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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE LIFE EXTENSION AND UPRATING THERMAL POWER OF OLKILOUTO UNITS 1 & 2

Expert Statement

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1 EXECUTIVE SUMMARY

Finland has notified Austria about the Environment Impact Assessment (EIA) procedure under the Espoo Convention and the EU EIA Directive for the project "Extending the service life of the Olkiluoto 1 and Olkiluoto 2 plant units and uprating their thermal power". Austria is participating in transboundary EIAs across the EU and in this case in Finland.

The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Federal Environment Agency to prepare an expert statement on the submitted documents.

The Environment Agency commissioned ENCO to elaborate an expert statement concerning the EIA report. For the expert statement, the EIA report has been evaluated in detail, including other publicly available documents that offer insight into the subject matter. Furthermore, a dispersion analysis has been undertaken selecting the source terms from a STUK report and actual weather that was identified as critical for the dispersion to Austria. The findings of the analysis are documented in the report.

The Teollisuuden Voima Oyj (TVO) is the Finnish operator of nuclear power plants, owner of the three operating nuclear units at the Olkiluoto plant. Units 1 and 2 are boiling water reactors that entered operation in 1978 and 1980, respectively. The original design lifetime of the O1 and O2 was set to 40 years, up to 2018. The licensed lifetime was extended in 2021 to 60 years. TVO is now considering an extension of the lifetime of the units for an additional 10 or even 20 years. In addition to the lifetime extension, the operator TVO is considering an increase of the power of the O1 and O2 to 940 MWe, to be achieved by increasing the effectiveness of the primary circulating pumps. In order to have the option for lifetime extension and/or for power increase, the operator TVO initiated the environmental impact assessment in accordance with the EU Directive 2014/52/EU.

It is not fully clear as to why the EIA was completed now, where the actual power uprate, if so decided – and the decision as per the EIA has not been made yet, will happen 3-4 years from now. Moreover, the decision for the lifetime extension is not expected sooner than a decade from now, and actually entering extended operation after 2038. Performing the EIA when the results of all analyses are available and the decision on how to proceed are taken, would allow for a much greater level of detail, minimising the uncertainties that exist now. Furthermore, a later EIA would benefit from the forthcoming PSR (one in 2028 and the next in 2038). As a minimum, the expert team believes that the EIA needs to be updated before the actual implementation of the power uprate and lifetime extension.

The EIA report described 3 different alternatives, including the zero alternative, within which the O1 and O2 units are to be shut down in 2038, the life extension alternative, with 10 and 20 years life extension and the power uprate alternative, to a 2750 MWth reactor power level and 970 MWe. While the alternatives of power uprate and lifetime extension are well described, this is not the case for the "zero" option. For the "zero" option the EIA concludes that the "the major positive impacts of extending the power plant's operation on climate, the energy market and the regional economy will end". While this might be correct, there is no other elaboration as to what could be the alternatives for Finland in case the zero option might be selected. This is a drawback of the EIA report, where the EU Directives require all options to be evaluated on their own merit.

Within the scope of previous lifetime extensions, the Olkiluoto units have been thoroughly evaluated, and various activities including inspections took place. Unlike the lifetime extension from 40 to 60 years, further extensions to 70 or even 80 years are still relatively new. This is due to a lack of the regulatory framework for such an extension which is indicated as being under consideration by STUK. Furthermore, another 20 years of lifetime extension might be associated with potentially unknown degradation mechanisms. Those need to be identified and assessed. Upon this, appropriate ageing management procedures to assure the safety of the NPP in the long run need to be selected and implemented. The EIA scoping document did not provide any relevant details as to what the lifetime extension entails, apart from saying that "the facility and its equipment need to fulfil regulatory requirements", and that "the status of equipment, systems and structures needs to be assessed, followed by the implementation of the ageing management programme".

It is relevant that for all SSCs that might be affected by the lifetime extension and simultaneous power uprate, identification of the degradation mechanisms that are different than currently considered or envisaged is conducted. The EIA report establishes that the "same basic principles for nuclear safety and radiological safety will be observed as used during the current operation. It is not just that the "basic principles of nuclear safety as for current operations" are to be observed. For a Gen II plant to remain in operation in the second half of this century, higher, contemporary (and likely future) safety standards would need to be complied with. It might be expected that STUK will set up such requirements for the Olkiluoto 1&2 units, and that the life extension programme will be consequential to those being complied with.

The EIA report fails to provide (numerical) safety targets, identification of SSCs that are ageing-critical if the operation is to be extended and does not indicate the criteria to be used in the decision making related with a possible life extension. From the expert teams' perspective, providing more detailed information and exact data on ageing management activities to assure and maintain safety for an extended lifetime, would greatly add to the credibility of the report.

Technically, the power uprate to 2750 MWth will be achieved by increasing the main circulation flow through the reactor from a current 8360 kg/sec to a new value of 10.000 kg/sec. The EIA report indicates that the increase in thermal power (by increasing the flow through the reactor) could be achieved by "modifications and reparameterization" of existing systems without changing their functionality. There are no details as to the modifications to be implemented and even less on the "reparameterization", or what kinds of parameters would be affected. Considering that in comparison with the original power level, the final uprated thermal power will be 37,5% higher, indicating that there were lots of margins (reserves) in the original design. As reducing the margins would generally have some effect on safety, a discussion as to the magnitude of such effects or a justification as to why the safety level would not be affected by a reduction of margins is needed. The EIA report states that "the power uprate has no effect on service life management", without offering any discussion or justification in this respect.

Possible safety impacts by events/accidents possibly affecting all units at the site have not been addressed in the EIA. While it is clear that this would be an extremely low probability event, due to the potentially large impact, at least a qualitative pass would need to be presented in the EIA.

In terms of external hazards, the EIA report offers a good discussion on how the modelling is done for Olkiluoto. It quotes a STUK regulation that requires that the external hazards with probability of occurrence higher than once in 100.000 years are modelled. The EIA report states that the contribution of the external hazards is low, i.e. 6% of total CDF". There is neither further clarification provided in the EIA report, nor has any actual description of specific events been provided. Even the list of "external threats" that were assessed with a PRA has not been provided. The contribution of external events on the total of large early release fraction (LERF) is not presented at all.

The radiological impact on countries located within a radius of 1000km from the Olkiluoto site (Austria is about 1400km away) has been assessed, using a source term of a maximum of 100 TBq, based on Section 22 of the Nuclear energy decree (161/1988). The accident sequence that is presented in the EIA report is a severe one, and leads to large scale damage of the core. However, due to intact containment, and the release being only through the containment filtered vent system, the EIA report concludes that the actual release of Cs 137 is much less than the safety goal (100 TBq). It is noted that the value of 100 TBq is not an actual physical limit of what could be released during a severe accident. There could be sequences which would lead to a release that is 1-2 orders of magnitude higher than 100 TBq.

The EIA report concludes that the radiation doses resulting from a radioactive release from the Olkiluoto units in a case of a severe accident "will remain statistically insignificant outside Finland's borders". The EIA report is focusing on the doses to an individual, rather than other parameters of specific interest to Austria, which is the deposition of radionuclides (Cs) on the ground. The reason why Austria has interest in this parameter is due to the fact that after the deposition reaches 650 Bq/m2, the protective measures in terms of monitoring and food controls kick in. Using a source term for the STUK document "Potential consequences of hypothetical nuclear power plant accidents in Finland" [3] and actually recorded weather, the JRODOS dispersion modelling determined that the deposition of Cs on Austrian territory could exceed 650 Bq. per m2.

2 ZUSAMMENFASSUNG

Finnland hat Österreich über das Verfahren zur Umweltverträglichkeitsprüfung (UVP) gemäß der Espoo-Konvention und der EU-UVP-Richtlinie für das Projekt „Betriebsdauerverlängerung und Erhöhung der thermischen Leistung der Reaktorblöcke Olkiluoto 1 und Olkiluoto 2" informiert. Österreich beteiligt sich an grenzüberschreitenden UVPs in der gesamten EU und in diesem Fall in Finnland.

Das Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie hat das Umweltbundesamt beauftragt, ein Gutachten zu den eingereichten Unterlagen zu erstellen.

Das Umweltbundesamt beauftragte ENCO mit der Ausarbeitung einer Expertenstellungnahme zum UVP-Bericht. Für die Expertenstellungnahme wurde der UVP-Bericht im Detail ausgewertet, einschließlich anderer öffentlich zugänglicher Dokumente, die Einblick in die Thematik geben. Darüber hinaus wurde eine Ausbreitungsanalyse durchgeführt, bei der die Quellenterme aus einem STUK-Bericht und das tatsächliche Wetter ausgewählt wurden, das als kritisch für die Ausbreitung nach Österreich identifiziert wurde. Die Ergebnisse der Analyse sind im Bericht dokumentiert.

Teollisuuden Voima Oyj (TVO) ist der finnische Betreiber von Kernkraftwerken und Eigentümer der drei in Betrieb befindlichen Kernkraftwerksblöcke im Kernkraftwerk Olkiluoto. Die Blöcke 1 und 2 sind Siedewasserreaktoren, die 1978 bzw. 1980 in Betrieb genommen wurden. Die ursprünglich geplante Lebensdauer von O1 und O2 war auf 40 Jahre bis 2018 festgelegt. Die genehmigte Lebensdauer wurde 2021 auf 60 Jahre verlängert. TVO erwägt nun, die Lebensdauer der Blöcke um weitere 10 oder sogar 20 Jahre zu verlängern. Neben der Lebensdauerverlängerung erwägt der Betreiber TVO eine Erhöhung der Leistung von O1 und O2 auf 940 MWe, die durch eine Steigerung der Effektivität der Primärumwälzpumpen erreicht werden soll. Um die Option einer Lebensdauerverlängerung und/oder einer Leistungssteigerung zu haben, hat der Betreiber TVO die Umweltverträglichkeitsprüfung gemäß der EU-Richtlinie 2014/52/EU eingeleitet.

Es ist nicht ganz klar, warum die UVP jetzt abgeschlossen wurde, wo doch die tatsächliche Leistungssteigerung, falls sie beschlossen wird – und die Entscheidung ist noch nicht gefallen – erst in 3-4 Jahren erfolgen wird. Darüber hinaus wird die Entscheidung über die Laufzeitverlängerung nicht früher als in einem Jahrzehnt erwartet, und der tatsächliche verlängerte Betrieb erst nach 2038. Die Durchführung der UVP, wenn die Ergebnisse aller Analysen vorliegen und die Entscheidung über das weitere Vorgehen getroffen wurde, würde ein viel höheres Maß an Detailgenauigkeit ermöglichen und die jetzt bestehenden Unsicherheiten minimieren. Darüber hinaus würde eine spätere UVP von den bevorstehenden PSÜ profitieren (eine im Jahr 2028 und die nächste im Jahr 2038). Das Expertenteam ist der Ansicht, dass die UVP zumindest aktualisiert werden muss, bevor die Leistungssteigerung und die Laufzeitverlängerung tatsächlich umgesetzt werden.

Der UVP-Bericht beschreibt drei verschiedene Alternativen, darunter die Null-Alternative, bei der die Blöcke O1 und O2 im Jahr 2038 abgeschaltet werden, die Lebensdauerverlängerungsalternative mit einer Laufzeitverlängerung um 10 bzw. 20 Jahre und die Leistungssteigerungsalternative auf eine Reaktorleistung von 2750 MWth bzw. 970 MWe. Während die Alternativen Leistungssteigerung und Lebensdauerverlängerung gut beschrieben sind, trifft dies auf die „Null“-Option nicht zu. In Bezug auf die „Null“-Option kommt die UVP zu dem Schluss, dass „die wesentlichen positiven Auswirkungen einer Verlängerung der Laufzeit des Kraftwerks auf das Klima, den Energiemarkt und die regionale Wirtschaft enden werden“. Dies könnte zwar richtig sein, es gibt jedoch keine weiteren Ausführungen dazu, welche Alternativen es für Finnland geben könnte, falls die Null-Option gewählt würde. Dies ist ein Manko des UVP-Berichts, da die EU-Richtlinien vorschreiben, dass alle Optionen für sich genommen bewertet werden müssen.

Im Rahmen früherer Laufzeitverlängerungen wurden die Olkiluoto-Blöcke gründlich bewertet und es fanden verschiedene Aktivitäten, darunter Inspektionen, statt. Im Gegensatz zur Laufzeitverlängerung von 40 auf 60 Jahre sind weitere Verlängerungen auf 70 oder sogar 80 Jahre noch relativ neu. Dies liegt an einem fehlenden regulatorischen Rahmen für eine solche Verlängerung, dessen Ausarbeitung STUK in Erwägung zieht. Darüber hinaus könnte eine weitere Laufzeitverlängerung um 20 Jahre mit potenziell unbekannten Degradationsmechanismen verbunden sein. Diese müssen identifiziert und bewertet werden. Daraufhin müssen geeignete Alterungsmanagementverfahren ausgewählt und umgesetzt werden, um die Sicherheit des Kernkraftwerks langfristig zu gewährleisten. Das UVP-Scopingdokument enthielt keine relevanten Details dazu, was die Laufzeitverlängerung beinhaltet, außer der Aussage, dass „die Anlage und ihre Ausrüstung die regulatorischen Anforderungen erfüllen müssen“ und dass „der Zustand der Ausrüstung, Systeme und Strukturen bewertet werden muss, gefolgt von der Umsetzung des Alterungsmanagementprogramms“.

Es ist wichtig, dass für alle Strukturen, Systeme und Komponenten (SSCs), die von der Lebensdauerverlängerung und der gleichzeitigen Leistungssteigerung betroffen sein könnten, die Degradationsmechanismen ermittelt werden, die sich von den derzeit in Betracht gezogenen oder vorgesehenen unterscheiden. Der UVP-Bericht legt fest, dass „dieselben Grundprinzipien für nukleare Sicherheit und radiologische Sicherheit eingehalten werden, die während des aktuellen Betriebs gelten. Es geht nicht nur darum, dass die Grundprinzipien der nuklearen Sicherheit wie für den aktuellen Betrieb“ eingehalten werden müssen. Damit ein Kraftwerk der zweiten Generation in der zweiten Hälfte dieses Jahrhunderts in Betrieb bleiben kann, müssen höhere, aktuelle (und wahrscheinlich auch zukünftige) Sicherheitsstandards eingehalten werden. Es ist zu erwarten, dass STUK solche Anforderungen für die Olkiluoto-Blöcke 1 und 2 festlegen wird und dass das Lebensdauerverlängerungsprogramm die Einhaltung dieser Anforderungen zur Folge haben wird.

Der UVP-Bericht enthält keine (numerischen) Sicherheitsziele, keine Identifizierung von SSCs, die bei einer Verlängerung des Betriebs alterungskritisch sind, und keine Kriterien, die bei der Entscheidungsfindung hinsichtlich einer möglichen Lebensdauerverlängerung herangezogen werden sollen. Aus Sicht der Expertenteams würde die Bereitstellung detaillierterer Informationen und genauerer Daten zu Alterungsmanagementmaßnahmen zur Gewährleistung und Aufrechterhaltung der Sicherheit über eine längere Lebensdauer die Glaubwürdigkeit des Berichts erheblich steigern.

Technisch wird die Leistungssteigerung auf 2750 MWth durch eine Erhöhung des Hauptumlaufstroms durch den Reaktor von derzeit 8360 kg/sec auf einen neuen Wert von 10.000 kg/sec erreicht. Der UVP-Bericht gibt an, dass die Steigerung der thermischen Leistung (durch Erhöhung des Stroms durch den Reaktor) durch „Modifikationen und Neuparametrisierung“ bestehender Systeme erreicht werden könnte, ohne deren Funktionalität zu verändern. Es gibt keine Details zu den durchzuführenden Modifikationen und noch weniger zur „Neuparametrisierung“ oder dazu, welche Parameter betroffen wären. Wenn man bedenkt, dass die endgültige gesteigerte thermische Leistung im Vergleich zum ursprünglichen Leistungsniveau um 37,5 % höher sein wird, deutet dies darauf hin, dass im ursprünglichen Design große Spielräume (Reserven) vorhanden waren. Da eine Reduzierung der Spielräume im Allgemeinen Auswirkungen auf die Sicherheit hätte, ist eine Diskussion über das Ausmaß solcher Auswirkungen oder eine Begründung dafür erforderlich, warum das Sicherheitsniveau durch eine Reduzierung der Spielräume nicht beeinträchtigt würde. Im UVP-Bericht heißt es, dass „die Leistungssteigerung keine Auswirkungen auf die Lebensdauerverwaltung hat“, ohne dass dies in irgendeiner Form diskutiert oder begründet wird.

Mögliche Sicherheitsauswirkungen durch Ereignisse/Unfälle, die möglicherweise alle Einheiten am Standort betreffen, wurden in der Umweltverträglichkeitsprüfung nicht berücksichtigt. Obwohl klar ist, dass die Wahrscheinlichkeit eines solchen Ereignisses äußerst gering ist, müsste die Umweltverträglichkeitsprüfung aufgrund der potenziell großen Auswirkungen zumindest einen qualitativen Nachweis vorweisen.

In Bezug auf externe Gefahren bietet der UVP-Bericht eine gute Diskussion darüber, wie die Modellierung für Olkiluoto durchgeführt wird. Es wird eine STUK-Verordnung zitiert, die vorschreibt, dass externe Gefahren mit einer Wahrscheinlichkeit von mehr als einmal in 100.000 Jahren modelliert werden müssen. Der UVP-Bericht gibt an, dass der Beitrag der externen Gefahren gering ist, d. h. 6 % der gesamten Kernschadenshäufigkeit (CDF). Der UVP-Bericht enthält weder weitere Erläuterungen noch eine tatsächliche Beschreibung spezifischer Ereignisse. Sogar die Liste der „externen Bedrohungen“, die mit einer probabilistischen Risikoanalyse (PRA) bewertet wurden, wurde nicht bereitgestellt. Der Beitrag externer Ereignisse zur Gesamtmenge der large early release fraction (LERF) wird überhaupt nicht dargestellt.

Die radiologischen Auswirkungen auf Länder in einem Umkreis von 1000 km um den Standort Olkiluoto (Österreich ist etwa 1400 km entfernt) wurden anhand eines Quellterms von maximal 100 TBq bewertet, basierend auf Abschnitt 22 der Kernenergieverordnung (161/1988). Der im UVP-Bericht dargestellte Unfallablauf ist schwerwiegend und führt zu großflächigen Schäden am Kern. Da die Sicherheitshülle jedoch intakt ist und die Freisetzung ausschließlich über das gefilterte Entlüftungssystem der Sicherheitshülle erfolgt, kommt der UVP-Bericht zu dem Schluss, dass die tatsächliche Freisetzung von Cs 137 weit unter dem Sicherheitsziel (100 TBq) liegt. Es ist anzumerken, dass der Wert von 100 TBq keine tatsächliche physikalische Grenze dessen darstellt, was bei einem schweren Unfall freigesetzt werden kann. Es könnte Abläufe geben, welche zu einer Freisetzung führen, die 1-2 Größenordnungen über 100 TBq liegt.

Der UVP-Bericht kommt zu dem Schluss, dass die Strahlendosen, die im Falle eines schweren Unfalls aus einer radioaktiven Freisetzung aus den Olkiluoto-Blöcken resultieren, „außerhalb der Grenzen Finnlands statistisch unbedeutend bleiben werden“. Der UVP-Bericht konzentriert sich auf die Dosen für einen Einzelnen und nicht auf andere Parameter, die für Österreich von besonderem Interesse sind, nämlich die Deposition von Radionukliden (Cs) auf dem Boden. Der Grund, warum Österreich an diesem Parameter interessiert ist, liegt in der Tatsache, dass ab einer Deposition von 650 Bq/m2 die Schutzmaßnahmen in Form von Überwachung und Lebensmittelkontrollen greifen. Unter Verwendung eines Quellterms für das STUK-Dokument „Potenzielle Folgen hypothetischer Kernkraftwerksunfälle in Finnland“ [3] und tatsächlich aufgezeichneter Wetterdaten hat die JRODOS-Dispersionsmodellierung ermittelt, dass die Deposition von Cs auf österreichischem Gebiet 650 Bq pro m2 übersteigen könnte.

3 INTRODUCTION AND OVERVIEW

The Teollisuuden Voima Oyj (TVO) is the Finnish operator of nuclear power plants, owner of the three operating nuclear units at the Olkiluoto plant located at the community of Eurajoki on the Finnish west coast. Units 1 and 2 are boiling water reactors that entered operation in 1978 and 1980, respectively. The third unit on the site, O3 is an EPR reactor that was commissioned in 2023. O1 and O2 are well operated plants, which is confirmed by a high availability (capacity factor of 93 to 97%) and generally low number of operational events.

The original design lifetime of the O1 and O2 was set to 40 years, up to 2018. Even before reaching the end of the design life, the licensed lifetime was extended to 60 years, meaning that the current license to operate the plant will expire in 2038. Recognising the contribution and importance to assure low carbon electricity generation for Finland, the operator TVO is considering an extension of the lifetime of the units for an additional 10 or even 20 years. The lifetime extension is said to be possible based on the analyses and maintenance activities that are being continuously performed while operating the Olkiluoto units 1 and 2. The decision on the length of the lifetime extension (10 or 20 years) will be made upon obtaining the results of the detailed studies and analyses, including economic impact.

In addition to the lifetime extension, the operator TVO is considering an increase of the power of the Ol1 and Ol2 units. This would not be the first increase of the units' power. Originally rated at 660 MWe, the units increased power initially to 710 MWe in 1984 and to 840 MWe in 1998. Those two power increases were achieved by increasing the power of the reactor. In the period 2005-6 and then 2010-12, the improvement of the turbine and related systems added to the efficiency of the plant, increasing the effective power level to 890 MWe per unit. Under consideration now is the third power increase that will bring the units' power to 940 MWe, to be achieved by increasing the effectiveness of the primary circulating pumps, i.e. by having a higher throughput of the circulating water that is removing the heat from the reactor.

In accordance with the prevailing regulatory framework in Finland, OL1 and OL2 are authorised to operate until 2038 with the present power level. A new/modified operating license is needed for either extending the lifetime or increasing the power level. As a part of the licensing process an environmental impact assessment is also required, including, in case of a power uprate, an amendment of the site environmental license. In order to have the option for lifetime extension and/or for power increase, the operator TVO initiated the environmental impact assessment in accordance with the EU directive 2014/52/EU.

As a part of the EIA process, TVO prepared and published the Environmental impact assessment programme (EIA scoping document) in January 2024. The EIA scoping document presented the concept and possible alternatives and discussed the assessments to be undertaken. Upon the EIA scoping document commented on by a variety of interest groups including EU MS that could be affected by transboundary release, a full EIA report was developed, comprehensively assessing the impact of the project onto the environment in Finland as well as internationally.

The Scoping EIA was subject to national and international reviews, as envisaged by the EU Directives. As it could be affected by the transboundary impact in a case of a severe accident at the Olkiluoto site, Austria participated in the EIA scoping process by undertaking the analysis and then developing an expert statement (UBA REP-0910) [1]. and submitting it to the Finnish competent authority, Ministry of Economic Affairs and Employment for consideration within the full EIA report. The expert statement contained almost 30 specific recommendations for specific subjects and the extent of analysis to be considered in the EIA report.

The competent authority, the Finnish Ministry of Economic Affairs and Employment issued on 25 April 2024 its "Statement in relation with the full EIA for the OL1 and OL2 plant units' lifetime extension and/or power uprate" [2]. This Statement summarises the process of the national and international consultations that took place, including a summarised listing of the comments received. As expected, the national comments mainly focused on the environmental impact in the short and medium range, where international comments, in particular Austrian ones, asked for more detailed information that would enable the assessment of the realistic risks that are related with both the lifetime extension and the power uprate.

In its Statement on the evaluation of the EIA programme, the competent authority established its requirements for the information to be contained as well as the assessments to be undertaken in the EIA analysis. In this, of the highest interest from the Austrian perspective are the sections focused on the "Continuation of operation, power uprating and management of ageing", which require that "risk factors … means of preventing or mitigating the impacts … are carefully assessed. This section summarises the requirements raised in the expert statement. Furthermore, related with "Risks caused by climate change and external threats", the competent authority specifically requires that the "External threats and the risks arising from climate change must be taken into account when assessing the safety", which is a key requirement. Finally, in the "Exceptional and accident situations and transboundary impacts" the competent authority stresses that the analyses of transboundary impact are to be assessed, but does not extend the requirements to accommodate for the potential releases which are beyond the Finnish regulatory safety target of 100 TBq, which was the core request in the expert statement.

While recognising that the EIA report "should also examine the plant's safety principles that aim to prevent or reduce major emissions in the event of severe accidents", the competent authority suggested that "more realistic emission estimates" are being considered, effectively establishing the "100 TBq" as the upper limit. This is implying that lower source terms would be more appropriate even in cases of the most severe accidents. This is contrary to the assessment in the expert statement, which concluded that source terms/release levels even higher than 100 TBq, though very unlikely, are possible and are to be assessed in the Transboundary impact section of the EIA report.

Being a potentially affected party in case of a radiological release from the Olkiluoto plant, Austria is participating in the Olkiluoto 1 and 2 lifetime extension/power uprate EIA procedure. In this respect, the Austrian Environment Agency (Umweltbundesamt) engaged an expert team to assess the EIA programme. The team reviewed the EIA report with the objective to determine whether the comments raised have been (appropriately) assessed. Furthermore, the expert team assessed the potential impact to the environment and population of Austria. This report documents the assessment on each of the areas of interest, as well as on the overall composition of the EIA report. This report is to serve as a support to Austrian participation in the international review process for the EIA report for Olkiluoto 1 and 2 power uprate and lifetime extension.

In addition to a detailed assessment of the EIA report, the expert team modelled the radioactivity dispersion, using the JRODOS suite, specifically selected weather as well as a range of source terms that might be relevant for the DEC B type severe accidents. The purpose of the analysis is to critically assess a possible impact on the population and environment in Austria, with the specific goal to minimise or even eliminate any possible adverse impact on Austria that might occur due to the implementation of the Olkiluoto 1&2 power uprate and the lifetime extension project.

Issues to be discussed during consultation

- Clarification of the statement that the competent authority suggested “more realistic emission estimates”, i.e. being below 100 TBq release. On which basis could such an estimate be made, given that STUK’s own report envisages much higher estimates in a worst case?
- Clarification on the fact that the competent authority specifically requires that the “external threats and the risks arising from climate change must be taken into account when assessing the safety”, where it appears that external threats have been covered rather superficially. Climate change was covered in the area of sea level rise, but not really in relation to the potential for increased severity of extreme weather.

4 PROCEDURAL ASPECTS OF THE EIA

The EIA process of the Olkiluoto lifetime extension/power uprate follows the steps that are required per the EU Directive 2011/92/EU. For the lifetime extension of nuclear power plants in the EU, the "Commission Notice regarding application of the Environmental Impact Assessment Directive (Directive 2011/92/EU of the European Parliament and of the Council, as amended by Directive 2014/52/EU) has to be followed. The process started with the Scoping EIA, which was opened for comments nationally and internationally. Following the collection of comments and their resolution by the competent authority, the full EIA was prepared. The EIA is again opened for comments nationally and for international participation, with the latter being of specific interest to Austria. In this respect, the EIA programme for the Olkiluoto 1&2 lifetime extension and power uprate comply with the requirements set forth.

In the scoping EIA the experts' comments requested a description of the planned activities that would be implemented during the extended lifetime to assure the safety of the units. Apart from a general statement that the high safety level will be maintained, that the ageing management activities will be implemented and that the plants' safety will comply with applicable regulatory requirements, to be verified by STUK, no further details were provided. Given that the Olkiluoto units may be, with the extended lifetime, in operation up to the year 2058, it is prudent to expect that there will be safety upgrades that will assure plant safety in line with the requirements for new reactors, including, e.g. Olkiluoto 3 which is a GEN III facility. Nevertheless, it is felt that the EIA report did not put enough lights on those important aspects.

Issues to be discussed during consultation

1. It is not fully clear as to why the EIA has been initiated at a stage when a) no real decision has been made in terms of the life extension and power uprate and b) when the analyses that would likely determine whether the power uprate and life extension should proceed or not have not been completed. Completing the analyses but also having clear requirements and conditions by STUK, in particular related with the safety level to be maintained up to 2058, would be essential for an EIA that aims at comprehensively assessing the environmental impact of the facility.
2. Given all the uncertainties and in particular the fact that the uprate (if agreed) is 3-4 years away and the life extension even more, 10-12 years, it is suggested that an update of the EIA is prepared when all currently unknown issues become known. Furthermore, the EIA will benefit from the results of the PSR due in 2028 (for uprate) and the next PSR due in 2038 for the lifetime extension.

5 ALTERNATIVES

The Olkiluoto units 1 and 2 are Boiling Water Reactors (BWR) designed by ASEA ATOM of Sweden, and commissioned in 1978 and 1980 for units 1 and 2, respectively. The units started with a thermal power of 2000 MWth and an electricity output of 660 MWe. The power of the reactor was upgraded in two stages, initially in 1984 to 2160 MWth and then between 1994 and 1998 to 2500 MWth, resulting in an electric output of 840 MWe. The electrical output of the units was further increased in 3 stages in the years 2005-6 and 2010-12 for an additional 50 MWe, by increasing efficiency of the turbine. Since the last power uprate, both units are licensed to operate at 890 MWe nominal power.

It is now planned to increase the power level of the reactor from 2500 MWth to 2750 MWth by increasing the flow through the reactor, i.e. by enabling higher removal of thermal energy generated. No structural changes are needed for such an increase. The increase of the thermal power will lead to an increase of the generated electrical power of the generator to reach a level of 970 MWe.

The original design life of the Olkiluoto units was 40 years, in line with other Gen II units that were constructed around the same time, envisaging the end of the lifetime in 2018 and 2020. In 2011 technical assessments and justifications needed for the extension of the lifetime for 20 years were undertaken. The lifetime extension license was applied for and then granted by the Finnish government in 2018, allowing the units to operate until 2038. It is now planned that the Olkiluoto units might extent their lifetime from 60 to an additional 10 or 20 years, to be decided once the analyses are completed and the need for modifications identified.

In order to allow for the lifetime extension to 70 or even 80 years (depending on the variant chosen) Olkiluoto units 1&2 need to undertake extensive analysis as well as specific inspection and testing to ascertain that the plant safety level could be maintained for the extended lifetime. Only upon all of those being completed and submitted to the Finnish nuclear regulator, it might be expected that the regulator would issue a permission (license) for the extended operation.

The EIA scoping document suggested that 3 different alternatives are to be investigated in the full EIA document to include:

The **ZERO alternative**, within which the O1 and O2 units are to be shut down in 2038, after 60 years of operation, on the date of the expiry of the current license

The **life extension alternative**, with two options, one with 10 years extension (i.e., until 2048) and another with 20 years extension (i.e., until 2058) so an operating lifetime of 70 and 80 years respectively.

The **power uprate alternative**, from the current 2500 MWth reactor power level and 890 MWe electricity generation to a 2750 MWth reactor power level and 970 MWe electricity generation.

For the variants with life extension and power uprate there are different possibilities, VE1 being extending the lifetime at the current power level, and then variant A and B denoting the extension of the lifetime for 10 or 20 years respectively. The variant with a power uprate, VE2 envisages the implementation of the power uprate activities to take place already in 2028, coinciding with the next periodic safety review (PSR), which is required to be undertaken by that time. As in the previous alternative, there are the variants A and B, denoting the life extension until 2048 and 2058 respectively.

Having assessed the EIA scoping, the expert team raised 3 issues that are relevant for understanding the options and the decision making process regarding which of the options is to be selected. The issues raised that were expected to be addressed in the full EIA report included the following:

1. For each of the alternatives, the EIA report shall provide a detailed discussion on the technical basis, the safety assessment, the impact assessments as well as the basis and criteria that is being used to evaluate the alternatives that are being considered
2. Alternatives like new NPPs or non-nuclear electricity sources are also to be considered as an option
3. The EIA should provide the technical description of the plant as it is and as expected for each alternative including the information on requirements for safety.

In terms of alternatives, those considered in the EIA report are the uprate, the lifetime extension and the “zero” option, meaning that the plant is to be shut down upon expiry of the current license. For the “zero” option, it is concluded that the “the major positive impacts of extending the power plant’s operation on climate, the energy market and the regional economy will end”. This point of view could be understood, as continued Olkiluoto operation will contribute to the generation of non-carbon electricity. It is nevertheless a bit unusual, in particular in the view of some other recent EIA studies for the lifetime extension around the EU, that alternative(s) of generating needed electricity from other sources has not been assessed as part of the EIA. The assessment of the alternatives is only mentioned in a short paragraph that concludes that there are limited possibilities to increase hydropower production, and the same applies to biomass (“woodfuel”). The renewables (solar and wind) are said to be constrained by their dependence on the weather. It is further stressed that having nuclear as a baseload source allows for export of electricity to the Baltics and Poland, effectively replacing coal generated electricity thus having a positive impact on the environment.

An additional argument for continued operation of the Olkiluoto 1 and 2 units is also in the security of the supply, which is an increasingly important consideration. In the view of the experts, lack of a deeper analysis of alternatives could be seen as a deficiency of the EIA study.

The experts suggested that the detailed discussion of technical bases, including safety analyses, impact assessment and the acceptance criteria are all addressed in the EIA. This comment has been addressed, but only marginally, by providing general information of the analyses to be undertaken.

Being developed on the basis of the EIA scoping document, the full EIA adds some information on the activities needed for both extending the lifetime and uprating the power. While it is known that the Olkiluoto units are very well operated, have a high availability factor and experienced very few safety-related events, the statement of what would need to be done in terms of assuring safety during the extended lifetime is on a general level, that "safety will be maintained" and that "STUK requirements will be complied with". From the experts' perspective, and as required in the comments raised on the EIA scoping programme, technical information on the assessments to be undertaken and the criteria to be used for judging acceptable safety levels are useful to be discussed in the EIA.

As raised in our comments on the EIA programme, if the Olkiluoto units are to stay in service until 2058, then the safety requirements of those units could no longer be the original Gen II safety requirements, but rather those for Gen III reactors like Olkiluoto 3. That would entail not just analysis and justification, but possibly more extensive safety upgrades. None of these have been discussed in the EIA report.

To an extent, the same applies for the power uprate discussion. What has been described is that the power uprate will be implemented by changing the operation of the reactor circulating pumps to achieve a higher evacuation of thermal energy from the reactor. It is said that the increase in thermal power would "be implemented by means of modifications and the reparameterization of existing systems". While this is understood and indeed possible that, e.g. steam lines or other structures would not need to be replaced for the power uprate (though, logically, the steam separator needs to be replaced to allow for an increased steam flow), a discussion of what kind of equipment might need to be replaced or otherwise modified would be a useful addition to the EIA. While the EIA report indicates that there will be a higher temperature of the water that is released in the environment (11 instead of 10 degrees C), it is not clear whether any structural changes in, e.g. the condenser cooling system might be needed.

It is further argued that the "equipment to be replaced will be designed while bearing in mind the extended service life", suggesting that it is known which equipment that might be, but no further information has been provided. Also, there is a difference in the timeline for the decision to be taken and implemented regarding the uprating and the life extension. Therefore, more clarity on the overall modifications, in particular those to assure safety, is sorely needed.

One of the functions to be modified as listed in the EIA is the residual heat removal system capacity, which would need to be increased to accommodate for higher thermal power. Again, it remains unclear what that would entail, just the pumps or heat exchanges or other equipment. It is unclear whether there would be a need for the adjustment of the ultimate heat sink, given the higher thermal power.

One safety related issue is nevertheless mentioned in relation to the uprate, though it is not really explained. The EIA report states that "the increase in the main circulation flow will cause temporary fluctuation in the electrical output of the OL1 and OL2 plant units that results from specific disturbances on the national electrical grid to increase". It is not at all clear whether this is meant to say that there will be a higher disturbance in case of, e.g. a load rejection, which is due to the 100 additional MWe power (as compared with the 1650 MWe of Olkiluoto 3), or something else. It is not really clear as to how the battery storage system would compensate for it. Furthermore, it is of interest to understand whether the power uprate might in some way lead to a higher frequency of the loss of off-site power (LOOP), or even station blackout (SBO) which then have a detrimental impact on safety, and whether any credit for the battery storage would be taken in this respect.

Considering the schedule provided in the EIA, which envisages a possibility for a power uprate within the current operating license, i.e. shortly after 2028, it is reasonable to expect that many studies have been undertaken, if nothing else, in a preliminary scope. Therefore, the question on the need for modifications or replacement of equipment and other changes to be introduced, e.g. in the set points for protection systems, sensitivity of the plant to disturbances, etc. are expected to be already available. As such the EIA would greatly benefit in those being described in the document.

Issues to be discussed during consultation

1. It is somewhat unusual that the "zero" option, i.e., shutting down Olkiluoto 1 & 2 at the time of expiry of the current license has not been addressed in any level of detail, except by concluding that "this would be a loss of generation of carbon free electricity". An overview in what might be available to replace those units could have been made, even if the conclusion might be the same, that power uprate and life extension of Olkiluoto 1&2 is a better alternative than the zero option.
2. The EIA report stated that "STUK regulatory requirements will be adhered to". This is of course obvious, as STUK would not give a license to a plant that does not adhere to the requirements. However, the requirements for the extended lifetime to 80 years are not yet known. On which basis could the EIA then conclude that those would be "adhered to"?
3. A related issue is which safety level would be required for plants to be in operation in 2058. It should be at least the one that is required for the plants that have come into operation recently, e.g. Olkiluoto 3. The EIA does not add any clarity whether the ultimate goal of the safety uprates that are necessary for the second lifetime extension of Oliklouto 1 and 2 would bring the units to a safety level comparable to Olkiluoto 3.

4. It appears that the EIA expected that the only (hardware) safety upgrade is adding a diesel driven injection pump that is shared between 2 units. On which basis was the conclusion reached that this is enough?
5. Which systems are expected to be “reparameterized (reparameterization of existing systems) in order to assure operability and safety for the increased power? How would the margins that might be expected to be reduced be restored or compensated?

6 LIFETIME EXTENSION TO 70/80 YEARS

Olkiluoto 1&2 are GEN II units, designed and constructed with technical and safety standards of the 1970's. As for most other GEN II plants, their lifetime was originally set at 40 years. With much experience gained in the operation of NPPs internationally, both operators and regulators recognised that the lifetime could be extended, subject to implementation of carefully planned ageing management activities. The extension of the lifetime to 60 years is the norm these days for western designed GEN II NPPs.

In 2011 the Olkiluoto units have been thoroughly evaluated, and various activities including inspections took place to enable the units to extent their lifetime for 20 years. In 2018 a license to extend the lifetime for 20 years was granted by the Finnish Government. The current operating license for the Olkiluoto units is set to expire in 2038.

Unlike the lifetime extension from 40 to 60 years, further extensions to 70 or even 80 years are still relatively new. This is both due to a lack of the regulatory framework but also due to potentially unknown degradation mechanisms. The US NRC has defined and in the meantime approved lifetime extensions for up to 80 years for several units, with EU regulators closely following. More of an issue is the need to identify the degradation mechanisms and then implement appropriate ageing management procedures to assure the safety of the NPP in the long run.

The EIA scoping document did not provide any relevant details as to what the lifetime extension from the current 60 to a future 70 to 80 years would entail, apart from saying that "the facility and its equipment need to fulfil regulatory requirements", and that "the status of equipment, systems and structures needs to be assessed, followed by the implementation of the ageing management programme".

Reflecting a lack of clarity in the EIA programme and with an intention to shed a light on the criteria as well as planned activities to enable the lifetime extension to 70 to 80 years, the expert team raised a series of questions, i.e. requested that subjects be addressed in the full EIA report. Those include:

1. The concept of how the operator TVO would deal with the technical ageing management challenges, including the listing of activities to be undertaken needs to be explained;
2. The EIA Report should detail design changes that are necessary to enable the lifetime extension;
3. The approach for the fulfilment of the regulatory requirements set by STUK for the lifetime extension beyond 60 years is to be presented;
4. The action plan for the implementation of the analysis for the PSR, which is relevant for the lifetime extension to 70/80 years;
5. The EIA shall address the concept how the safety level for lifetime extension assures that the Olkiluoto units 1 and 2 are reaching (to be judged against) the safety objectives set for new reactors;

6. Numerical values in terms of the CDF, LERF and /or other available metrics should be provided.

The full EIA report addresses the issue of the lifetime extension of Olkiluoto 1&2, though that is at a much higher level than what is expected to be done to address specific questions by the experts. While more comprehensive than the information provided in the EIA programme (scoping), the description is well short of the details requested. In any case, the description is on the "objectives" level, rather than providing concrete details.

The expert team understand that the lifetime extension is still more than a decade away, as the current operating license is to expire in 2038. Nevertheless, the preliminary activities, in particular studies and monitoring of the status of SSCs should already be going on in order to prepare for the development of the ageing management programme. In particular, the consideration of potentially different or accelerating degradation mechanisms for post-2038 is a very important element to consider. This is particularly relevant for SSCs that would be affected by an eventual power uprate, where a combination of e.g. higher flows, radiation impact and material ageing might create degradation mechanisms that are different than currently considered or envisaged.

The EIA report establishes that the "same basic principles for nuclear safety and radiological safety will be observed as used during the current operation", while indicating that "evolving legislation" would need to be taken into account. For the lifetime extension "safety improvements will also be made in line with a good level of safety culture", which is an obvious statement, but does not really stress the key focus of ageing management, which is identifying degradation mechanisms and then implementing the ageing management programme to minimise or rectify effects.

As highlighted by the expert team, it is not just that the "basic principles of nuclear safety as for current operations" are to be observed. For a Gen II plant to remain in operation in the second half of this century, higher, contemporary (and likely future) safety standards would need to be complied with. The experts expect that STUK will set up such requirements for the Olkiluoto 1&2 units, and that the life extension programme will be consequential to those being complied with.

The EIA report stresses that an "efficient anticipation and management of ageing allows for extending the service life in line with current processes". Obviously, what is meant is that the ageing management programme and procedures that were put in place between 2011 and 2018 to enable initial life extension are working properly. Nevertheless, it needs to be recognised that those procedures are envisaged and designed to keep the plants well protected against ageing phenomena up to the current end of lifetime (2038) and are not necessarily the right ones to assure the plants integrity for another extension of the lifetime. New ageing analyses, including in particular identification of possibly new or different degradation mechanisms, perhaps additionally impacted by the phenomena caused by increased power, are needed.

The EIA report rightly points out that the "key analyses for ageing of structures and components … have been drawn up for a service life of 60 years; if the service life is extended, they will be updated for 80 years of operation". Nevertheless, the EIA report is neither saying which analyses are to be undertaken, nor which SSCs would be targeted, except mentioning "plant sections important to safety" and "piping and piping supports".

While still being abstract as to which SSCs are addressed in the ageing management programme, the EIA report is helpful in adding that "Ageing management also includes the management of technological obsolescence", which is expected to become of increasing importance as the Olkiluoto units age. It has to be said that it is known in the industry that Olkiluoto maintains an impressive policy of spare parts and refurbishment of components, which together with dedicated preventive maintenance contributes to a high availability factor and a high safety level (seen as absence of safety incidents) of the units. Further, the material tracking programme for non-replaceable components is expected to generate the reference data to decide on operability or repair needs for SSCs.

Apart from mentioning that the "ageing management and its related processes continue under STUK's supervision" and adding that the "authority requirements may change with evolving legislation" the EIA report does not address STUK's expected policies for considering the lifetime extension beyond 60 years. While it is clear that such a policy may not be fully defined yet, the outlines of the policy would be a helpful addition to the EIA report's discussion on the lifetime extension concept.

All in all, the EIA report provided a high level overview of the current ageing management activities at the Olkiluoto 1&2 units, with a focus on principles, by stressing the integration of ageing management in the maintenance activities. At the same time, the EIA report fails to provide any clarity in relation with the expected requirements for the life extension beyond 60 years, the critical ageing and degradation mechanisms or at least the investigations planned to determine new degradation mechanisms, in particular those that might be initiated/accelerated by the physical effects of a power uprate.

The EIA report fails to provide (numerical) safety targets, identification of SSCs that are ageing-critical if the operation is to be extended and does not indicate the criteria to be used in the decision making related with a possible life extension. The basis for the decision making for extending the lifetime for an additional 10 or 20 years is not addressed at all.

From the expert teams' perspective, providing more detailed information and exact data on ageing management activities to assure and maintain safety for an extended lifetime, would greatly add to the credibility of the report.

Issues to be discussed during consultation

Apart from indicating that the ageing management procedures are being applied through the maintenance activities, the EIA does not say anything as to how Olkikuoto would assure that the full spectrum of degradation mechanisms that might be different than those for the initial life extension would be identified and the ageing management procedure designed?

1. This is particularly relevant as the total power would be increased by more than 35%, meaning that the plant will be operating very far from its original design envelope. This requires particular attention to analyses to be undertaken to assure safety for the plant.
2. The EIA mentioned that the “plant sections important to safety” and “piping and piping supports” will be addressed in the life extension assessment. It would be appropriate for the EIA to list all the SSC (and maybe particularly structures) that would be assessed as a part of the lifetime extension preparation of the 80 years lifetime.
3. The EIA for the lifetime extension, in particular considering that the decision has not been taken and that it is still at least a decade away, to clearly present and justify the criteria that will be adhered to when making a decision on the lifetime extension.

7 POWER UPRATE TO 970 MWE

Following upon the previous power uprates, Olkiluoto Units 1 and 2 might further increase the power of the reactor to 2750 MWth with a corresponding increase of the generating capacity to 970 MWe. The power uprate is envisaged to be implemented after the year 2028, meaning still within the existing operating license. Then the operation at uprated power will continue in the lifetime extension, regardless whether this is for 10 or 20 years.

Technically, the power uprate to 2750 MWth will be achieved by increasing the main circulation flow through the reactor from current 8360 kg/sec to a new value of 10.000 kg/sec. The increased feed flow will increase the steam generation, allowing for a higher load on the turbine, meaning higher generation of electricity, i.e. 970 MWe. The EIA programme indicates that the increase in thermal power (by increasing the flow through the reactor) could be achieved by "modifications and reparameterization" of existing systems without changing their functionality. There are no details as to the modifications to be implemented and even less of the "reparameterization", or what kinds of parameters would be affected.

There is a need for replacement of the steam separators that are located at the reactor outlet, but that would be implemented during a regular refuelling outage. As per the EIA report there are no other critical issues, i.e. components replacement, etc. that are essential to increase the power level.

Considering that in comparison with the original power level, the final uprated thermal power will be 37,5% higher, indicating that there were lots of margins (reserves) in the original design. However, some of these "reserves" are being "used up" to achieve higher power level. As reducing the margins would generally have some effect on safety, a discussion as to the magnitude of such effects or a justification as to why the safety level would not be affected by a reduction of margins is needed.

The only modification that is specifically mentioned is the one to add the diesel-powered reactor make-up system that will serve both units and be located externally to the current buildings. The diesel driven make up system is needed to accommodate for the flooding of the reactor core in case of a total loss of power, making other systems unavailable. In such a case the diesel driven system will inject the water into the reactor. As already discussed in the section on alternatives, the new battery storage system is planned to help with the fluctuations of power, which would somehow be related or introduced due to the power uprate.

The EIA report states that "the power uprate has no effect on service life management", without offering any discussion or justification in this respect. As above, given the way the GEN II NPPs were designed, there are (significant) built-in margins in many SSCs, which are now being used. However, an increased power of 37.5 %, with the reactor vessel, fuel geometry and pipelines the same, may add the mechanical and thermal loads on all of the components and/or structures. Furthermore, coupled with extending the service life, it might be expected that the margins would be "used up" or possibly other degradation mechanisms might develop (e.g., higher flow velocities, coupled with radiation damage) that might further reduce the margins. The EIA report does not offer any discussion in this regard, and even less a justification, in particular related with safety.

The experts requested that the discussion on potential reductions of the safety margins, analyses of eventual cliff edge effects, in particular for the operation in the extended lifetime, is to be presented the EIA report. Regretfully, this has not been provided. Other requests raised by the experts that were not comprehensively addressed include:

1. The details of the safety case where the margins are estimated, showing that the remaining margins are sufficient in compliance with the safety requirements in place;
2. The list of the analyses that will be done within the PSR (due 2028) that would justify the safety margin with the power uprate;
3. Impact of the power uprate for the plant's SSCs that are subject to ageing management in the view of lifetime extension.

The EIA report states that the concept for the power uprate has been considered "when replacing equipment" at the units. However, apart from the circulating water pumps, the EIA report does not specify which other equipment might have been changed. What is nevertheless stressed is the need to increase the capacity of the residual heat removal pumps.

Further, the EIA report states that "as a safety improvement related to the power uprating… a new feed water source has been investigated". This might be referring to the diesel driven make-up water pump and associated tank that is mentioned elsewhere, which is seemingly planned to be used in cases where a loss of power might occur (SBO). But it might be something else; it is unclear from the EIA report.

Further, it is mentioned that "further improvements and equipment replacements" are required for electrical systems but also "at the turbine plant, increased process flows will require the replacement of some components". It looks like the uprating will in fact necessitate multiple (numerous) component replacements and other adjustments, which is contrary to other statements given in the EIA report. While it could be understood that the analyses are not yet completed, it is not clear as to why the EIA report could not describe or simply list those.

In particular the discussion of the safety impact, including justification (or compensatory measures as needed) of the reduction of safety margins would be very helpful, along with the list of parameters within the plant's protection and control systems that would need to be adjusted due to the power uprate.

Issues to be discussed during consultation

1. The EIA report states that "the power uprate has no effect on service life management". It would be very important to justify such a statement, because higher flow in the reactor and the power conversion system might be expected to have an effect on the service life of various SSCs.
2. The EIA report states that the concept for the power uprate has been considered "when replacing equipment" at the units. However, apart from the circulating water pumps, the EIA report does not specify which other equipment might have been replaced and when.
3. The EIA report indicates that there is a need to increase the capacity of the residual heat removal pumps, but does not say how a higher capacity would be reached, and whether any other modifications (apart from pumps) might be needed
4. The EIA report states that "as a safety improvement related to the power uprating … a new feed water source has been investigated". It is unclear from the EIA report as to what specifically this referred to.
5. The EIA report states that "further improvements and equipment replacements" are required for electrical systems but also "at the turbine plant, increased process flows will require the replacement of some components". Even if not final (due to analyses needed) a list of SSCs that might require replacement or even further improvement would help in understanding the magnitude of activities needed for the power uprate.

8 EXTERNAL EVENTS AND MULTIPLE UNITS ON SITE

The Olkiluoto island currently houses 3 (operational) units, as well as SNF/radioactive waste facilities. The EIA programme (scoping) mentioned that the joint impact of 3 units in operation at the Olkiluoto site will be assessed in the EIA report, and that was done. However, the assessment focused on the immediate impact from thermal plume (cooling water release) by all 3 units; to visual traffic and even radioactive doses for the population caused by the authorised emissions from all three units.

Possible safety impacts by events/accidents possibly affecting all units at the site have not been addressed, not even mentioned. It is clear that this would be an extremely low probability event (except maybe in a case of an external hazard simultaneously affecting all units, i.e. Fukushima type scenario). However, due to potentially large impact at least a qualitative pass over possible events affecting or causing accidents at multiple units at the site is, in the view of the experts, needed to be presented in the EIA.

The EIA programme (scoping) indicated that the EIA report will assess the impact of potential incidents and accidents based on “authority requirements”, and that those will be described on a “general level”. The experts felt this has not been fulfilled in the EIA report. Things like radiological releases at one unit limiting the availability to operate other units, or events that might cause large scale destruction would need to be addressed as well.

In the terms of external hazards, i.e. external impact that could affect the site and in this way jeopardise safe operation of the Olkiluoto 1&2 units, the EIA report offers a good discussion on how the modelling is done for Olkiluoto. It starts by quoting a STUK regulation that requires that the external hazards with probability of occurrence higher than once in 100.000 years are modelled. The EIA report stated that the “risk significance of … external threats is estimated … probabilistic risk analysis (PRA)” and that the “… significance of earthquakes and other external threats … is fairly low, approx. 6% of total CDF”.

There is neither further clarification provided in the EIA report, nor has any actual description of specific events been provided. Even the list of “external threats” that were assessed with a PRA has not been provided, so it is not clear what is included, only the “natural” phenomena or also man-made events, including aircraft crashes, localised fires etc. While it is understood that the details related to the man-made hazards and their sequences/impact are not to be published, at least an indication whether those are actually thoroughly analysed would contribute to an understanding of the vulnerability of the Olkiluoto units to external hazards.

Most importantly, in terms of the off-site impact, the contribution of external events on the total of large early release fraction (LERF), indicating the outcome of the Level 2 PRA is (much) more important. Whether the external events are also contributing to LERF with such a low value is not discussed.

Possible impact of climate change is being addressed in the EIA, though regretfully without too much detail being made available. The discussion on the sea level rise concludes that it is likely not an issue because the land mass currently rises more than the sea level. That might change during the extended lifetime of Olkiluoto. Still, the sea level rise is not such that it could jeopardise the safety of the Olkiluoto units.

The report mentioned that there might be increasing temperatures and rainfall, but does not offer any discussion regarding a potential impact on the plant, in particular related with adverse weather. An issue in this consideration is that the Olkiluoto 1&2 units were from the beginning designed to withstand harsh weather conditions, so it is not very likely that the increase of extreme weather due to climate change would be beyond the design envelope. Anyhow, the EIA would benefit from more details and a discussion as to what has been considered.

In this evaluation of the EIA programme (scoping) the expert team indicated several areas where more information was expected in the EIA. It is clear that the assessment in the EIA report would have benefited from specific areas being addressed in some more detail, including:

1. A discussion on the assessment of the man-made external events;
2. Assessment of a combination of external events, including consideration of multiple plants on the site;
3. For each of the external event assessments, information on the safety margins, cliff-edge effects and eventually needed/planned safety improvements, needs to be presented.

The Olkiluoto units are of a robust design and the Olkiluoto site has a lower probability of external hazards (e.g., seismic or tsunami) than many other nuclear sites. Therefore, the overall risk of external events is likely not that large. Also, the human-induced hazards are, due to relative isolation, not that high. However, such a conclusion cannot quite be reached from the EIA report because it introduced the issues at a very high level, and did not provide any details that could support discussions.

It is understood that the main aim of the EIA is to assess the local impact, but in the view of a potential transboundary impact, a more thorough discussion of the safety impact and the impact of different scenarios would clearly be helpful.

Issues to be discussed during consultation

1. An engineering pass into the accident potentially affecting all units at the Olkiluoto site, i.e. the Fukushima scenario would be a good addition to the EIA.
2. The list of external hazards, man-made and natural that have been considered and the resulting contribution to CDF and LERF needs to be provided.

9 TRANSBOUNDARY IMPACT

The EIA report discussed the transboundary impact, providing the expected radiological impact on countries located within a radius of 1000km from the Olkiluoto site (Austria is about 1400km away). The source term used in the assessment of the transboundary impact is based on Section 22 of the Nuclear energy decree (161/1988), which specified that the amount of radioactive releases is limited to 100 TBq of Cs-137. This corresponds to an accident level of 6 in the international INES scale.

It is noted that the value of 100 TBq has been prescribed in the Finnish legislation, though it is a kind of "safety goal" rather than an actual physical limit of what could be released during a severe accident. In the view of the experts, the discussion on the severe accidents contained in the EIA report does not really select the most limiting (highest imaginable) release category. There would be sequences that would likely have a (significantly) lower probability, but would lead to a release that is 1-2 orders of magnitude higher than 100 TBq used in the transboundary assessment. Just for a comparison, in the Fukushima accident, the estimate for release of Cs-137 was about 17 PBq.

The accident sequence that is presented in the EAI report is a severe one, and leads to large scale damage of the core. However, due to intact containment, and the release being only through the containment filtered vent system, the EIA report concludes that the actual release of Cs 137 is much less that the safety goal (100 TBq). Nevertheless, this release value was used in the modelling. It is stated that the modelling uses assumptions for ensuring that the assessed fallout and radiation doses are conservative, which in the view of experts is not the case.

The modelling of radiation doses and fallout was performed for distances up to 1000 km from the point of release using the Tuulet 2.0.0, software, which is said to be approved by STUK. While the report says that the Tuulet software takes into account the configuration and the release height, no details were provided as to what has specific values have been used. Also, the weather used is said to be for a period of 3 years, as recorded by the Olkiluoto weather station. It is not entirely clear which weather sources were used for the dispersion calculation for modelling the impact up to 1000km from the site.

The EIA report concludes that the radiation doses resulting from a radioactive release from the Olkiluoto units in a case of a severe accident "will remain statistically insignificant outside Finland's borders". The maximum radiation dose at a distance of 1000km is said to be 0.43 mSv, so well within the annual background dose. The radiation doses at distances of more than 1000 km have not been calculated but based on expert assessments to be no higher than 0.02–0.03 mSv. Austria would be in that category, with a minimum distance of 1400km.

The distance of 1400km nominally exceeds a suggested radius of the Ingestion and Commodities Planning Distance (ICPD) defined in the IAEA general safety requirements. Those are defined as “Area around a facility for which emergency arrangements are made to take effective emergency response actions following the declaration of a general emergency in order to reduce the risk of stochastic effects among members of the public and to mitigate non-radiological consequences as a result of the distribution, sale and consumption of food, milk and drinking water and the use of commodities other than food that may have contamination from a significant radioactive release.” [13].

Nevertheless, the EIA report is focusing on the doses to an individual, rather than other parameters of specific interest to Austria, which is the deposition of radionuclides (Cs) on the ground. The reason why Austria has interest in this parameter is due to the fact that after the deposition reaches 650 Bq/m2, a threshold above which the protective measures in terms of monitoring and food controls kick in. It is also worth noting that contamination can have different effects depending on the time of year and land use. Even if the doses to the population from a radioactive release are small, the fact that the protective measures will be activated makes a nuclear accident in a plant that is relatively distant from Austrian territory an important event.

Historical data on the Chernobyl and Fukushima accidents show that accidents may have consequences far beyond those predicted during the planning process. Therefore, planning for an emergency should consider possible effects of a large-scale accident with a potential for contamination even far beyond emergency planning zones and distances defined for a specific nuclear facility.

In order to assess whether, under specific circumstances, the limit value for the protective measures in Austria could be exceeded, the expert team undertook an investigation and conducted related dispersion modelling. The aim of the assessment was neither to estimate probabilities of a release nor to estimate any averages in the deposition. The goal was simply to assess whether a marginal severe accident at Olkiluoto could possibly cause a deposition on Austrian territory which is above 650 Bq/m2.

A document “Potential consequences of hypothetical nuclear power plant accidents in Finland” [3] prepared by the Finnish Radiation and Nuclear Safety Authority provides an assessment of the environmental consequences of radioactive releases from severe accidents for Finnish nuclear power plants. For each plant evaluated, the document assesses the source term at the different severity levels.

The source terms that were used in the calculations are referenced in the STUK publication “Potential consequences of hypothetical nuclear power plant accidents in Finland” as source terms for Basic, Large and Very Large release and a series of radionuclides. Of interest were the very large releases for Olkiluoto 1 and 2, and in particular Caesium, which is the most relevant radionuclide for ground deposition. This source term was then used in the JRODOS dispersion modelling to assess the deposition on Austrian territory.

Table 1: The potential source term for a Very Large release case [4]

	Olkiluoto 1&2 [TBq]	Olkiluoto 3[TBq]
Cs-137	2.4 × 104	6.1 × 104
Cs-134	2.6 × 104	8.3 × 104
I-131	2.5 × 105	4.2 × 1105
Sr-89	1 × 103	1.6 × 103
Sr-90	72	180
Te-127m	1.3 × 103	2.4 × 103
Kr-87	5.2 × 104	8.0 × 104
Kr-88	4.5 × 105	6.9 × 105
Xe-133	5.2 × 106	8.7 × 106
Xe-135	2.3 × 106	4.0×10^6

The Very Large release category sequences described in [4], considers the reactor in shutdown and large openings through the containment pressure boundary, leading to a significant pathway to the environment. The release occurs 48 h after the start of maintenance and termination of the fission chain reaction. Release lasts for 12 hours, and the exact activities of the release are shown in Table 1. The total release of the Very Large case is comparable to the Fukushima NPP accident and roughly one order of magnitude smaller than the Chernobyl NPP accident.

Ideally, atmospheric dispersion modelling for a specific type of accident with a release would be done with daily meteorological data for at least one year to understand transport and deposition of a radioactive plume in all meteorological conditions. As the goal of modelling was only to confirm whether a deposition of Cs-137 above 650 Bq/m2 from an accident in Olkiluoto would be possible, what was taken as the weather for the analysis was a historical weather pattern that could support dispersion of the radioactive plume to Austria.

Local Scale Model Chain (LSMC), a short-range atmospheric dispersion model in JRODOS, was used for atmospheric dispersion modelling. With the default JRODOS grid, this model can be used for simulations at distances less than 800 km. For the calculations at distances larger than 800 km from the accident location, the so-called “ENSI grid” was chosen over the default JRODOS grid. ENSI grid was developed for the Swiss Federal Nuclear Safety Inspectorate (ENSI) and later added in JRODOS for all users. One of its features is that it allows calculations with the LSMC model to fairly large distances.

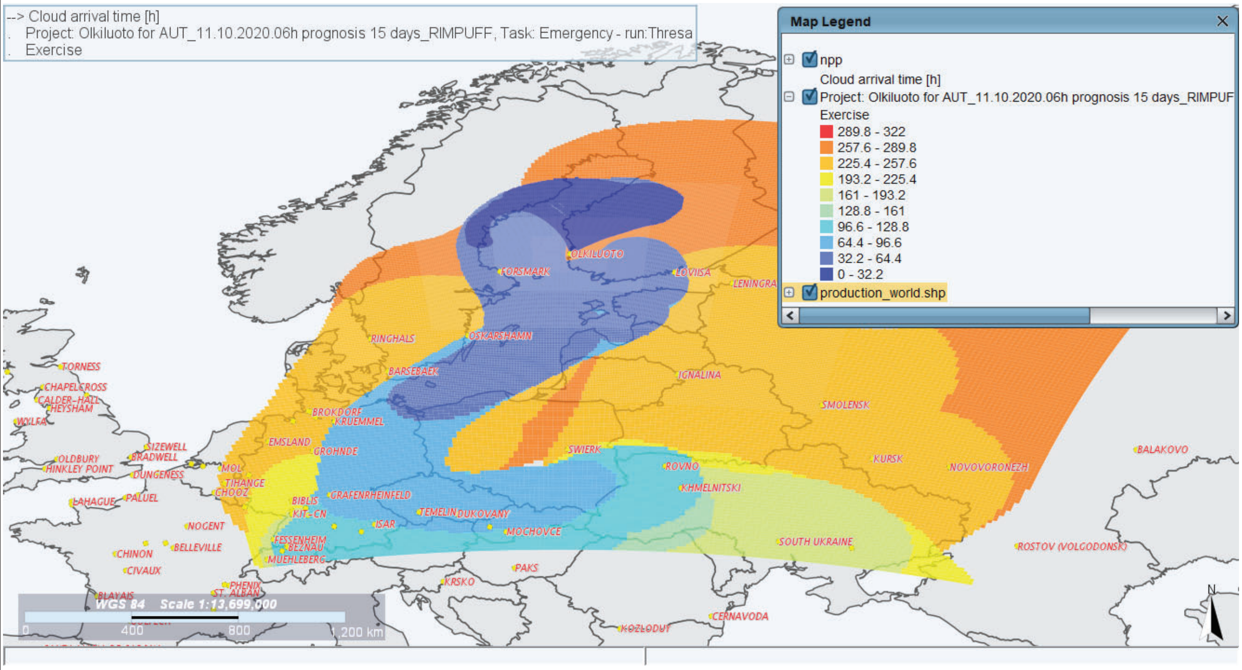
Presented here are the results of one of the calculations which confirmed possibility of ground contamination in Austria from a release in Olkiluoto 1.

Location:	Olkiluoto
Release start:	11 October 2020, 06:00 UTC
Release end:	11 October 2020, 18:00 UTC
Prognosis duration:	330 hours

Information on cloud arrival time (Fig. 1) tells when the cloud is expected to arrive to the affected country. In the case presented here, it takes at least 64 hours for the cloud to reach Austrian territory. As it heavily depends on the weather, cloud arrival time may be significantly different for different meteorological conditions.

Figure 1: Cloud arrival time

Figure 1: Simulated cloud arrival time with LSMC in JRODOS

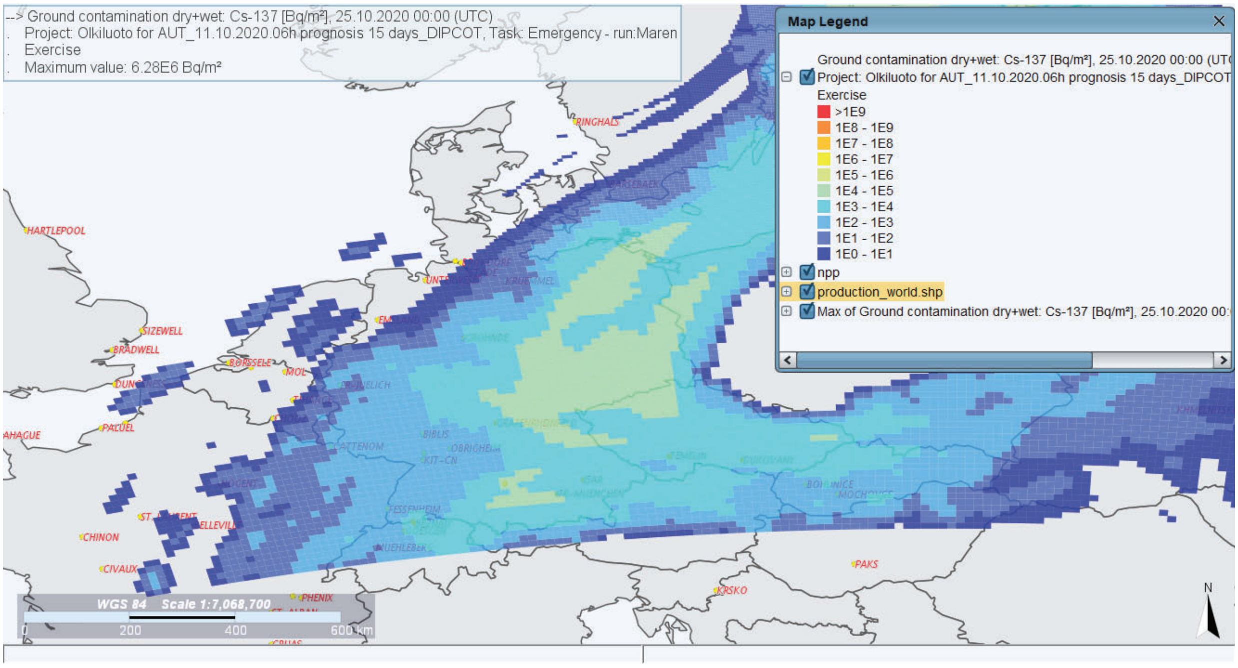


Source: Umweltbundesamt

umweltbundesamt

Figure 2: Ground contamination with Cs-137 from the Very Large release case in Olkiluoto 1

Figure 2: Simulated ground contamination with LSMC in JRODOS



Source: Umweltbundesamt

umweltbundesamt

Deposition of the radioactive material released in an accident depends on a number of factors: characteristics of a release, meteorological conditions, deposition surface and others. For this task, meteorological conditions for the period 11 – 25 October 2020, which led to transport of a radioactive plume over Austrian territory, were chosen.

Results of the JRODOS calculation for the Very Large case in which 2.4 × 10^{16} Bq of Cs-137 was released (source term for Ol1 and Ol2), presented in Figure 2, show that there is a possibility of contamination in Austria above 1000 Bq/m2 with the maximum calculated value exceeding 5×10^{3} Bq/m2.

JRODOS calculations confirm that the release of radioactive material from a very large accident in Olkiluoto units 1 and 2 might cause ground contamination on Austrian territory, with a total deposition of Cs-137 exceeding 650 Bq/m2. The probability of such contamination was not assessed in this study.

Compared to the values from the Table 1 and Table 2 of the Austrian Catalogue of measures for radiological emergencies [19], results of the JRODOS modelling could not confirm that the values for Cs-137 and I-131 contamination in leafy vegetables and milk following a very large release from Olkiluoto NPP would exceed EU-maximum values. However, one should be aware that the results based on modelling of transport of radioactive material can significantly differ from the actual measured values meaning that the results of this calculation should not be interpreted as a confirmation that a very large release even from a distant source, such as Olkiluoto NPP could not cause contamination of food above EU-maximum levels.

While the experts understand that the probability of this scenario is low, it cannot be excluded. Therefore, it was felt that the limitation taken by the EIA to assess the dispersion of radioactivity up to 1000 km is not ideal, because in case of a severe accident, the effect might well be felt beyond that distance. Furthermore, the 100 TBq limit set in the Finnish regulation is a legitimate safety goal, but when calculating the environmental impact far afield, it obviously does not encompass all of the imaginable accident sequences. It is relevant to note that some other comments in the Olkiluoto EIA programme argue the same way, that a source term beyond 100 TBq should be used.

Recognising the low probability of the sequence used by STUK to define the "very large release" category, the expert team is of the opinion that a detailed discussion of the sequences that could lead to very large releases like, e.g. critical external hazards, should be presented as a part of the EIA report, along with their probability of occurrence. In such a way, a broad picture of the range of imaginable sequences, accompanied by their (very low, in case of very large releases) probability would better depict the actual risk level from the lifetime extension and power uprate at Olkiluoto units 1 and 2.

In its review of the EIA programme (scoping) the expert team suggested various information related with the severe accidents and transboundary impact to be discussed in the EIA report. Although this suggestion was not followed by the EIA authors, the expert team maintains that for the quality and comprehensiveness of the EIA report those should have been addressed.

Issues to be discussed during consultation

1. Detailed description of severe accident scenarios and their sequences, and the resulting estimated source terms for each of those (not just Cs-137, but other relevant radionuclides for transboundary impact);
2. Detailed description of the assumptions taken when modelling accident sequences addressing source term, including duration of a release, levels of release, energy, etc.;
3. Thorough presentation of the dispersion modelling, including the weather parameters taken (covering a range of weather situations as well as the determination of radiation impacts deposits, doses to the population, etc.);
4. Resulting probability distribution of the radiological impact, covering all cases.

10 GLOSSARY

AMP .... Ageing Management Programme

Bq .... Becquerel

CDF .... Core damage frequency

DBA .... Design Basis Accident

DEC-A/B .... Design Extension Condition

EIA .... Environmental impact assessment

EU .... European Union

IAEA .... International Atomic Energy Agency

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

LERF .... Large early release fraction

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

LTE .... Lifetime Extension

MW .... Megawatt

MWe .... Megawatt electric

MWth .... Megawatt thermal

NPP .... Nuclear power plant

PBq .... Petabecquerel

PSR .... Periodic safety review

SSC .... System Structures & Components

STUK .... Säteilyturvakeskus – Finnish nuclear regulator

TBq .... Terabecquerel

TVO .... Teollisuuden Voima Oyj – Betreiberfirma von O1 & 2

WENRA .... Western European Nuclear Regulators' Association

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