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Climate Action, Environment,
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Vienna, 21.10.2021

Espoo Convention, Proposed lifetime extension Doel 1+2; Final expert statement AT

Dear Mr. Fernandez,

Austria is participating in the transboundary EIA procedure pursuant to the Espoo Convention and Art. 7 EIA Directive for the lifetime extension of Doel 1+2 since significant adverse impacts on Austria's environment cannot be excluded by the implementation of the proposed project.

A public participation procedure was carried out between 15th of April and 15th of June 2021 in Austria. Comments received from the public including an expert statement commissioned by the Federal Ministry for Climate Action for consideration pursuant to Art. 6 Espoo Convention and Art. 8 EIA Directive were submitted to Belgium by letter dated 29th of June 2021 (Ref. Nr. 2021-0.449.634).

Due to the existing Coronavirus situation, Austria and Belgium agreed to conduct consultations according to Art. 5 Espoo Convention and Art. 7 EIA Directive in a written form. Austria would like to thank Belgium again for the answers to the questions listed in the expert statement, which were received by Austria on 1st of September 2021.

The Federal Ministry for Climate Action commissioned experts to evaluate the answers. Please find enclosed the **final expert statement**. Austria asks Belgium to consider the final expert statement according to Art. 6 Espoo Convention and Art. 8 EIA Directive. We would also like to request Belgium to send the final decision pursuant to Art. 6 Espoo Convention and Art. 9 EIA Directive.

Austria would like to thank Belgium for the good cooperation.

Kind regards,

On behalf of the Federal Minister

Mag. Antonia Massauer

NPP Doel 1&2/Belgium

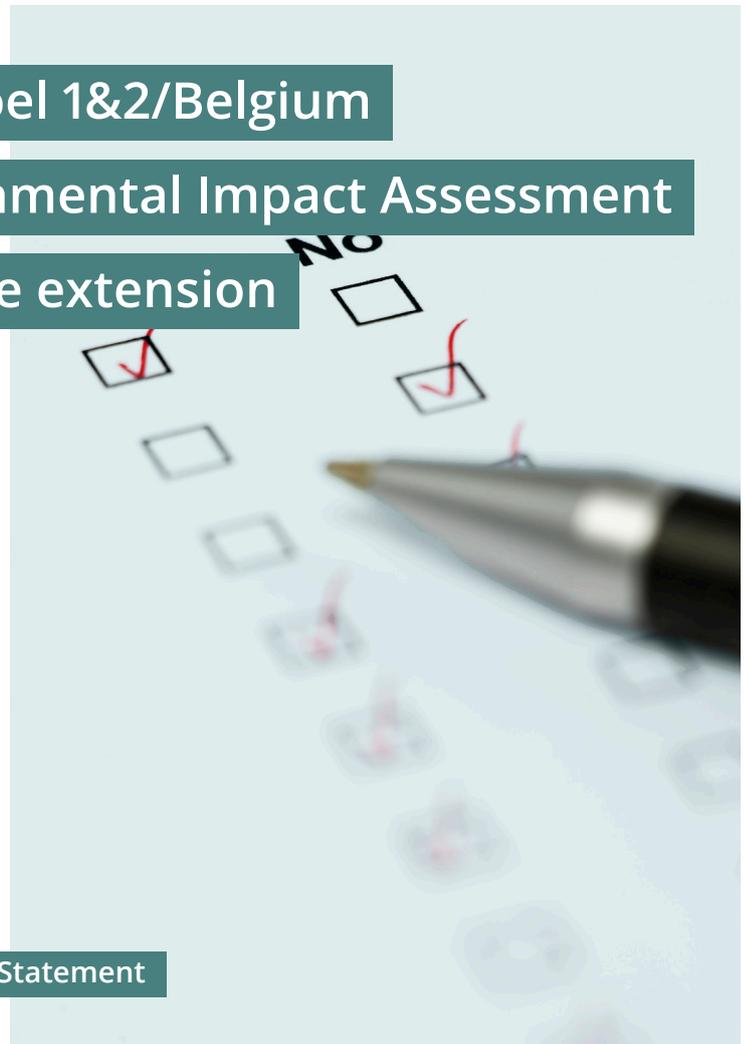
Environmental Impact Assessment

Lifetime extension

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

pulswerk
Das Beratungsunternehmen des
Österreichischen Ökologie-Instituts

Final Expert Statement



NPP DOEL 1&2/BELGIUM ENVIRONMENTAL IMPACT ASSESSMENT LIFETIME EXTENSION

Final Expert Statement

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SUMMARY

The Belgian nuclear power plant (NPP) Doel contains four units. Doel 1&2 were put into operation in 1975, Doel 3 in 1982 and Doel 4 in 1985. The NPP site is located on the left bank of the River Schelde approximately 3 km from the Dutch border.

In August 2020, Belgium notified Austria about the lifetime extension for Doel 1&2 until 2025 as a proposed activity in the framework of the Espoo Convention and the Aarhus Convention, and Austria participates in the trans-boundary Environmental Impact Assessment (EIA). The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Environment Agency Austria to coordinate the assessment of the submitted EIA Documents in the framework of an expert statement (UMWELTBUNDESAMT 2021). In this expert statement, questions and preliminary recommendations were formulated.

In September 2021, the Belgian side provided answers to these questions in written form. (ANSWERS 2021) 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 minimize or eliminate possible significant adverse impacts on Austria which might result from this project.

Procedures and alternatives

Belgium had legally determined the operation time of all four reactors in Doel to last 40 years; therefore, Doel 1&2 should have been shut-down already in 2015. However, without conducting an EIA the so-called nuclear phase-out law introduced a 10-year life-time extension in 2015. In 2016, NGOs filed a suit against this law with the Constitutional Court of Belgium which asked the European Court of Justice (ECJ) for a preliminary ruling. On 5 March 2020, the amended 2015 nuclear phase-out law was annulled by the Constitutional Court of Belgium on the basis of the ECJ ruling. However, the Constitutional Court decided to maintain the law's effect until a new law will be in force to ensure supply security. For this reason the necessary EIA needs to be completed until 31 December 2022.

According to ANSWERS (2021), the EIA results will be taken into account for the revised version of the nuclear phase-out law. But it remains unclear in which manner this will take place. Furthermore, it is unclear how and when the EIA results (e.g. for safety updates) will be taken into account in the periodic safety review, especially before the amended nuclear phase-out law will be approved. This should be clarified.

Spent fuel and radioactive waste

Spent fuel assemblies and radioactive waste can cause negative impacts on human health and the environment, proof of safe disposal is necessary to prevent those. Proof entails defining the estimated amount of the expected additional inventory of spent fuel assemblies and radioactive waste from lifetime extension and the capacities for interim storage and final disposal.

The interim storage capacities for spent fuel are reported to be sufficient for Doel 1&2 including the life-time extension period until 2025.

The design life-time for the SCG interim storage for spent fuel from Doel 1&2 will be up to 85 years. It is questionable if the design of the SCG is suited for such a long period of time, or an even longer in case that no final repository will be available when planned.

Long-term operation of this reactor type

The Doel 1&2 plants are pressurized water reactors (PWR) from Westinghouse, already operating for 45 years. This leads to negative ageing effects which constitutes a safety problem. According to the EIA Report (UVP-BERICHT 2021), ageing processes and their possible consequences are under control. However, this statement raises doubts because in April 2018, damage occurred unexpectedly in an injection line into the reactor pressure vessel, which was only noticed due to a relatively large leak.

Another ageing-related problem is the embrittlement of the reactor pressure vessels. Only very general information about this issue is provided. Quantitative values of the brittle fracture transition temperature RT_{NDT} should have been presented to confirm the statement the RT_{NDT} is well below the pressurized thermal shock criteria.

A comprehensive ageing management program (AMP) is necessary to limit the age-related failures at least to a certain degree. However, the IAEA SALTO (Safety Aspects of Long-Term Operation) mission which took place in February 2017, revealed deficits in the AMP, which were not even removed until the follow-up mission which took place in June 2019. All recommendations of the SALTO-Mission were implemented until May 2020.

Despite extensive backfitting, Doel 1&2 still have significant design deficiencies. The safety concept as such is outdated. For example, the units of Doel 1&2 share several safety systems.

In 2014, WENRA published a revised version of the Reference Level (RL) for existing reactors. A major update to the RLs was the revision of Issue F, which introduced the concept of Design Extension Conditions (DEC). The 2014 WENRA RL has been adopted in Belgian legislation now. However, it has not yet been evaluated whether Doel 1&2 meet these requirements. This will not to be done before June 2022.

The IAEA, WENRA and the Directive 2014/87/EURATOM each introduce different safety standards for existing plants and new plants. However, the safety requirements for new plants are also to be used as reference for the existing once in the frame of Periodic Safety Review to identify "reasonably practicable" safety improvements. According to the ANSWERS (2021) the separation of DC power supplies was not considered "reasonably practicable" for Doel 1&2 in the Long Term Operation (LTO) project.

All measures of the action plan for the LTO project have been implemented. However, the LTO action plan does not fully reflect the current requirements and all technically feasible backfitting measures.

Accident analysis

The EU stress test results revealed a large number of deficits in the Severe Accident Management (SAM) of the Belgian nuclear power plants. A wide range of remedies has been realized in the frame of the National Action Plan. However, they partly consisted only in the procurement of mobile equipment.

According to the EIA Report (UVP-BERICHT 2021), after the implementation of the Long Term Operation (LTO) measures, the update of the Probabilistic Safety Assessment (PSA) showed that the core damage frequency has been more than halved in particular thanks to the additional deployment of Filtered Containment Venting Systems (FCVS). Data on core damage frequency (CDF) and large release frequency (LRF) have not been provided in the EIA Report. In terms of safety the fact that the CDF reduction has been achieved by the installation of FCVS which should have taken place years or decades ago, does not deserve praise.

To assess the radiological impacts of a Beyond-Design-Basis-Accident (BDBA), the Complete Station Black-Out scenario (CSBO) was used. It is not explained why this scenario is considered as a covering event. Considering the results of the "Belgian stress tests National report on nuclear power plants - Man-made events" (FANC 2012) it is not comprehensible that an aircraft crash is covered by a CSBO scenario. There is no convincing technical justification of the chosen accident scenario. In addition, it is pointed out that for other accident scenarios measures are implemented to reduce the probability. It is not justified to base the argumentation solely on the low probability of an accident.

Several accident scenarios exist which could threaten the containment integrity, thus making large releases possible. It should be noted that NEA (2020) stated that the PSA-2 analyses for Doel 1&2 calculated that 40% of core-melt accidents cause containment failure (by melt-through of the base, containment-bypass or ex-vessel steam explosions). Those analyses refer to the status of the plant in 2010. The safety improvements and their impacts on the PSA results are unknown; they should have been presented during the EIA procedure.

A DEC-B analysis has been performed by the operator, but the safety authority has not completed the assessment of this analysis. In addition, ANSWERS (2021)

did not clarify whether reasonably practicable mitigation measures have been identified to address the consequences of a significant core damage.

The source term used in the EIA Report results from a core meltdown accident, but under the assumption that the integrity of the containment is maintained.

The accident analyses in the EIA procedure should have used a possible source term derived from the calculation of the current PSA 2. Even though the probability of severe accidents with an early and/or large release is considered very low, the consequences of these accidents are very severe. It is necessary to analyze a number of severe accidents, including those with containment failure to assess the consequences of BDBAs. Such severe accidents cannot be excluded for Doel 1&2.

Accidents caused by external events

The EIA documents contained only very general information on the NPP Doel 1&2 design against the impact of natural hazards and the plant's protection against such impacts. This limited information was significantly improved by documents and answers of the Belgian side that were provided in addition to the EIA Documents in September 2021 (ANSWERS 2021; ELECTRABEL 2015; FANC 2020a). These documents allow concluding that natural hazards that apply to the site were identified and analysed. ANSWERS (2021) and FANC (2020a) concordantly stated that the design bases of the Doel 1&2 NPP and the corresponding protection account for natural events with severities that correspond to frequencies of occurrence of 10^{-4} per year. Seismic hazards have been re-assessed in 2011 and 2015. According to FANC (2020a) adequate protection is in place for seismic hazards, external flooding and extreme weather phenomena. It was not possible to make this conclusion from the earlier submitted EIA documents. ANSWERS (2021) further confirmed that analyses also considered hazard combinations that apply to the site, although based on outdated American Nuclear Society's guidelines which were withdrawn in 1988. The expert team therefore suggests to apply up-to-date WENRA requirements and guidelines for confirming the analyses of hazard combinations.

Accidents caused by third parties

Acts of terrorism and sabotage can have significant impacts on nuclear facilities and cause severe accidents – also for Doel 1&2. But the EIA documents left them out. Comparable EIA documents have discussed such events to a certain degree. While precautions against acts of sabotage and terrorism cannot be discussed publicly in detail during the EIA process for reasons of confidentiality, EIA documents should present the necessary legal requirements.

Information about the requirements for protection against the intended crashes of a commercial airliner would be of particular interest, because the Doel 1&2 reactor building is vulnerable toward an airplane crash. Ageing-related

degradation can further decrease the building's robustness. According to ANSWERS (2021), those requirements are legally classified. However, other countries' legislation does not classify these requirements.

In ANSWERS (2021), it is stated that the resistance of Doel 1&2 against representative airplanes has been demonstrated. However, one result of the Belgian Stress Tests showed that in the event of a commercial aircraft crash, significant damage could occur to the outer containment of Doel 1&2. (FANC 2012) The subsequent, and very likely, failure of the cooling system could result in a severe accident, namely an open containment core meltdown accident. The radioactive releases would be very high and would occur particularly early.

A recent assessment of nuclear safety in Belgium indicates deficiencies compared to the necessary nuclear safety requirements: The 2020 Nuclear Threat Initiative (NTI) Index assesses nuclear safety conditions in terms of protecting nuclear facilities. With a total of 80 points out of 100, Belgium is ranking only 16th out of 47 countries; this points to an insufficient level of protection. Deficits exist for protection against insiders and in the field of cyber security.

It should be noted that in recent years, according to FANC (2020b), there has been a particular threat situation for nuclear facilities in Belgium.

Trans-boundary impacts

A severe accident with releases reaching Austrian territory can have significant trans-boundary impacts on Austria. The EIA report contained dose calculations for Beyond-Design-Basis-Accidents with an intact containment. However, it cannot be understood as proven that a higher source term cannot occur. In addition, certain weather conditions can lead to contamination also in Austria. Because the EIA did not provide adequate calculations, the impacts on Austria could be underestimated. Those impacts range from exceeding the 1 mSv annual effective dose for children as well as for adults to possibly reaching the intervention threshold value according to the Federal Emergency Plan (BMK 2020) and the need for agricultural protection measures according to the Austrian catalogue of countermeasures (BMLFUW 1994).

The expert team recommends conducting calculations of trans-boundary impacts for a severe accident with containment failure or containment bypass and a severe accident with fuel damage in the storage pool independently of the determined frequency of occurrence if they are physically possible.

ZUSAMMENFASSUNG

Das belgische Kernkraftwerk (KKW) Doel besteht aus vier Blöcken. Doel 1&2 wurden 1975 in Betrieb genommen, Doel 3 1982 und Doel 4 1985. Der Standort liegt am linken Ufer des Flusses Schelde in ca. 3 Kilometer Entfernung zur Grenze zu den Niederlanden.

Belgien hat im August 2020 Österreich die Laufzeitverlängerung von Doel 1&2 bis 2025 als vorgeschlagene Aktivität im Rahmen der Espoo Konvention und der Aarhus Konvention notifiziert, und Österreich beteiligt sich an der grenzüberschreitenden Umweltverträglichkeitsprüfung (UVP). Das Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie beauftragte das Umweltbundesamt die Bewertung der vorgelegten UVP-Unterlagen im Rahmen einer Fachstellungnahme zu koordinieren. (UMWELTBUNDESAMT 2021) In dieser Fachstellungnahme wurden die Fragen und vorläufige Empfehlungen formuliert.

Im September 2021 übermittelte die belgische Seite Antworten auf diese Fragen in schriftlicher Form. (ANSWERS 2021) In der vorliegenden abschließenden Fachstellungnahme werden diese Antworten bewertet und abschließende Empfehlungen gegeben.

Ziel der österreichischen Beteiligung am UVP-Verfahren ist es, mögliche signifikante nachteilige Auswirkungen des Projekts auf Österreich zu minimieren oder zu verhindern.

Verfahren und Alternativen

Die Laufzeit aller vier Reaktoren in Doel wurde in Belgien gesetzlich mit 40 Jahren festgelegt. Somit hätten die Laufzeiten von Doel 1&2 bereits 2015 enden müssen. Eine Laufzeitverlängerung um 10 Jahre wurde jedoch 2015 in dem sogenannten Kernausstiegsgesetz festgelegt, dies ohne Durchführung einer UVP. Gegen dieses Gesetz erhoben NGOs 2016 Klage beim belgischen Verfassungsgerichtshof. Dieser wandte sich im Rahmen eines Vorabentscheidungsverfahrens an den Gerichtshof der Europäischen Union (ECJ). Am 05.03.2020 wurde das geänderte Kernausstiegsgesetz aus 2015 basierend auf dem Urteil des ECJ vom belgischen Verfassungsgerichtshof aufgehoben. Jedoch entschied der Verfassungsgerichtshof, um die Versorgungssicherheit weiterhin zu gewährleisten, dennoch die Auswirkungen des Gesetzes aufrechtzuerhalten, bis ein neues Gesetz verabschiedet ist. Dafür muss die erforderliche UVP bis 31.12. 2022 durchgeführt worden sein.

Laut den Antworten (ANSWERS 2021) werden die Ergebnisse der UVP in der abgeänderten Version des Kernausstiegsgesetzes berücksichtigt. Es ist allerdings unklar, in welcher Weise dies geschehen wird. Weiters ist unklar, ob und wann die UVP-Ergebnisse (z.B. für Nachrüstungen) im Rahmen der Periodischen Sicherheitsüberprüfung berücksichtigt werden, bevor das abgeänderte Kernausstiegsgesetz beschlossen wird. Dies sollte geklärt werden.

Abgebrannte Brennelemente und radioaktive Abfälle

Abgebrannte Brennelemente und radioaktive Abfälle können negative Folgen für Mensch und Umwelt verursachen. Um dies zu verhindern, ist ein Nachweis für die sichere Entsorgung notwendig. Dieser Nachweis umfasst eine Abschätzung des aus der Laufzeitverlängerung erwarteten zusätzlichen Inventars an abgebrannten Brennelementen und radioaktiven Abfällen und der Kapazitäten für ihre Zwischen- und Endlagerung.

Die Zwischenlagerkapazitäten für abgebrannte Brennelemente werden als ausreichend für Doel 1&2 inklusive der Laufzeitverlängerung bis 2025 beschrieben.

Die Lebensdauer des SCG Zwischenlagers für abgebrannte Brennelemente aus Doel 1&2 kann bis zu 85 Jahren betragen. Es ist fragwürdig, ob die Auslegung des SCG für solch eine lange oder sogar noch längere Zeitperiode geeignet ist, falls zum geplanten Zeitpunkt kein Endlager zur Verfügung stehen sollte.

Langzeitbetrieb des Reaktortyps

Die Anlagen Doel 1&2 sind Druckwasserreaktoren (DWR) von Westinghouse und seit 45 Jahren in Betrieb. Das bedeutet, dass negative Alterungseffekte eingetreten sind und somit ein Sicherheitsproblem darstellen. Laut dem UVP-Bericht (UVP-BERICHT 2021) sind die Alterungsprozesse und deren möglichen Konsequenzen unter Kontrolle. Dennoch bestehen Zweifel an dieser Aussage, da es im April 2018 zu einer Beschädigung an einer Einspritzleitung in den Reaktordruckbehälter kam, die nur aufgrund eines relativ großen Lecks festgestellt wurde.

Ein anderes Alterungsproblem ist die Versprödung des Reaktordruckbehälters. Zu diesem Thema wurde nur sehr allgemein gehaltene Information zur Verfügung gestellt. Es hätten quantitative Sprödebruchübergangstemperatur (RT_{NDT})-Werte präsentiert werden sollen, um die Aussage zu bestätigen, dass der RT_{NDT} Wert ausreichend weit unter Thermoschock-Kriterien liegen.

Ein umfassendes Alterungsmanagementprogramm (AMP) ist notwendig, um alterungsbedingte Ausfälle zumindest bis zu einem gewissen Grad zu begrenzen. Die im Februar 2017 durchgeführte SALTO (Safety Aspects of Long-Term Operation) Mission der IAEO fand jedoch Defizite im Alterungsmanagementprogramm, die auch bis zur Follow-up Mission im Juni 2019 nicht beseitigt waren. Alle Empfehlungen der SALTO-Mission waren bis Mai 2020 umgesetzt.

Trotz weitreichender Nachrüstungen liegen bei Doel 1&2 noch signifikante Auslegungsdefizite vor. Das gesamte Sicherheitskonzept ist veraltet. So werden einige Sicherheitssysteme für beide Reaktoren von Doel 1&2 verwendet.

Die WENRA veröffentlichte 2014 eine revidierte Version der Referenz Levels (RL) für bestehende Reaktoren. Eine weiterreichende Aktualisierung der RL war die Revision von Issue F, die das Konzept der Design Extension Conditions (DEC) einführt. ANSWERS (2021) lässt darauf schließen, dass die 2014 WENRA RL in die nationale Gesetzgebung aufgenommen wurde. Offen ist allerdings noch die

Evaluierung, inwieweit Doel 1&2 diese Anforderungen erfüllt, da diese Evaluierung nicht vor Juni 2022 abgeschlossen sein wird.

Die IAEO, die WENRA und die Richtlinie 2014/87/EURATOM führen jeweils unterschiedliche Sicherheitsstandards für existierende Anlagen und für neue Anlagen ein. Diese Sicherheitsanforderungen für neue Reaktoren sollen aber auch als Referenz herangezogen werden, um bei den bestehenden Anlagen im Rahmen der periodischen Sicherheitsüberprüfungen die „vernünftig machbaren“ Sicherheitsverbesserungen zu identifizieren. Laut ANSWERS (2021) wird die Trennung der Gleichstromversorgung im Doel 1&2 LTO-Projekt als nicht „vernünftig machbar“ ausgeschlossen.

Laut dem Dokument ANSWERS (2021) wurden alle Maßnahmen des Aktionsplans für den Langzeitbetrieb LTO umgesetzt. Allerdings enthält der LTO-Aktionsplan nicht alle aktuellen Anforderungen und technisch machbaren Nachrüstmaßnahmen.

Unfallanalyse

Die Ergebnisse der EU-Stresstests haben viele Mängel des Severe Accident Managements (SAM) in den belgischen KKW aufgezeigt. Im Rahmen des Nationalen Aktionsplans wurden zahlreiche Abhilfemaßnahmen umgesetzt. Diese bestanden zum Teil aber nur in der Beschaffung mobiler Geräte.

Laut UVP-BERICHT (2021) verbessert sich nach Umsetzung der Long Term Operation (LTO)-Maßnahmen die nukleare Sicherheit. Die Aktualisierung der probabilistischen Sicherheitsanalyse (PSA) zeigte, dass sich die Kernschadensfrequenz, insbesondere durch die Nachrüstung der Filtered Containment Venting Systeme (FCVS), mehr als halbiert hat. Angaben zu Häufigkeiten für Kernschadensfrequenz (CDF) und große Freisetzungen (LRF) sind im UVP-BERICHT (2021) nicht vorhanden. Zudem sind die in der PSA ermittelten Häufigkeiten lediglich als grober Risiko-Indikator zu verstehen. Unter Sicherheitsgesichtspunkten ist es außerdem wenig anerkennenswert, dass die Reduzierung der CDF durch eine seit Jahren bzw. Jahrzehnten überfällige Nachrüstung eines FCVS erfolgte.

Als auslegungsüberschreitender BDBA-Unfall zur Ermittlung der radiologischen Auswirkungen wird das Szenario Complete Station Black-Out (CSBO) verwendet. Es wird nicht erklärt, wieso dieses Szenario als abdeckendes Ereignis aufgefasst wird. Die Resultate des "Belgian stress tests National report on nuclear power plants - Man-made events" (FANC 2012) lassen nicht die Schlussfolgerung zu, dass ein Flugzeugabsturz von einem CSBO abgedeckt wäre. Es besteht keine technische Begründung für das gewählte Unfallszenario. Bei anderen Unfallszenarien wird damit argumentiert, dass Maßnahmen zur Reduktion der Wahrscheinlichkeit umgesetzt wurden. Es ist allerdings nicht gerechtfertigt, nur mit der geringen Wahrscheinlichkeit für einen Unfall zu argumentieren.

Es gibt einige Unfallszenarien, die die Integrität des Sicherheitsbehälters gefährden könnten, so dass große Freisetzungen möglich sind. In NEA (2020) wurde angegeben, dass in den PSA-2 Analysen für Doel 1&2 errechnet wurde, dass

40 % der Kernschmelzunfälle ein Containmentversagen (durch Durchschmelzen des Fundaments, Containment-Bypass und Ex-Vessel-Dampfexplosion) verursachen. Diese Analysen beziehen sich auf den Anlagenzustand von 2010. Die seitdem erfolgten Sicherheitsverbesserungen und deren Auswirkungen auf die Ergebnisse der PSA sind nicht bekannt und hätten im Rahmen des UVP-Verfahrens dargestellt werden sollen.

Eine DEC-B Analyse wurde vom Betreiber durchgeführt, jedoch hat die Nuklearaufsichtsbehörde die Bewertung dieser Analyse noch nicht abgeschlossen. Zusätzlich wird aus ANSWERS (2021) nicht ersichtlich, ob vernünftigerweise machbare Maßnahmen zur Vermeidung identifiziert wurden, die gegen die Konsequenzen von schwerer Brennstoffbeschädigung zur Anwendung kämen. Der Quellterm im UVP-Bericht stammt aus einem Kernschmelzunfall, für den allerdings angenommen wurde, dass die Integrität des Containments aufrechterhalten wird.

Die Störfallanalysen im UVP-Verfahren sollten einen möglichen Quellterm verwenden, der aus der Berechnung der aktuellen PSA-2 abgeleitet ist. Wenn auch die Wahrscheinlichkeit schwerer Unfälle mit frühen und/oder hohen Freisetzungswahrscheinlichkeiten als sehr gering eingeschätzt wird, so sind doch die Folgen dieser Unfälle sehr signifikant und es ist notwendig, eine Reihe von schweren Unfällen zu analysieren, um BDBA-Unfälle bewerten zu können, einschließlich derer mit Containment-Versagen. Derartige schwere Unfälle können für Doel 1&2 nicht ausgeschlossen werden.

Unfälle durch externe Ereignisse

Die UVP-Dokumente enthielten nur sehr allgemeine Informationen über die Auslegung des KKW Doel 1&2 und den Schutz des Kernkraftwerks gegen die Auswirkungen natürlicher Gefährdungen. Diese geringe Information wurde durch die Übermittlung von Dokumenten und Antworten der belgischen Seite im September 2021 (ANSWERS 2021; ELECTRABEL 2015; FANC 2020a) als Zusatz zu den UVP-Unterlagen deutlich verbessert. Diese Dokumente lassen den Schluss zu, dass die für diesen Standort in Frage kommenden natürlichen Gefährdungen identifiziert und analysiert wurden. ANSWERS (2021) und FANC (2020a) stellen übereinstimmend fest, dass die Auslegung des KKW Doel 1&2 und der damit erzielte Schutz gegen natürliche Ereignisse mit Eintrittswahrscheinlichkeiten von 10^{-4} pro Jahr ausreichend ist. Die seismische Gefährdung wurde in den Jahren 2011 und 2015 neu bewertet. Laut FANC (2020a) besteht adäquater Schutz für seismische Gefährdungen, externe Überflutung und extreme Wetterphänomene. Es war nicht möglich, diese Schlussfolgerung aus den zunächst erhaltenen UVP-Dokumenten zu ziehen. ANSWERS (2021) bestätigt des Weiteren, dass die Analyse auch Kombinationen von Gefährdungen berücksichtigte, die für den Standort gelten, wenn auch unter Verwendung veralteter Richtlinien der American Nuclear Society, die 1988 zurückgezogen wurden. Daher empfiehlt das Expert:innenteam, die aktuellen Anforderungen und Richtlinien von WENRA anzuwenden, um die Analysen der Gefährdungskombinationen zu bestätigen.

Unfälle durch Beteiligung Dritter

Terroristische Anschläge und Sabotageakte können erhebliche Auswirkungen auf kerntechnische Anlagen haben und schwere Unfälle verursachen, auch bei Doel 1&2. Dennoch werden sie in den UVP-Dokumenten nicht erwähnt. In vergleichbaren UVP-Dokumenten wurden solche Ereignisse in gewissem Maße diskutiert. Obwohl die Vorkehrungen gegen Sabotage und Terroranschläge aus Gründen der Vertraulichkeit im UVP-Verfahren nicht öffentlich im Detail diskutiert werden können, sollten die notwendigen gesetzlichen Anforderungen in den UVP-Dokumenten dargelegt werden.

Informationen zum Thema Schutz gegen gezielte Abstürze von Verkehrsflugzeugen wären von großem Interesse, weil die Reaktorgebäude von Doel 1&2 gegenüber einem Flugzeugabsturz verwundbar sind. Alterungsbedingte Degradation kann die Widerstandsfähigkeit der Gebäude weiter reduzieren. Laut ANSWERS (2021) unterliegen diese Informationen zu den Anforderungen einer gesetzlich vorgesehenen Geheimhaltung, im Gegensatz zur gesetzlichen Regelung in anderen Ländern, die diese Klassifizierung nicht enthält.

ANSWERS (2021) wurde für Doel 1&2 eine Widerstandsfähigkeit gegen den Absturz eines repräsentativen Flugzeuges nachgewiesen. Eines der Ergebnisse der belgischen Stresstests zeigte jedoch, dass im Falle eines Absturzes eines Verkehrsflugzeuges das äußere Containment von Doel 1&2 schweren Schaden erleiden könnte. (FANC 2012). Das anschließende und sehr wahrscheinliche Versagen des Kühlsystems könnte zu einem schweren Unfall wie einem Unfall mit Brennstoffschmelze bei offenem Containment führen. Die radioaktiven Freisetzungen wären sehr hoch und würden sehr früh eintreten.

Eine aktuelle Bewertung der nuklearen Sicherheit in Belgien weist auf Defizite im Vergleich zu den notwendigen Anforderungen hin: Der Nuclear Threat Initiative (NTI)-Index 2020 bewertet die Bedingungen für die nukleare Sicherheit in Bezug auf den Schutz der Nuklearanlagen vor Sabotageakten. Mit einer Gesamtpunktzahl von 80 von 100 möglichen Punkten rangiert Belgien nur auf Platz 16 von 47 Ländern, was auf ein verbesserungsfähiges Schutzniveau hinweist. Defizite bestehen im Schutz vor Innentätern und im Bereich Cybersicherheit.

Anzumerken ist laut FANC (2020b), dass in den letzten Jahren in Belgien eine besondere Bedrohungslage für kerntechnische Anlagen bestand.

Grenzüberschreitende Auswirkungen

Ein schwerer Unfall mit Freisetzungen, die österreichisches Territorium erreichen, kann zu signifikanten grenzüberschreitenden Auswirkungen auf Österreich führen. Im UVP-Bericht werden für einen auslegungsüberschreitenden Unfall mit intaktem Containment Dosisberechnungen für die Nachbarländer Belgiens durchgeführt. Es ist jedoch nicht nachgewiesen, dass das Auftreten eines höheren Quellterms ausgeschlossen werden kann. Zudem können bei bestimmten Wettersituationen Kontaminationen auch in Österreich auftreten. Da

entsprechende Berechnungen in der UVP nicht vorgelegt wurden, könnten die Auswirkungen auf Österreich unterschätzt werden. Diese Auswirkungen reichen von der Überschreitung der 1-Jahres-Effektivdosis von 1 mSv sowohl für Kinder als auch für Erwachsene bis zu möglichen Überschreitungen der Interventionswerte laut Gesamtstaatlichem Notfallplan (BMK 2020) und der Notwendigkeit für landwirtschaftliche Schutzmaßnahmen wie etwa der vorgezogenen Ernte laut Maßnahmenkatalog (BMLFUW 1994).

Es wird empfohlen, die grenzüberschreitenden Auswirkungen für einen schweren Unfall mit Versagen des Containments bzw. mit Containment-Bypass sowie für einen schweren Unfall mit einem Brennelementschaden im Lagerbecken zu berechnen, und zwar unabhängig von deren ermittelter Eintrittswahrscheinlichkeit, solange diese physikalisch möglich sind.

1 INTRODUCTION

The Belgian nuclear power plant (NPP) Doel contains four units. Doel 1&2 were put into operation in 1975, Doel 3 in 1982 and Doel 4 in 1985. The NPP site is located on the left bank of the River Schelde approximately 3 km from the Dutch border.

The operating time of all four reactors in Doel was set by law in Belgium at 40 years. This means that the lifetimes of Doel 1&2 should have ended in 2015. However, an extension of the operating time was decided in 2015 with the so-called nuclear phase-out law, without carrying out an environmental impact assessment (EIA). Due to a lawsuit, however, this law was declared null and void, and the EIA must now be carried out.

Strictly speaking two EIAs are conducted together. The first one is an EIA at the strategic level, carried out by SCK-CEN (Belgian Nuclear Research Centre) on behalf of the Belgian Federal Public Service Economy, SMEs and Self-employed and Energy. The second EIA is on the work required by the new nuclear phase-out law to be adopted. This second EIA is carried out by Electrabel, the operator and owner of Doel 1&2. The competent authority here is the Federal Agency for Nuclear Control (FANC).

In August 2020, Belgium notified Austria about the lifetime extension for Doel 1&2 until 2025 as a proposed activity in the framework of the Espoo Convention and the Aarhus Convention, and Austria participates in the trans-boundary Environmental Impact Assessment (EIA). The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Environment Agency Austria to coordinate the assessment of the submitted EIA Documents in the framework of an expert statement (UMWELTBUNDESAMT 2021). In this expert statement, questions and preliminary recommendations were formulated.

In September 2021, the Belgian side provided answers to these questions in written form. (ANSWERS 2021) 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 minimize or eliminate possible significant adverse impacts on Austria which might result from this project.

2 PROCEDURE AND ALTERNATIVES

2.1 Short summary of the expert statement

Belgium had legally determined the operation time of all four reactors in Doel to last 40 years; therefore Doel 1&2 should have been shut-down already in 2015. However, without conducting an environmental impact assessment (EIA), the so-called nuclear phase-out law introduced a 10-year life-time extension in 2015. In 2016, NGOs filed a suit against this law with the Constitutional Court of Belgium which asked the European Court of Justice (ECJ) for a preliminary ruling. On 5 March 2020, the amended 2015 nuclear phase-out law was annulled by the Constitutional Court of Belgium on the basis of the ECJ ruling. However, the Constitutional Court decided to maintain the law's effect until a new law will be in force to ensure supply security. For this reason the necessary EIA needs to be completed until 31 December 2022.

According to information published on the Belgian authorities' websites for the public participation the EIA results will be taken into account for the revised version of the nuclear phase-out law. It is unclear however whether and in which manner the EIA results will be taken into account in the framework of the licensing procedure (e.g. for safety updates) being aware of the fact that the lifetime extension has already been decided in 2015; according to the current status, life-time extension will last only for four additional years (February and December 2025 respectively). The decommissioning of Doel 1&2 will be subject to an EIA of its own.

Maintaining supply security was used as the reason for the life-time extension of Doel 1&2. An analysis from 2020 however showed that even an immediate shut-down of the reactors Doel 1&2 would not have negative impacts on Belgium's supply security. Whether the argument of maintaining supply security can be kept up is doubtful.

2.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F1 *How will the results of the EIA be taken into account by the end of the 2025 term?*

Written answer by the Belgian side

We understand this question as how the Environmental Impact Assessments will be taken into account by the end of 2025. However, the Environmental Impact Assessment is limited to understand the impact of extending the working

life of the Doel 1 and 2 nuclear reactors, over the period 2015-2025, i.e. the Project (postponement of desactivation¹) which is compared with the reference situation (desactivation).

Assessment of the answer

The question has not been answered sufficiently. In the comment on VE1 (see below) a part of the answer is given, namely that the EIA results will be sent to the federal legislator together with the new draft of the nuclear phase-out law.

The introduction of the ANSWERS (2021) explains furthermore the procedure as follows: *“Reminder of the ongoing procedure : The project of the Belgian State is to extend the lifetime of the Doel 1 and Doel 2 nuclear power reactors by ten years. In order to be executed, this project must be authorized by several authorities: the Belgian State and the safety authority. The current consultation procedure concerns the authorization to be granted by the Belgian state. The outcome of this authorization process is a law allowing the lifetime extension. Besides the law that allows the lifetime extension, there is a separate independent procedure with the safety authority where, in the framework of the periodic safety review, the long term operation is assessed and the necessary modifications need to be approved. The operation conditions and thus the safety rules to be followed to operate the reactors lies within the responsibility of the Safety Authority.”*

As explained in the EIA documents, the recent EIA consists of two EIAs conducted together: firstly, the EIA at the strategic level, carried out by SCK-CEN (Belgian Nuclear Research Centre) on behalf of the Belgian Federal Public Service Economy, SMEs and Self-employed and Energy; and secondly, the EIA related to the necessary work, carried out by Electrabel on behalf of the Federal Agency for Nuclear Control (FANC).

It is still unclear whether and in which manner the EIA results (e.g. for safety updates) will be taken into account in the above mentioned separate, independent procedure with the safety authority in the framework of the periodic safety review, especially before the amended nuclear phase-out law will be approved.

Preliminary recommendation VE1

It is recommended that the results of the EIA be included in the approval of the lifetime extension.

Written answer by the Belgian side

The results of the Environmental Impact Assessment and the respective consultations will be sent to the federal legislator together with the preliminary draft law related to the postponement of the desactivation of the Doel 1 and Doel 2 nuclear reactors.

¹ The Belgian side uses the term desactivation instead of decommissioning.

Assessment of the answer

See assessment of the answer on question 1 (F1). The preliminary recommendation remains valid.

2.3 Conclusions and final recommendations

According to ANSWERS (2021), the EIA results will be taken into account for the revised version of the nuclear phase-out law. But it remains unclear in which manner this will take place. Furthermore it is unclear how and when the EIA results (e.g. for safety updates) will be taken into account in the procedure with the safety authority in the framework of the periodic safety review, especially before the amended nuclear phase-out law will be approved. This should be clarified.

Final recommendation FR1

It is recommended that the results of the EIA be included in the approval of the lifetime extension.

3 SPENT FUEL AND RADIOACTIVE WASTE

3.1 Short summary of the expert statement

Spent fuel assemblies and radioactive waste can cause negative impacts on human health and the environment, proof of safe disposal is necessary to prevent those. Proof entails defining the estimated amount of the expected additional inventory of spent fuel assemblies and radioactive waste from lifetime extension and the capacities for interim storage and final disposal. Data on the expected inventory for the 2015-2025 period were presented, but information on necessary storage capacities which are lacking should have been delivered in the EIA framework.

3.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F2 *What is the status and timetable for the construction of the interim storage facility SF2?*

Written answer by the Belgian side

The SF² installation is not intended to be used for the storage of the spent fuel from Doel 1 and Doel 2. The SF² installation is built for the storage of the spent fuel from Doel 3 and Doel 4. See Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.6.3.2. and the answer to F3.

The SF² building has been recently licensed, with start of construction 2nd half of 2021 and completion by 2025.

Assessment of the answer

The question has been answered.

Question F3 *What impact could it have on the interim storage of spent fuel from Doel if SF2 cannot be commissioned in time?*

Written answer by the Belgian side

The SF² installation is not intended to be used for the storage of the fuel from Doel 1 and Doel 2. The SF² installation is built for the storage of the fuel from Doel 3 and Doel 4. See Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.6.3.2. The fuel from Doel 1 and Doel 2 will be dry stored in fuel containers in the existing, licensed building SCG on

the site of KCD which has sufficient storage room for the spent fuel of Doel 1 and Doel 2, including the LTO period.

Assessment of the answer

The question has been answered.

Question F4 *How long is the interim storage of the spent fuel elements from Doel foreseen? (Design of the existing SCG interim storage facility and the planned SF2 interim storage facility)?*

Written answer by the Belgian side

The SCG stores the spent fuel from D12; see Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.6.3.2: *"The existing capacity of the SCG is sufficient for the fuel elements produced as a result of the operation of KCD-1 and KCD-2 resulting from the Project. As a result, the SF2 project is only relevant to the operation of KCD-3 and KCD-4 and independent of the Project (LTO of KCD-1 and KCD-2)."* The duration of the storage depends on the availability of a solution for the definitive storage of spent fuel (which is in the authorities' scope).

The current storage installation of SCG on the site of Doel is licensed for an unlimited period and will undergo a Periodic Safety Review every 10 years to demonstrate it is still compliant and safe for future storage of the spent fuel elements of Doel 1 and Doel 2 on site for as long as it is necessary.

Assessment of the answer

The question is answered, if also the answer to question F5 is taken into account. The design life of the interim storage SCG is up to about 2080. It was commissioned in 1995². Therefore the planned lifetime is about 85 years with the option for prolongation. It is questionable if the design of the SCG is suited for such a long time period (or an even longer one).

Question F5 *What is planned if there is no final repository for spent fuel available at the end of the lifetime of the interim storage facilities?*

Written answer by the Belgian side

It is the responsibility of ONDRAF/NIRAS together with the Belgian Authorities to define the strategy and timeline for the final repository for spent fuel elements. The final repository is foreseen for 2080 at the earliest. The current foreseen lifetimes of the interim storage facilities are in line with this timing (including a

² <https://synatom.be/en/our-technical-activities/back-end-of-the-nuclear-fuel-cycle/>

margin). In case the geological repository would not be operational in time, interim storage will be prolonged. This can be realised through lifetime extension of existing facilities or through construction of a new facility.

Assessment of the answer

The question is answered.

Question F6 *When will the decision be made on reprocessing or direct disposal?*

Written answer by the Belgian side

No timing has yet been fixed for this policy decision. ONDRAF/NIRAS has been given the task by the Federal Government to study the geological disposal of both spent fuel and reprocessed waste.

Assessment of the answer

The question is answered.

Question F7 *Is there sufficient capacity at Belgoprocess for the interim storage of radioactive waste from the lifetime extension?*

Written answer by the Belgian side

The storage capacity at Belgoprocess is regularly assessed and communicated to the safety authorities, to comply with the legal requirements on the used storage capacity and on the required buffer storage capacity, taking into account future waste arisings declared by the waste producers, such as those from the Doel 1 and 2 life time extensions. This mechanism allows for timely decisions on the development of additional storage capacity, if and when needed.

Assessment of the answer

The question is answered.

Preliminary recommendation VE2

In order to demonstrate the safe disposal of radioactive waste and spent fuel, more extensive information on the capacities of interim and final storage facilities should be provided. Furthermore, alternative disposal options should be presented in case these capacities are not available in time.

Written answer by the Belgian side

Recent information on amounts and capacities of radioactive waste and facilities can be found in the recent joint convention report (NIRAS/ONDRAF & FANC

website): 6th Review Meeting of the Convention on Nuclear Safety (fgov.be). It is the responsibility of ONDRAF / NIRAS together with the Belgian Authorities to define the strategy and timeline for the safe long-term management of all the Belgian radioactive waste, including the spent fuel elements if declared as waste.

Link: <https://fanc.fgov.be/nl/system/files/be-jc-6th-review-meeting.pdf>

Assessment of the answer

The 6th Joint Convention Report informs that the interim storage facilities for spent fuel at the Doel and Tihange sites were approximately 60% and 75% full respectively as of mid-2017, and that they will be saturated by 2022. (National Report 2017, p. 20), and: *“So as not to jeopardise nuclear electricity production because of the saturation of existing storage facilities, new storage facilities are currently under study for commissioning prior to this date.”*

According to ANSWERS (2021), construction for the new interim storage in Doel SF² will start in the 2nd half of 2021, completion is envisaged for 2025. This is a few years later than 2022. Even if the SF² is only foreseen for spent fuel from Doel 3&4, it can therefore nevertheless result in lack of available capacity for Doel 1&2.

3.3 Conclusions and final recommendations

Spent fuel assemblies and radioactive waste can cause negative impacts on human health and the environment, proof of safe disposal is necessary to prevent those. Proof entails defining the estimated amount of the expected additional inventory of spent fuel assemblies and radioactive waste from lifetime extension and the capacities for interim and final disposal. Data on the expected inventory for the 2015-2025 period were presented. The interim storage capacities for spent fuel are reported to be sufficient for Doel 1&2 including the lifetime extension period until 2025.

The design life-time for the SCG interim storage for spent fuel from Doel 1&2 will be up to 85 years. It is questionable if the design of the SCG is suited for such a long period of time or an even longer in case that no final repository will be available when planned.

4 LONG-TERM OPERATION OF REACTOR TYPE

4.1 Short summary of the expert statement

The Doel 1&2 plants are 2-loop pressurized water reactors (PWR) from Westinghouse, already operating for 45 years. The long operational time led to negative ageing effects for the structures, systems and components which constitutes a safety problem. This became visible in April 2018, when a damage in the injection pipe of the Doel 1 reactor pressure vessel occurred. Another age-related problem is the reactor pressure vessel embrittlement.

A comprehensive ageing management program (AMP) is necessary to limit the age-related failures at least to a certain degree. However, the SALTO (Safety Aspects of Long-Term Operation) mission which took place in February 2017, revealed deficits in the AMP, which were not even removed until the follow-up mission which took place in June 2019.

The entire safety concept for Doel 1&2 is outdated. Significant design deficits remain in spite of the extensive safety upgrades undertaken.

In 2014, WENRA published a revised version of the Reference Level (RL) for existing reactors. It should be noted that Belgium has not implemented 52 RL out of the 342 RL as of January 1, 2019. (WENRA RHWG 2020a)

The IAEA, WENRA and the Directive 2014/87/EURATOM each introduced different safety standards for existing plants and new plants. At the same time those safety standards also require the application as reference for the existing plants for the Periodic Safety Review (PSR) to identify “reasonably practicable” safety improvements.

According to the EIA Report (UVP-BERICHT 2021) the proposed technical improvements for Doel 1&2 are designed to reduce the safety deficits compared to the newest PWR nuclear power plants. The process to identify the changes in the plants to be implemented was conducted in three steps: The “Long List of Concerns” was reduced to a “Short List of Main Safety Issues”, which was then the basis to realize the best technical solutions. The EIA documents did not provide any of the two lists nor the respective selection criteria.

4.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F8 *What was the result of a re-inspection of the problematic areas of the injection pipes during the inspection?*

Written answer by the Belgian side

The result of the re-inspection of the problematic areas of the injection pipes is that there is no degradation detected. The Safety Authority confirmed this result. Follow up inspections are foreseen during next outages. There is no impact on the conclusions of the Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2.

Assessment of the answer

The question is answered.

Question F9 *What are the current results concerning the embrittlement of the reactor pressure vessels (RPV) in Doel 1&2 (brittle fracture transition temperature RT_{NDT}, brittle fracture safety verification)?*

Written answer by the Belgian side

As part of the LTO Study phase, done before 2015, the TLAA (Time Limited Ageing Assessment) has been made of the RPV and the results were presented to the Safety Authority who has reviewed them as part of the approval process of the LTO file and confirmed that there is no issue for extending the operating lifetime for 10 years. The results are available at the FANC (Safety Authority).

See also Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2 §1.6.1: *“The LTO report [Electrabel, 2012] shows that the ageing processes and their potential consequences are under control. It is assured that the systems, structures and components will continue to function as intended during the extended operating period. It also raises the safety level of the plants to the highest possible level.”*

As part of the LTO new external dose meters were installed during the LTO outage to follow up the fluency of the Reactor Pressure Vessel. Current follow up inspections and monitoring programs confirmed the results from the TLAA, i.e. that the RT_{NDT} is well below the PTS criteria as defined using R.G.1.99 rev 2, Regulatory Position 2. These results were shared with the Safety Authority.

Link: <https://fanc.fgov.be/nl/system/files/2012-06-30-electrabel.pdf>

Assessment of the answer

The question is answered, but only in general terms. In addition, reference is made to the LTO report of 2012, which also contains only general information and in Dutch only. Quantitative values of the RT_{NDT} should have been presented to confirm the statement that this RT_{NDT} is well below the pressurized thermal shock criteria.

Question F10 *Has a systematic assessment of the design deviations of Doel 1&2 from current international safety standards and requirements been carried out?*

Written answer by the Belgian side

Yes. That is the exact definition of a Periodic Safety Review. Under the Belgian Nuclear Safety regulations, nuclear power plant operators must conduct a Periodic Safety Review at least once every 10 years, and this following the IAEA NS-G-2.10, now superseded by IAEA SSG-25 guideline. This process was concluded for Doel 1 and Doel 2 in 2015 covering the period 2015 - 2025. Also as part of the LTO Design evaluation a detailed analysis was performed and design improvements were identified and implemented.

See Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2 §1.6.1: *“Therefore, the definition of the proposed changes is the result of a long process of study and selection from among the possible alternatives, with a view to improving nuclear safety. By improving nuclear safety, there is less chance of nuclear damage and less chance of a discharge with environmental impact. The final choice is the subject of the LTO report [Electrabel, 2012].”*

Link: <https://fanc.fgov.be/nl/system/files/2012-06-30-electrabel.pdf>

Assessment of the answer

The question is answered. It is stated that this assessment took place in 2015 for the period 2015 - 2025. This confirms the assessment of the Austrian Expert Statement on the EIA Report for Doel 1&2 that the plant does not meet current safety requirements (UMWELTBUNDESAMT 2021). The ANSWER (2021) again refers to the LTO report from 2012 that is in Dutch and only contains general information.

Question F11 *Which safety systems and Severe Accident Management (SAM) systems are shared between the units?*

Written answer by the Belgian side

A number of safety systems are common for Doel 1 and Doel 2. These are the HP – Safety Injection pumps (4 pumps in total), the Spray pumps (4 pumps in total), Component Cooling System (4 pumps and 4 heat exchangers grouped in pairs). For severe accident conditions, multi-unit accident events have been considered. There is a system that assigns interchangeable emergency pumps and diesels to a particular plant in case of accident.

Link: <https://afcn.fgov.be/fr/system/files/2011-10-31-electrabel-kc-doel.pdf>

Assessment of the answer

The question is answered. It is confirmed that several safety systems and severe accident management equipment are shared. These systems are very important for the cooling of the reactor core. Shared systems or equipment increase the probability of common cause failures and therefore the probability of an accident. In ANSWERS (2021), reference is made to a Belgian report from 2011.

Question F12 *To what extent was the application of international documents (IAEA, WENRA) legally binding in the lifetime extension?*

Written answer by the Belgian side

IAEA (e. g. SSG-25) and WENRA documents (e.g. WENRA RL 2008 and WENRA RL 2014) which have been implemented in the Belgian legislation are binding.

Assessment of the answer

The question is answered.

Question F13 *When will the WENRA Reference Levels (RL) 2014 be fully implemented in the Belgian regulatory framework? When will it be verified that Doel 1&2 meet the requirements of WENRA RL 2014?*

Written answer by the Belgian side

The WENRA RLs 2014 have been fully implemented in Belgian Law in the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations. This Royal Decree provides the modalities including the transitory regime to be compliant with its requirements.

The Royal Decree of 19th February 2020 requires the operators to carry out studies by June 2022 in order to determine whether its requirements are met.

Besides, after the Fukushima Accident, design improvements were identified through the Belgian Stress Tests, which were a precursor for WENRA RL 2014, and these design improvements are already implemented.

Assessment of the answer

The question is answered. The ANSWERS (2021) indicates that the 2014 WENRA RL has been adopted in Belgian legislation. However, whether or not Doel 1&2 is meeting those requirements has not been evaluated and will not be evaluated before June 2022.

Question F14 *Have the recommendations and suggestions of the 2017 SALTO mission been fully implemented?*

Written answer by the Belgian side

In the framework of the SALTO mission in February 2017, the IAEA review team raised 13 recommendations and suggestions for improvement.

(See information on the FANC website: <https://afcn.fgov.be/fr/content/lafcn-publie-le-rapport-salto-de-doel-1-et-2>)

In June 2019, a SALTO Follow-Up mission was conducted by IAEA to review the progress in the resolution of these issues.

The conclusions of this review were the following:

- 1 issue was assessed as insufficient progress to date
- 8 issues were assessed as satisfactory progress to date
- 4 issues were assessed as issue resolved

(See information on the FANC website: <https://fanc.fgov.be/de/news/internationale-experten-haben-bei-doel-1-und-2-eine-sicherheitsueberpruefung-durchgefuehrt>)

All eight issues with 'satisfactory progress' have been resolved as foreseen in the final stage of the LTO outages of Doel 1 and Doel 2.

For the one issue with 'insufficient progress' at the time of the SALTO Follow-Up mission, a specific action plan has been put in place to take into account the formulated remarks by IAEA.

This action plan and the final resolution of all related actions has been presented to and approved by the FANC in May 2020.

In September 2020, the FANC has informed the IAEA LTO Program Manager about this evaluation and thus the final closure of the action plan in the framework of the SALTO mission.

Link: <https://fanc.fgov.be/nl/system/files/2019-11-14-doel-salto-fu-final-report-2-redacted-vdef.pdf>

Assessment of the answer

The question is answered. According to ANSWERS (2021) all the SALTO mission's recommendations and suggestions have been implemented by May 2020.

Question F15 *What technically feasible improvements to meet modern safety requirements were not considered "reasonably practicable" for Doel 1&2 under the lifetime extension?*

Written answer by the Belgian side

For all identified Main Safety Issues (MSI), analyses were performed to identify technically feasible solutions to tackle the issue and to select the best possible solution, taking into account the criterion called Core Damage Frequency (CDF) reduction and other criteria such as technical feasibility and associated costs (see Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.7.1: *“This process is made with the Safety Authorities. For the details of the chosen solutions, we refer to the LTO Doel 12 Technical Report as mentioned in the references of the EIA.”*)

The only proposed improvement, which was not reasonably practicable to be implemented, was the separation of the DC power supplies. It would be difficult to achieve this separation since it would require changes throughout the whole plant.

The PSA result demonstrates that this electrical base concept of Doel 1-2 does not contribute significantly to the CDF.

Link: <https://fanc.fgov.be/nl/system/files/2012-06-30-electrabel.pdf>

Assessment of the answer

The question is answered. The separation of DC power supplies was not done because it would require many changes that would have taken time and costs. This was explained with PSA results showing that the basic electrical concept of Doel 1&2 does not contribute significantly to the core damage frequencies (CDF). However, the values of the CDF were not provided.

Question F16 *Which measures were on the "Long List of Concerns"? Which measures were on the "Short List of Main Safety Issues" and which were implemented? What criteria were used for decision making?*

Written answer by the Belgian side

The selection of the Main Safety Issues (MSI) is a process based on safety studies, including a criterion called Core Damage Frequency (CDF) reduction (see Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, § 3.4.7.1) together with other criteria such as technical feasibility and associated costs. This process is made with the Safety Authority. For the details of the chosen implemented solutions, we refer to the LTO Doel 12 Technical Report as mentioned in the references of the Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2.

Link: <https://fanc.fgov.be/nl/system/files/2012-06-30-electrabel.pdf>

Assessment of the answer

The question is not answered. It only repeated the information that was already provided with the EIA Report. For details of the selected solutions, it referred to the LTO Technical Report, which on the one hand is written in Dutch and on the other hand also contains only general information.

Question F17 *Have all the measures in the action plan for the LTO project already been implemented?*

Written answer by the Belgian side

Yes, all the actions have been implemented, the status is available on the FANC website in the end status report LTO Doel 12.

Link: https://fanc.fgov.be/nl/system/files/2020-05-29-10010965229-00-bijlage_-syntheserapport-lto-d12-v0-200429-def.pdf

Assessment of the answer

The question is answered. It is stated that all measures of the action plan for the LTO project already have been implemented. However, it is also confirmed in ANSWERS (2021) that the LTO action plan does not include the current requirements or all technically feasible backfitting measures.

Preliminary recommendation VE3

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

Written answer by the Belgian side

This principle is embedded in the Belgian Nuclear Regulatory Framework, as part of the "nuclear safety objective" defined in the Royal Decree of 9 October 2018 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations. Also, each NPP is subject to a Periodic Safety Review at least every 10 years where potential improvements to further prevent accidents can be identified. This process is reviewed and challenged by the Belgian Safety Authority. As part of the PSR (following IAEA NS-G-2.10 now superseded by IAEA SSG 25) the selected Needs and Opportunities for Improvement are identified and implemented as part of the PSR implementation plan, for which a timetable is developed, and approved by the Safety Authority.

Link: https://fanc.fgov.be/nl/system/files/2015-11-30_ebl-psrii-doe12-lto-synthese-report.pdf

Assessment of the answer

The ANSWERS (2021) confirmed that many modifications, but not all technically available modifications were done.

Preliminary recommendation VE4

It is recommended that all requirements of WENRA Reference Level F be met. In case of deviations, the reasons should be explained.

Written answer by the Belgian side

The operator will comply with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011, featuring all WENRA reference levels, in accordance with the modalities as set by the Royal Decree.

Assessment of the answer

As explained above a comparison of the safety level of the plant with the requirements of the updated WENRA RL should be completed by June 2022.

Preliminary recommendation VE5

It is recommended to provide the following additional information:

- a) Detailed descriptions of the safety systems, including information on requirements for the important safety-relevant systems and components. In addition, detailed description of the measures taken to control serious accidents or to mitigate their consequences.
- b) Information on the national requirements and international recommendations applied.
- c) Comprehensible presentation and overall evaluation of all deviations from the current state of science and technology. This representation should include:
 - Any deviations from current requirements for redundancy, diversity, and independence of safety levels.
 - Incompleteness of the data basis and plant documentation used.
 - Presentation of all safety-related evaluations or parameter definitions by personal assessments ("engineering judgement").
 - Deviations from the state of the art in science and technology with regard to the verification methods used, the technical estimates and calculation methods.
 - Available safety margins for the individual safety-relevant components (in particular for the reactor pressure vessels) and their respective age-related changes compared to the initial state.

Written answer by the Belgian side

This request for information is very broad, not specific enough to allow a concrete response and is likely to involve undisclosed classified information. In any case, it goes beyond the scope of the EIA.

As explained in the preamble of this document, the procedure and the information relating to the safety of installations is the responsibility of the Belgian Safety Authority. Such information is included in the safety report.

The safety report and the EIA follow different objectives. The safety report aims to validate compliance with the safety national and international requirements and recommendations which define all the technical and organisational measures that must be taken at all stages of the design, construction, operation and decommissioning of the plant of nuclear installations in order to avoid accidents and to limit their consequences if they should nevertheless occur. The EIA aims to study the environmental impacts that the project is likely to have both in normal operation and in accidental situations.

Assessment of the answer

The request has not been followed. The information listed would be necessary to assess the existing risks for Austria from the operation of Doel 1&2.

4.3 Conclusions and final recommendations

Doel 1&2 have been in operation for more than 45 years. This means that negative ageing effects of the structures, systems and components are a safety issue. According to the EIA Report, ageing processes and their possible consequences are under control. However, this statement may be questioned because in April 2018 unexpected damage occurred in an injection line into the reactor pressure vessel, which was only noticed due to a relatively large leak. Inspections revealed further spots of damage. According to ANSWERS (2021), no further degradations were found last year. Additional inspections are scheduled.

Another ageing-related problem is the embrittlement of the reactor pressure vessels. Only very general information about this issue is provided. Quantitative values of the RT_{NDT} should have been presented to confirm the statement that the RT_{NDT} is well below the pressurized thermal shock criteria.

A comprehensive ageing management program (AMP) is necessary to limit ageing-related failures at least to some extent. The IAEA's Safety Aspects of Long-Term Operation (SALTO) mission conducted in February 2017 found deficiencies in the AMP that had not been fully addressed even by the follow-up mission in June 2019. According to ANSWERS (2021) all recommendations and suggestions of the SALTO-Mission were implemented until May 2020.

Despite extensive backfitting, Doel 1&2 still have significant design deficiencies in 2011. For example, the reactor building and the building housing the spent fuel pools are vulnerable to external impacts. The entire safety concept of Doel 1&2 is outdated. According to ANSWERS (2021), several safety systems and severe accident management equipment are shared for Doel 1&2. These systems are very important for the cooling of the reactor core. Shared systems or equipment increases the probability of common cause failures and therefore the probability of an accident.

In 2014, WENRA published a revised version of the Reference Levels (RL) for existing reactors. The aim of the revision was to take into account the lessons learned from the accident at the Fukushima Daiichi NPP. A major update to the RLs was the revision of Issue F, which introduced the concept of Design Extension Conditions (DEC). The ANSWERS (2021) indicated that the 2014 WENRA RL has been adopted in Belgian legislation. However, it has not yet been evaluated whether Doel 1&2 meet these requirements and will not to be done before June 2022.

The IAEA, WENRA as well as Directive 2014/87/Euratom introduce different safety standards for existing plants and for new plants. However, these safety requirements for new reactors should also be used as a reference to identify the "reasonably practicable" safety improvements for the existing plants during the periodic safety reviews.

ANSWERS (2021) mentioned that the separation of DC power supplies as technically feasible improvement to meet modern safety requirements were not considered "reasonably practicable" for Doel 1&2 in the LTO project. It is explained that the separation of DC power supplies was not undertaken because it would require many changes that would have taken time and costs. It is stated that the PSA results show that the basic electrical concept of Doel 1&2 does not contribute significantly to the core damage frequencies (CDF). However, the values of the CDF were not provided.

According to the EIA Report (UVP-BERICHT 2021) the process to identify the modifications to be implemented in the LTO-project was conducted in three steps: The "Long List of Concerns" was reduced to a "Short List of Main Safety Issues", which was then the basis to realize the best technical solutions. The EIA documents did not provide any of the two lists nor the respective selection criteria. The ANSWERS (2021) only repeated the information that was already provided with the EIA Report.

For details of the selected solutions, it referred to the LTO Technical Report, which on the one hand is written in Dutch and on the other hand also contains only general information.

In ANSWERS (2021), it is stated that all measures of the action plan for the LTO project have been implemented. However, the LTO action plan does not include the current requirements or all technically feasible backfitting measures.

Final recommendation FR2

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

Final recommendation FR3

It is recommended that all requirements of WENRA Reference Level F be met. In case of deviations, the reasons should be explained.

5 ACCIDENT ANALYSIS

5.1 Short summary of the expert statement

The EU stress test results revealed a large number of deficits in the Severe Accident Management (SAM) of the Belgian nuclear power plants. A wide range of remedies has been realized in the frame of the National Action Plan. However, partly they consisted only in the procurement of mobile equipment.

According to the EIA Report (UVP-BERICHT 2021), nuclear safety will be improved after the implementation of the Long Term Operation (LTO) measures. The update of the Probabilistic Safety Assessment (PSA) showed that the core damage frequency has been more than halved in particular thanks to the additional deployment of Filtered Containment Venting Systems (FCVS). Data on core damage frequency (CDF) and large releases (LRF) have not been provided in the EIA Report. Moreover, the frequencies calculated by the PSA are to be understood only as a rough risk indicator. In terms of safety the fact that the CDF reduction has been achieved by the installation of FCVS which should have taken place years or decades ago, does not deserve praise.

To assess the radiological impacts of a Beyond-Design-Basis-Accident, the Complete Station Black-Out scenario (CSBO) was used. Why this scenario should be sufficient as a covering event was not explained nor why the base would not melt through. No preventive equipment is installed to prevent an accident scenario with late large releases.

The source term which is used as the covering severe accident resulted from a core melt accident, however with the containment integrity maintained. That the containment integrity would not fail during an accident, in particular caused by an airplane crash, has not been proven.

Several accident scenarios exist which could threaten the containment integrity, thus making large releases possible. NEA (2020) stated that the PSA-2 analyses for Doel 1&2 established that 40% of core-melt accidents cause containment failure (by melt-through of the base, containment-bypass or ex-vessel steam explosions). Those analyses refer to the status of the plant in 2010. The safety up-rates and their impacts on the PSA results are unknown; they should have been presented during the EIA procedure.

The accident analysis in the EIA Report should have used a possible source term which is deducted from a calculation in the currently valid PSA-2. In any case the EIA Report should have contained a sound explanation for the source term used. To make an assessment of Beyond-Design-Basis-Accidents (BDBA) possible it is necessary to analyze severe accidents with containment failure and/or containment bypass. Such severe accidents are possible for Doel 1&2.

The Directive 2014/87/EURATOM should be used as reference to identify reasonably practicable safety improvements. In line with this rule, core-melt acci-

dents which would lead to early or large releases have to be practically eliminated. The EIA Report (UVP-BERICHT 2021) for Doel 1&2 does not mention the concept of “practical elimination”.

5.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F18 *What are the source terms for the beyond design-basis accidents calculated in PSA Level 2?*

Written answer by the Belgian side

The PSA Level 2 of Doel 1/2 considers the following categories for grouping the source terms of all accidental scenarios:

- small releases less than 0.01% of the initial core inventory
- medium releases between 0.01% and 0.1% of the initial core inventory
- large releases between 0.1% and 1% of the initial core inventory
- very large releases above 1% of the initial core inventory

Besides, these categories are assessed for the different classes of radionuclides released.

Assessment of the answer

The question is not answered. The source term for a severe accident calculated in the PSA 2 was not provided, only some information about categories of releases. It has to be pointed out that the translation of the question was not correct. The original question was about the source term of beyond design accidents (BDBAs).

Question F19 *What is the technical justification for the BDBA chosen for the calculation of possible cross-border effects? Why is this accident considered to also cover the crash of an aircraft?*

Written answer by the Belgian side

See justification developed in Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.7.1.

Calculations demonstrating the representative character of the radiological source term of the selected scenario for the BDBA sequences, using the different available PSA models, were made and reviewed by the Safety Authority, to demonstrate the appropriate choice of the BDBA (Complete Station Black-Out,

CSBO). The representative character of the radiological source term and radiological consequences of this BDBA scenario compared to the scenario of a realistic accidental airplane crash was also demonstrated and shared with the Safety Authority.

For all other accident analyses mitigation measures are implemented to decrease the accident probability and consequences.

Assessment of the answer

The question is answered. However, the technical justification for the chosen accident scenario consisted in the argument that the nuclear safety regulator had agreed to this choice. In addition, it is pointed out that for other accident scenarios measures are implemented to reduce the probability. It is not justified to point only to the low probability of an accident.

Question F20 *How is a meltdown of the foundation due to a core meltdown to be prevented?*

Written answer by the Belgian side

In the early 2000, severe accident management guidelines have been implemented to mitigate core meltdown accidents. At the same period a cavity flooding device has been installed at units D12 to allow water from the sump to enter the reactor cavity pit to enable quenching the corium in case of a severe accident leading to a potential vessel failure.

Link: <https://afcn.fgov.be/fr/system/files/2011-10-31-electrabel-kc-doel.pdf>

Assessment of the answer

The question is answered. Yet doubts persist concerning the reliability of the above measures to prevent a basement meltdown. Comprehensive investigations or studies are not referenced. Such studies were performed by EDF and IRSN as part of the LTE project of the French 900 MW reactors. (UMWELTBUNDESAMT 2021a)

Question F21 *Why was no accident scenario with containment bypass calculated in the EIA?*

Written answer by the Belgian side

See justification on the envelope case, in Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.7.1 and answer to question F19. Concerning accident scenario with Containment bypass, in case of DEC-B, it has been demonstrated that this scenario is practically eliminated as requested by the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations.

Assessment of the answer

The question is answered. According to the ANSWERS (2021), a containment bypass scenario has been practically excluded. It remains unclear whether the demonstration of practical exclusion has been made in accordance with WENRA RHWG (2019). It should also be noted that according to NEA (2020) the PSA 2 analyses for Doel 1&2 determined that 40% of core melt accidents cause containment failure. The phenomena connected to containment failure are foundation meltdown, containment bypass and ex-vessel steam explosion.

Question F22 *Did the EIA process include an analysis of the crash of a representative commercial airliner and a representative military aircraft, or was an alternative event considered instead? Which aircraft were determined to be representative?*

Written answer by the Belgian side

An alternative event was considered as it was demonstrated by safety studies that the aircraft crash accident is covered by the CSBO scenario with regards to the radiological consequences, see Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, §3.4.7.1. This demonstration has been shared with the Safety Authority. The aircraft characteristics are legally classified due to information related to the physical protection of the NPP.

Assessment of the answer

The question is partly answered. The answer confirmed that instead of analyzing an airplane crash scenario an alternative event (CSBO scenario) was considered. It is explained the aircraft characteristics are legally classified. However, considering the results of the report “Belgian stress tests National report on nuclear power plants - Man-made events” (FANC 2012) from a technical point of view it is not justified to assume that an aircraft crash is covered by a CSBO scenario.

Question F23 *Has a DEC-B analysis been performed or will be performed to identify reasonably practicable measures to mitigate the consequences of significant fuel damage or conditions that could result in early or large radioactive releases, to the extent such damage or conditions have not been determined to be extremely unlikely with a high degree of confidence?*

Written answer by the Belgian side

A DEC-B analysis has been performed and is under instruction with the Safety Authority in accordance with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations.

Assessment of the answer

The question is partly answered. A DEC-B analysis has been performed but the safety authority has not completed the assessment of this analysis. In addition, it remains unclear whether reasonably practicable mitigation measures have been identified to address the consequences of significant core damage.

Preliminary recommendation VE6

It is recommended to apply the WENRA safety objectives for new NPPs to identify reasonably practicable safety improvements for Doel 1&2. Even if the probability of an accident scenario is very low, all additional reasonably practicable safety improvements to reduce the risk should be implemented. It is recommended that the concept of practical exclusion for accidents with early or large releases will be used for this approach.

Written answer by the Belgian side

As part of the LTO Design area, one of the pillars is a benchmark with New NPP's. The analysis (<https://fanc.fgov.be/nl/system/files/2015-07-03-electrabel.pdf>) has led to some improvement projects which were implemented as part of the Doel 1 and Doel 2 LTO programme, in line with WENRA safety objectives. Besides, as mentioned previously, design improvements identified in the Belgian Stress Tests performed after Fukushima, were also implemented.

As explained above, the WENRA RLs 2014 have been fully implemented in Belgian Law in the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations. This Royal Decree provides a transitory regime to be compliant with its requirements. The Royal Decree of 19th February 2020 requires the operators to carry out studies by June 2022 in order to determine whether its requirements are met.

Preliminary recommendation VE7

It is recommended to provide the following information on incident analyses and the results of the PSA (Level 1 and 2) in order to be able to comprehensibly assess whether Austria is potentially affected:

- Core damage frequency (CDF) and large (early) release frequency (L(E)RF).
- Contribution of internal events and internal and external hazards to CDF and L(E)RF.
- Share of core meltdown accidents leading to containment failure
- List of beyond design basis accidents (BDBAs) and associated source terms.
- Source terms of the BDBAs including releases from the fuel pools
- Time periods to restore safety functions after loss of heat dissipation and/or station blackout and cliff edge effects.

- Measures taken to control major accidents or mitigate their consequences.

Written answer by the Belgian side

The Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, § 3.4.7.1 contains the expected radiological consequences for Austria in an accidental situation and the methodology that led to this result.

Assessment of the answer

The request has not been followed. However, this information would be needed to evaluate the risks Doel 1&2 poses for Austria.

5.3 Conclusions and final recommendations

The results of the EU stress tests revealed deficiencies of the Belgian NPP's Severe Accident Management (SAM). Numerous remedial measures were implemented as part of the National Action Plan. However, some of these consisted only in the procurement of mobile equipment to prevent a severe accident or to mitigate its consequences.

According to the EIA Report, nuclear safety was improved after implementation of the LTO measures. It is stated that the probabilistic safety analysis (PSA) update shows that the core damage frequency (CDF) has more than halved, especially due to the retrofit of the Filtered Containment Venting Systems (FCVS). However, data on CDF and large releases frequency (LRF) are not provided in the EIA Report. From a safety point of view, it is also not credible that the reduction of the CDF was achieved by an implementation of a FCVS, which has been overdue for years or decades.

The Complete Station Black-Out (CSBO) scenario is used as the beyond-design-basis accident (BDBA) for determining radiological consequences. It is not explained why this scenario is considered as a covering event. Preservation of containment integrity during an accident, particularly triggered by an aircraft crash, is not proven. In ANSWERS (2021), it is confirmed that the CSBO scenario is considered instead of an airplane crash. However, considering the results of the "Belgian stress tests National report on nuclear power plants - Man-made events" (FANC 2012) it is not comprehensible that an aircraft crash is covered by a CSBO scenario.

There is no convincing technical justification of the chosen accident scenario. In addition, it is pointed out that for other accident scenarios measures are implemented to reduce the probability. It is not justified to point only to the low probability of an accident. The source term of the severe accident, which is referred to as a covering severe accident, results from a core meltdown accident, but under the assumption that the integrity of the containment is maintained.

According to the ANSWERS (2021), a containment bypass scenario has been practically excluded. It is not said whether the demonstration of practical exclusion has been made in accordance with WENRA RHWG (2019).

It should also be noted that according to NEA (2020) the PSA 2 analyses for Doel 1&2 determined that 40% of core melt accidents cause containment failure. The phenomena connected to containment failure are foundation meltdown, containment bypass and ex-vessel steam explosion. These analyses refer to the plant`s status in 2010. The safety improvements made since then and their impact on the results of the PSA are not known and should have been presented as part of the EIA procedure.

There are accident scenarios that could compromise the integrity of the containment, therefore making large releases possible. A DEC-B analysis has been performed by the operator, but the nuclear safety authority has not completed the assessment of this analysis. ANSWERS (2021) does not clarify whether reasonably practicable mitigation measures have been identified to address the consequences of significant core damage.

The accident analyses in the EIA procedure should have used a possible source term derived from the calculation of the current PSA 2. Even though the probability of severe accidents with an early and/or large release is considered very low for the existing plants, the consequences of these accidents are very severe. For assessing the consequences of BDBAs, it is necessary to analyze a number of severe accidents, including those with containment failure and containment bypass. Such severe accidents are possible for Doel 1&2.

Final recommendation FR4

It is recommended to apply the WENRA safety objectives for new NPPs to identify reasonably feasible safety improvements for Doel 1&2. Even if the probability of an accident scenario is very low, all additional reasonably feasible safety improvements to reduce the risk should be implemented. It is recommended that the concept of practical exclusion for accidents with early or large releases will be used for this approach.

6 ACCIDENTS CAUSED BY EXTERNAL EVENTS

6.1 Short summary of the expert statement

The EIA documents contained only general information on the NPP Doel 1&2 design against the impact of natural hazards and the plant's protection against such impacts. The information is limited to a few specific data on flooding (river floods, extreme precipitation), storm and extreme temperatures, which are discussed in the climate change context. Under this aspect the risk of flooding the plants during heavy rain events is highly relevant because such flooding and the failure of the drainage systems have been observed in recent years several times. A comprehensive evaluation of natural hazards is lacking. It was not possible to understand whether and to which extent natural hazards have been dealt with in the framework of the most recently conducted Periodic Safety Review (PSR) or in the framework of the „Long Term Operation (LTO)“ project. WENRA (2021) requires a periodic review of possible impacts of natural hazards, the minimum being one during the 10-year PSR. If necessary, the results from the review should lead to an adaptation of the plant design basis and be taken into account for the assessment of Beyond-Design-Basis-Accidents (WENRA 2015, 2021).

That Doel 1&2 is sufficiently protected against the impacts of natural hazards has not been proven.

6.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F24 *As part of the EIA process and/or as part of the extension of the operating license for Doel 1&2 (LTO), has the original design basis been systematically reviewed with respect to the impact of natural hazards?*

Written answer by the Belgian side

As part of the Belgian regulations, each NPP is subject to a Periodic Safety Review at least every 10 years. This process is reviewed and challenged by the Belgian Safety Authority. As part of the PSR (following IAEA NS-G-2.10 now superseded by IAEA SSG 25) the selected Needs and Opportunities for Improvement are identified and implemented as part of the PSR implementation plan, including with respect to the impacts of natural hazards. See also answer to F25.

Link : https://fanc.fgov.be/nl/system/files/2015-11-30_ebl-psrii-doel-12-lto-synthese-report.pdf

Assessment of the answer

Neither the written reply nor the referenced document (ELECTRABEL 2015) provided evidence of a systematic re-evaluation of the site-specific hazards as part of the EIA process or the extension of the operating license for Doel 1&2. However, FANC (2020a)³ provided evidence that the Stress Tests of the Belgian nuclear power plants comprised a reassessment of the *protection* of the nuclear reactors against seismic and external-flooding hazards as well as extreme meteorological conditions. This included re-assessments of the site-specific seismic hazard in 2011 and 2015. The results were approved by Belgian Regulatory Authority (FANC) in 2016. For external flooding and extreme weather conditions FANC (2020a) only reports on *protection measures* leaving open whether new *hazard assessments* were conducted or not.

Question F25 *Have new hazard analyses for natural hazards at the site been carried out as part of the EIA process and/or as part of the extension of the operating license (LTO) for Doel 1&2 and/or other projects?*

Written answer by the Belgian side

As part of the Belgian regulations, each NPP is subject to a Periodic Safety Review (PSR) at least every 10 years. This process is reviewed and challenged by the Belgian Safety Authority. The PSR contains a chapter dedicated to SF7 Hazards (following IAEA NS-G-2.10, now superseded by IAEA SSG 25): "*The objective of the review of hazard analysis is to determine the adequacy of protection of the nuclear power plant against internal and external hazards with account taken of the actual plant design, actual site characteristics, the actual condition of SSCs and their predicted state at the end of the period covered by the PSR, and current analytical methods, safety standards and knowledge.*" This assessment was performed in 2015 as part of the PSR - LTO for Doel 1 and Doel 2 and submitted to the Belgian Safety Authority. According to the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations, complementary analyses have been performed, including with respect to the impacts of natural hazards.

Link: https://fanc.fgov.be/nl/system/files/2015-11-30_ebl-psrii-doel-12-lto-synthese-report.pdf

Assessment of the answer

The reply referred to IAEA NS-G-2.10 and IAEA SSG 25 providing guidance for *determining the adequacy of protection of the nuclear power plant against internal and external hazards in PSR*. This, however, is not necessarily identical with WENRA (2021) requiring a periodic review of *possible impacts of natural hazards*, the minimum being one during the 10-year PSR. If necessary, the results from the review should lead to an adaptation of the plant design basis and be taken

³ Referenced in answer to question F27 below

into account for the assessment of Beyond-Design-Basis-Accidents (WENRA 2015, 2021).

The answer of the Belgian side therefore essentially repeated the answer to Question F24 leaving open whether or not new and updated assessments of the site-specific external flooding hazards and extreme weather conditions have been performed. Re-assessments of the site-specific seismic hazards were completed in 2011 and 2015 (FANC 2020a).

Question F26 *If new hazard analyses have been performed: did they confirm the original design of the equipment, or were safety-related retrofits necessary?*

Written answer by the Belgian side

The complementary analyses done following the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations lead mainly to the confirmation of the design basis or design extension conditions from previous PSR and Stress Tests (seism, external flooding, extreme weather conditions) and some procedural improvements regarding extreme temperature were identified and implemented.

Assessment of the answer

The answer sufficiently clarified the question. In addition, FANC (2020a) stated that the seismic hazard re-assessments for Doel 1 and Doel 2 performed in 2011 and 2015 “nearly conformed with the values used in the design basis”. The document, however, refrained from quantifying the exact meaning of “nearly” (FANC 2020a, p. 9).

Question F27 *Has the design of Doel 1&2 taken into account impacts from extreme meteorological events, especially for heavy rain (flash flood) events with an average recurrence interval of 10,000 years?*

Written answer by the Belgian side

Yes, this has been taken into account. See PSR report on FANC website, as well as the "National final report on the stress tests of nuclear power plants" issued by FANC in September 2020. (see paragraph 3.1.3).

Link: https://fanc.fgov.be/nl/system/files/2015-11-30_ebl-psrii-doel-12-lto-synthese-report.pdf, <https://afcn.fgov.be/fr/system/files/best-2020.pdf>

Assessment of the answer

The answer indicated that extreme events with recurrence frequencies of 10^{-4} per year are considered.

Question F28 *Does the design capacity of the site's drainage system meet the requirements resulting from a flash flood with a 10,000-year return period?*

Written answer by the Belgian side

This subject has been considered in frame of PSR and BEST. See PSR report on FANC website, as well as the "National final report on the stress tests of nuclear power plants" issued by FANC in September 2020. (see paragraph 3.1.3): "At Doel, the licensee finalized its re-evaluation of the impact of heavy rains in 2014 and concluded that the site is satisfactorily protected against the potential impact of heavy rains."

Finally requirements resulting from a flash flood with a 10,000-year return period has been successfully readdressed in frame of the project that has as objective to get compliancy with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (considering a.o. WENRA RL 2014).

Link: https://fanc.fgov.be/nl/system/files/2015-11-30_ebl-psrii-doel-12-lto-synthese-report.pdf, <https://afcn.fgov.be/fr/system/files/best-2020.pdf>

Assessment of the answer

According to the answer the design capacity of the site's drainage system meets the requirements resulting from a flash flood with a 10,000-year return period.

Question F29 *In the EIA documents, the probability of a dike breach at the "most critical location" is given as once in 1,700 years and the resulting flood height at the site is given as up to 60 cm water depth. Are these values consistent with WENRA's (2021) safety expectations for natural hazards, particularly with the establishment of a 10^{-4} per year probability of occurrence for design basis accidents?*

Written answer by the Belgian side

Yes, this is compliant. It is an outcome of the complementary analysis done as part of the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for nuclear installations.

Link: <https://afcn.fgov.be/fr/system/files/best-2020.pdf>

Assessment of the answer

The answer claimed that the relatively high probability of a dam breach (once in 1.700 years) is still in line with the WENRA's (2021) safety expectations for natural hazards, particularly with the definition of a design basis flood that corresponds to a probability of occurrence of 10^{-4} per year. No information is provided on how this conformity is achieved. If correct, the Belgian answer must imply that the flood heights of up to 60 cm at the site resulting from dam breach are (1) enveloped by the design basis flood and (2) adequate volumetric protection for all buildings and basements housing SSCs relevant to safety as well as all subsurface ducts that lead to such buildings and basements is in place.

Question F30 *Is the investigated "representative beyond-design-basis accident" also representative for beyond-design-basis earthquake loads? What is the safety margin of the containment design and the containment filtered venting systems relative to the design-basis earthquake?*

Written answer by the Belgian side

Yes, the analysis of the maximum credible earthquake (MCE) has been performed. The results of the MCE determination for the Doel site is below 0,1 PGA. Indeed it has to be noted that the particular characteristics of subsoil layers between bedrock and surface make it impossible to go above >0,1g PGA.

As such there are significant safety margins on the containment design and the containment filtered venting systems relative to the design-basis and beyond design basis earthquake.

Assessment of the answer

The answer of the Belgian side sufficiently clarified the question.

Preliminary recommendation VE8

It appears uncertain whether all natural hazards relevant to the site have been considered in the site safety analysis, as required by WENRA (2021) and further explained by WENRA (2015). The expert team recommends using the "Non-Exhaustive List of Natural Hazards" (WENRA 2015) as a starting point to ensure that all site-specific hazards affecting Doel 1&2 are considered.

Written answer by the Belgian side

In compliance with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for nuclear installations, the "Non-exhaustive list of Natural Hazards" (WENRA 2015) has been considered as a starting basis in the site safety analysis.

Assessment of the answer

The answer confirmed that actions consistent with the recommendation have already been implemented. The recommendation is therefore outdated.

Preliminary recommendation VE9

It appears uncertain whether all hazard combinations have been considered in the assessment of the site, as required by WENRA (2021) and further explained by WENRA (2015). The expert team recommends the use of a hazard correlation diagram (e.g. Decker & Brinkman 2017) as a starting point to ensure that all relevant combinations are considered.

Written answer by the Belgian side

In compliance with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for nuclear installations, hazard combinations have been taken into account for the assessment of the site, considering further independent, correlated, induced combinations of events.

The methodology is based on the ANSI/ANS 2.12⁴: “Guidelines for combining natural and external man-made hazards at power reactor sites” uses a combination of deterministic and probabilistic arguments to obtain a list of screened in combinations of events. The probabilistic criterion is also used to characterize the combinations.

Assessment of the answer

The answer stated that actions consistent with the recommendation have already been implemented. The cited reference, ANSI (1978), however, is an outdated standard and has been withdrawn by the American Nuclear Society already in 1988.

The recommendation to consider up-to-date requirements (WENRA 2021) and guidance (WENRA 2015; Decker & Brinkman 2017) for the analysis of hazard combinations relevant to the site is therefore still valid.

Preliminary recommendation VE10

The expert team recommends re-evaluating the probability of occurrence of extreme precipitation leading to flooding of the site and comparing the results with the capacity of the drainage system. The rainfall intensity corresponding to the occurrence probability of 10^{-4} per year should be used as a design basis for the capacity of the drainage system.

⁴ ANSI (1978)

Written answer by the Belgian side

Yes, this has been taken into account. See the "National final report on the stress tests of nuclear power plants" issued by FANC in September 2020. (see paragraph 3.1.3):

"At Doel, the licensee finalized its revaluation of the impact of heavy rains in 2014 and concluded that the site is satisfactorily protected against the potential impact of heavy rains."

Link : <https://afcn.fgov.be/fr/system/files/best-2020.pdf>

Assessment of the answer

The answer confirmed that actions consistent with the recommendation have already been implemented. The recommendation is no longer relevant.

Preliminary Recommendation VE11

The expert team recommends upgrading the capacity of the drainage systems to ensure that precipitation intensities with probabilities of occurrence of 10^{-4} per year do not result in

- water intrusion into buildings housing safety-related systems and components,
- flooding of the basements of such buildings

Written answer by the Belgian side

Yes, this has been verified. See the "National final report on the stress tests of nuclear power plants" issued by FANC in September 2020. (see paragraph 3.1.3):

"At Doel, the licensee finalized its revaluation of the impact of heavy rains in 2014 and concluded that the site is satisfactorily protected against the potential impact of heavy rains."

Finally, requirements resulting from a flash flood with a 10,000-year return period has been successfully readdressed in frame of the project that has as objective to get compliancy with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (considering a.o. WENRA RL 2014).

Link : <https://afcn.fgov.be/fr/system/files/best-2020.pdf>

Assessment of the answer

The answer confirmed that actions consistent with the recommendation have already been implemented. The recommendation is no longer relevant.

Preliminary recommendation VE12

The expert team recommends considering all combinations of relevant flood height determining processes such as river floods, spring tides, storm surges and waves when assessing the flood risk from the Scheldt. (WENRA 2016a).

Written answer by the Belgian side

Initial analyses have been performed as part of the Belgian Stress Tests, and were complemented with additional studies in compliance with the Royal Decree of 19th February 2020 which modifies the Royal Decree of 30 November 2011 on the Safety Requirements for Nuclear Installations considering the combinations as mentioned.

Link: https://fanc.fgov.be/nl/system/files/2015-11-30_ebl-psrii-doel-12-lto-synthese-report.pdf

Assessment of the answer

The answer confirmed that actions consistent with the recommendation have already been implemented. The recommendation is no longer relevant.

6.3 Conclusions and final recommendations

Evaluation of the documents⁵ and answers⁶ of the Belgian side that were provided in written form in addition to the EIA Documents in September 2021 lead the expert team to conclude the following.

The assessment of natural hazards that can have a negative impact on the safety of the Doel 1&2 NPP started from the "Non-exhaustive list of Natural Hazards" published by WENRA (2015). The Belgian side stated that all natural hazards that apply to the site were identified and analysed. ANSWERS (2021) further stated that the design bases of the Doel 1&2 NPP and the corresponding protection are robust to withstand natural hazards with severities that correspond to frequencies of occurrence of 10^{-4} per year. FANC (2020a) provided concordant information stating, in addition, that seismic hazards have been re-assessed in 2011 and 2015 (FANC 2020a). According to FANC (2020a) adequate protection is in place for seismic hazards, external flooding and extreme weather phenomena. It was not possible to make this conclusion from the earlier submitted EIA documents.

According to ANSWERS (2021), the analyses also considered hazard combinations that apply to the site. Analyses were based on the guidelines provided by

⁵ ELECTRABEL (2015); FANC (2020a)

⁶ ANSWERS (2021)

ANSI (1978). ANSI (1978), however, is an outdated standard and has been withdrawn by the American Nuclear Society already in 1988. The expert team therefore suggests to consider up-to-date WENRA requirements and guidelines for analysing hazard combinations.

The answers by the Belgian side confirmed that actions consistent with all preliminary recommendations have already been implemented, except for the analysis of hazard combinations which was based on outdated US standards (ANSI 1978).

Final recommendation FR5

Assessment of hazard combinations that apply to the site were performed according to ANSI (1978). This, however, is an outdated standard that has been withdrawn by the American Nuclear Society already in 1988. It is therefore recommended to consider up-to-date requirements (WENRA 2021) and guidance (WENRA 2015; DECKER & BRINKMAN 2017) for the analysis of hazard combinations relevant to the site.

7 ACCIDENTS WITH THIRD PARTIES' INVOLVEMENT

7.1 Short summary of the expert statement

Acts of terrorism and sabotage can have significant impacts on nuclear facilities and cause severe accidents. However, they are not mentioned in the EIA documents. Comparable EIA documents have discussed such events to a certain degree.

While precautions against acts of sabotage and terrorism cannot be discussed publicly in detail during the EIA process for reasons of confidentiality, EIA documents should present the necessary legal requirements.

Information on the topic of terror acts would be very important when taking into account the significant impact of possible acts of terrorism. Information about the requirements for protection against the intended crashes of a commercial airliner would be of particular interest, because the Doel 1&2 reactor building is vulnerable toward an airplane crash according to a 2012 FANC report. (FANC 2012) Ageing-related degradation can further decrease the building's robustness.

A recent assessment reveals deficits compared to the necessary requirements: The 2020 NTI index rated the conditions for nuclear safety in relation to the nuclear facilities' protection against acts of sabotage. With a total of 80 points out of 100, Belgium is ranking only 16th out of 47 countries; this points to an insufficient level of protection. (NTI 2021) Deficits exist for protection against insiders and in the field of cyber security.

It has to be noted that in the past Belgian nuclear facilities were exposed to a specific threat situation.

7.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F31 *What are the requirements for the protection of Doel 1&2 with respect to the intentional crash of a commercial aircraft?*

Written answer by the Belgian side

A specific analysis has been performed on this topic as part of the Belgian Stress Tests, and requirements are defined by the Safety Authority (information is legally classified due to information related to the physical protection of the NPP).

The resistance of Doel 1 and Doel 2 against representative airplanes has been demonstrated. Additional measures against consequences of aircraft crash have been implemented following the Belgian Stress Tests.

Assessment of the answer

The statement refers to legal provisions which demand keeping the requirements legally classified. However, in most cases legal requirements are not classified. In other countries like Germany these requirements are known to the public. Furthermore, it is stated that the robustness of Doel 1&2 against representative airplanes has been demonstrated. Additional measures against consequences of aircraft crash have been implemented following the Belgian Stress Tests. However, one result of the Belgian Stress Tests was that in the event of a commercial aircraft crash, significant damage could occur to the outer containment of Doel 1&2. Therefore, it cannot be excluded that engines and other rigid parts could penetrate the containment. (FANC 2012) The subsequent, very likely, failure of the cooling system could result in a severe accident namely an open containment core meltdown accident. The radioactive releases would be very high and would occur particularly early.

Question F32 *Against which external attacks must the reactor building and other safety-relevant buildings be designed? Is this protection still guaranteed despite adverse ageing effects?*

Written answer by the Belgian side

This information is legally classified due to information related to the physical protection of the NPP.

Assessment of the answer

It is stated that this information is subject to classification law. However, legal requirements are mostly not classified. In other countries like Germany these requirements are known. The question concerning adverse ageing effects is not answered.

Question F33 *What were the main outcomes of the IAEA's International Physical Protection Advisory Service (IPPAS) mission conducted in 2019?*

Written answer by the Belgian side

This information is legally classified due to information related to the physical protection of the NPP.

Question F34 *How is the current threat level for nuclear facilities in Belgium assessed, what is the current threat level and what does this mean for Doel 1&2?*

Written answer by the Belgian side

This information is legally classified due to information related to the physical protection of the NPP.

Assessment of the answer

It is again stated that the information is classified. This is interesting because last year, information about this issue was published by FANC (2020b).

Preliminary recommendation VE13

The EIA process should present the general requirements related to the protection against an intentional crash of a commercial aircraft and other acts of terrorism and sabotage.

Written answer by the Belgian side

This information is legally classified due to information related to the physical protection of the NPP. A specific analysis has been performed on this topic as part of the Belgian Stress Tests, and requirements are defined by the Safety Authority.

Link: https://fanc.fgov.be/nl/system/files/specificaties_stress_tests_fanc.pdf

Preliminary recommendation VE14

In view of the particular threat situation in Belgium, high priority should be given to potential accidents by third parties (terrorist attacks or acts of sabotage). Protection against potential cyber-attacks and internal perpetrators should be improved.

Written answer by the Belgian side

This information is legally classified due to information related to the physical protection of the NPP.

7.3 Conclusions and final recommendations

Terrorist attacks and acts of sabotage can have a significant impact on nuclear facilities and cause severe accidents - also for Doel 1&2. Nevertheless, they are not mentioned in the EIA documents. In comparable EIA documents, such

events have been discussed to some extent. Although precautions against sabotage and terrorist attacks cannot be discussed in detail publicly in the EIA process for reasons of confidentiality, the necessary legal requirements should be outlined in the EIA documents.

Information on the subject of terrorist attacks would be of great interest given the significant impact of possible attacks. In particular, the EIA document should include information on the requirements for protection against an aircraft crash. According to ANSWERS (2021), the information of the requirements is classified. However, in most countries these requirements are not classified and are known to the public, e.g. in Germany.

Furthermore, it is stated that the robustness of Doel 1&2 against representative airplanes has been demonstrated. Additional measures against consequences of aircraft crash have been implemented following the Belgian Stress Tests. However, one result of the Belgian Stress Tests was that in the event of a commercial aircraft crash, significant damage could occur to the outer containment of Doel 1&2. Therefore, it cannot be excluded that engines and other rigid parts could penetrate the containment. The subsequent and very likely failure of the cooling system could result in a severe accident namely an open containment core meltdown accident. The radioactive releases would be very high and would occur particularly early.

A recent assessment of nuclear safety in Belgium indicates deficiencies in fulfilling the necessary nuclear security requirements: The 2020 NTI Index assesses nuclear safety conditions in terms of protecting nuclear facilities from acts of sabotage. With an overall score of 80 out of 100, Belgium ranks only 16th out of 47 countries, indicating a level of protection that could be improved. (NTI 2021) There are deficits in protection against internal perpetrators and in the field of cyber security.

It should be noted that according to FANC (2020b), a particular threat situation for nuclear facilities in Belgium) has occurred in recent years. Information in ANSWERS (2021) declared that information about the current situation is classified.

Final recommendation FR6

In view of the particular threat situation in Belgium, high priority should be given to potential accidents by third parties (terrorist attacks or acts of sabotage). Protection against potential cyber-attacks and internal perpetrators should be improved.

8 TRANS-BOUNDARY IMPACTS

8.1 Short summary of the expert statement

A severe accident with releases reaching Austrian territory can have significant trans-boundary impacts on Austria. The EIA report contains dose calculations for Belgium's neighbouring countries for Beyond-Design-Basis-Accidents with an intact containment. However, it cannot be understood as proven that a higher source term cannot occur. In addition, certain weather conditions can lead to contamination also in Austria. Because the EIA did not provide adequate calculations, the impacts on Austria could be underestimated. Those impacts range from exceeding the 1 mSv annual effective dose for children as well as for adults to possibly reaching the intervention threshold value according to the Federal Emergency Plan (BMK 2020) and the need for agricultural protection measures according to the Austrian catalogue of counter-measures (BMLFUW 1994).

The expert team recommends conducting calculations of trans-boundary impacts for a severe accident with containment failure or containment bypass and a severe accident with fuel damage in the storage pool independently of the determined frequency of occurrence if they are physically possible.

8.2 Questions & preliminary recommendations, answers and assessment of the answers

Question F35 *What is the largest source term identified in the probabilistic safety analyses (PSA) (regardless of its probability)?*

Written answer by the Belgian side

Given the answer to F18, the largest source term identified in the PSA Level 2 is associated to very large releases, meaning more than 1% of the initial core inventory.

Assessment of the answer

The question is not answered. The term “*more than 1% of the initial core inventory*” is not sufficient to evaluate the calculation of the possible transboundary consequences. The used source term for the EIA Report should be provided bilaterally.

Question F36 *What are the results of the dispersion calculation for this source term? It is requested to present these results also 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 overall national emergency plan (BMK 2020).

Written answer by the Belgian side

Detailed results are provided for neighbour countries of Belgium. (see Environmental Impact Report : Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2, § 3.4.7.1). At further distance, these coefficients are lower and resulting doses insignificant.

Reference accident		Dose at the Dutch border (mSv)	License limit (mSv)
LOCA	Effective dose	0.28	2.7
	Thyroid dose	5.4	5.4
FHA at the fuel basin	Effective dose	0.46	1.5
	Thyroid dose	5.4	8.0
CSBO	Effective dose	0.45	none
	Thyroid dose	0.19	none

“For the countries of France, Germany, Luxembourg, and the United Kingdom (bordering Belgium), dose calculations were performed based on the calculations done for the Dutch border based on the design-based accidents FHA and LOCA. These calculations show that the doses would be reduced by a factor of about 65 for France, 80 for Germany, 120 for Luxembourg and 130 for the United Kingdom compared to the results at the Dutch border. For other countries that are further than 1000 km away from KCD-1 and KCD-2 (such as Sweden, Austria, Poland, Czech Republic, Denmark, and Ireland), the impacts are limited by the impacts evaluated at the Luxembourg border, i.e., at least 120 times lower than at the Dutch border, thus implying a nonsignificant radiological impact due to the design-based accidents “ [Tractebel, 2020d].

The calculated effective dose at Luxembourg border for the CSBO based on the above, leads to the value of 0,00375 mSv. This calculated effective dose will be lower at the Austrian border because of further dilution effects due to the distance. Comparing this value at the Luxembourg border (conservatively) with the Austrian Emergency Plan, where the limit is 1 mSv over 2 days for persons younger than 18 years and pregnant woman (table 23) shows that no measures would have to be taken.

Assessment of the answer

The question has not been answered fully. Besides the fact that the used source term has not been provided (see above F35), only dose results of dispersion calculations were given, but no contamination data.

Preliminary recommendation VE15

It is recommended to calculate the transboundary impacts for a severe accident with containment failure or containment bypass and for a severe accident with fuel pool damage, regardless of their determined probability of occurrence, as long as they are physically possible.

Written answer by the Belgian side

Calculations are made for envelope scenarios, in a deterministic way (regardless of event probability) as well as using the PSA models, leading to insignificant doses at further distance. (Environmental Impact Report: Doel Nuclear Power Station for the LTO of Doel 1 and Doel 2 § 3.4.7.1 and further).

Assessment of the answer

As discussed also in chapter 7, the possibility of a Beyond-Design-Basis-Accidents with a higher source term than used in the EIA calculations cannot be excluded. Therefore the calculated doses might underestimate impacts on Austria. The preliminary recommendations remains valid.

8.3 Conclusions and final recommendations

A severe accident with releases reaching Austrian territory can have significant trans-boundary impacts on Austria. The EIA report contains dose calculations for Beyond-Design-Basis-Accidents with an intact containment. However, it cannot be understood as proven that a higher source term cannot occur. In addition, certain weather conditions can lead to contamination also in Austria. Because the EIA did not provide adequate calculations, the impacts on Austria could be underestimated. Those impacts range from exceeding the 1 mSv annual effective dose for children as well as for adults to possibly reaching the intervention threshold value according to the Federal Emergency Plan (BMK 2020) and the need for agricultural protection measures according to the Austrian catalogue of countermeasures (BMLFUW 1994).

Final recommendation FR7

It is recommended to calculate the transboundary impacts for a severe accident with containment failure or containment bypass and for a severe accident with fuel pool damage, regardless of their determined probability of occurrence, as long as they are physically possible.

9 SUMMARY OF FINAL RECOMMENDATIONS

9.1 Procedure and alternatives

Final recommendation FR1

It is recommended that the results of the EIA be included in the approval of the lifetime extension.

9.2 Long-term operation of reactor type

Final recommendation FR2

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

Final recommendation FR3

It is recommended that all requirements of WENRA Reference Level F be met. In case of deviations, the reasons should be explained.

9.3 Accident analysis

Final recommendation FR4

It is recommended to apply the WENRA safety objectives for new NPPs to identify reasonably feasible safety improvements for Doel 1&2. Even if the probability of an accident scenario is very low, all additional reasonably feasible safety improvements to reduce the risk should be implemented. It is recommended that the concept of practical exclusion for accidents with early or large releases will be used for this approach.

9.4 Accidents caused by external events

Final recommendation FR5

Assessment of hazard combinations that apply to the site were performed according to ANSI (1978). This, however, is an outdated standard that has been withdrawn by the American Nuclear Society already in 1988. It is therefore recommended to consider up-to-date requirements (WENRA 2021) and guidance (WENRA 2015; Decker & Brinkman 2017) for the analysis of hazard combinations relevant to the site.

9.5 Accidents with third parties' involvement

Final recommendation FR6

In view of the particular threat situation in Belgium, high priority should be given to potential accidents by third parties (terrorist attacks or acts of sabotage). Protection against potential cyber-attacks and internal perpetrators should be improved.

9.6 Trans-boundary impacts

Final recommendation FR7

It is recommended to calculate the transboundary impacts for a severe accident with containment failure or containment bypass and for a severe accident with fuel pool damage, regardless of their determined probability of occurrence, as long as they are physically possible.

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11 GLOSSARY

AMP	Ageing Management Program
BDBA	Beyond Design Basis Accident
CDF	Core Damage Frequency
CSBO	Complete Station Blackout
Cs-137	Caesium-137
DC	Direct Current
DEC	Design Extension Conditions
EIA	Environmental Impact Assessment
ENSREG	European Nuclear Safety Regulation Group
FANC	Federaal Agentschap voor Nucleaire Controle,
FCVS	Filtered Containment Venting System
.....	Federal Agency for Nuclear Control
HLW	High level waste
I-131	Iodine-131
IAEA	International Atomic Energy Agency
kBq	KiloBecquerel
KCD	Kerncentrale Doel, NPP Doel
LILW	Low and intermediate level waste
LOOP	Loss of Offsite Power
LRF	Large Release Frequency
LTE	Life-time Extension
LTO	Long Term Operation
NGO	Non-governmental organisation
NPP	Nuclear Power Plant
NTI	Nuclear Threat Initiative
ONDRAF/NIRAS	National Agency for Radioactive Waste and Enriched Fissile Materials
PGA	Peak Ground Acceleration

PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PWR.....	Pressurized Water Reactor
RL.....	Reference Level
RTNDT.....	Brittle fracture transition temperature
SAM	Severe Accident Management
SBO.....	Station Blackout
SCG.....	Interim Storage for Spent Fuel, also referred to as BCG
SF2.....	Spent Fuel Storage Facility
SRL.....	Safety Reference Level
TAW	tweede algemene waterpassing, second general leveling
WENRA WGWD	WENRA Working Group on Waste and Decommissioning
WENRA.....	Western European Nuclear Regulators Association

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