungary's Paks nuclear power plant, using the argument of security of energy supply. The Danube is an important European waterway and borders numerous Natura

2000 areas. (Parliamentary question to the EC by Jutta Paulus (Verts/ALE[5])) It is not clear what effects this decree is having.

Conclusions and requirements for the EIA Report

When deciding on the lifetime extension of existing nuclear power plants, it must be taken into account that hazards may change during the period of extended operation. This applies in particular to the risk posed by extreme weather events, as such events will become more frequent and/or more severe as a result of climate change. It needs to be ensured that the expected effects of climate change on the NPP's safety are adequately taken into account.

Requirements

Regarding external hazards, the following requirements apply to the EIA Report. The report is expected to include:

- A documentation on how hazards and hazard combinations that apply to the site have been selected (hazard screening).
- A comprehensive description how Design Extension Conditions (DEC) shall be analysed in the LTE process in accordance with Issues T6. and TU6. The EIA Report is expected to show how the overall goal formulated by WENRA, i.e., to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents, will be achieved in the LTE process.

The EIA Report should include additional information on the Danube water temperature:

- What was the highest temperature measured at the Paks water canal outlet by MVM?
- On how many days have the measurements shown a temperature of 30°C or above?
- How is the water temperature measured? (method, exact site)
- Are the water measurement data published?
- What consequences will the new decree from 2024 have that allows new temperature limits for the Danube?

[5] https://www.europarl.europa.eu/doceo/document/P-10-2024-001906_EN.html

7 SUMMARY OF RECOMMENDATIONS

The recommendations for the content and the development of the EIA for the second lifetime extension for Paks I units, presented and justified in the previous sections are summarized below.

Recommendations related to procedural aspect and the schedule of activities for EIA

The EIA report should provide detailed information on the scope and the schedules of relevant licensing processes at the level of the nuclear regulatory authority, including the timeline for the development of relevant safety justification. It should describe, which information, mainly plant specific technical data – at the date of the publication of the EIA Report - are assumptions and which data are based on the results of the analyses undertaken (including the date of its elaboration)

The EIA report should describe how the public will be informed after the EIA procedure in Hungary and abroad are completed, but also on the review and approval for the second lifetime extension at the nuclear regulatory authority. With respect to these, the results of the PSR for each unit of Paks I as well as the results of the lifetime estimates for all safety relevant SCC are of special interest.

Recommendations related to the required safety enhancements for Paks I units

It is recommended that the key elements of safety justification for the second lifetime extension are thoroughly reviewed against the safety requirements as defined in the Hungarian Nuclear safety code as well as in the WENRA objectives for new reactors. The result of such an investigation should to be reported in the EIA, together with the listing of safety measures the implementation of which is a necessity for the continuing operation of Paks I Units for the duration of the extended lifetime.

Recommendations related to the simultaneous operation of Paks I and Paks II units

The EIA Report should contain the following information on possible interactions among multiple units, including assessment of external impacts affecting all the units at the site (as well as the SNF interim store):

- Assessment of the severe weather conditions, including the Danube River/flooding while considering the effects of climate change;
- A summary of outcomes of the assessment of man-made external events like aircraft crashes, terrorism or sabotages, including insider events and terrorist attack;

- Assessment of a combination of external events, including consideration of interactions among multiple units on the site;
- Assessment of the cliff edge effects for individual and multiple unit;
- Investigation into interaction among the plants, including effects like turbine missiles;
- Thorough analysis of the possible events affecting multiple units on the site, with a view on establishing an enveloping radiological release source term.
- Assessment of the effects on the operation and safe shutdown of other units in a case where one or more units at the site have released radioactivity into the environment, making site access and/or communication difficult or impossible.

Recommendations related to the seismic risks of the Paks site

The EIA report is expected to include:

- A description of the current design basis requirements for all seismotectonic hazards applicable to the site (vibratory ground motion, soil liquefaction, surface displacement) and all relevant hazard combinations, including earthquake-induced fire.
- A comprehensive schedule and timeline for reviewing seismotectonic hazards in the framework of the LTE process to accord with WENRA requirements and guidance. Hazard reviews should notably account for advances of science and technology, and new information, and consider conducting independent hazard assessments involving different groups of experts and considering all relevant interpretations (WENRA 2020b).
- A comprehensive description of the safety requirements and safety targets that must be achieved in the LTE process. According to MVM (2024)
  a. "the frequency of core damage [CDF] leading to a severe accidental release shall not exceed 10^{-4}/year" and
  b. LERF must not exceed 10^{-5}/year, calculated for all severe accident event chains **excluding earthquakes.**
- The stated value for CDF is not in line with WENRA requirements. The approach to calculate LERF exempting earthquake is not in line with international practice.
- A comprehensive description how Design Extension Conditions (DEC) shall be analysed in the LTE process in accordance with Issues T6. and TU6. of the WENRA Reference Levels (WENRA 2014; 2021). The EIA Report is expected to show how the overall goal formulated by WENRA, i.e., to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents, will be achieved in the LTE process. Reasonably practicable improvements with the aim to prevent severe accidents are notably also required by COUNCIL DIRECTIVE 2014/87/EURATOM Article 8a lit. (b).

With respect to seismic engineering: The EIA report requires the documentation of the seismic design and performance (e.g. evaluation of failure probabilities, seismic safety margins) of the NPP in full agreement with accepted codes/guidelines (IAEA 2014, IAEA 2021, IAEA 2024) of all load bearing elements, systems, and components.

The EIA Report should cover not only comprehensive information of analysis results concerning seismology and earthquake engineering but also:

- seismic qualification certificates of materials (e.g. structural concrete, structural steel, fastening systems, etc.),
- seismic qualification certificates of structure, systems, and components (e.g. provide seismic qualification certificates of the equipment),
- comprehensive documentation regarding seismic retrofit and detailing of interfaces between e.g. equipment and the load bearing structure,
- comprehensive information of the PSHA such as the entire UHS, and seismic hazard disaggregation to visualize the influence of magnitude and distance to the total seismic hazard.
- framework and methodology to perform seismic risk assessment and computation of seismic safety margins,
- assessment of multi-hazard scenarios (e.g. fire after earthquake etc. should be covered).

Recommendations related to the ageing management processes at Paks I

Regarding the ageing management program, the following issues should be presented in the EIA Report:

- The concept of how the Paks I units operator MVM plans to deal with the ageing management, including schedule of activities and their interaction;
- The EIA Report should detail any design changes that are necessary to enable the second lifetime extension;
- The EIA report shall detail the investigations that are planned to identify potentially different degradation mechanisms that might become relevant for the operation between 50 and 70 years ;
- The EIA has to provide a detailed explanation on the assurance of integrity and functionality of the major (and minor) structures that are either safety related (containment , various buildings and structures) of Paks I units, until the end of the second extended lifetime;
- Plans for dealing with (increased) obsolesce of equipment for 70 years of operation;
- The relation of the ageing management program with the forthcoming PSR that will be implemented within the currently licensed extended lifetime;
- The EIA report shall address the concept how the safety level for the extended lifetime corresponds with the safety objectives set for new reactors;

- The EIA shall provide the CDF, LERF and/or other available metrics and estimates for the
    a. end of currently licensed lifetime and
    b. end of the second extended lifetime, which is now sought.

Recommendations related to the environmental impact of Paks I units

Regarding external hazards, the following requirements apply to the EIA Report. The report is expected to include:

- A documentation on how hazards and hazard combinations that apply to the site have been selected (hazard screening).
- A comprehensive description how Design Extension Conditions (DEC) shall be analysed in the LTE process in accordance with Issues T6. and TU6. The EIA Report is expected to show how the overall goal formulated by WENRA, i.e., to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents, will be achieved in the LTE process.

The EIA Report should include additional information on the Danube water temperature:

- What was the highest temperature measured at the Paks water canal outlet by MVM?
- On how many days have the measurements shown a temperature of 30°C or above?
- How is the water temperature measured? (method, exact site)
- Are the water measurement data published?
- What consequences will the new decree from 2024 have that allows new temperature limits for the Danube?

8 GLOSSARY

AGNES .... Advanced General and New Evaluation of Safety

ASME .... American society of mechanical engineers

BDBA .... Beyond design basis accidents

BMK .... Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

DBA .... Design Basis Accident

DEC .... Design extension conditions

DG .... Diesel generator

DICA .... Dry Interim Spent Fuel Storage Facility

EIA .... Environmental impact assessment

ENSREG .... European nuclear safety regulators group

EU .... European Union

FSAR .... Final safety analysis report

GW .... Gigawatt

HAEA .... Hungarian atomic energy commission

HVAC .... Heating ventilation and air conditioning

IAEA .... International Atomic Energy Agency

IGALL .... International generic ageing lesson learned

I&C .... Instrumentation and control

LERF .... Large early release fraction

LOCA .... Loss of coolant accident

LTO .... Long Term Operation

MAF .... Mean annual frequency

MVM .... Operator of Paks Nuclear Power Plant Ltd

MS .... Member state (of the EU)

MWe .... Megawatt electric

NPP .... Nuclear power plant

PGA .... Peak ground acceleration

PSHA .... Probabilistic seismic hazard assessment

PSR .... Periodic safety review

RAW/RW............................. Radioactive Waste

RPV .... Reactor pressure vessel

SAMG .... Severe accident management guidelines

SBO..................................... Station black out

SG .... Steam generator

SNF .... Spent Nuclear Fuel

SSC .... System Structures & Components

SEA .... Strategic Impact Assessment

TMI .... Tree mile island (US NPP)

TPR .... Topical peer review

UBA .... Umweltbundesamt

UHRS .... Uniform Hazard Response Spectra

WWER................................. Water water energy reactor

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umweltbundesamt

Umweltbundesamt GmbH
Spittelauer Laende 5
1090 Vienna/Austria

Tel.: +43-1-313 04

office@umweltbundesamt.at
www.umweltbundesamt.at

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VERIFIED ENVIRONMENTAL MANAGEMENT
AT-000484

ISBN 978-3-99004-795-8