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Climate Action, Environment,
Energy, Mobility,
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Reference number: 2022-0.151.235

Vienna, 28.02.2022

Espoo, NPP Loviisa 2020, AT Final expert statement

Dear Ms Rantakallio,

Austria is participating in the transboundary EIA procedure pursuant to the Espoo Convention and Art. 7 EIA Directive for the lifetime extension of the nuclear power plant Loviisa by the Finnish developer Fortum Power and Heat Oy.

Finland and Austria agreed to hold written consultations pursuant to Art. 5 Espoo Convention and Art. 7 EIA Directive. We would like to thank Finland for submitting the Finish answers to the Austrian questions of the expert statement by E-mail dated 14 January 2022. The Federal Ministry for Climate Action commissioned experts to evaluate the answers. Please find enclosed the final statement of the experts.

Austria asks Finland to consider the final expert statement according to Art. 6 Espoo Convention and Art. 8 EIA Directive. We would also like to request Finland kindly to send the final decision pursuant to Art. 6 Espoo Convention and Art. 9 EIA Directive in due time.

Austria would like to thank Finland for the good cooperation.

Enclosure

Kind regards,

On behalf of the Federal Minister

Dr. Ursula Platzer-Schneider

umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

NPP Loviisa 1 & 2
Life-time Extension
Environmental Impact Assessment

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

pulswerk
Das Beratungsunternehmen des
Österreichischen Ökologie-Instituts

Final Expert Statement

umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

NPP LOVIISA 1&2 LIFE-TIME EXTENSION ENVIRONMENTAL IMPACT ASSESSMENT

Final Expert Statement

Oda Becker
Gabriele Mraz

REPORT
REP-0804

VIENNA 2022

pulswerk
Das Beratungsunternehmen des Österreichischen Ökologie-Instituts

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Title photograph © iStockphoto.com/imagestock

Contracting authority Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, Sektion VI – Klima- und Energie, Abteilung VI/8 – Allgemeine Koordination von Nuklearangelegenheiten;

BMK GZ: 2021-0.557.724

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 978-3-99004-628-9

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SUMMARY

The nuclear power plant Loviisa consists of two units, Loviisa 1 and 2. The NPP is owned by Fortum Power and Heat Oy. The current operating licence issued by the Finnish government is valid until the end of 2027 and 2030, respectively.

Fortum is now evaluating the extension of the operation time of Loviisa by approximately another 20 years once the current license will have expired. Another option would be the start of decommissioning of the plant.

For the purpose of this evaluation an Environmental Impact Assessment (EIA) is being conducted in accordance with the Espoo-Convention and the EU EIA Directive.

In 2020, the EIA Scoping has been conducted. It was completed with the Ministry of Economic Affairs and Employment (MAEA) issuing its Statement on 23 November 2020. (MAEA 2020) The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) commissioned the Environment Agency Austria to provide an expert statement for the scoping phase (UMWELTBUNDESAMT 2020), and again the expert statement for assessing the EIA Report that has been submitted in October 2021. (UMWELTBUNDESAMT 2022)

In this expert statement, questions and preliminary recommendations were prepared to which the Finnish side provided answers in written form in January 2022. (ANSWERS 2022) The final expert statement at hand assesses these answers and gives final recommendations.

Austria participates in the EIA procedure to minimise or even eliminate possible significant adverse impacts on Austria resulting from the project.

Procedure and alternatives

It is welcomed that Finland undertakes an EIA for the planned lifetime extension of Loviisa 1&2 NPP.

Two main options have been assessed – a 20-years lifetime extension followed by decommissioning (VE1) or the start of decommissioning right after the current licenses will have expired (VE0). In its answers the Finnish side clarified that a life-time extension of 23 years is envisaged for Loviisa-1and for Loviisa-2 of 20 years thereby reaching the maximum life-time for the whole NPP in 2050.

The answers also confirmed that it is unclear when Fortum will take its decision for or against the life-time extension, 2022 being the most likely option.

On 14 Jan 2022, the MAEA issued its reasoned conclusion on the EIA.

Spent fuel and radioactive waste

The decommissioning of the NPP will generate low and intermediate level radioactive waste for which no capacities are available now. These additional capacities will have to be provided for both possible options, VE1 and VE0. Additional spent fuel will arise from lifetime extension, the extension of the interim spent fuel storage is envisaged. In its answer, the Finnish side provided information on possible options to enlarge the capacities in the interim storage for spent fuel.

New results on copper corrosion led to criticism of the KBS-3 method which might be used in the final spent fuel repository. The Finnish side argued that for the long-term safety case all relevant research has been analyzed and discussed. Nevertheless, justified doubts remain whether the copper canisters will stay intact as long as planned.

Long-term operation of the reactor type VVER 440

The reactor units at the Loviisa nuclear power plant were connected to the electrical grid in 1977 (Loviisa 1) and 1980 (Loviisa 2). The Loviisa plant reached its original design lifetime of 30 years in 2007–2010. The Finnish Government granted the new operating licences in July 2007. Thus, the currently envisaged lifetime extension would be the second lifetime extension.

Nuclear power plants undergo two types of time-dependent changes:

- Physical ageing of structures, system and components (SSCs), which results in degradation, i. e. gradual deterioration in their physical characteristics.
- Obsolescence of technologies and design, i. e. the plants becoming out of date in comparison with current knowledge, standards and technology.

To limit ageing-related failures at least to a certain degree, a comprehensive ageing management program (AMP) is necessary. In 2013 the Finnish Nuclear Regulator STUK published a guide dedicated to ageing management, which has been updated since. According to ANSWERS (2022) the new requirements are applied in the PSR. However, STUK has not finalized the review of the PSR. It should be mandatory to implement necessary improvements before the approval of the lifetime extension.

Finland participated in the Topical Peer Review (TPR) "Ageing Management" under the Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations, amended by Directive 2014/87/EURATOM, carried out in 2017/18. The overall conclusion was that the ageing management has been satisfactory. However, some challenges and areas for improvement were identified and Finland is establishing a national action plan to address the findings. The national action plan and its progress were not presented in the EIA Report. The implementation of the necessary action was scheduled for completion by 31/12/2021, but this has not been achieved yet. A final date for completing the outstanding issue is not given in ANSWERS (2022).

One of the ageing management issues at the Loviisa NPP is the irradiation embrittlement of the Loviisa reactor pressure vessels (RPVs). Some measures will have to be taken to enable the extended lifetime because the brittle fracture risk can be managed only until the end of the 50-year plant lifetime. Currently Fortum is planning to add additional shield elements on the outer periphery of the reactor core of unit 2, which lowers the neutron doses in the RPV weld. According to ANSWERS (2022), an evaluation of the options for further action (e. g. re-annealing) is ongoing. Annealing of a RPV's weld seam was carried out for Loviisa unit 1 in 1996.

Some years ago, a failure has been detected in a low-pressure safety injection (TH) nozzle of Loviisa 1 RPV. According to ANSWERS (2022), inspections have been performed and periodic inspections will be carried out in the future. In light of the safety relevance of these components, it is recommended to increase the frequency and scope of periodic inspection of the nozzles.

At the request of the government of Finland, an IAEA Operational Safety Review Team (OSART) of international experts visited Loviisa Nuclear Power Plant in March 2018; a follow up mission was carried out in February 2020. The OSART missions revealed deficits in plant maintenance and monitoring; both have safety relevance for lifetime extension. The issues have already been solved, however shortcomings in the past can have impacts on the safety of the future operation.

The development of science and technology continuously produces new knowledge about possible failure modes, properties of materials, and verification, testing and computational methodologies. This leads to technological ageing of the existing safety concepts in nuclear power plants. At the same time, as a result of lessons learned in particular from the major accidents at Three Mile Island, Chernobyl and Fukushima Daiichi, earlier safety concepts are becoming obsolete (conceptual ageing).

The units of the Loviisa NPP are Russian designed Generation II VVER-440 type pressurized water reactors. External hazards such as earthquakes, chemical explosions or aircraft impacts were not taken into account in the original design of these plants. To overcome major shortcomings of the design, both Finnish VVER-440/V-213 reactors are equipped with Western-type containment and control systems.

Compared to current knowledge, standards and technology, the old Loviisa NPP is increasingly out of date The VVER-440 reactors are designed as twin units, sharing many safety systems/components and Severe Accident Management (SAM) systems/equipment. Shared safety systems/equipment increases the risk of common-cause failures affecting the safety of both reactors at the same time. ANSWERS (2022) confirmed that for the lifetime extension no design changes are envisaged.

Western European Nuclear Regulator's Association (WENRA) has revised the Safety Reference Levels (SRLs) for existing reactors with the aim to integrate the lessons learned from the 2011 Fukushima Dai-ichi accident. A list of 342 SRLs has been published in 2014. The WENRA safety reference level F1.1 requires analysis of Design Extension Conditions (DEC) with the purpose of further improving the safety of the nuclear power plant. The principle for continuous improvement is laid down in Section 7a of the Finish Nuclear Energy Act (990/1987): *"The safety of nuclear energy use shall be maintained at as high a level as practically possible."* However, when deciding how a new or revised regulatory guide is applied for a specific operating nuclear facility, STUK can approve an exemption when it considers a safety improvement not reasonably practicable. Improvements considered not reasonably practicable at the Finnish operating NPPs include e.g. protection measures against large civil aircraft crashes. In ANSWERS (2022), it is admitted that there are several technically possible improvements to meet modern safety requirements that were not considered "reasonably practicable" (e. g. application of redundancy, separation and diversity principles). However, it does not explain what the improvements are, nor what the criteria are for this evaluation. Measures to increase redundancy, separation and diversity generally have a positive impact on safety.

The WENRA Reference level have been again updated in 2020. For lifetime extension, the WENRA documents do not have to be taken explicitly into account. However, they are used if they have already been adopted in the national regulations. The 2014 WENRA RLs have already been incorporated into the national requirements According to ANSWERS (2022), STUK has not yet planned the implementation of the 2020 WENRA RL. The 2020 WENRA RLs, added obsolescence to Issue I (Aging Management). In addition, the hazards to be addressed in the safety case need to be completed. (WENRA RHWG 2021a) Therefore, it would be important to implement 2020 WENRA RL in the Finnish regulation and apply it when approving lifetime extension.

Furthermore, the WENRA "Safety Objectives for New Power Reactors" should be used as a reference for identifying reasonably practicable safety improvements for the Loviisa NPP. The most ambitious WENRA safety objective consists of reducing potential radioactive releases to the environment from accidents with core melt. Core melt accidents which would lead to early or large releases would have to be practically eliminated. Even if the probability of an accident sequence is very low, any additional reasonably practicable design features, operational measures or accident management procedures to further lower the risk should be implemented.

According to ANSWERS (2022), it is planned to reduce the calculated risks for a core meltdown accident only with modifications in the safety analysis by reducing conservatism in the calculation; corresponding plant modifications are not planned. In ANSWERS (2022) it is admitted that not further design changes are envisaged in the context of the lifetime extension.

Accident analyses

The EIA Report includes a description of an assumed severe reactor accident. The assessment is based on the assumption that a quantity of radioactive substances (100 TBq of nuclide Cs-137) corresponding to the limit value of a severe accident in accordance with section 22b of the Nuclear Energy Decree 161/1988 is released into the environment.

According to the regulation, a nuclear power plant unit shall be designed in a way that the mean value of the frequency of a Cs-137 release during an accident into the atmosphere in excess of 100 TBq is less than $5 \cdot 10^{-7}$/year. In the latest update of the probabilistic risk assessment Level 2 for Loviisa NPP in 2018, it was estimated that the total frequency of a large release (LRF) to the environment is about $7.8 \cdot 10^{-6}$ per reactor year.

The accident analyses in the EIA Report should have used a possible source term for a severe accident derived from the calculation of the current level 2 probabilistic safety analysis (PSA 2). While the calculated probability of severe accidents with large releases for existing plants is very small, the damage caused by these accidents is very large. In this context it is important to emphasize that the calculated frequency of large releases of the Loviisa NPP is above the limits set in STUK's regulatory guide.

According to ANSWERS (2022), Fortum has performed Level 1 and 2 PSA and these are updated every year. One result of a Level 2 PSA are the source terms of large and/or early releases. However, it is not clear why these results are not used in the EIA Report to calculate the possible impact of a severe accident.

Maintaining containment integrity under severe accident conditions is an important issue for accident management. The Loviisa NPP severe accident management (SAM) strategy relies heavily on retaining corium inside the pressure vessel (in-vessel retention (IVR)). However, there are some safety issues that could endanger the containment integrity (containment bypass scenarios, cliff-edge effects in shutdown states) Continuous efforts have been made to reduce frequencies of bypass sequences and this work will continue in the future as well. However, until now large releases of radioactive substances are possible. ANSWERS (2022) confirmed that no design features are in place to cope with these accident scenarios, but procedures are available to try to cope with these accidents.

The values given in ANSWERS (2022) show that external events only contribute little to core damage frequency (CDF) and large (early) release frequency (L(E)RF). However, the seismic risk is not included appropriately yet because the work is ongoing.

The Fukushima Dai-ichi accident highlighted inter alia the importance of the Defense-in-Depth principle and the continued need to ensure that the design basis adequately addresses external hazards.

When the Loviisa NPP units were built no regulatory requirements on **seismic design** existed and earthquake loads were not considered separately in the design. According to STUK, the reassessment of the seismic hazard and seismic risk has turned out to be challenging for the Loviisa plant. Recent hazard updates for Loviisa show increased values of ground accelerations especially for long return periods. At the Loviisa NPP, the SAM systems are not designed to withstand earthquakes, therefore the sufficient operability of these systems after an earthquake has not yet been confirmed. According to ANSWERS (2022) seismic modifications are required but the seismic evaluation has not yet been completed.

The Loviisa NPP is located on the coast of the Gulf of Finland, approximately 90 km east of Helsinki. In the past decades the threat posed by **flooding** has increased for many nuclear power plant sites. In consequence of the TEPCO Fukushima Dai-ichi accident, safety improvements have been implemented at the Loviisa NPP. To ensure the long-term decay heat removal in case of loss of seawater, an alternative ultimate heat sink has been implemented. To ensure adequate design basis for the improved flood protection, Loviisa NPP contracted updating of the seawater level extreme value distribution by the Finnish Meteorological Institute. According to the new results the expected seawater levels at low frequencies of occurrence are higher than previously estimated.

According to the Intergovernmental Panel on Climate Change (IPCC), the type, frequency and intensity of **extreme weather events** are expected to change as Earth's climate changes.

According to ANSWERS (2022), the list of natural hazards assessed in the recent PSR is comprehensive. However, the expert team recommends the use of the "Non-exhaustive List of Natural Hazard Types" (WENRA 2015) to ensure that all site-specific hazards are addressed. In the PSR, several causally linked hazards are evaluated. However, according to WENRA (2015) also credible combinations of non-causally linked hazards should be considered.

Accidents with involvement of third parties

Nuclear power plants are vulnerable to a broad spectrum of possible attacks. Terrorist attacks or acts of sabotage on Loviisa may have significant impacts. However, in the EIA procedure malicious acts of third parties against Loviisa NPP and their possible effects are not discussed. In comparable EIA procedures such events were addressed to some extent.

The terror threat to nuclear power plants has received considerable public attention in the last twenty years. This attention has focused on the hazard of the deliberate crash of a large airliner.

Although precautions against sabotage and terror attacks cannot be discussed in detail in public in the EIA procedure for reasons of confidentiality, the necessary legal requirements should be set out in the EIA documents. Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. The EIA Report only provides very limited information on this topic. ANSWERS (2022) did not provide any further information. Whether a study on the possible impact of a commercial aircraft crash was conducted was not even stated.

The reactor buildings of the Loviisa NPP are not designed against an airplane crash and according to STUK, improvements are not "practically reasonable". In connection with the lifetime extension for the Loviisa NPP also a potential terrorist attack on the spent fuel pools should have been evaluated in the EIA Report.

Trans-boundary impacts

A severe accident with releases reaching Austrian territory can lead to significant impacts on Austria. In the EIA Report an accident was calculated with a source term of 100 TBq Cs-137, dispersion calculations were made to cover a distance of up to 1,000 km. This might underestimate impacts on Austria. It is not proven that the occurrence of a higher source term can be excluded and a calculation distance of 1,000 km is insufficient to assess impacts on Austria.

ZUSAMMENFASSUNG

Das Kernkraftwerk Loviisa verfügt über zwei Reaktorblöcke, Loviisa 1 und 2. Das Kraftwerk steht im Eigentum des Unternehmens Fortum Power and Heat Oy. Die geltenden Betriebsgenehmigungen, die von der finnischen Regierung erteilt wurden, sind jeweils bis Ende 2027 bzw. 2030 gültig.

Fortum erwägt nun die Verlängerung der Lebensdauer des KKW Loviisa um etwa 20 weitere Jahre nach Ablauf der geltenden Genehmigung. Die Alternative dazu wäre der Beginn der Dekommissionierung des Kernkraftwerks.

Dafür wird ein Umweltverträglichkeitsverfahren gemäß der Espoo-Konvention und der EU-UVP-Richtlinie durchgeführt.

Im Jahre 2020 wurde das UVP-Scoping durchgeführt. Es wurde vom finnischen Ministerium für Wirtschaftliche Angelegenheiten und Arbeit (MAEA) mit der Stellungnahme vom 23. November 2020 abgeschlossen (MAEA 2020). Das Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK) beauftragte das Umweltbundesamt mit der Erstellung einer Fachstellungnahme für die Scoping-Phase (UMWELTBUNDESAMT 2020) wie auch mit der Fachstellungnahme zur Bewertung des UVP-Berichts, der im Oktober 2021 übermittelt worden war. (UMWELTBUNDESAMT 2022)

In dieser Fachstellungnahme waren Fragen und vorläufige Empfehlungen ausgearbeitet worden, die die finnische Seite im Jänner 2022 schriftlich beantwortete. (ANSWERS 2022) Das vorliegende finale Expert:innengutachten evaluiert die Antworten und gibt abschließende Empfehlungen.

Österreich beteiligt sich an diesem UVP-Verfahren, um mögliche signifikante nachteilige Auswirkungen des Projekts auf Österreich zu minimieren oder zu beseitigen.

Verfahren und Alternativen

Es ist zu begrüßen, dass Finnland für die geplante Lebensdauerverlängerung von Loviisa 1&2 eine Umweltverträglichkeitsprüfung (UVP) durchführt.

Es wurden zwei prinzipielle Optionen untersucht – eine Lebensdauerverlängerung von 20 Jahren mit anschließender Dekommissionierung (VE1) oder ein Dekommissionierungsbeginn sofort nach Ablauf der aktuell geltenden Genehmigungen (VE0). In der Beantwortung erklärte die finnische Seite, dass für Loviisa-1 eine Lebensdauerverlängerung von 23 Jahren und für Loviisa-2 von 20 Jahren angestrebt wird, womit im Jahre 2050 die maximale Lebensdauer des ganzen KKW erreicht wird.

Dabei wurde auch bestätigt, dass es noch unklar ist, wann Fortum die Entscheidung für oder gegen die Lebensdauerverlängerung treffen wird, wobei 2022 als die wahrscheinlichste Option zu betrachten ist.

Am 14. Jänner 2022 machte das Wirtschaftsministerium (MAEA) die sogenannte Informierte Stellungnahme zur UVP bekannt.

Abgebrannte Brennelemente und radioaktiver Abfall

Bei der Dekommissionierung des KKW werden schwach- und mittelaktive Abfälle anfallen, für die noch keine Lagerkapazitäten verfügbar sind. Diese zusätzlichen Kapazitäten werden für beide in Betracht kommende Optionen – VE1 und VE0 – geschaffen werden müssen. Zusätzlicher abgebrannter Brennstoff wird durch die Lebensdauerverlängerung anfallen, eine Ausweitung der Zwischenlagerung ist vorgesehen. In der Beantwortung informierte die finnische Seite über die möglichen Optionen für die Erweiterung der Kapazitäten im Zwischenlager für abgebrannte Brennelemente.

Neue Forschungsergebnisse zur Kupferkorrosion führten dazu, dass die sogenannte KBS-3 Methode, die als Lagerungstechnologie für das Endlager für abgebrannte Brennelemente verwendet werden könnte, nun in die Kritik geraten ist. Die finnische Seite führte an, dass für die langfristige Sicherheit sämtliche relevanten Forschungsergebnisse analysiert und diskutiert wurden. Dennoch bleiben begründete Zweifel darüber bestehen, ob die Kupferbehälter tatsächlich so lange wie geplant unzerstört bestehen bleiben werden.

Langfristiger Betrieb des Reaktortyps WWER/440

Die Reaktorblöcke des KKW Loviisa wurden 1977 (Loviisa 1) und 1980 (Loviisa 2) ans Netz genommen und erreichten somit die ursprünglich für dieses Reaktordesign vorgesehene Lebensdauer von 30 Jahren im Jahre 2007 bzw. 2010. Die finnische Regierung erteilte im Juli 2007 neue Betriebsgenehmigungen. Bei den nun geplanten Verlängerungen würde es sich daher um die zweite Lebensdauerverlängerung handeln.

Bei Kernkraftwerken kommt es zu zwei Arten von alterungsbedingten Veränderungen:

- Physische Alterung der Strukturen, Systeme und Komponenten (SSCs), die in eine Degradierung, d.h. schrittweise Verschlechterung ihrer physikalischen Merkmale mündet.
- Obsoleszenz von Technologie und Design, wenn die Anlagen gegenüber aktuellem Wissen, aktuellen Standards und aktueller Technologie veraltet sind.

Um das alterungsbedingte Versagen zumindest bis zu einem gewissen Grad zu beschränken, wird ein umfassendes Programm für das Alterungsmanagement (AMP) benötigt. Die finnische Atomaufsichtsbehörde STUK publizierte 2013 eine Anleitung zum Alterungsmanagement, die mittlerweile einer Aktualisierung unterzogen wurde. Laut ANWERS (2022) werden die neuen Anforderungen bereits in der PSÜ angewendet. STUK hat die Überprüfung der PSÜ allerdings noch nicht abgeschlossen. Die Umsetzung der notwendigen Auflagen sollte verpflichtend abgeschlossen sein, bevor die Lebensdauerverlängerungen genehmigt werden.

Finnland beteiligte sich an der Topical Peer Review (TPR) "Ageing Management", die 2017/18 gemäß der Richtlinie 2009/71/EURATOM über einen Gemeinschaftsrahmen für die nukleare Sicherheit kerntechnischer Anlagen – novelliert 2014/87/EURATOM – durchgeführt wurde. Die abschließende Bewertung bezeichnete das Alterungsmanagement als ausreichend. Dennoch wurden einige Problempunkte und Bereiche identifiziert, bei denen Verbesserungen erzielt werden könnten. Zur Umsetzung dieser Erkenntnisse hat Finnland einen nationalen Aktionsplan aufgesetzt. Dieser nationale Aktionsplan und die Fortschritte bei dessen Umsetzung werden im UVP-Bericht nicht angeführt. Die Realisierung der notwendigen Maßnahmen sollte mit 31. Dezember 2021 abgeschlossen sein, was allerdings nicht gelungen ist. ANSWERS (2022) führt nicht an, wann die offenen Punkte abgeschlossen sein werden.

Eines der Probleme beim Alterungsmanagement beim KKW Loviisa ist die strahlungsbedingte Versprödung der Reaktordruckbehälter (RDB). Um die Lebensdauerverlängerung zu ermöglichen, müssen einige Maßnahmen durchgeführt werden, weil das Risiko der Versprödungsbrüche nur bis zum Ende der 50-jährigen Lebensdauer behandelt werden kann. Aktuell plant Fortum zusätzliche Abschirmelemente im äußeren Bereich des Reaktorkerns von Block 2 anzubringen, wodurch die Neutronendosen an der Schweißnaht des RDB reduziert werden. Laut ANSWERS (2022) ist die Evaluierung der Optionen für die weitere Vorgangsweise (etwa Glühen) im Laufen. Das Glühen der RDB-Schweißnaht wurde für Loviisa 1 im Jahre 1996 durchgeführt.

Vor einigen Jahre wurde ein Versagen in den Niederdrucksicherheits-Einspritzröhren beim RDB von Loviisa 1 entdeckt. Laut ANSWERS (2022) wurden Inspektionen durchgeführt, die auch als periodische Inspektionen weiterhin stattfinden werden. Angesichts der Sicherheitsrelevanz dieser Komponenten wird empfohlen die Frequenz und den Umfang der periodischen Inspektionen der Röhren zu erhöhen.

Auf Einladung der finnischen Regierung besuchte das IAEA Operational Safety Review Team (OSART), eine Mission internationaler Expert:innen, das Kernkraftwerkwerk Loviisa im März 2018, und im Februar 2020 wurde eine Follow-up Mission durchgeführt. Die OSART-Missionen deckten Defizite bei der Wartung und dem Monitoring des Kraftwerks auf, wobei beide Bereich für die Lebensdauerverlängerung von Relevanz sind. Diese Fragen wurden bereits gelöst, doch können Fehler aus der Vergangenheit in Zukunft zu Sicherheitsproblemen im Betrieb führen.

Wissenschaft und Technik bringen laufend neues Wissen über Versagensmodi, Materialeigenschaften und Überprüfungs-, Test- und Computermethoden hervor. Dadurch tritt für die Sicherheitskonzepte der laufenden Kernkraftwerke eine technologische Alterung ein. Die Erkenntnisse aus den großen Reaktorunfällen wie Three Mile Island, Tschernobyl und Fukushima Dai-ichi führen gleichzeitig dazu, dass die früheren Sicherheitskonzepte obsolet werden (konzeptuelle Alterung).

Die Reaktoren des KKW Loviisa sind Druckwasserreaktoren der Generation II der russischen Reaktorserie WWER-440. Im ursprünglichen Design dieser Reaktoren wurden externe Gefährdungen wie Erdbeben, chemische Explosionen oder Flugzeugabstürze nicht berücksichtigt. Um die größeren Designdefizite abzufedern, sind beide finnische WWER-440/V-213 Reaktoren mit einem Containment und Steuerungssystem westlicher Provenienz ausgestattet.

Das alte Kernkraftwerk in Loviisa ist im Vergleich zum aktuellen Wissenstand sowie zu den aktuellen Standards und Technologien zunehmend veraltet. Die WWER-440 Reaktoren sind Doppelblockanlagen, die sich viele Betriebssysteme/Komponenten und die Anlagen für die Beherrschung schwerer Unfälle (SAM) teilen. Diese geteilten Systeme erhöhen das Risiko für ein Versagen aus gemeinsamer Ursache und für die gleichzeitige Sicherheitsbeeinträchtigung beider Reaktoren. ANSWERS (2022) bestätigte, dass für die Lebensdauerverlängerungen keine Designänderungen geplant sind.

Die Western European Nuclear Regulator's Association (WENRA) hat die Safety Reference Levels (SRL) für bestehende Reaktoren revidiert, um die Erkenntnisse und Lektionen zu integrieren, die aus dem Unfall von Fukushima Dai-ichi im Jahre 2011 gezogen wurden. Im Jahre 2014 wurde eine Liste von 342 SRLs veröffentlicht. Gemäß WENRA Safety Reference Level F1.1 sollte eine Analyse der Erweiterten Auslegungsbedingungen (Design Extension Conditions, DEC) durchgeführt werden, um die Sicherheit des KKW zu erhöhen. Das Prinzip der kontinuierlichen Sicherheitserhöhung ist in Abschnitt 71 des finnischen Atomenergiegesetzes (990/1987) festgelegt: *„Die Sicherheit in der Kernenergienutzung ist auf dem höchsten praktisch realisierbaren möglichen Niveau zu erhalten".* Bei der Entscheidung darüber, ob eine neue oder revidierte Vorgabe für eine bestimmte Nuklearanlage angewendet werden soll, kann STUK jedoch eine Ausnahme genehmigen, wenn eine Sicherheitsvergabe für nicht vernünftigerweise praktikabel betrachtet wird. Verbesserungen, die bei den in Betrieb befindlichen finnischen KKW für nicht vernünftigerweise praktikabel gehalten werden, betreffen etwa Sicherheitsmaßnahmen gegen den Absturz großer Verkehrsflugzeuge. In ANSWERS (2022) wird angeführt, dass einige technisch möglichen Verbesserungen zur Erreichung moderner Sicherheitsanforderungen als nicht „vernünftigerweise praktikabel" betrachtet wurden (d.h. Anwendung des Prinzips von Redundanz, Trennung und Diversität). Nicht erläutert wird jedoch, um welche Verbesserungen es sich handelte oder welche Kriterien bei dieser Evaluierung herangezogen wurden. Maßnahmen zur Erhöhung der Redundanz, Trennung und Diversität haben allgemein eine günstige Auswirkung auf die Sicherheit.

Die WENRA Reference Levels wurde 2020 aktualisiert. Die WENRA Dokumente müssen für die Lebensdauerverlängerung nicht explizit verwendet werden, werden jedoch in Fällen herangezogen, wo sie bereits in das nationale Regelwerk aufgenommen wurden. Das ist für die 2014 WENRA Richtlinien der Fall. Laut ANSWERS (2022) sieht STUK die Umsetzung der WENRA Richtlinien 2020 nicht vor, die das Thema Obsoleszenz in Issue I (Alterungsmanagement) aufnahm.

Auch sind die Gefährdungen im Safety Case zu ergänzen (WENRA RHWG 2021a). Daher wäre es wichtig, die WENRA 2020 RL in das finnische Regelwerk aufzunehmen und bei der Genehmigung von Lebensdauerverlängerungen anzuwenden.

Auch die WENRA "Safety Objectives for New Power Reactors" sollten als Referenz für die Identifizierung vernünftigerweise praktikabler Sicherheitsverbesserungen für das KKW Loviisa herangezogen werden. Das ehrgeizigste Sicherheitsziel von WENRA besteht aus der Reduktion potentieller radioaktiver Freisetzungen bei Kernschmelzunfällen: Kernschmelzunfälle mit möglichen frühen oder hohen Freisetzungen sind praktisch auszuschließen. Selbst wenn die Wahrscheinlichkeit eines Unfalls sehr gering ist, sollten alle vernünftigerweise praktikablen Maßnahmen im Design, Betrieb oder Unfallmanagement umgesetzt werden, um das Risiko weiter zu verringern.

Laut ANSWERS (2022) ist geplant, das berechnete Risiko für einen Kernschmelzunfall nur mit Modifikationen in der Sicherheitsanalyse zu senken, indem der Konservatismus in der Berechnung verringert wird. Es sind keine adäquaten Modifikationen am Kraftwerk geplant, denn ANSWERS (2022) stellt klar, dass im Zusammenhang mit der Lebensdauerverlängerung keine Designänderungen durchgeführt werden.

Unfallanalysen

Der UVP-Bericht enthält eine Beschreibung eines angenommenen schweren Reaktorunfalls. Die Bewertung beruht auf der Annahme einer in die Umwelt freigesetzten Menge an radioaktiven Stoffen (100 TBq Cs-137), die dem Grenzwert für einen schweren Unfall gemäß Abschnitt 22b der finnischen Kernenergieverordnung 161/1988 entspricht.

Die Regelung schreibt für die Auslegung für Kernkraftwerke vor, dass bei einem Unfall die durchschnittliche Freisetzungshäufigkeit von Cs-137 von mehr als 100 TBq in die Atmosphäre unter $5 \bullet 10^{-7}$/a bleiben muss. Die jüngste Aktualisierung der Probabilistischen Risikobewertung Level 2 für das KKW Loviisa erfolgte im Jahre 2018 und ging von einer Gesamthäufigkeit für große Freisetzungen (LRF) in die Umwelt von $7{,}8 \bullet 10^{-6}$ pro Reaktorjahr aus.

Die Unfallanalyse im UVP-Bericht hätten als möglichen Quellterm für einen schweren Unfall einen Wert verwenden sollen, der sich aus der Berechnung des aktuellen PSA Level 2 ergibt. Wenn auch die Wahrscheinlichkeit für schwere Unfälle mit frühen und/oder großen Freisetzungen bei bestehenden Kraftwerken als sehr gering eingeschätzt wird, so ist doch der eintretende Schaden enorm, der durch diese Unfälle verursacht werden würde. Daher ist es in diesem Zusammenhang wichtig herauszustreichen, dass die berechnete Häufigkeit für hohe Freisetzungen aus dem KKW Loviisa über den Grenzwerten der STUK-Regelung liegt.

Laut ANSWERS (2022) hat Fortum die PSA Level 1 und Level 2 durchgeführt und aktualisiert diese jedes Jahr. Zu den Ergebnissen einer PSA Level 2 zählen auch die Quellterme von hohen und/oder frühen Freisetzungen. Allerdings ist unklar, warum diese Ergebnisse nicht im UVP-Bericht zur Berechnung möglicher Auswirkungen schwerer Unfälle herangezogen werden.

Der Erhalt der Containment-Integrität unter den Bedingungen schwerer Unfälle ist ein wichtiges Thema für das Unfallmanagement. Das Management des KKW Loviisa für die Beherrschung schwerer Unfälle (SAM) beruht weitgehend auf dem Rückhalt des Coriums innerhalb des Reaktordruckbehälters (in-vessel retention (IVR)). Allerdings gibt es einige Sicherheitsprobleme, die die Containment-Integrität beeinträchtigen könnten (Szenarien mit Containment-Bypass, Cliff-edge Effekte im abgeschalteten Zustand). Es wird an der Reduktion der Frequenzhäufigkeit von Bypass-Sequenzen kontinuierlich gearbeitet und diese Anstrengungen werden fortgesetzt. In diesem Zusammenhang ist festzuhalten, dass die Freisetzung von großen Mengen an radioaktiven Stoffen zum gegenwärtigen Zeitpunkt möglich ist. ANSWERS (2022) bestätigt, dass für die Beherrschung dieser Unfallszenarien keine Vorkehrungen im Design vorliegen, sondern betriebliche Verfahren zur Unfallbeherrschung zur Anwendung kommen sollen.

Die in ANSWERS (2022) angeführten Werte zeigen, dass externe Ereignisse nur wenig zur Kernschmelzhäufigkeit (CDF) und hohen (frühen) Freisetzungshäufigkeit (L(E)RF) beitragen. Die seismischen Risiken sind allerdings noch nicht ausreichend berücksichtigt, da die Arbeiten noch laufen.

Der Unfall von Fukushima Dai-ichi zeigte unter anderem die Wichtigkeit des Prinzips des tiefengestaffelten Sicherheitskonzepts, aber auch die anhaltende Notwendigkeit sicherzustellen, dass die Auslegung externe Gefährdungen ausreichend berücksichtigt.

Zur Zeit der Errichtung der Reaktorblöcke des KKW Loviisa gab es keine Vorschriften der Aufsichtsbehörden für die **seismische Auslegung,** Erdbebenlasten wurden in der Auslegung nicht gesondert betrachtet. Laut STUK erwies sich die erneute Bewertung der seismischen Gefährdung und des seismischen Risikos als Herausforderung für das KKW Loviisa. Die jüngsten Gefährdungsberichte für Loviisa zeigen erhöhte Bodenbeschleunigungswerte insbesondere bei langen Eintrittsperioden. Beim KKW Loviisa wurden die SAM-Systeme nicht so ausgelegt, dass sie gegenüber Erdbeben widerstandsfähig wären und daher kann auf keine ausreichende Betriebseignung dieser Systeme nach einem Erdbeben verwiesen werden. Laut ANSWERS (2022) sind seismische Modifikationen notwendig, doch wurden die seismischen Evaluierungen noch nicht abgeschlossen.

Das KKW Loviisa liegt an der Küste des Golfs von Finnland, etwa 90 km östlich von Helsinki. Über die letzten Jahrzehnte hat sich die Gefährdung durch **Überflutungen** für viele KKW-Standorte erhöht. In Folge des Unfalls des KKW Fukushima Dai-ichi kam es auch beim KKW Loviisa zur Umsetzung von Maßnahmen zur Sicherheitserhöhung. Zur Absicherung der langfristigen Zerfallswärmeabfuhr bei einem Verlust des Meerwassers wurde eine alternative Wärmesenke eingerichtet. Diese Modifikation besteht aus zwei luftgekühlten Kühleinheiten pro Reaktoreinheit, die von einem luftgekühlten Dieselgenerator versorgt werden. Um eine entsprechende Auslegung für den verbesserten Schutz gegen

Überflutungen sicherzustellen, beauftragte das KKW Loviisa beim Finnischen Meteorologischen Institut eine Aktualisierung der Verteilung extremer Werte des Meeresspiegels. Die neuen Ergebnisse für die erwarteten Meeresspiegelhöhen bei niedriger Eintrittshäufigkeit sind höher als ursprünglich angenommen.

Laut dem Intergovernmental Panel on Climate Change (IPCC) werden sich die Art, die Häufigkeit und die Intensität **von extremen Wetterereignissen** in Folge des Klimawandels ändern.

Laut ANSWERS (2022) ist die Liste der natürlichen Gefährdungen aus der jüngst durchgeführten PSÜ umfassend. Dennoch empfiehlt das Expert:innenteam die "Non-exhaustive List of Natural Hazard Types" (WENRA 2015) bei der Überprüfung heranzuziehen, dann dadurch wird sichergestellt, dass alle für den Standort spezifischen Gefährdungen erfasst werden. In der PSÜ werden einige kausal zusammenhängende Gefährdungen evaluiert. Allerdings sollten laut WENRA (2015) auch glaubhafte Kombinationen aller nicht kausal zusammenhängenden Gefährdungen betrachtet werden.

Unfälle mit der Beteiligung Dritter

Kernkraftwerke sind gegenüber einem breiten Spektrum möglicher Angriffe verletzbar, auch auf das KKW Loviisa ausgeübte Terrorattacken oder Sabotageakte können schwerwiegende Auswirkungen haben. Dennoch befassten sich die UVP- Dokumente nicht mit bösartigen Handlungen Dritter gegen das KKW Loviisa, mögliche Auswirkungen werden nicht behandelt. Im Gegensatz zu dieser Vorgangsweise berücksichtigten vergleichbare UVP-Verfahren diese Ereignisse bis zu einem gewissen Ausmaß.

Die Terrorgefährdung von Kernkraftwerken erfuhr in den letzten zwanzig Jahren beträchtliche öffentliche Aufmerksamkeit. Diese Aufmerksamkeit konzentrierte sich auf die Gefahren eines beabsichtigten Absturzes eines großen Verkehrsflugzeugs.

Wenn auch die Vorkehrungen gegen Sabotage und Terrorangriffe nicht öffentlich in einem UVP-Verfahren aufgrund notwendiger Vertraulichkeit nicht besprochen werden können, so sollten doch die gesetzlichen Anforderungen in den UVP-Dokumenten dargelegt werden. Angesichts der enormen Konsequenzen von potentiellen Terrorangriffen, wäre Information dazu von größtem Interesse. Der UVP-Bericht enthält dazu nur sehr wenig Information, auch ANSWERS (2022) hat dazu keine weiteren Informationen gebracht. Es wurde nicht einmal erwähnt, ob eine Studie zu den möglichen Auswirkungen eines Absturzes eines Verkehrsflugzeugs durchgeführt wurde.

Die Reaktorgebäude des KKW Loviisa sind nicht gegen einen Flugzeugabsturz ausgelegt und STUK bezeichnete eine derartige Nachbesserung als nicht "vernünftigerweise praktikabel". Im Zusammenhang mit der Lebensdauerverlängerung des KKW Loviisa hätte ein möglicher Terrorangriff auf die Abklingbecken mit den abgebrannten Brennelementen im UVP-Bericht bewertet werden sollen.

Grenzüberschreitende Auswirkungen

Ein schwerer Unfall mit großen Freisetzungen kann zu signifikanten grenzüberschreitenden Auswirkungen auf Österreich führen. Für den UVP-Bericht wurde ein Unfall mit einem Quellterm von 100 TBq Cs-137 berechnet, die Ausbreitungsrechnungen berücksichtigten eine Entfernung von bis zu 1.000 km. Dies kann zu einer Unterschätzung der Auswirkungen auf Österreich führen. Es ist nicht nachgewiesen, dass ein höherer Quellterm ausgeschlossen werden kann, und die Berechnung für die Distanz von 1.000 km ist zu gering, um Auswirkungen auf Österreich abschätzen zu können.

INTRODUCTION

The nuclear power plant Loviisa consists of two units, Loviisa 1 and 2. Loviisa 1 started commercial operation in 1977 and Loviisa 2 in 1980. The NPP is owned by Fortum Power and Heat Oy (in short: Fortum), a wholly owned subsidiary of Fortum Corporation. The current operating licence issued by the Finnish government is valid until the end of 2027 and 2030, respectively.

Fortum is now evaluating the extension of the operation time of Loviisa by approximately another 20 years once the current license will have expired. Another option would be the start of decommissioning of the plant.

For the purpose of this evaluation an Environmental Impact Assessment (EIA) is being conducted in accordance with the Espoo-Convention and the Finnish EIA Act which is based on the EU EIA Directive. Austria has been notified by Finland on this project. The coordinating EIA authority in Finland is the Ministry of Economic Affairs and Employment (MEAE), the project developer is Fortum, the EIA consultant is Ramboll Finland Oy. The Ministry of the Environment is in charge of the trans-boundary participation.

In 2020, the EIA Scoping which is also referred to as EIA Programme has been conducted. It was completed with the MAEA issuing its Statement on 23 November 2020. (MAEA 2020). The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) commissioned the Environment Agency Austria to provide an expert statement for the scoping phase (UMWELTBUNDESAMT 2020), followed up by an expert statement evaluating the EIA Report in October 2021. (UMWELTBUNDESAMT 2022)

In this expert statement, questions and preliminary recommendations were formulated. In January 2022, the Finnish side provided answers to these questions in written form. (ANSWERS 2022) The final expert statement at hand assesses these answers and gives final recommendations.

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

1 PROCEDURE AND ALTERNATIVES

1.1 Summary of the expert statement

It is welcomed that Finland undertakes an EIA for the planned lifetime extension of Loviisa 1&2.

The provided EIA Documents were in general complete.

The provided information did not clarify when the decision for or against the life-time extension will be taken, and if 20 years will be final decision and the limit for life-time extension.

It would be welcomed if the presentations and the documentation of the international hearing which was held on 7 October 2021 in Finnish and Swedish language would also be made available in English.

1.2 Questions, answers and assessment of the answers

Question 1 *How should the wording of the envisaged life-time extension "a maximum of approximately 20 years" be interpreted: Could the life-time extension be also longer than 20 years?*

Written answer by the Finnish side

The EIA procedure covered the option of extending the power plant's operation until 2050, that corresponds to 20 years extension for Loviisa 2 and 23 years extension for Loviisa 1. Current licences are valid until the end of 2027/Loviisa unit 1 and 2030/Loviisa unit 2. There are no plans to continue the operation of Loviisa nuclear power plant beyond 2050.

Assessment of the answer

The question has been answered.

Question 2 *When will the decision on one of the options be taken by Fortum?*

Written answer by the Finnish side

Fortum has not set a date when the decision will be made, but most likely it will be made in 2022.

Assessment of the answer

The question has been answered.

Question 3 *What are the results from the international hearing on 7 October 2021?*

Written answer by the Finnish side

The Ministry of Economic Affairs and Employment (MEAE) organized a public event on 7 October 2021 locally in Loviisa. The event was streamed online and remote participation was thus possible. In addition to the organizers, five persons were present at the event and a maximum of 63 persons followed it on the Internet. The event consisted of expert presentations and a discussion section during which the public could ask questions. The questions could also have been asked in English. The presentations were in Finnish, Swedish and, in essential parts, in English.

The purpose of the event was to share information with a focus on the local perspective, such as impacts on surface water, regional economic impacts and the results of resident surveys. Citizens asked questions e.g. about nuclear waste management, the impacts of cooling water, the carbon neutrality of nuclear power, radiation safety and security of energy supply. The participants did not ask questions in English.

The EIA process is still ongoing and MEAE takes all opinions and statements into consideration in the coordinating authority's informed conclusion.

Assessment of the answer

The question has been answered.

1.3 Conclusions and final recommendations

It is welcomed that Finland undertakes an EIA for the planned lifetime extension of Loviisa 1&2. The provided EIA Documents were in general complete.

In its answers the Finnish side clarified that a life-time extension of 23 years is envisaged for Loviisa-1and for Loviisa-2 of 20 years thereby reaching the maximum life-time for the whole NPP in 2050.

The answers also confirmed that it is unclear when Fortum will take its decision for or against the life-time extension, 2022 being the most likely option.

The hearing in Loviisa provided the public with information with a focus on the local perspective. However, the impacts of possible severe accidents are also of interest in a transboundary context, as can be seen on the MAEA's website with a range of NGOs from abroad which have participated in the EIA. Therefore it would be welcomed if the hearings of future EIA procedures in Finland would devote more space to transboundary aspects and provide simultaneous interpretation into English.

MAEA issued its reasoned conclusion on the EIA on 14 January 2022. (MAEA 2022)

2 SPENT FUEL AND RADIOACTIVE WASTE

2.1 Summary of the expert statement

The decommissioning of the NPP will generate low and intermediate level radioactive waste for which no capacities are available now. These additional capacities will have to be provided for both possible options, VE1 and VE0.

Additional spent fuel will arise from lifetime extension, the extension of the interim spent fuel storage is envisaged. However, information on timetables and alternative waste management options in case the capacities will not be available in time was lacking.

New results on copper corrosion led to criticism of the KBS-3 method which might be used in the final spent fuel repository. It should be explained how Finland will respond to the corrosion problem in connection with the KBS-3 method.

2.2 Questions, answers and assessment of the answers

Question 4 *What is the timetable for the planned increase of the interim storage capacity for spent fuel?*

Written answer by the Finnish side

The storage capacity is increased gradually as new capacity is needed. Existing fuel racks have already been replaced with new dense fuel racks increasing the storage capacity and this will also be done in the future. In late 2030's some other actions, like utilizing old spent fuel storage, building new pools (extension of existing new interim storage or new storage) or start final disposal that will free storage capacity, are needed.

Assessment of the answer

The questions has been answered.

Question 5 *Can you please describe the options for capacity increasement of the spent fuel interim storage by high-density storage in more detail?*

Written answer by the Finnish side

In spent fuel storage 2 fuel can be stored in a denser configuration than in the old racks, due to the structure and materials (boron steel) of the new fuel racks. This has already been done for some pools.

In spent fuel storage 1 the fuel is stored in transfer casks and there is possibility to have more of these casks in the pools. Technical studies are ongoing.

Assessment of the answer

The questions has been answered.

Question 6 *Why will the storage system used for spent fuel interim storage not be switched to a state-of-the-art dry storage system?*

Written answer by the Finnish side

Pool storage is a safe way to store the fuel and there is no need to change the concept.

Assessment of the answer

The questions has been answered. Wet storage, especially in an old interim storage facility, is generally no longer considered state of the art.

Question 7 *Which alternative options are planned for the case that the interim and the final disposal facilities for spent fuel are not available in time?*

Written answer by the Finnish side

Fortum currently plans to aim for capacity increase of the interim storage at the site. There is enough time to plan and implement the needed actions for this. For the Posiva final disposal facility the handling of the first operating license has started in January 2022 and the spent fuels from Fortum Loviisa units are planned in this license application

Assessment of the answer

The questions has been answered.

Question 8 *Will the KBS-3 method be used despite of problematic results of copper corrosion research? How will the copper corrosion problems be dealt with?*

Written answer by the Finnish side

KBS-3 method will be used by Posiva company. All the relevant research results are thoroughly analyzed and discussed in the long-term safety case to be issued by Posiva in connection with their application for the operating license. Posiva has now submitted their operating licence application to Ministry of Economic Affairs and Employment (Dec. 2021).

Assessment of the answer

The question has been answered. There is an extensive debate ongoing on the corrosion of copper under the conditions of a deep geological repository, and justified doubts remain whether copper canisters will stay intact as long as planned.

2.3 Conclusions and final recommendations

The decommissioning of the NPP will generate low and intermediate level radioactive waste for which no capacities are available now. These additional capacities will have to be provided for both possible options, VE1 and VE0. Additional spent fuel will arise from lifetime extension, the extension of the interim spent fuel storage is envisaged.

In its answer, the Finnish side provided information on possible options to enlarge the capacities in the interim storage for spent fuel.

New results on copper corrosion led to criticism of the KBS-3 method which might be used in the final spent fuel repository. The Finnish side argued that for the long-term safety case all relevant research has been analyzed and discussed. Nevertheless, justified doubts remain whether the copper canisters will stay intact as long as planned.

3 LONG-TERM OPERATION OF REACTOR TYPE VVER-440

3.1 Summary of the expert statement

A comprehensive ageing management program (AMP) is necessary to limit ageing-related failures at least to a certain degree. In 2013 the Finnish Nuclear Regulator STUK published a guide dedicated to ageing management. The guide has been updated since and the most recent version was published in February 2019. According to STUK, the utilities have encountered several challenges in complying with the new requirements. The EIA Report did not make clear whether the current AMP for Loviisa meets the new requirements.

Finland participated in the Topical Peer Review (TPR) "Ageing Management" under the Nuclear Safety Directive 2014/87/EURATOM, carried out in 2017/18. The overall conclusion stated that the ageing management was satisfactory. However, several challenges and areas for improvement were identified and Finland has established a national action plan to address the findings.

One ageing management issue at the Loviisa NPP has required a significant amount of work and attention from the licensee and STUK over the years. This issue is the irradiation embrittlement of Loviisa RPV. Several modifications to reduce this risk have been implemented. During the latest operating licence renewal process Fortum submitted a comprehensive analysis concluding that the brittle fracture risk can be managed until the end of the 50-year plant lifetime. However, the very important safety issue of the embrittlement of the RPVs is only presented in a general manner in the EIA Report.

At the request of the government of Finland, an IAEA Operational Safety Review Team (OSART) of international experts visited Loviisa Nuclear Power Plant in March 2018 and in a follow up mission in February 2020. The OSART missions revealed deficits in plant maintenance and monitoring; this is relevant for lifetime extension.

The old Loviisa NPP is increasingly out of date in comparison with current knowledge, standards and technology. The VVER-440 reactors are designed for example as twin units, sharing many operating systems and safety systems. The sharing of safety systems increases the risk of common-cause failures affecting the safety of both reactors at the same time. The EIA Report did not explain whether there are any design changes envisaged for the lifetime extension.

The WENRA safety reference level F1.1 requires analysis of Design Extension Conditions (DEC) with the purpose of further improving the safety of the nuclear power plant. When deciding how a new or revised regulatory guide is applied for a specific operating nuclear facility, STUK can approve an exemption when it considers a safety improvement not reasonably practicable. Improvements considered not reasonably practicable at the Finnish operating NPPs include e.g. protection measures against large civil aircraft crash.

The WENRA "Safety Objectives for New Power Reactors" should be used as a reference for identifying reasonably practicable safety improvements for the Loviisa NPP. The most ambitious WENRA safety objective is to reduce potential radioactive releases to the environment from accidents with core melt. Accidents with core melt which would lead to early or large releases would have to be practically eliminated. Practical elimination of an accident sequence cannot be claimed solely based on compliance with a general cut-off probabilistic value. Even if the probability of an accident sequence is very low, any additional reasonably practicable design features, operational measures or accident management procedures should be implemented to lower the risk further. (UMWELTBUNDESAMT 2022)

3.2 Questions, answers and assessment of the answers

Question 9 *Does the aging management program now comply with the new requirements from 2019 and 2020?*

Written answer by the Finnish side

Yes, in Periodic Safety Review to STUK this kind of assessment was done.

Assessment of the answer

The question has been answered.

Question 10 *When will the STUK regulation implement the updated 2020 WENRA reference level for existing reactors?*

Written answer by the Finnish side

STUK has not scheduled implementation of the 2020 WENRA Safety Reference Levels (SRLs). Also, WENRA has not set a target date for their implementation in national regulatory systems yet. They will be considered in the upcoming activity to reform the Finnish regulations. However, STUK has actively participated in developing of the SRLs and has not identified major gaps between the new SRLs and existing Finnish requirements, although a detailed gap analysis has not been carried out so far. STUK also participates in the peer review of the implementation of the SRLs in national regulations within WENRA as part of the activities in WENRA's Reactor Harmonisation Working Group (RHWG) when it takes place in future. At the moment, STUK sees no significant effects from implementation of the 2020 SRLs on the Finnish safety requirements and on regulatory oversight of the NPPs in Finland.

Assessment of the answer

The question has not been answered. According to ANSWERS (2022), STUK has not yet planned to implement WENRA RL 2020. The review of the WENRA RL showed the need to include obsolescence in Issue I (Aging Management). In addition, the hazards to be addressed in the safety case needed to be completed. To achieve this, Item S (Protection Against Internal Fires) was expanded to include all internal hazards (Item SV) and Item T (Natural Hazards) was extended to include all external hazards (Item TU). (WENRA RHWG 2021a) Therefore, it would be important to implement WENRA RL 2020 in the Finnish regulation and apply it for the approval of lifetime extension.

Question 11 *Has the STUK ageing management expert group made recent observations/conclusions?*

Written answer by the Finnish side

STUK will finalize the review of periodic safety review probably in spring 2022.

Assessment of the answer

The question cannot be answered yet, because the STUK ageing management expert group has not finalized the review.

Question 12 *When will the two remaining issues from the national action plan relating to the Topical Peer Review (TPR) "Ageing Management" under the Nuclear Safety Directive 2014/87/EURATOM be completed?*

Written answer by the Finnish side

Overall Ageing Management Program (OAMP) of Loviisa NPP has been updated and implemented during 2019-2021 using IAEA SSG-48 as a guiding document. The issue related to extended shutdown is still open.

Assessment of the answer

The question was only partly answered. No final date for the outstanding issue related to the extended shutdown is given. According to STUK (2021d), Fortum shall identify structures, systems, and components (SSCs) that are subject to various degradation mechanisms during extended plant shutdowns and define measures to monitor, prevent or mitigate aging in these SSCs. These measures are expected to be completed by the end of 2021. However, no new deadline for the completion of this action is provided.

Question13 *Which measures will be performed concerning the very important safety issue of the reactor pressure vessels (RPVs) ageing (embrittlement)? Is re-annealing of the RPV of Loviisa 2 envisaged? What are the remaining safety margins?*

Written answer by the Finnish side

The reactor pressure vessel safety margins are followed constantly and in case of current lifetime, no actions are needed. For extended lifetime some actions are needed and currently Fortum is planning to add additional shield elements on the outer periphery of the reactor core, which lowers the neutron doses in reactor pressure vessel weld that is limiting for lifetime. First shield elements were added in the beginning of plant operation in 1980's. The shield elements have similar geometry than fuel elements, but contain steel instead of nuclear fuel.

Re-annealing is one possibility in the future. This and other possibilities will be studied further before any decision and there is no urgent need for these actions

Assessment of the answer

The question has been answered.

Question 14 *What are the recent results of the inspections of all nozzles of the RPV? Are there any measures envisaged?*

Written answer by the Finnish side

Inspections have been performed and periodic inspections will be carried out also in the future. There are no additional measures envisaged as the nozzles fulfil the requirements and they are safe to operate.

Assessment of the answer

The question has been answered. In response to the deficiencies identified several years ago and the safety relevance of these components, the frequency and the scope of periodic inspection of the nozzles could be increased.

Question 15 *Are the results of the evaluation of the conditions of the RPV internals and head penetrations (including trends of events, and envisaged exchange measures) already available?*

Written answer by the Finnish side

According to inspections and analyses the requirements are fulfilled. Periodic inspections will be carried out and the margins are followed constantly.

Assessment of the answer

The question has been answered.

Question 16 *Are there any problems with aging of the ice condensers (as mentioned by the Loviisa Deputy Director in August 2020)?*

Written answer by the Finnish side

Fortum has a continuous surveillance programme as part of the ageing management to follow the condition of the ice condensers. The functionality of the ice-condenser doors is tested by periodic testing. During annual outages Fortum also carries out inspections to the ice baskets and structures of the ice condensers.

There have not been identified any significant ageing related issues regarding the ice condensers.

Assessment of the answer

The question has been answered.

Question 17 *Is information about the conditions of components of the primary circuit and the electrical installations (including trends of events, and envisaged exchange measures) already available?*

Written answer by the Finnish side

There are systematic monitoring and ageing management procedures. Components are replaced or additional qualifications done, when necessary.

Assessment of the answer

The question has been answered.

Question 18 *What are the findings of the OSART follow up mission 2020? Have any recommendations or suggestions not yet been resolved?*

Written answer by the Finnish side

There were two findings from the OSART mission considering LTO-area (long term operation) in follow-up mission in 2020. They were related to scoping and screening list and monitoring/inspection programmes. Progress regarding both findings was considered satisfactory during OSART follow-up mission and since then all findings have been fully resolved.

Assessment of the answer

The question has been answered.

Question 19 *Has the cause for the noise of the Loviisa 1 reactor pressure tank's foreign material monitoring system already been clarified?*

Written answer by the Finnish side

The reason for the noise is known and it is caused by tolerances in some components. There have not been any damages and there is no safety concern related to this.

Assessment of the answer

The question has been answered.

Question 20 *Which technically possible improvements to meet modern safety requirements have been considered not "reasonably practicable" for the Loviisa NPP?*

Written answer by the Finnish side

There are some requirements that are not "reasonably practicable". Some of the issues are related to details in application of redundancy, separation and diversity principles. These have been analyzed using probabilistic methods (PRA) and have low safety impact. Seismic evaluations are ongoing and there will be some modifications in the future, like changes in component supports.

Assessment of the answer

The question has been answered only in general terms. It admitted that technically possible improvements to meet modern safety requirements were identified but not considered "reasonably practicable" for the Loviisa NPP. However, the response does not define those upgrade measures or which criteria were applied for this assessment. Measures to increase redundancy, separation and diversity generally have an impact on safety.

Question 21 *Which safety systems/components and Severe Accident Management (SAM) systems/equipment are shared between Loviisa 1 and 2?*

Written answer by the Finnish side

The main principle is that both plant units have independent main safety systems. There are some diverse and additional systems that are common to plant units. Shared systems in figure 7- 6 of EIA report are:

11. Power supply from hydro power station
13. Diesel generator plant
15. Auxiliary emergency feedwater system has two subsystems, one for each unit. Cross connection is possible.

Severe accident management systems are partly shared between plant units. Sea water circuit of containment external spray system (16 in figure 7-6 of EIA report), severe accident management electrical systems and some severe accident I&C systems are shared. It should be noted that there are two redundancies thus single failure was considered.

Assessment of the answer

The question has been answered; that the list of safety systems/components and Severe Accident Management (SAM) systems/equipment shared between Loviisa 1 and 2 was provided. As a general rule, shared systems always increase the risks of common cause failures. Thus, examination could be conducted to find out whether modifications to increase the independence of the units might provide additional safety benefits.

Question 22 *Which design changes are planned in the context of the envisaged lifetime extension?*

Written answer by the Finnish side

The main principle is to constantly upgrade the plant as it has been explained in more detail in chapter 7.8 of EIA report. Loviisa power plant has implemented several projects that improve nuclear safety. Safety related modifications due to lifetime extension are related to seismic events.

Due to ageing, modernizations have been done and this will continue in the future as well. In recent years, extensive renewals have been carried out on the automation of the power plant, and ageing systems and equipment have been modernized. In 2014–2018, Loviisa power plant implemented the most extensive modernization programme in the plant's history, in which Fortum invested approximately EUR 500 million.

Assessment of the answer

The question has been answered, not further design changes are envisaged in the context of the lifetime extension.

Question 23 *Which existing buildings should be renovated or new constructed in framework of the lifetime extension?*

Written answer by the Finnish side

In the EIA, Fortum has stated the following and there has not been any update since: *"In the possible case of life time extension, additional new buildings could be built in the power plant area. Such new buildings could include a cafeteria building in the vicinity of the office building, an inspection or reception warehouse, a wastewater treatment plant and a storage hall for waste as well as a welding hall".*

Renovation is related to majority of buildings at site.

Assessment of the answer

The question has been answered.

Question 24 *Which documents of WENRA will be taken into account for the lifetime extension in a binding form?*

Written answer by the Finnish side

Fortum has not evaluated fulfilment of WENRA requirements. See also answers to Q10 and Q25.

Assessment of the answer

The question has been answered. The WENRA documents have not to take in account for lifetime extension. However, they are used if they have already been adopted in the national regulations.

Question 25 *Are the results from comparing the design features and measures of the Loviisa NPP with all requirements of SRL F already available?*

Written answer by the Finnish side

Fortum has done comparison to national requirements, not to WENRA reference levels. As mentioned in answer to Q10, there are no large gaps between national requirements and WENRA SRL's. Issue F of WENRA's SRLs have been implemented in Finnish safety requirements.

Assessment of the answer

The question has been answered.

Question 26 *Have measures been planned to meet the safety objective O2 (accident without core melt) for lifetime extension?*

Written answer by the Finnish side

In EIA report chapters 9.21 and 9.22 several different releases are analyzed. Probabilistic risk assessment (PRA) and core damage frequency is discussed in EIA report chapter 7.8. Also external events are considered in the PRA.

The goal is to operate the plant safely. The work is continuous and several modifications have been done in the past. The safety objective is achieved.

Assessment of the answer

The question has been answered.

Question 27 *Will lifetime extension measures been planned to come as close as reasonably practicable to meet the safety objective O3 (accidents with core melt)?*

Written answer by the Finnish side

The goal is to decrease the level 2 PRA numerical value. Currently there are some quite conservative assumptions and more detailed studies are ongoing. The goal is to have best estimate assumptions. There will also be some changes in the guidance. There are currently no specific plans for plant changes except some seismic modification can be relevant also for severe accident management systems as well. Plant changes will be done if needed.

Assessment of the answer

The question has been answered. According to ANSWERS (2022), it is planned to reduce the calculated risks for a core meltdown accident only with modification in the safety analysis by reducing conservatism in the calculation. Corresponding plant modifications are not planned.

Question 28 *Has STUK already finished the review of the submitted PSR? What results did the PRS deliver? Will all requirements stemming from the results be applied as preconditions for the lifetime extension approval?*

Written answer by the Finnish side

STUK has not yet finalized the review for the power plant, but the decision is expected in the spring of 2022. Results of PSR will naturally be taken into account in connection to possible operating license application.

For the low and intermediate level waste repository, STUK issued its decision in December 2022. STUK states in its decision that the operating safety and long-term safety are at a good level in the final disposal facility for low- and intermediate-level waste, and the licensee has the necessary procedures and resources in place to continue safe operation.

Assessment of the answer

The question has been answered. It should be mandatory to implement necessary improvements before the life-time extension is granted.

3.3 Conclusions and final recommendations

A comprehensive ageing management program (AMP) is necessary to limit ageing-related failures at least to a certain degree. In 2013 the Finnish Nuclear Regulator STUK published a guide dedicated to ageing management, which has been updated since. According to ANSWERS (2022) the new requirements are applied in the PSR. However, STUK has not finalized the review of the PSR. It should be mandatory to implement necessary improvements before the approval of the lifetime extension.

Finland participated in the Topical Peer Review (TPR) "Ageing Management" under the Nuclear Safety Directive 2014/87/EURATOM, carried out in 2017/18. The overall conclusion stated that the ageing management was satisfactory. However, several challenges and areas for improvement were identified and Finland has established a national action plan to address the findings. Despite the implementation of the necessary action was scheduled to the 31/12/2021, it is not finalized yet. A final date for completing the outstanding issue is not given in ANSWERS (2022).

One of the ageing management issues at the Loviisa NPP is the irradiation embrittlement of Loviisa RPV. Some measures will have to be taken to enable the extended lifetime because the brittle fracture risk can be managed only until the end of the 50-year plant lifetime. Currently Fortum is planning to add additional shield elements on the outer periphery of the reactor core of unit 2, which lowers the neutron doses in the RPV weld. According to ANSWERS (2022), an evaluation of the options for further actions (e. g. re-annealing) is ongoing. Annealing of a RPV's weld seam was carried out for Loviisa unit 1 in 1996.

Some years ago, a failure has been detected in a low-pressure safety injection (TH) nozzle of Loviisa 1 RPV. According to ANSWERS (2022) inspections have been performed and periodic inspections will be carried out also in the future. It is recommended to increase the frequency and scope of periodic inspection of the nozzles due to the safety relevance of these components.

At the request of the government of Finland, an IAEA Operational Safety Review Team (OSART) of international experts visited Loviisa NPP in March 2018; a follow -up mission was carried out in February 2020. The OSART missions revealed deficits in plant maintenance and monitoring; both have safety relevance for lifetime extension. The issues have already been solved, however shortcomings in the past can have impacts on the safety of the future operation.

Compared to current knowledge, standards and technology, the old Loviisa NPP is increasingly out of date. The VVER-440 reactors for example are designed as twin units, sharing many safety systems/components and Severe Accident Management (SAM) systems/equipment. Shared safety systems increase the risk of common-cause failures affecting the safety of both reactors at the same time.

The WENRA safety reference level F1.1 requires analysis of Design Extension Conditions (DEC) with the purpose of further improving the safety of the nuclear power plant. When deciding how a new or revised regulatory guide is applied for a specific operating nuclear facility, STUK can approve an exemption when it considers a safety improvement not reasonably practicable. Improvements considered not reasonably practicable at the Finnish operating NPPs include e. g. protection measures against large civil aircraft crash.

ANSWERS (2022) admitted that technically possible improvements to meet modern safety requirements were identified but not considered "reasonably practicable" for the Loviisa NPP. However, the response does not define those upgrade measures or which criteria were applied for this assessment. Measures to increase redundancy, separation and diversity generally have an impact on safety.

For lifetime extension, the WENRA documents do not have to be taken explicitly into account. However, they are used if they have already been adopted in the national regulations. The 2014 WENRA RLs have already been incorporated into the national requirements. According to ANSWERS (2022), STUK has not yet planned the implementation of the 2020 WENRA RL. The 2020 WENRA RLs added obsolescence to Issue I (Aging Management). In addition, the hazards to be addressed in the safety case needed to be completed. (WENRA RHWG 2021a) Therefore, it is important to implement 2020 WENRA RL in the Finnish regulation and apply it for the approval of lifetime extension.

The WENRA “Safety Objectives for New Power Reactors” should be used as a reference for identifying reasonably practicable safety improvements for the Loviisa NPP. The most ambitious WENRA safety objective consists of reducing potential radioactive releases to the environment from accidents with core melt. Core melt accidents which would lead to early or large releases would have to be practically eliminated. Even if the probability of an accident sequence is very low, any additional reasonably practicable design features, operational measures or accident management procedures should be implemented to further lower the risk.

According to ANSWERS (2022), it is planned to reduce the calculated risks for a core meltdown accident only with modifications in the safety analysis by reducing conservatism in the calculation; corresponding plant modifications are not planned. In ANSWERS (2022) it is admitted that not further design changes are envisaged in the context of the lifetime extension.

3.3.1 Final recommendations

FR 1 It is recommended to implement all technically available safety improvements to prevent accidents.

FR 2 It is recommended to implement the 2020 WENRA RL in the Finnish regulation and apply it for the approval of lifetime extension of the Loviisa NPP.

FR 3 It is recommended to complete the outstanding issue resulting from the Topical Peer Review (TPR) "Ageing Management" before approval of lifetime extension.

FR 4 It is recommended to increase the frequency and scope of periodic inspection of the nozzles due to the deficiencies identified several years ago and the safety relevance of these components.

FR 5 It is recommended to evaluate if a modification to further increase the independence of the units could provide an additional safety benefit.

FR 6 It is recommended to reduce the risks of a core meltdown accident not only with modification of the calculation in the safety cases by reducing conservatism but also to evaluate whether further plant modifications are possible.

FR 7 It is recommended to re-evaluate which technically possible improvements to meet modern safety requirements that were not considered "reasonably practicable" (e. g. application of redundancy, separation and diversity principles) should be implemented to reduce the risks further.

FR 8 It should be mandatory to implement necessary improvements resulting from the PSR before the approval of the lifetime extension.

4 ACCIDENT ANALYSIS

4.1 Summary of the expert statement

The accident analyses in the EIA Report should have used a possible source term for a severe accident derived from the calculation of the current PSA 2. Even though the probability of severe accidents with a large release for existing plants is estimated to be very small, the damage caused by these accidents is very large. In this context it is important to emphasize that the calculated frequency of large releases of the Loviisa NPP is above the limits set in STUK's regulatory guide YVL A.7.

The source term used in the EIA Report should be justified on the basis of existing PSA results. In any case, the EIA Report should have contained a comprehensible justification for the source term used. In principle, possible beyond-design-basis accidents should be part of the EIA, irrespective of their probability of occurrence.

Maintaining containment integrity under severe accident conditions is an important issue for accident management. The Loviisa NPP severe accident management (SAM) strategy strongly relies on retaining corium inside the pressure vessel (in-vessel retention (IVR). However, there are some safety issues that could endanger the containment integrity (containment bypass scenarios, cliff-edge effects in shutdown states), thus large releases are possible.

When the Loviisa NPP units were built no regulatory requirements on seismic design existed and earthquake loads were not considered separately in the design. According to STUK, the reassessment of the seismic hazard and seismic risk has turned out to be challenging for the Loviisa plant. Recent hazard updates for Loviisa show increased values of ground accelerations especially for long return periods. According to the EIA Report the improvement measures are still ongoing. At the Loviisa NPP, the SAM systems are not designed to withstand earthquakes, therefore there is no confirmation on the sufficient operability of these systems after an earthquake.

The Loviisa NPP is located on the coast of the Gulf of Finland, approximately 90 km east of Helsinki. In the past decades the threat posed by flooding has increased for many nuclear power plant sites. In consequence of the TEPCO Fukushima Dai-ichi accident, safety improvements have been implemented at the Loviisa NPP. However, according to new results the expected seawater levels at low frequencies of occurrence are higher than previously estimated.

In the context of accident analyses, several questions remained open, making it impossible to assess in a comprehensible way if Austria is potentially affected. (UMWELTBUNDESAMT 2022)

4.2 Questions, answers and assessment of the answers

Question 29 *Are the results from the PSA analyses (levels 2) including source terms and frequencies for severe accidents with (early) large releases (LRF or LERF) already available?*

Written answer by the Finnish side

Fortum has performed level 1 and 2 PRA and these are updated every year. In level 2 PRA also large early release is evaluated.

Assessment of the answer

The question has been answered. However, it is not clear why these results are not used in the EIA Report to calculate the possible impact of a severe accident.

Question 30 *How much is contributed by internal and external events to CDF, LRF and LERF?*

Written answer by the Finnish side

External events contribute 13 % of CDF, 20 % of LRF and 5 % of LERF. The rest is contributed by internal events.

Assessment of the answer

The question has been answered. The values show that external events only make a small contribution to CDF, LRF and LERF. However, it is unclear whether the seismic risk evaluation has already been included because the work is ongoing.

Question 31 *Has been performed a probabilistic safety analyses (PSA) level 3?*

Written answer by the Finnish side

Several dose calculations have been performed but level 3 PRA has not been performed.

Assessment of the answer

The question has been answered. However, a Level 3 PSA should be performed to evaluate the possible risks appropriately. A Level 3 PSA is an assessment of the off-site public risks attributable to a spectrum of possible accident scenarios involving a nuclear installation. Compared to Level 1 and Level 2 PSAs, a Level 3 PSA thus represents a more comprehensive characterisation of the off-site risks for the public attributable to a spectrum of possible accident scenarios involving a nuclear installation and provides an important input to cost-benefit analyses used to evaluate proposed risk management options. This activity is focussed on off-site radiological consequence analyses that are performed as part of an integrated PSA that includes all three analysis levels.

Question 32 *In which manner have the safety issues of the in-vessel retention concept which could endanger the containment integrity (containment bypass scenarios, cliff-edge effects in shutdown states) been solved?*

Written answer by the Finnish side

There are procedures for this kind of events. For shutdown state new guidance was implemented in 2017. Success is evaluated using PRA.

Assessment of the answer

The question has been answered in a general manner; details about the procedures are not given. However, the answer confirmed that no design features are in place to cope with these accident scenarios.

Question 33 *What are the results of current studies on earthquakes, floods and extreme weather conditions? When have these studies been performed?*

Written answer by the Finnish side

Studies for extreme weather conditions had already been done before Fukushima and they are included in PRA. After Fukushima some re-evaluations were done and these have been finalized. For example, the flood frequencies were re-evaluated in 2015 and plant modifications were implemented during 2015-2020. Alternate heat sink (air cooling by cooling towers) was finalized in 2015. Seismic plant walkdowns were performed in 2018 and more detailed studies are ongoing. Preliminary results indicate that the importance of seismic events in PRA could in-crease, but they would not become dominant.

Main results are presented in connection to Q30. The external event frequency is only a small fraction of core damage frequency.

Assessment of the answer

The question has been answered only in a very general manner. It was stated that the evaluation of the extreme weather event and flooding hazard resulted in some plant modification (e. g. implementing of an alternative heat sink). However, more detailed studies into the seismic hazard are ongoing.

Question 34 *Which external events have been considered in the recent PSR?*

Written answer by the Finnish side

In PRA following events have been considered:

- Hydrological and oceanographic phenomena: Sea water level, frazil ice, low and high sea water temperature.
- Meteorological phenomena: High and low air temperature, wind, tornados, freezing rain, snow fall, lightning. In some cases also climate change has been considered.
- Geological phenomena: Seismic events.
- Biological impurities in water, like algae.
- Non-weather related phenomena: Ship and oil accidents, explosions.

Same events were considered also in PSR.

Assessment of the answer

The question has been answered. The list of natural hazards assessed in the recent PSR is comprehensive. However, the expert team recommends the use of the "Non-exhaustive List of Natural Hazard Types" (WENRA RHWG 2015) to ensure that all site-specific hazards are addressed.

Question 35 *Which combinations of external events have been considered in the last PSR?*

Written answer by the Finnish side

Events are combined in the following way:

- High wind with one of following: o Biological impurities in water,
  - frazil ice,
  - Low air temperature or
  - icing conditions (this poses alone no risk to plant and is considered only in combination with wind)
- High wind, frazil ice and clogging conditions for certain air in-takes due to icing or snowing combined
- High wind, biological impurities in water and clogging conditions for certain air intakes due to icing or snowing combined
- Low sea water level and biological impurities in water combined with all initiating events including internal events

Same events were considered also in PSR.

Assessment of the answer

The question has been answered. According to ANSWERS (2022), several causally linked hazards are evaluated. However, according to WENRA RHWG (2015) also credible combinations of non-causally linked hazards should be considered.

Question 36 *Which safety margins, cliff-edge effects and envisaged improvement measures are applied for the lifetime extension concerning seismic hazard, flooding hazards and extreme weather events?*

Written answer by the Finnish side

According to YVL B.7 background memo the events with frequency 10-7 need to be considered and this has been done for events other than seismic events.

There will be seismic modifications. As seismic evaluations are still on-going, the exact value cannot be given yet.

Assessment of the answer

The question has not been answered; safety margins, cliffs, or planned improvements have not been mentioned. The answer only indicates that seismic modifications are required but that the seismic evaluation has not yet been completed.

4.3 Conclusions and final recommendations

The accident analyses in the EIA Report should have used a possible source term for a severe accident derived from the calculation of the current level 2 probabilistic safety analysis (PSA 2). While the calculated probability of severe accidents with large releases for existing plants is very low, the damage caused by these accidents is very large. In this context it is important to emphasize that the calculated frequency of large releases of the Loviisa NPP is above the limits set in STUK's regulatory guide YVL A.7.

According to ANSWERS (2022), Fortum has performed level 1 and 2 PSA and these are updated every year. One result of a level 2 PSA are the source terms of large and/or early releases. However, it is not clear why these results are not used in the EIA Report to calculate the possible impact of a severe accident.

Maintaining containment integrity under severe accident conditions is an important issue for accident management. The Loviisa NPP severe accident management (SAM) strategy relies heavily on retaining corium inside the pressure vessel (in-vessel retention (IVR)). However, there are some safety issues that could endanger the containment integrity (containment bypass scenarios, cliff-edge effects in shutdown states), thus large releases are possible. ANSWERS (2022) confirmed that no design features are in place to cope with these accident scenarios; but procedures are available to try to cope with these accidents.

The values given in ANSWERS (2022) show that external events only contribute little to core damage frequency (CDF) and large (early) release frequency (L(E)RF). However, the seismic risk is not included appropriately yet because the work is ongoing.

When the Loviisa NPP units were built no regulatory requirements on seismic design existed and earthquake loads were not considered separately in the design. The reassessment of the seismic hazard and seismic risk has turned out to be challenging for the Loviisa plant. According to ANSWERS (2022), seismic modifications are required but the seismic evaluation has not yet been completed. At the Loviisa NPP, the SAM systems are not designed to withstand earthquakes, therefore the sufficient operability of these systems after an earthquake has not yet been confirmed. Preliminary results indicate that the importance of seismic events in PSA could increase, but they would not become dominant.

The Loviisa NPP is located on the coast of the Gulf of Finland. In the past decades the threat posed by flooding has increased for many nuclear power plant sites. In consequence of the TEPCO Fukushima Dai-ichi accident, safety improvements have been implemented at the Loviisa NPP. However, according to new results the expected seawater levels at low frequencies of occurrence are higher than previously estimated.

According to ANSWERS (2022), the list of natural hazards assessed in the recent PSR is comprehensive. However, the expert team recommends the use of the "Non-exhaustive List of Natural Hazard Types" (WENRA RHWG 2015) to ensure that all site-specific hazards are addressed. In the PSR, several causally linked hazards are evaluated. However, according to WENRA RHWG (2015) also credible combinations of non-causally linked hazards should be considered.

4.3.1 Final recommendations

FR 9 It is recommended to apply the WENRA safety objectives for new NPPs to identify reasonably feasible safety improvements for Loviisa. Even if the probability of an accident scenario is very low, all additional reasonably feasible safety improvements to reduce the risk should be implemented. The concept of practical exclusion for accidents with early or large releases should be used for this approach.

FR 10 It is recommended to consider all natural hazards relevant to the site, the expert team recommends the use of the "Non-exhaustive List of Natural Hazard Types" (WENRA RHWG 2015) to ensure that all site-specific hazards are addressed.

FR 11 It is also recommended to consider all hazard combinations as required by WENRA RHWG (2021a) and further explained by WENRA RHWG (2015). It is recommended to evaluate not only the several causally linked hazards but also credible combinations of non-causally linked hazards. (See WENRA RHWG 2015)

FR 12 It is recommended to perform a Level 3 PSA to evaluate the possible risks appropriately. Compared to Level 1 and Level 2 PSAs, a Level 3 PSA represents a more complete characterisation of the off-site public risks attributable to a spectrum of possible accident scenarios involving a nuclear installation.

5 ACCIDENTS WITH INVOLVEMENT OF THIRD PARTIES

5.1 Summary of the expert statement

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the Loviisa NPP. Although precautions against sabotage and terror attacks cannot be discussed in detail in public in the EIA procedure for reasons of confidentiality, the necessary legal requirements should be set out in the EIA documents. Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. The EIA Report only provided very limited information on this topic.

5.2 Questions, answers and assessment of the answers

Question 37 *Are there any studies about the consequences of a commercial airplane crash against the Loviisa NPP available?*

Written answer by the Finnish side

Extensive risk analysis and measures to mitigate possible risks is of course part responsible nuclear operations. The requested information is part of the power plant's security arrangements, thus confidential (Covered also in the law for publicity for authorities 1999/621 §24). Therefore more detailed information on this topic cannot be shared.

Assessment of the answer

The question has not been answered. The results of the study could be confidential, this is the case in many countries, but not in all. In Switzerland and Belgium, for example, the results are also published. However, the question did not ask for the results, but only whether a study on the potential impact of a commercial aircraft crash has been conducted.

5.3 Conclusions and final recommendations

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also at the Loviisa NPP. Although for reasons of confidentiality, precautions against sabotage and terror attacks cannot be discussed in detail in public in the EIA procedure the necessary legal requirements should be set out in the EIA documents. Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. The EIA Report only provides very limited information on this topic. ANSWERS (2022) also did not provide any further information; not even whether a study of the effects of a commercial aircraft crash was conducted.

5.3.1 Final recommendations

FR 13 It is recommended to present the general requirements with respect to the protection against the deliberate crash of a commercial aircraft and other terror attacks and acts of sabotage.

6 TRANS-BOUNDARY IMPACTS

6.1 Summary of the expert statement

A severe accident with releases reaching Austrian territory can lead to significant impacts on Austria. In the EIA Report an accident was calculated with a source term of 100 TBq Cs-137, dispersion calculations were made to cover a distance of up to 1,000 km. This might underestimate impacts on Austria. Firstly, it is not proven that the occurrence of a higher source term can be excluded; and secondly, a calculation distance of 1,000 km is insufficient to assess impacts on Austria.

6.2 Questions, answers and assessment of the answers

Question 38 *Please provide data of the largest source term identified in the probabilistic safety analyses (PSA) (regardless of its probability)?*

Written answer by the Finnish side

Finnish legislation and requirements set 100 TBq target for Cs-137 and this has been accepted by competent authority (Ministry of Economic Affairs and Employment of Finland) to be used for evaluations in EIA.

Assessment of the answer

The question has been answered by referring to Finnish legal requirements. As already discussed in chapter 4 "Accident analysis", this might not be the highest possible source term.

Question 39 *Please provide the results of the dispersion calculation for this source term. It would be welcomed if these results were also presented for Austrian territory. It would be welcome if the results of the dispersion calculation were comparable with the Austrian catalogue of countermeasures (see also table 3: Values for agricultural countermeasures A07 (BMLFUW 2014), and with the Austrian national emergency plan (BMK 2020).*

Written answer by the Finnish side

Document for international hearing represents the dose evaluation up to 1000 km without any protective measures related to population. The doses are not evaluated considering local conditions but this approach is considered conservative for central Europe. Table 6-2 of international hearing document represents the deposition of most important nuclides up to 1000 km. Local organizations may evaluate the impact of the countermeasures using these values.

Assessment of the answer

No dispersion calculations were made for a distance of more than 1,000 km from Loviisa.

6.3 Conclusions and final recommendations

A severe accident with releases reaching Austrian territory can lead to significant impacts on Austria. In the EIA Report an accident was calculated with a source term of 100 TBq Cs-137, dispersion calculations were made to cover a distance of up to 1,000 km. This might underestimate impacts on Austria. It is not proven that the occurrence of a higher source term can be excluded and a calculation distance of 1,000 km is insufficient to assess impacts on Austria.

7 SUMMARY OF FINAL RECOMMENDATIONS

7.1 Long-term operation of reactor type VVER.440

7.1.1 Final recommendations

FR 1 It is recommended to implement all technically available safety improvements to prevent accidents.

FR 2 It is recommended to implement the 2020 WENRA RL in the Finnish regulation and apply it for the approval of lifetime extension of the Loviisa NPP.

FR 3 It is recommended to complete the outstanding issue resulting from the Topical Peer Review (TPR) "Ageing Management" before approval of lifetime extension.

FR 4 It is recommended to increase the frequency and scope of periodic inspection of the nozzles due to the deficiencies identified several years ago and the safety relevance of these components.

FR 5 It is recommended to evaluate if a modification to further increase the independence of the units could provide an additional safety benefit.

FR 6 It is recommended to reduce the risks of a core meltdown accident not only with modification of the calculation in the safety cases by reducing conservatism but also to evaluate whether further plant modifications are possible.

FR 7 It is recommended to re-evaluate which technically possible improvements to meet modern safety requirements that were not considered "reasonably practicable" (e. g. application of redundancy, separation and diversity principles) should be implemented to reduce the risks further.

FR 8 It should be mandatory to implement necessary improvements resulting from the PSR before the approval of the lifetime extension.

7.2 Accident Analysis

7.2.1 Final recommendations

FR 9 It is recommended to apply the WENRA safety objectives for new NPPs to identify reasonably feasible safety improvements for Loviisa. Even if the probability of an accident scenario is very low, all additional reasonably feasible safety improvements to reduce the risk should be implemented. The concept of practical exclusion for accidents with early or large releases should be used for this approach.

FR 10 It is recommended to consider all natural hazards relevant to the site, the expert team recommends the use of the "Non-exhaustive List of Natural Hazard

Types" (WENRA RHWG 2015) to ensure that all site-specific hazards are addressed.

FR 11 It is also recommended to consider all hazard combinations as required by WENRA RHWG (2021a) and further explained by WENRA RHWG (2015). It is recommended to evaluate not only the several causally linked hazards but also credible combinations of non-causally linked hazards. (See WENRA RHWG 2015))

FR 12 It is recommended to perform a Level 3 PSA to evaluate the possible risks appropriately. Compared to Level 1 and Level 2 PSAs, a Level 3 PSA represents a more complete characterisation of the off-site public risks attributable to a spectrum of possible accident scenarios involving a nuclear installation.

7.3 Accidents with involvement of third parties

7.3.1 Final recommendations

FR 13 It is recommended to present the general requirements with respect to the protection against the deliberate crash of a commercial aircraft and other terror attacks and acts of sabotage.

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GLOSSARY

AMP .... Ageing Management Programme

Bq .... Becquerel

BMK .... Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology

CDF .... Core Damage Frequency

Cs-137 .... Caesium-137

DBE .... Design Basis Earthquake

DEC .... Design Extension Conditions

DiD .... Defence in Depth

EIA .... Environmental Impact Assessment

ENSREG .... European Nuclear Safety Regulators Group

EOP .... Emergency Operating Procedures

EU .... European Union

g .... Gravitational Acceleration

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

I-131 .... Iodine-131

IAEA .... International Atomic Energy Agency

ILW .... Intermediate level waste

IVR .... In Vessel Retention

LILW .... Low and intermediate level waste

LLW .... Low level waste

LOCA .... Loss of Coolant Accident

LRF .... Large Release Frequency

MAEA .... Ministry of Economic Affairs and Employment

NPP .... Nuclear Power Plant

NTI .... Nuclear Threat Initiative

OAMP .... Overall ageing management program

PGA .... Peak Ground Acceleration

PSA .... Probabilistic Safety Assessment

PWR .... Pressurized Water Reactor

RCS .... Reactor Coolant System

RHWG .... Reactor Harmonization Working Group

RL .... Reference Level

RPV .... Reactor Pressure Vessel

SAM .... Severe Accident Management

SC .... Sealed Containment

SSC .... Structure, Systems and Components

STUK .... Radiation and Nuclear Safety Authority

TBq .... Tera-Becquerel, E12 Bq

TPR .... Topical Peer Review

TWh .... Tera Watt hour

UNECE .... United Nations Economic Commission for Europe

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

WENRA .... Western European Nuclear Regulators´ Association

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ISBN 978-3-99004-628-9