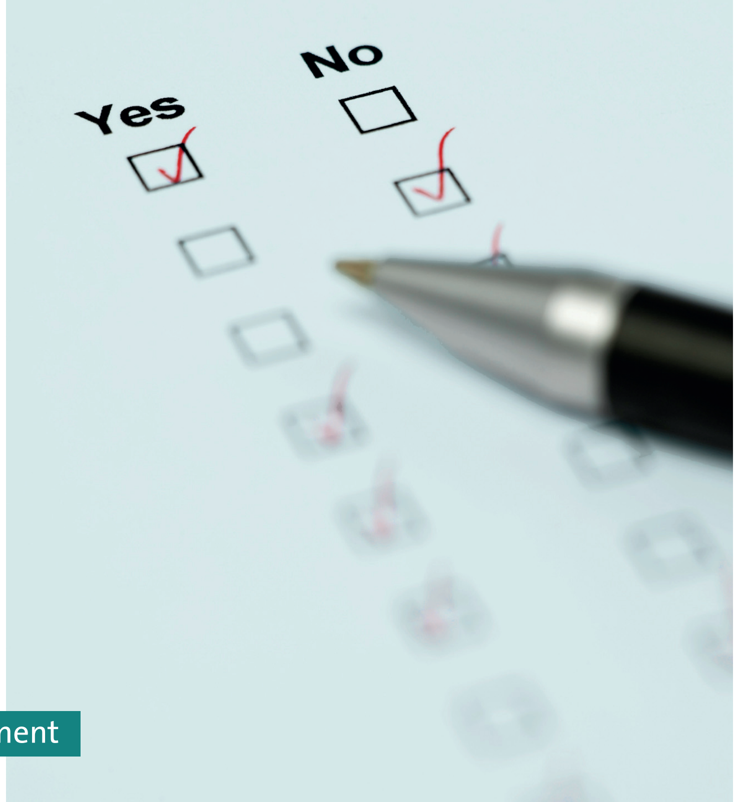
ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

Sizewell C

Environmental Impact Assessment



Expert Statement

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Energie, Mobilität,
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pulswerk
Das Beratungsunternehmen des
Österreichischen Ökologie-Instituts

SIZEWELL C

ENVIRONMENTAL IMPACT ASSESSMENT

Expert Statement

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Commissioned by
Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology,
Directorate VII/10 General Coordination of Nuclear Affairs
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SUMMARY

At the Sizewell site in Suffolk, UK, a new NPP – Sizewell C – is planned. The proposed NPP comprises two UK European Pressurised Reactors (UK EPR™) units with a net electrical output of 1,670 MW per unit.

At the Sizewell site, two Magnox reactors are being decommissioned (Sizewell A), and a PWR is in operation (Sizewell B). Project applicant for Sizewell C is the company NNB Generation Company Ltd (also referred to as SZC Co. in the Environmental Statement).

The UK has notified the application of NNB to Austria according to Art. 4 of the ESPOO Convention. A trans-boundary Environmental Impact Assessment is conducted under UK law (infrastructure planning regulations 2017) and the ESPOO Convention. The authority in charge is the UK Planning Inspectorate.

Although an enormous amount of documents has been submitted in the EIA procedure, **the information provided in the EIA documents is not sufficient to assess the significant trans-boundary effects**. For an assessment of trans-boundary impacts, detailed information on severe accident risks is necessary, however, the EIA documents do not contain severe accident calculations.

At this point in time, when renewables have already become cheaper than nuclear energy it is necessary to update the **assessment of alternatives** for every newbuild plant and not to rely on older data. For the Environmental Impact Assessment of a new NPP, it would also be necessary to update the electricity demand to substantiate the decision for new nuclear instead of the deployment of renewables.

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore an EIA for a new NPP needs to assess the nuclear waste management. But no sufficient proof of safe disposal for spent fuel and radioactive waste was provided in the EIA documents. Interim storage capacities for spent fuel are not available yet, and it has not been made clear if they will be available once Sizewell C will be generating spent fuel. Also no information is provided on the geological final repository for spent fuel and high level waste, neither on the site, the technology or the timetable.

Before the claiming or deciding that the KBS-V3 method will be used for the spent fuel canisters for the final repository prove should be provided that copper corrosion will not become a problem in the long-term.

Reactor Type

According to the ES, the design of the UK EPR™ units is based on technology used successfully and safely around the world for many years. However only two units of the EPR™ are in operation: Taishan 1 and 2 (China) since 2018 and 2019 respectively. Three reactors are currently under construction, one each in Finland (Olkiluoto 3. OL3), France (Flamanville 3, FL3) and the U.K. (Hinkley Point C1). The projects OL3 and FL3 are many years behind their initial schedule. The length of the construction period and the many difficulties demonstrate the complexity of the EPR design.

The EPR was conceived as a reactor with an improved capability to withstand various types of threats and events while reducing the consequences of serious accidents. Nonetheless, its design basis needs to be re-examined in the light of the Fukushima accident. Regarding Station Black Out (SBO), backfitting measures are necessary and planned, but the actual design problems remain. The relatively high thermal power of the EPR, for example, reduces the time for the operator to react efficiently during accident sequences to avoid a severe accident.

On December 13, 2012, the Office for Nuclear Regulation (ONR) has issued a Design Acceptance Confirmation (DAC) for the UK EPR™ design. During GDA process, however, ONR has identified several “findings” that are important to safety and still need to be resolved (Assessment Findings).

If the ex-vessel cooling of the molten core is functioning as planned, this new feature would have the potential to reduce the probability of large releases in case of a severe accident. However, the ONR´s assessment emphasised uncertainties regarding the functionality of the Core Melt Stabilisation System; in several Assessment Findings the need for further examination of nearly all important safety issues is addressed. Taking into account all the facts, it is questionable if preserving containment integrity is guaranteed by the proposed safety design and features.

Accident Analysis

With regard to possible accidents, reference is made to the Generic Design Assessment (GDA). The ES states that a detailed assessment of safety, security and environmental risks associated with the UK EPR™ design has been undertaken as part of the GDA process. However, this assessment was concluded eight years ago. Since this evaluation, the state of science and technology underwent further development. This is reflected in new international and European regulations and guidelines.

According to EDF/AREVA, the UK EPR™ is a Generation 3+ reactor; its safety approach at the design level is based on an improved concept of defence in depth. EDF/AREVA claim that the plant’s safety concept meets advanced regulatory requirements so that, on the one hand, accident situations resulting in a core melt that would subsequently lead to large early releases are practically eliminated and, on the other hand, the consequences of low pressure core melt sequences that would require protective measures for the public are very limited both in area and time.

The claimed “practical elimination” of a large early release is not sufficiently demonstrated by the UK EPR^{TM} PSA.

It is important to note that a recently published WENRA report provides a common understanding of the approach to demonstrate the avoidance of early releases and large releases by using the notion of practical elimination. (WENRA 2019) According to WENRA (2019), demonstrating practical elimination via “extreme unlikeliness with a high degree of confidence” has to be based on the two pillars of deterministic and probabilistic considerations. For the deterministic part of the demonstration, practical elimination should be primarily based on design provisions, supported by operational provisions.

In the specific PSA of the UK EPR^{TM} many factors are not included, because they are out of scope, or not addressed appropriately (for example, Common Cause Failure (CCF)).

Generally, PSA results should only be understood as rough indicators of risk. All PSA results are beset with considerable uncertainties, and there are factors contributing to NPP hazards which cannot be included in the PSA. Therefore, for rare events the probability of occurrence as calculated by a PSA should not be taken as an absolute value but as an indicative number only. Hence, it is problematic in practice to reliably demonstrate the fulfilment of a probabilistic goal by PSA.

All in all, severe accidents with high releases of caesium-137 (>100 TBq) cannot be excluded although their calculated probability is below 1E-7/a. Consequently, such accidents should have been included in the EIA since their effects can be widespread and long-lasting.

Site-specific factors (in particular possible danger of flooding, climate change effects) could endanger Sizewell C. Flooding can have catastrophic consequences for a nuclear power plant. The EIA documents explained that a detailed assessment of site-specific nuclear safety and security risks would be undertaken as part of the nuclear site licensing regime. The authorities accepted that with this regulatory processes in place regarding the safety of the UK EPR^{TM} reactors the EIA does not need to present a detailed assessment of nuclear safety risks.

For ensuring compliance with the safety goals of new nuclear power plants consisting in the requirement that accidents leading to early or large releases have to be practically eliminated, a comprehensive Probabilistic Safety Analysis (Extended PSA) would be required, which takes into consideration all relevant internal and external events and possible accident causes. It is important to note that site-specific factors (such as hazards of seismic or tsunami events, climate change impacts) that could endanger the plant are not discussed appropriately in the Environmental Statement.

Accidents with involvement of third parties

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the planned Sizewell C reactors. Although the EIA process for reasons of confidentiality cannot discuss precautions against sabotage and terror attacks in detail in public, the necessary legal requirements should be set out in the EIA documents.

Information regarding the issue of terror attacks would be of interest to the Austrian side, considering the large consequences of potential attacks.

Trans-boundary impacts

The results of the analysis of trans-boundary effects of a potential severe accident at the Sizewell NPP site indicate that significant trans-boundary effects on Central Europe (including Austria) cannot be excluded. The results also indicate the need for intervention measures in Austria. Such measures include agricultural countermeasures, but also iodine prophylaxis for risk groups.

Moreover, the results emphasise the importance of a serious evaluation and discussion of the severe accident scenarios for Sizewell C in the framework of the trans-boundary EIA.

The information the EIA procedure provided so far does not permit a meaningful assessment of the effects that conceivable accidents at Sizewell C could have on Austrian territory. The analysis of a severe accident scenario would close this gap and allow for a discussion of the possible impacts on Austria.

ZUSAMMENFASSUNG

Am Standort Sizewell in Suffolk im Vereinigten Königreich ist ein neues KKW in Planung – Sizewell C. Das geplante KKW besteht aus zwei Reaktoren des Typs UK European Pressurised Reactors (UK EPR™) mit einer Nettostromleistung von 1.670 MW pro Block.

Am Standort Sizewell befinden sich zwei Magnox-Reaktoren in Dekommissionierung (Sizewell A) und ein Druckwasserreaktor (Sizewell B) in Betrieb. Die Projektwerberin für Sizewell C ist das Unternehmen NNB Generation Company Ltd (in der Umwelterklärung auch als SZC Co. bezeichnet).

Das Vereinigte Königreich hat Österreich den Antrag von NNB gemäß Art. 4 der ESPOO-Konvention notifiziert. Eine grenzüberschreitende Umweltverträglichkeitsprüfung wird gemäß britischem Gesetz (Infrastrukturplanungsverordnung 2017) und der ESPOO-Konvention durchgeführt. Die zuständige Behörde ist das UK Planning Inspectorate.

Obwohl eine enorme Dokumentenmenge für das UVP-Verfahren übermittelt wurde, **sind die für die UVP zur Verfügung gestellten Informationen nicht ausreichend, um signifikante grenzüberschreitende Auswirkungen zu beurteilen.** Für eine Bewertung der grenzüberschreitenden Auswirkungen sind detaillierte Informationen über die Risiken von schweren Unfällen notwendig, doch sind in den UVP-Unterlagen Berechnungen zu schweren Unfällen nicht enthalten.

Angesichts der Tatsache, dass erneuerbare Energien mittlerweile kostengünstiger sind als Kernenergie, ist es notwendig, die **Alternativenprüfung** bei jedem Neubau aktualisiert durchzuführen und nicht alte Daten heranzuziehen. Für die UVP eines neuen KKW wäre es notwendig, den Strombedarf zu aktualisieren, um die Entscheidung für ein neues KKW statt für erneuerbare Energien zu begründen.

Abgebrannte Brennstäbe und radioaktiver Abfall können negative Umweltauswirkungen haben und daher ist es notwendig, dass eine UVP für ein neues KKW deren Entsorgung prüft. Doch die UVP-Unterlagen enthalten keinen ausreichenden Entsorgungsnachweis von abgebrannten Brennstäben und radioaktiven Abfällen. Die Zwischenlagerkapazitäten für abgebrannte Brennstäbe stehen noch nicht zur Verfügung und es ist nicht klar, ob diese zur Verfügung stehen werden, sobald in Sizewell C abgebrannte Brennstäbe anfallen werden. Auch zum geologischen Tiefenlager für abgebrannte Brennstäbe und hoch radioaktive Abfälle wurden weder ein Standort, die Technologie noch der Zeitplan angegeben.

Bevor es möglich ist, die KBS-V3 Methode als die Lösung für die Behälter für abgebrannte Brennstäbe im Endlager zu bezeichnen und sich für diese zu entscheiden, sollte der Nachweis erbracht werden, dass die Kupferkorrosion kein längerfristiges Problem darstellt.

Reaktortyp

Laut der Umwelterklärung basiert das Design der UK EPR™ Blöcke auf einer Technologie, die weltweit erfolgreich ist und sicher über viele Jahre zum Einsatz kommt. Doch sind nur zwei Reaktorblöcke des EPR™ in Betrieb: Taishan 1 und 2 (China) seit 2018 bzw. 2019. Drei Reaktoren sind zurzeit in Bau, je einer in Finnland (Olkiluoto 3, OL3), Frankreich (Flamanville 3, FL3) und im Vereinigten Königreich (Hinkley Point C1). Die Projekte OL3 und FL3 sind bereits Jahre gegenüber dem ursprünglichen Plan in Verzug. Die Dauer der Bauzeit und viele Schwierigkeiten zeugen von der hohen Komplexität des EPR-Designs.

Das Design des EPR wurde ausgelegt, um eine verbesserte Widerstandsfähigkeit gegenüber verschiedenen Arten von Gefährdungen und Ereignissen zu erreichen und gleichzeitig die Folgen schwerer Unfälle reduzieren zu können. Dennoch ist es notwendig, das Design im Lichte des Fukushima-Unfalls neu zu bewerten. Betreffend Station Black Out (SBO) sind Nachrüstmaßnahmen nötig und geplant, die wesentlichen Designprobleme bleiben jedoch bestehen. So reduziert etwa die relative hohe thermische Leistung des EPR die Zeitdauer für die Betriebsmannschaft effektiv bei Unfallsequenzen einzugreifen und schwere Unfälle zu verhindern.

Am 13. Dezember 2012 veröffentlichte die Nuklearaufsicht, das Office for Nuclear Regulation (ONR), die Design Acceptance Confirmation (DAC) für das Design des UK EPR™. Während des Verfahrens zur Generischen Designbewertung (Generic Design Assessment, GDA) gelangte das ONR allerdings noch zu einigen Erkenntnissen (Assessment Findings), die sicherheitsrelevant und noch nicht gelöst sind.

Falls die äußere Kühlung des Reaktordruckbehälters für den geschmolzenen Kern wie geplant funktionieren sollte, könnte diese neue Einrichtung das Potential haben, die Wahrscheinlichkeit großer Freisetzungen bei schweren Unfällen zu reduzieren. Allerdings hat das ONR die Unsicherheiten betreffend die Funktionalität des Kernschmelzstabilisierungssystems unterstrichen. In mehreren Bewertungsergebnissen wird die Notwendigkeit für weitere Untersuchungen nahezu aller wichtigen Sicherheitsfunktionen angesprochen. Unter Berücksichtigung aller Fakten ist es fraglich , ob der Erhalt der Containment-Integrität durch das geplante Sicherheitsdesign und die Sicherheitseinrichtungen garantiert ist.

Unfallanalyse

Betreffend mögliche Unfälle wird auf die Generische Designbewertung (Generic Design Assessment (GDA)) verwiesen. Die Umwelterklärung hält fest, dass eine detaillierte Analyse der Sicherheit, Sicherung und der Umweltrisiken im Zusammenhang mit dem UK EPR™ Design im Rahmen des GDA-Verfahrens durchgeführt wurde. Seit dieser Bewertung kam es allerdings beim Stand von Wissenschaft und Technik zu Weiterentwicklungen. Dies wird von den neuen internationalen und Europäischen Regelwerken und Richtlinien reflektiert.

Laut EDF/AREVA handelt es sich beim UK EPR™ um einen Generation 3+ Reaktor. Dessen Sicherheitsansatz auf Designebene beruht auf einem verbesserten gestaffelten Sicherheitskonzept. EDF/AREVA behaupten, dass das Sicherheitskonzept die fortgeschrittenen regulatorischen Anforderungen erfüllt: Dadurch seien Unfallsituationen mit Kernschmelze, die in Folge zu großen frühen Freisetzungen führen würden, praktisch ausgeschlossen und die Folgen von Niederdruck-Kernschmelzsequenzen, die Schutzmaßnahmen für die Öffentlichkeit erfordern würden, zeitlich und örtlich sehr begrenzt.

Der behauptete „praktische Ausschluss“ von großen frühen Freisetzungen ist nicht ausreichend durch die probabilistische Sicherheitsbewertung (PSA) für den UK EPR^{TM} nachgewiesen.

Der jüngst veröffentlichte WENRA-Bericht legt ein gemeinsames Verständnis zum Ansatz der Nachweisführung für die Vermeidung von frühen Freisetzungen und großen Freisetzungen mittels des praktischen Ausschlusses dar (WENRA 2019). Gemäß diesem WENRA-Ansatz hat der praktische Ausschluss durch „extreme Unwahrscheinlichkeit mit hoher Vorhersagesicherheit“ auf den beiden Säulen deterministischer und probabilistischer Betrachtungen zu erfolgen. Für den deterministischen Nachweis sollte der praktische Ausschluss vor allem auf Design-Vorkehrungen basieren, unterstützt durch Betriebsregeln.

In der spezifischen PSA für den UK EPR^{TM} sind viele Faktoren nicht einbezogen, da sie außerhalb des Anwendungsbereichs sind oder nicht adäquat berücksichtigt wurden (z.B. CCF, Störfall mit gemeinsamer Ursache).

Generell sollten PSA-Ergebnisse nur als grobe Risikoindikatoren verstanden werden. Alle PSA-Ergebnisse sind mit deutlichen Unsicherheiten behaftet und es gibt Faktoren, die zu Gefährdungen für KKW beitragen, allerdings in der PSA nicht betrachtet werden können. Daher sollten die für seltene Ereignisse mit einer PSA errechneten Eintrittshäufigkeiten nicht als absoluter Wert, sondern nur als Annäherung betrachtet werden. Deshalb ist es problematisch, in der Praxis die Erreichung eines probabilistischen Ziels mit einer PSA zu belegen.

In Summe können schwere Unfälle mit einer hohen Freisetzungsrate von Cäsium-137 (>100 TBq) nicht ausgeschlossen werden, selbst wenn deren berechnete Wahrscheinlichkeit unter 1E-7/a liegt. Daher hätten solche Unfälle in der UVP inkludiert werden sollen, da deren Auswirkungen weiträumig und lange andauernd sein können.

Standort-spezifische Faktoren (vor allem mögliche Gefahren durch Hochwasser, Auswirkungen des Klimawandels) könnten Sizewell C gefährden. Hochwasser kann für ein Kernkraftwerk katastrophale Konsequenzen haben. Die UVP-Unterlagen erläuterten, dass eine detaillierte Bewertung der standort-spezifischen nuklearen Sicherheit und der Sicherungsrisiken als Teil des Standortgenehmigungsverfahrens durchgeführt wird. Die Behörden akzeptierten, dass mit diesen Aufsichtsverfahren betreffend die Sicherheit der UK EPR^{TM} Reaktoren die UVP keine detaillierten Prüfungen der nuklearen Sicherheitsrisiken präsentieren muss.

Um die Sicherheitsziele für neue Kernkraftwerke zu erfüllen, die den praktischen Ausschluss von Unfällen vorsehen, die frühe oder große Freisetzungen bedeuten, wäre eine umfassende PSA nötig (Extended PSA), die alle relevanten internen und externen Ereignisse und möglichen Unfallursachen berücksichtigen würde. Standort-spezifische Faktoren (wie das Risiko von seismischen Ereignisse oder Tsunamis, Auswirkungen des Klimawandels), die das Kraftwerk gefährden könnten, werden in der Umwelterklärung nicht ausreichend behandelt.

Unfälle mit Beteiligung Dritter

Terrorangriffe und Sabotageakte können schwere Auswirkungen auf Nuklearanlagen haben und schwere Unfälle verursachen, natürlich auch bei den geplanten Sizewell C-Reaktoren. Wenn auch im UVP-Verfahren aufgrund der Vertraulichkeit die Vorkehrungen gegen Sabotage und Terrorangriffe nicht im Detail öffentlich besprochen werden können, so sollten die notwendigen rechtlichen Anforderungen in den UVP-Dokumenten skizziert sein.

Aufgrund der enormen Konsequenzen potentieller Angriffe sind Informationen über die Problematik von Terrorangriffen für Österreich von Interesse.

Grenzüberschreitende Auswirkungen

Die Ergebnisse der Analysen zu grenzüberschreitenden Auswirkungen potentieller schwerer Unfälle am Standort des KKW Sizewell zeigen, dass signifikante grenzüberschreitende Auswirkungen auf Mitteleuropa (auch Österreich) nicht ausgeschlossen werden können. Die Resultate zeigen auch, dass Interventionsmaßnahmen in Österreich nötig werden können. Diese schließen auch landwirtschaftliche Gegenmaßnahmen ein, sowie Iodprophylaxe für Risikogruppen.

Außerdem zeigen die Resultate, wie wichtig eine seriöse Evaluierung und Diskussion der Szenarien schwerer Unfälle im KKW Sizewell C im Rahmen der grenzüberschreitenden UVP ist.

Die Informationen des UVP-Verfahrens lassen soweit keine sinnvolle Bewertung der Auswirkungen zu, die vorstellbare Unfälle im KKW Sizewell C auf österreichisches Territorium haben könnten. Die Analyse eines Szenarios für schwere Unfälle würde diese Lücke schließen und eine Diskussion über die möglichen Auswirkungen auf Österreich ermöglichen.

1 INTRODUCTION

At the Sizewell site in Suffolk, UK, a new NPP – Sizewell C – is planned. The proposed NPP comprises two UK European Pressurised Reactors (EPR) units with a net electrical output of 1,670 MW per unit.

At the Sizewell site, two Magnox reactors are being decommissioned (Sizewell A), and a PWR is in operation (Sizewell B). Project applicant for Sizewell C is the company NNB Generation Company Ltd (also referred to as SZC Co. in the Environmental Statement).

The UK has notified the application of NNB to Austria according to Art. 4 of the ESPOO Convention. A trans-boundary Environmental Impact Assessment is conducted under UK law (infrastructure planning regulations 2017) and the ESPOO Convention. The authority in charge is the UK Planning Inspectorate.

The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Environment Agency Austria to provide the expert statement at hand assessing the submitted documents. The objective of the Austrian participation in the ESPOO procedure is to give recommendations to minimise or even eliminate possible significant adverse impacts on Austria resulting from the project.

2 OVERALL AND PROCEDURAL ASPECTS OF THE ENVIRONMENTAL IMPACT ASSESSMENT

In this chapter overall and procedural aspects of the environmental impact assessment (EIA) procedure are discussed, including the evaluation of the completeness of the provided documents and the fulfilment of the requirements of the ESPOO Convention.

2.1 Provided documents and treatment in the EIA documents

The following documents were provided by the UK side and are quoted in this expert statement as follows:

Environmental Statement:

- Non-technical summary (quoted as ES_Non-technical Summary 2020)
- Volume 1: Introduction, 6 chapters
- Volume 2: Assessment, 28 chapters
- Volume 3-9: Off-site developments, 12 chapters
- Volume 10: Cumulative and trans-boundary, 5 chapters

The documents of the Environmental Statement are quoted as "ES_Vx_Chx 2020". The files are published on the website of the UK Planning Inspectorate: https://infrastructure.planninginspectorate.gov.uk/projects/eastern/the-sizewell-c-project/?ipcsection=docs. Selected files have also been published on https://www.umweltbundesamt.at/uvp-kkw-sizewell.

More documents are published on the Planning Inspectorate's website, however, they have no relevance to assessing possible trans-boundary impacts on Austria.

Alternatives

The Non-technical Summary links the construction of new NPPs to the Overarching National Policy Statement for Energy of 2011 and the National Policy Statement for Nuclear Power Generation. (ES_Non-technical Summary 2020, chapter 2) In the latter, eight potentially suitable sites for new NPP are listed, Sizewell being among them. In December 2017, the Government confirmed its assessment that nuclear power remains key to meet the climate goals, and also confirmed the suitable sites.

The chosen reactor type, the UK EPR^{TM}, has already been assessed and approved by the Office for Nuclear Regulation in the Generic Design Assessment procedure.

Therefore no alternative sites and no alternative reactor design have been considered in this EIA procedure. (ES_Non-technical Summary 2020, chapter 3.2) Alternatives only concern details of the construction phase and aspects relevant for local areas. These were assessed are discussed in Volume 2, chapter 6.

2.2 Discussion

An enormous amount of documents has been provided on the website of the Planning Inspectorate. For members of the public it might be rather overwhelming to sort through this material. The non-technical summary will be helpful to get an overview.

It might be confusing for members of the public that besides the UK participation procedure, a trans-boundary EIA is ongoing, but only in some EU countries. It would be helpful to explain the procedures in a more structured manner.

Information on severe accident risk is especially relevant for the assessment of trans-boundary impacts. But no severe accident calculations have been made available in the EIA documents – for more information see Chapter 7 of this expert statement.

Therefore, even though a vast amount of documents was delivered for the EIA they are insufficient to conduct an assessment of significant trans-boundary effects.

Alternatives

The EIA documents argued that alternatives to building a new NPP in general and to the Sizewell site are not necessary because the adopted policies and government decisions made clear the way for the NPP earlier. Recently the NFLA (Nuclear Free Local Authorities) questioned the data the UK electricity demand forecast is based on. The NFLA argues for a fundamental reassessment of the need for new nuclear reactors which the UK Government's National Policy Statement is proposing. For example, electricity generation in 2018 was some 63 TWh (16%) lower than in 2005, a reduction equivalent to 2.5 times the output of the new nuclear plant being built at Hinkley Point C or proposed for Sizewell C. This is despite the UK population increasing by 10% from 60 million to 66 million people. Furthermore, nuclear generation was 72 TWh in 2016 or about 21% of electricity produced in the UK. Total installed nuclear capacity is around 8.9 GW. Yet an accelerated programme of LED lighting installation alone, for example, could reduce peak electricity demand by almost 8 GW. (NFLA 2019)

This argument is supported by the National Infrastructure Commission, an advisory board to the UK Government: *"New nuclear power stations are unlikely to be an additional source of electricity in the 2020s, with the possible exception of Hinkley Point C. Large scale projects have long construction timelines and often face delays*. NIC 2018, p. 40f.)

2.3 Conclusions, questions and preliminary recommendations

Although an enormous amount of documents has been submitted in the EIA procedure, the information provided in the EIA documents is not sufficient to assess the significant trans-boundary effects. For an assessment of trans-boundary impacts, detailed information on severe accident risks is necessary, however, the EIA documents lack severe accident calculations.

At this point in time, when renewables have already become cheaper than nuclear energy it is necessary to update the assessment of alternatives for every newbuild plant and not to rely on older data. For the Environmental Impact Assessment of a new NPP, it would also be mandatory to update the electricity demand to substantiate the decision for new nuclear instead of the deployment of renewables.

3 SPENT FUEL AND RADIOACTIVE WASTE

In this chapter the planned management of the spent fuel and radioactive waste generated by Sizewell C is assessed.

3.1 Treatment in the EIA documents

Chapter 7 of Volume 2 of the Environmental Statement presents an overview of the planned management of spent fuel and radioactive waste expected to arise from the operation of the Sizewell C Project. (ES_V2_Ch7 2020)

Radioactive waste can be generated already in the construction phase due to the demolition of the existing Sizewell B outage store which is necessary to make space for the Sizewell C NPP.

The operator and site licensee is responsible for the generated nuclear waste.

In the UK, spent fuel is not categorized as nuclear waste due to its plutonium and uranium content that could be separated by reprocessing. Nevertheless, a Government White Paper from 2008 concluded that new NPP in UK should proceed on the basis that spent fuel will not be reprocessed. (ES_V2_Ch7 2020, p 11) On p. 14 it is clarified that SZC Co. has no plans to reprocess spent fuel at Sizewell C; the spent fuel will be moved into an interim storage and later into a disposal. The nuclear waste facilities at Sizewell C are designed to manage only spent fuel and radioactive waste from Sizewell C and not from other NPP in UK. (ibid. p. 14)

Low level waste (LLW) will be transferred to the radioactive waste building of Sizewell C unit 1 for processing in preparation for disposal. The disposal of LLW will be in off-site facilities. Expected volumes of LLW were assessed from comparable existing French NPPs as part of the Generic Design Assessment process. For each LLW type an estimated raw waste volume, the preferred waste arrangement, and for some LLW types alternative waste arrangements are listed in table 7.6 (ibid. p. 26f.) Preferred arrangements are incineration or recycling, the least desired option is the LLW final repository near Drigg in Cumbria. (ibid. p.22) The acceptance of all the LLW in a LLW repository has been agreed in principle. The LLW repository will be closed before end of operation time of SZC, but new repository capacities will be provided by the Nuclear Decommissioning Authority (NDA) when needed. (ibid. p.23) 146.1 m^3 LLW are estimated to be generated per year by two UK EPR™ (ibid. p. 26f.), this would result in 8,766 m^3 for 60 years of operation.

Very low level waste (VLLW) could be disposed of to specifically approved landfill sites. (ibid. p. 24)

Intermediate level waste (ILW) will be conditioned and packaged in passively safe containers on-site. Following decay, part of the ILW will become LLW and taken out of the ILW management. (ibid. p. 29f.) 1,200 m^3 ILW raw waste are anticipated over 60 years operation time for two UK EPR™s. (ibid. p. 34)

The containers shall be put into a future ILW interim storage facility. After end of operation of the NPP the ILW containers are planned to be transferred from the interim store into a geological repository provided that such a repository is available. If there is no final repository available, the ILW interim storage on-site may need refurbishment to extend its life. (ibid., p. 37)

A total of 6,800 **spent fuel** assemblies are expected to arise from the two UK EPR^{TM} over 60 years. They will be stored in the fuel pool of the reactor up to ten years, and after that transferred into an **interim storage facility (ISFS)**. This interim storage, which is in planning, will have a capacity of 7,378 spent fuel assemblies. (ibid. p. 38) Today there is no final repository for spent fuel, and it will not be available before Sizewell C could start operation. Therefore, it is planned to provide the future interim storage with sufficient capacity to store all spent fuel on-site. Preferred by SZC Co. is a dry interim storage. It will be designed for an operation time of 120 years. (ibid., p. 38f.) After decommissioning of the NPP the ISFS will be modified to function as a standalone facility. (ibid., p. 40)

The future **geological repository** for spent fuel will be operated by Radioactive Waste Management Ltd. In their timeline it is scheduled that the repository will be able to take up spent fuel from Sizewell C from 2130. Before, legacy waste has to be disposed of in the repository. (ibid., p. 43) Spent fuel from the UK EPR^{TM} could be suitable for disposal 55 years after end of generation. It is assumed that it will take 8.5 years to transfer the spent fuel to the repository. (ibid., p. 43)

The spent fuel will be encapsulated for final repository by using the Swedish KBS-3V method. (ibid., p. 44) For this method, an over-package with a durable, corrosion resistant material is foreseen. An **encapsulation facility** is foreseen to be constructed on the Sizewell C site, but could also be a shared facility.

3.2 Discussion

The expected amount of radioactive waste and spent fuel arising from operation of Sizewell C is declared. Especially the safe disposal of the spent fuel, HLW and ILW is important to avoid environmental impacts. But as of yet, no interim storage capacity for spent fuel is available. It is foreseen to construct a dry interim storage for spent fuel on the site, but no information was provided on when this interim storage will be operable. In principle, a dry interim storage is more preferable in terms of safety than a wet storage.

Neither a timetable for the anticipated final geological repository has been provided. It is assumed that spent fuel from Sizewell C can be transferred to this future geological repository from 2130, but further information is lacking: When will the site be chosen, when will the technology be chosen? What will happen if in 2130 no GDF is available?

Therefore no sufficient proof of disposal for spent for spent fuel, HLW and ILW has been provided.

In the Environmental Statement it is mentioned that for the encapsulation of the spent fuel the Swedish KBS-V3 method will be preferred. This method includes using copper canisters and assuming that copper does not corrode significantly while covered in clay. But there are also independent scientific studies showing that the copper canisters may corrode much faster than was assumed. This was also recognised by the Swedish Environmental Court in its opinion of 2018.[1]. It

[1] http://www.mkg.se/en/translation-into-english-of-the-swedish-environmental-court-s-opinion-on-the-final-repository-for-sp, seen 02 Sept 2020

should be clarified if UK also plans to use copper for its canisters and how the corrosion problem will be solved.

3.3 Conclusions, questions and preliminary recommendations

Spent fuel and radioactive waste can cause adverse environmental impacts and therefore an EIA for a new NPP needs to assess the nuclear waste management. But no sufficient proof of safe disposal for spent fuel and radioactive waste was provided in the EIA documents. Interim storage capacities for spent fuel are not available yet, and it has not been made clear if they will be available once Sizewell C will be generating spent fuel. Also no information is provided on the geological final repository for spent fuel and high level waste, neither on the site, the technology or the timetable.

Before the claiming or deciding that the KBS-V3 method will be used for the spent fuel canisters for the final repository prove has to be delivered that copper corrosion will not become a problem in the long-term.

Questions

1. *What is the timetable of the planned dry interim storage for spent fuel?*
2. *What is the status of the geological repository for spent fuel and HLW?*
3. *How can the safe storage of spent fuel be ensured in case the interim storage and final disposal will not be available in time?*
4. *Is it planned to use copper for the spent fuel canisters, and if yes, how will the copper corrosion problem be solved?*

Preliminary recommendation

1. To demonstrate the safe management of nuclear waste and spent fuel from Sizewell C detailed information on the interim storage and final disposal should be provided; also alternative nuclear waste management solutions in case these facilities will not be operable in time.

4 REACTOR TYPE

4.1 Treatment in the EIA documents

SZC Co. is proposing to build a new nuclear power station at Sizewell in East Suffolk, known as Sizewell C. The proposed Sizewell C nuclear power station would comprise two UK EPR™ units with an expected net electrical output of approximately 1,670 MW per unit, giving a total site capacity of approximately 3,340 MW.

The ES stated: The design of the UK EPR™ units is based on technology used successfully and safely around the world for many years, which has been enhanced by innovations to improve performance and safety. The UK EPR™ design has passed the Generic Design Assessment (GDA) process, and has been licensed and permitted at Hinkley Point C. The UK EPR™ reactor is the same reactor design which is being constructed at Hinkley Point C.

Hinkley Point C is currently under construction and is expected to start generating in 2025. Hinkley Point C is the first new nuclear power station to be constructed in the UK for more than 20 years. Like Sizewell C, it will use the EPR™ technology. (ES_V1_Ch1 2020)

Unit 1 of the UK EPR™ is scheduled to commence 12 months earlier than Unit 2. The Sizewell C nuclear power station would have an operational life of 60 years. (ES_V2_Ch4 2020)

The UK EPR™ reactor produces heat from nuclear fission which takes place in the reactor core. The core is contained within a thick-walled steel pressure vessel which is approximately 10 m high and 5.5m in diameter. Within the core of each UK EPR™ reactor, there would be 241 fuel assemblies each containing a 17 by 17 array of fuel rods comprising uranium dioxide pellets in a sealed cladding tube. Once the fuel is loaded in the reactor core, the reactor can operate at full power continuously in a 'fuel cycle' of up to 18 months. Spent fuel removed from the reactor core would undergo several years of storage to cool in the pools inside the plant before transfer to the ISFS.

In addition to the auxiliary connection to the grid, backup power supply to the units is also provided by on-site back-up diesel generators (Emergency Diesel Generators (EDGs) and Ultimate Diesel Generators (UDGs)) and dedicated batteries.

The primary system, housed in the reactor building, is a closed water-filled pressurised system which enables the heat produced by the nuclear fission reaction inside the fuel assemblies in the reactor core to be extracted. The system comprises the reactor pressure vessel and four separate cooling loops, each containing a reactor coolant pump and steam generator.

The high-pressure conditions of the system, which are controlled by a single pressuriser, prevent the cooling water from boiling even though the temperature of the water is around 330ºC. The water within the system, which is heated by the fission occurring in the reactor, passes through tubes within the steam generators. These act as heat exchangers whereby heat is transferred through the tube walls into the water of the separate secondary system which flows outside and between the tubes. The primary coolant water, having passed through the steam generators is then pumped back to the reactor vessel.

The secondary system is also closed, independent of the primary system and operates at a lower pressure. The open circuit cooling system would be independent of the primary and secondary systems and would draw water directly from the sea. It would absorb heat from the secondary system in the condensers and other parallel heat exchanger systems and, after a single passage through these systems, the now heated water would then be discharged back to the sea.

The UK EPR™ design complies with safety requirements formulated by the French and German nuclear safety authorities for the next generation of nuclear reactors. According to EDF and AREVA, the UK EPR™ is a Generation 3+ reactor and benefits through its evolutionary design from global international experience acquired at both PWR system operational level in western countries, and French and German engineering design experience. The safety approach at the design level is based on an improved concept of defence in depth (UK EPR 2012, 3.1).

The Risk Reduction Category A (RRC-A) is introduced to complement the deterministic Design Basis Analysis by considering a set of Design Extension Conditions (DEC) involving multiple failure events. Analysis of the DECs is used to identify additional safety measures (so-called 'RRC-A features'), which make it possible to prevent the likelihood of the occurrence of severe accidents in these complex situations. One RRC-A sequence is concerned with the Loss of Offsite Power (LOOP), combined with the total failure of the four Emergency Diesel Generators (EDGs), whilst at-power (state A). The RRC-A features associated with this functional sequence are the two Station Black Out (SBO) diesel generators which supply electrical power to the emergency supply system for the Emergency Feed Water System, trains 1 and 4. The operator switches to the SBO diesel generators manually (UK EPR 2012, 16.1).

The plant's safety concept meets advanced regulatory requirements so that, on the one hand, accident situations with core melt which would lead to large early releases are practically eliminated and, on the other hand, low pressure core melt sequences (Risk Reduction Category B, RRC-B) necessitate protective measures for the public, which are very limited both in area and time. RRC-B is concerned with preserving the containment integrity in the long-term. This task encompasses the prevention of

- Hydrogen risks for the containment in the long-term,
- Containment failure due to exposure of the concrete base-mat to core melt,
- Containment failure due to containment over-pressurisation.

The possibility of hydrogen combustion in the long-term is avoided by installing autocatalytic recombiners in the containment. An ex-vessel core melt stabilisation system avoids the penetration of the liner and concrete base-mat, and, subsequently, the interaction between molten core and subsoil, and long-term groundwater contamination. By maintaining the melt in a cooled configuration, the stabilisation system further prevents the heat-up of the concrete in the lower containment region. This eliminates the risk of thermal deformation and induced crack formation in the concrete slab. For long-term decay heat removal, the UK EPR™ has a dedicated containment heat removal system (CHRS) (UK EPR 2012, 16.2).

Every type of accident, which has the potential to breach the containment early in the accident, could result in large early releases. Practical elimination of these accidents is achieved by specific engineered safety features that concern the following phenomena (UK EPR 2012, 16.2):

- Core melt under high pressure and direct containment heating
- Large steam explosions which can threaten the containment
- Hydrogen combustion phenomena potentially critical to containment integrity.

4.2 Discussion

According to the ES, the design of the UK EPR™ units is based on technology used successfully and safely around the world for many years. However, only two units of the EPR™ are in operation: Taishan 1 and 2 (China) since 2018 and 2019, respectively.

Three reactors are currently under construction, one each in Finland (Olkiluoto 3), France (Flamanville 3) and the U.K. (Hinkley Point C1). All of these projects are many years behind their initial schedule.

In December 2003, Finland became the first country to order a new nuclear reactor in Western Europe since 1988. On 7 March 2019, the Cabinet approved the operating license for the EPR at **Olkiluoto (OL3)**, which has been under construction since August 2005. The reactor has seen multiple revised start-up dates.

Fuel loading at the Olkiluoto 3 EPR will not take place until March next year, according to a revised schedule provided to TVO by the Areva-Siemens consortium. Grid connection is now scheduled for October 2021, with regular electricity production due to start in February 2022. TVO listed the following issues having caused delays in the project schedule: slowly progressing system testing; technical problems that have been identified in tests; and the increase in the amount of maintenance work caused by project delay. The lack of necessary spare parts has also resulted in delays. Technical problems have been related to sea water system equipment; cracks in the pressuriser safety valves' spring loaded pilot control valves; faulty components in emergency diesel generators and the pressuriser surge line vibration problem. Faulty cable insulation has been detected in certain automation cabinets. (WNN 2020)

In December 2007, EDF started construction on **Flamanville-3 EPR** (FL3) with a scheduled start date of 2012. The project has been plagued with detailed-design issues and quality-control problems, including basic concrete and welding issues similar to those at the Olkiluoto (OL3) project in Finland. In April 2018, it was discovered that the main welds in the secondary steam system did not conform with the technical specifications; so by the end of May 2018 EDF stated that repair work might again cause a delay of several months. In fact, the delay will be several years, and the start-up of FL3 is now not expected before the end of 2022. (WNISR 2019)

On 28 June 2019, the EPR project at **Hinkley Point C** project in the U.K. was finally officially declared as "under construction", almost seven months after the beginning of the concreting of the foundations for the reactor building—the usual international setpoint for construction start.

The length of the construction period and the many difficulties of the OL3 and the FL3 demonstrate the complexity of the EPR design. It is to be expected that problems will also arise in the construction of Sizewell C. It can be assumed that despite the repair of quality deficiencies some deficiencies will remain.

Critical Role of Station Black-Out (SBO)

To provide the necessary electrical power for safety relevant systems in case of loss of offsite power, the EPR is equipped with four emergency diesel generators (EDG). A loss of offsite power combined with the failure of the four EDG would lead to the unavailability of various safety relevant systems. The EPR is equipped with additional power sources, the so-called SBO-diesel generators (SBO-DGs).

The SBO-DGs are diversified with regard to the EDGs. Therefore, according to AREVA, a common cause failure (CCF) of the SBO-DGs together with the EDGs had not to be considered before the accident at Fukushima.

The diesel buildings, each housing two EDGs and one SBO-DG, are designed to withstand earthquakes and explosions. However, the EPR diesel buildings' protection against aircraft crash is provided exclusively by the different positions of the buildings on the site, which are separated by the reactor building. A physical protection of the buildings is not implemented for the EPR. (HIRSCH 2011).

According to the Stress Tests for Olkiluoto 3, in case of SBO, if countermeasures were unsuccessful, the uncovering of the core would take place within 3 hours with extensive fuel damage within 4 hours and pressure vessel melt-through within 7 to 8 hours after an accident starts (ENSREG 2012a).

Generic Design Assessment (GDA)

The ONR has undertaken a Generic Design Assessment (GDA) of the UK EPR™ nuclear reactor during the period from July 2007 to December 2012. On December 14, 2011, ONR issued an Interim Design Acceptance Confirmation (IDAC) for the UK EPR™ nuclear reactor. There were a number of open GDA Issues which had to be addressed.

The ONR report (2012) summarises the work undertaken to assess EDF and AREVA's responses to the 31 GDA Issues and documents why ONR is content to provide a Design Acceptance Confirmation (DAC).

The GDA Issues include resilience to internal hazards, adequacy of the structural integrity of the built-structures, doubts about I&C system and the consideration of human factors.

Although limited to 31 in number, the majority of the individual GDA Issues are a composite made up of a number of often quite involved tasks to be executed (LARGE 2012a).

Findings that were identified during the regulators' GDA assessment are important to safety but are not considered critical to the decision to start nuclear island safety-related construction, are known as Assessment Findings (AF). After GDA, the Assessment Findings will be subject to appropriate control as part of normal regulatory oversight (ONR 2012).

During GDA a total of 82 design change proposals have been identified; during the GDA close-out phase another 54 design improvements have been proposed by EDF and AREVA within their responses to the GDA Issues (ONR 2012).

These design and safety improvements have now been accepted within GDA by ONR. Further development of the details of these modifications will be progressed after GDA, during the site-specific phase. (ONR 2012).

In addition, as a result of the post Fukushima review, EDF and AREVA identified five design change proposals, covering 16 resilience enhancements (ONR 2012).

EDF and AREVA's safety case for GDA Step 4 was described in their March 2011 Pre-Construction Safety Report (PCSR). This was updated during the GDA Issue close-out phase to take account of new information, to improve the clarity of the safety arguments, and to include agreed design changes. The updates were incorporated into a final version of the PCSR which was submitted in November 2012 (ONR 2012).

On December 13, 2012, ONR has closed the generic design assessment (GDA) and has issued the Design Acceptance Confirmation (DAC) for the UK EPR™.

During GDA process, however, ONR has identified several "findings" that are important to safety and still need to be resolved (Assessment Findings). In the important topics containment hydraulics performance / severe accident and Probabilistic Safety Analysis (PSA), ONR has raised 26, respectively 46, Assessment Findings.

In the following section, ONR´s assessments including Assessment Findings (AF) are described to some extent in order to evaluate the possibility of severe accidents at Sizewell C could have significant transboundary effects on Central Europe (including Austria).

Containment Sump Clogging

In design-basis faults, reactor coolant inventory is generally replenished by safety injection from the in-containment refuelling water storage tank (IWRST).

However, this tank has a limited size and ultimately will be empty. In the largest loss-of coolant accidents this can happen in a matter of hours. Under these circumstances, the operator is required to realign the injection pump suction lines to take water from the containment sump. It is necessary to ensure that debris in the containment building is not swept into the primary circuit where it would impair cooling (ONR 2011b). This problem is not sufficiently resolved. The UK EPR™ project should identify a design which reduces risks in this area as far as reasonably practicable (ALARP) (AF-UKEPR-CSA-07).

Primary Depressurisation System (PDS)

The containment design takes into account consequences related to a severe accident, but without considering loads induced by High Pressure Melt Ejection (HPME). In the context of severe accidents, the primary depressurisation system aims to avoid the possibility of HPME and the potential for Direct Containment Heating (DCH), phenomena which can lead to early containment failure. The manual operation of the PDS introduces a degree of uncertainty into the time and rate of depressurisation.

The PCSR does not fully describe the functional requirements of the PDS during design basis and severe accidents. The successful initiation of the PDS is a key step within the severe accident management procedures in preventing high pressure accident scenarios leading to a HPME (ONR 2011b). The operator may depressurise the Reactor Cooling System (RCS) at various stages during the fault conditions. Depressurisation is anticipated to be activated by the operator when the core outlet temperature reaches 650°C. The core outlet temperature is also proposed to be used for initiation of severe accident management procedures associated with control of debris and containment performance. The measurement systems indicating core conditions used to initiate the accident management procedures have to justify, in particular concerning common cause failure (CCF) (AF-UKEPR-CSA-08).

Ex-Vessel Cooling of Molten Core

To stabilize the molten core in a severe accident, the EPR relies on an ex-vessel strategy. The intent of the design is that the molten material will be spread sufficiently evenly so that it can be cooled efficiently and retained in a stable configuration where it cannot damage the structure of the containment building. The design is also intended to minimise the release of gas from concrete materials as a result of melt-concrete interaction.

The molten material from the RPV is first collected in the reactor pit. In the pit, the corium is temporarily retained by a layer of sacrificial concrete. The time delay and the admixture of the concrete leads to a collection of core melt in the pit and a more uniform spectrum of possible melt states at the end of the retention process. Finally, the melt will penetrate the melt plug consisting of concrete and a metal plate (of Al/Mg-alloy) and flow into the core catcher properly.

Because of the retention and collection in the pit, the subsequent spreading and the stabilisation measures are largely independent of the uncertainties associated with in-vessel melt pool formation and RPV failure; there is a one-step release into the spreading area. There, the spread melt is to be stabilised by flooding and external cooling.

The cooling of the melt in the core catcher by the overflow of water from the in-containment refuelling water storage tank (IRWST) is fully passive and triggered by the arrival of melt in the core catcher. The water first fills the central supply duct underneath the core catcher, then enters the horizontal cooling channels and submerges the space behind the sidewalls. After filling, it will overflow onto the surface of the melt. Solidification of the melt is to be achieved within a few days.

If the ex-vessel cooling of the molten core is functioning as planned, this new feature would have the potential to reduce the probability of large releases in case of a severe accident.

However, the ONR´s assessment emphasised uncertainties regarding the functionality of different steps of the Core Melt Stabilisation System (ONR 2011b):

The mass of ablated concrete is one of the key factors affecting the corium viscosity influencing the spreading capability and potentially the layer inversion. According to ONR (2011b), the presence of the layer inversion phenomenon for the bounding scenario of the minimum ablated concrete quantity has to demonstrate. This justification is required to ensure that the risk associated with any significant interactions between water and the metallic layer is avoided. The response should also demonstrate that the resultant corium viscosity is appropriate for the bounding scenario of the maximum ablated concrete quantity (AFUKEPR- CSA-13).

The claim, that the potential presence of chunks of concrete above the melt plug at the time of bottom head failure has no significant consequences on the melt plug opening has to be justified (AF-UKEPR-CSA-15).

In the opinion of ONR (2011b), a blockage of the cooling channels under the spreading plate is not adequately examined by EDF and AREVA. ONR (2011b) therefore made an Assessment Finding requiring that this has to be addressed (AF-UKEPR-CSA-19).

In order to examine the claims made for spreading of the core melt within the spreading compartment, ONR commissioned the German Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) to perform a set of independent confirmatory analyses to develop an appreciation of the extent of the uncertainties (ONR 2011b). The confirmatory analysis demonstrated a shortfall in some assumptions made in the PCSR methodology. Updated spreading calculations for bounding scenarios have to be provided (AF-UKEPR-CSA-20).

Steam Explosion in Accident Conditions

The possibility of steam explosions constitutes a problem during severe accidents. Such explosions, which can damage the containment, can occur when the molten core falls into a pool of water. In this case, the melt can fragment into small particles; heat transfer to the water is extremely fast, with abrupt vaporisation as a result. According to ONR (2011b), a steam explosion is not a totally incredible event, and so there is a need to assess the damage potential. Therefore, the risk of a steam explosion in the RPV bottom head (in-vessel) and in the reactor pit and spreading compartment (ex-vessel) have been considered.

ONR (2011b) concluded that EDF and AREVA have presented a safety case based on current international understanding such that the probability of an in-vessel steam explosion sufficiently energetic to breech the RPV is very low. But ONR (2011b) pointed out that this assessment is based on subjective views on melt progression and conversion efficiencies, supported, in part, by limited modelling and the experimental database.

Melt can also contact water ex-vessel, either in the reactor pit, transfer channel or spreading compartment. The design intention is that the reactor pit and transfer channel are maintained dry. However, in some accident scenarios water may accumulate in the reactor pit. Measure(s) and arrangement(s) for inspection in order to ensure that the reactor pit is kept sufficiently dry are required by ONR (AF-UKEPR-CSA-21).

Corium Re-criticality

One essential safety function which needs to be addressed is the ability to shut down the chain reaction and retain the core subcritical. The potential for re-criticality is one of the hazards to be considered when the core configuration is lost (ONR 2011b). This requires consideration of the pool of molten debris formed once the core has relocated to the RPV lower head and the corium melt as it moves from the RPV into ex-vessel positions. According to ONR (2011b), the risk of re-criticality due to the relocated molten material and its progression within the

Core Melt Stabilisation System (CMSS) should receive further examination (AF-UKEPR-CSA-22).

Measures against Containment Overpressure

The ex-vessel core cooling system has to be seen in connection with the Containment Heat Removal System (CHRS). This system controls the containment pressure. It consists of a spray system and allows recirculation through the cooling structure of the molten core retention device to mitigate the consequences of the considered accident scenario. The CHRS serves to avoid containment failure while the molten core is stabilised in the core catcher. It also aims to avoid venting of the containment.

ONR highlighted that UK EPR™ design does not have a filtered discharge facility to vent the containment. EDF and AREVA indicated that the EOPs recommend discharging into the adjacent buildings as an alternative to a filtered discharge. ONR consider that this strategy could lead to increased radiological releases following a severe accident to the peripheral buildings, limiting access for recovery and potential use of equipment.

ONR stated that it will expect that the EPR project should identify a design which reduces risks in this area as far as reasonably practicable and, therefore, raising an Assessment Finding requesting that a potential licensee demonstrate why the proposed design is ALARP (AF-UKEPR-CSA-25).

Prevention of Hydrogen Combustion

The containment has a dedicated combustible gas control system (CGCS) with two subsystems to avoid containment failure:

- The hydrogen reduction system consists of 47 passive autocatalytic recombiners (PAR) installed in various parts of the containment.
- The hydrogen mixing and distribution system.

The EPR containment is designed based on a two-region concept; inner containment (inaccessible) and outer containment with limited access to equipment while the reactor is operating at power. This is facilitated by the provision of radiation shielding within the containment and also thin contamination barriers.

This separation is convenient for plant operations but complicates the combustible gas management during an accident by delaying dilution and mixing (ONR 2011b).

Several of the equipment rooms surrounding the Reactor Coolant System (RCS) are isolated from the rest of the containment during normal operation. In the event of an accident, communication is established between these equipment rooms, thereby eliminating any potential dead-end compartments where non-condensable gases could accumulate. A series of mixing dampers and blowout panels would open to transform the containment into a single volume.

ONR sees the need to consider whether it is ALARP to take additional measures to limit peak hydrogen concentrations (AF-UKEPR-CSA-23).

Performance of PAR

Additional confirmatory experimental work is required by ONR to provide greater assurance that fission product poisoning of passive autocatalytic recombiners (PARs) is unlikely to adversely influence their operational capabilities (AF-UKEPR-CSA-24).

4.3 Conclusions, questions and preliminary recommendations

The EPR was conceived as a reactor with an improved capability to withstand various types of threats and events while reducing the consequences of serious accidents. Nonetheless, its design basis needs to be re-examined in the light of the Fukushima accident (MAKHIJANI 2012). Regarding Station Black out (SBO), backfitting measures are necessary and planned, but the actual design problems remain. The relatively high thermal power of the EPR, for example, reduces the time for the operator to react efficiently during accident sequences to avoid a severe accident.

The length of the construction period and the many difficulties of the OL3 and the FL3 demonstrate the complexity of the EPR design. It is to be expected that problems will also arise in the construction of Sizewell C. It can be assumed that despite the repair of quality deficiencies some deficiencies will remain.

If the ex-vessel cooling of the molten core is functioning as planned, this new feature would have the potential to reduce the probability of large releases in case of a severe accident. However, the ONR´s assessment emphasised uncertainties regarding the functionality of the Core Melt Stabilisation System; in several Assessment Findings the need for further examination of nearly all important safety issues is addressed. Taking into account all the facts, it is questionable if preserving containment integrity is guaranteed by the proposed safety design and features neither in the long-term nor in the short term.

Currently, it cannot be proven beyond doubt that **severe accidents with high releases cannot occur.**

Questions

1. *Which of the assessment findings of the ONR´s GDA step 4 Assessment of Severe Accidents for the UK EPR^{TM} have already been solved? How were they solved and if not, when is a solution expected for those?*
2. *Does the UK EPR^{TM} correspond to the EPR in Finland and/or France? If not, where does the design deviate?*

5 ACCIDENT ANALYSIS

5.1 Treatment in the EIA documents

Chapter 27 of Volume 2 of the Environmental Statement (ES) presents an assessment of the Major Accidents and Disasters (MA&D) that have the potential to arise during the construction and operation of the Sizewell C power station.

It is stated that a detailed assessment of safety, security and environmental risks associated with the UK EPR™ design has been undertaken as part of the Generic Design Assessment (GDA) process. A Design Acceptance Confirmation (DAC) was granted by the Office for Nuclear Regulation (ONR) and a Statement of Design Acceptability (SoDA) was issued by the Environment Agency in December 2012, confirming that the risks to the public and the environment had been eliminated or mitigated by design sufficiently to be considered as acceptable. (ES_V2_Ch27 2020)

Furthermore, it is explained that a detailed assessment of site-specific nuclear safety and security risks would be undertaken as part of the nuclear site licensing regime. For compliance with the nuclear site licensing regime, SZC Co. would need to ensure the safe operation of the Sizewell C Project. This includes providing the ONR with a robust Safety Case demonstrating that all hazards associated with the development or that may impact the development are well understood and adequate arrangements are in place to reduce these risks to an acceptable level. It is considered that the ONR would not grant a nuclear site licence for the Sizewell C Project unless it is demonstrated that all nuclear safety and security risks have been mitigated to ALARP levels.

According to the ES, it has been agreed with the ONR, Environment Agency, SCC and ESC that with the regulatory processes in place surrounding the safety and security of the UK EPR™ reactors, a detailed assessment of nuclear safety and security risks is not required to be presented as part of the EIA. Instead, it is considered that compliance with existing regulatory regimes would reduce nuclear safety and security risks to be tolerable if ALARP (not significant).

The MA&D assessment therefore provides a summary of the types of hazards covered by the GDA, nuclear site licensing, and other regulatory regimes, their reasonably foreseeable worst-case environmental consequence, and a summary of the required mitigation, in the form of regulatory requirements, to reduce these risks to ALARP. This is to ensure that the processes for mitigating nuclear safety and security risks are transparent and understood by all.

The methodology for the MA&D assessment followed the below staged process:

- Stage 1: Identification of hazards and threats
- Stage 2: Screening of hazards and threats
- Stage 3: Identification of mitigation and
- Stage 4: Identification of residual risks and their significance.

It is emphasized that no modelling or details calculations have been undertaken but qualitative assessment approach has been adopted. Where information is not available, professional judgement has been used to reach a conclusion. A ‘long list' of hazards and threats has been identified and discussed with relevant stakeholders.

These hazards were identified on the basis that they could occur within the Sizewell C Project sites and that the Sizewell C Project could be considered vulnerable to these natural hazards:

- Meteorological Hazards
  - flooding (comprising flooding following heavy rainfall events and coastal flooding following storm surge)
  - storms and gales
  - drought
  - heatwave
  - cold and snow
  - lightning and electrical storms
  - events of reduced visibility
  - extreme humidity (high and low)
- Geological Hazards
  - ground instability
  - seismic hazards
- Other Natural Hazards
  - wildfires
  - space weather

Some further information on each of these hazards has been provided in chapter 27 of Volume 2. (ES_V2_Ch27 2020)

Flood Risk Assessment (FRA)

An FRA has been undertaken for the Sizewell C Project given that part of the main development site and parts of the associated development sites are located in Flood Zone 3 and the site area is over one hectare. The assessment considers flood risk both to, and as a result of, the proposed development over the lifetime of the project. The FRA has considered potential sources of flooding from: fluvial; coastal; groundwater; surface water resulting from intense rainfall (pluvial) events; sewers (also resulting from intense pluvial events); and non-natural water bodies (i.e. canals and reservoirs), either from individual or multiple sources. The FRA has been undertaken on a site by site basis. Effects on flood risk arising from climate change and any future geomorphological change, including the potential for increased flooding risk due to coastal erosion, have also been considered. (ES_V1_Ch1 2020)

Probabilistic Safety Analysis (PSA)

The PSA for the UK EPR™ is described in Chapter 15 of the Pre-Construction Safety Report (PCSR). The PSA is noted as a contribution to a key objective ensuring that the risk of release of radioactive products to the environment is reduced to As Low As Reasonably Practicable (ALARP) (ONR 2011a).

The PSA has been carried out at Level 1, 2 and 3. The PSA considers all modes of operation including low power, shut-down and refuelling.

PSA Level 1

The Level 1 PSA considers both internal events and internal and external hazards that, together with total or partial failure of protection or mitigation measures, can lead to core damage, and evaluates the resulting core damage frequency (CDF). Other end points that do not result in core damage but may lead to potential releases, including those relating to the spent fuel pool, are included (ONR 2011a).

The calculated core damage frequencies (CDF) are summarised in Table 1.

CDF internal events	5.31E-7/yr
CDF internal hazards	1.01E-7/yr
CDF external hazards	7.59E-8/yr
CDF total	**7.08E-7/yr**

Table 1: Core damage frequencies (CDF) (ONR 2011a)

Level 2 PSA

According to EDF/AREVA, the Level 2 PSA results show that the strong containment and dedicated severe accident mitigation measures of the EPR plant are efficient in reducing the frequency and magnitude of releases to the environment in the case of a severe core damage event (UK EPR 2012, 15.4).

The calculated large release frequency and the large early release frequency including all states and the spent fuel pool are summarised in Table 2 (UK EPR ONR 2012, 15.4).

LRF	7.69E-8/yr	10.8% of CDF
LERF	4.07E-8/yr	5.7% of CDF

Table 2: Large (early) release frequency (L(E)RF) (2011a)

The Level 2 PSA results were also presented in terms of "release risk", which is the frequency of a given release multiplied by its magnitude (UK EPR 2012, 15.4). For the purpose of presenting, three isotopes which are known to be important for consequences are considered. These are Cs-137, I-131 and Sr-90.

Spent fuel pool accidents contribute significantly (86%) to the Cs-137 release risk. The second most contributing events (9%) are bypass events: interfacing system LOCAs and steam generator tube ruptures (SGTR).

5.2 Discussion

With regard to possible accidents, reference is made to the Generic Design Assessment (GDA). It is stated that a detailed assessment of safety, security and environmental risks associated with the UK EPR^{TM} design has been undertaken as part of the GDA process. However, this assessment was concluded eight years ago. Since this evaluation, the state of science and technology has developed further. Those new developments need to be taken into account to make a valid statement on the occurrence of major accidents.

Furthermore, it is explained that a detailed assessment of site-specific nuclear safety and security risks would be undertaken as part of the nuclear site licensing regime. The authorities accepted that with this regulatory processes in place regarding the safety of the UK EPR^{TM} reactors and the EIA does not need to present a detailed assessment of nuclear safety risks.

Probabilistic Safety Analysis

PSA results are of considerable value for the orientation of NPP designers and regulators (for example, to identify weak points in a reactor design).

On the other hand, the inherent limitations of PSA should not be forgotten – such analyses are beset with considerable uncertainties, and some risk factors are difficult to include in a PSA, or cannot be included at all:

- Unexpected plant defects or unforeseen physical or chemical processes could not be included in the PSA.
- New ageing phenomena can only be incorporated in PSAs in retrospect.
- Complex forms of human error are extremely difficult to model.
- Due to the complexity of an NPP, some accident initiators or sequences are simply bound to be overlooked or omitted.

In the following, the specific limitations of the UK EPR^{TM} PSA are described.

Out of Scope Items

The following items have been agreed with EDF and AREVA as being outside the scope of the GDA process and hence have not been included in the assessment by ONR.

- Any requirement on the PSA modelling that needs detailed design information or site-specific data
- Failure Modes and Effects Analysis (FMEA) for initiating event analyses
- Test frequencies of key components

List of Initiating Events (IEs) is not complete yet

According to ONR, there are a number of IEs identified related to plant systems that are not yet included in the PSA, due to lack of design detail. As mentioned above, the Failure Mode and Effect analysis (FMEAs) supporting IE derivation is out of scope.

Influence of the HVAC not considered

Loss of ventilation/room coolers (Heating, Ventilation and Air Conditioning, HVAC) during other accident sequences was also not included. The potential impact of the inclusion of HVAC based on the French EPR study could be a 6% increase in the CDF.

Generic LOOP not confirmed bonding

Regarding the initiating event frequencies, the generic loss of offsite power (LOOP) frequency is not confirmed (AF-UKEPR-PSA-019). Since LOOP situations have a considerable contribution to the CDF, this is important.

Review of the Modelling of the I&C required

There will be further development of I&C that will need to be incorporated into the PSA during post GDA phases. ONR requires that the modelling of the I&C in the PSA is reviewed. This should include explicit consideration of I&C based initiating events (including spurious signals) and the potential dependencies between such initiators and the safety mitigation systems and potential dependencies between the cues for operator action and signals used for the automatic I&C (AF-UKEPR-PSA-015). It is also required by ONR that future updates of the model explicitly include the actuators associated with the compact model, and also take into account any CCF related to the actuators (AF-UKEPR-PSA-016).

Human Reliability Analysis (HRA) are not substantiated

The inclusion of pre-initiating Human Failure Events (HFEs) is incomplete. Only misalignment of manual valves is considered explicitly, motor operated and solenoid valves, automatically realigned on a system demand and manoeuvrable from the main control room (MCR), are not considered.

The HRA in the UK EPR™ PSA is largely assumption-based, with no underlying substantiation. ONR requires that substantiation for the Human Reliability Analysis (HRA) in the form of task analyses, procedures and training is provided to underpin the numerical Human Failure Event (HFE) values used in the PSA. The substantiation should include further consideration of pre-initiating HFEs and the potential for HFE dependencies (pre & post fault) (AF-UKEPR-PSA-017).

Common Cause Failures (CCF) are not considered appropriate

Only global CCF parameters are used, which provide no discrimination between different CCF groups for overall risk estimates (AF-UKEPR-PSA-025).

Scope of the internal and external hazards PSA is limited

- The potential dependency between combinations of extreme weather events (snow and wind) and consequential LOOP has to be taken into account and, if necessary, the PSA has to be amended (AF-UKEPR-PSA-028).
- Concerning external hazards only those leading to the loss of ultimate heat sink (LUHS) are effectively addressed in all PSA levels. The other external hazards have not been included due to their low occurrence frequency and consequences. This assumption has to be confirmed (AF-UKEPR-PSA-029).
- The use of an appropriate loss of ultimate heat sink frequency for the site is not confirmed yet (AF-UKEPR-PSA-030).

- Hazards such as internal explosion, turbine missiles and animal infestation are considered and, if necessary, have to be included in the PSA model (AFUKEPR-PSA-031).
- Full scope Internal Fire PSA as well as a full scope Internal Flooding PSA has to perform as the detailed design evolves (AF-UKEPR-PSA-034; AF-UKEPRPSA-036).
- Internal hazards that might be caused by a seismic event, such as fire or flooding, have to be analyzed in detail and to be included in the PSA model supporting the Seismic Margin Assessment (SMA) (AF-UKEPR-PSA-037).
- The impact of seismic faults during shutdown has to be addressed in a consistent manner with other contributions to the risk during shutdown (AFUKEPR-PSA-038).
- The scope of the PSA has to be expanded to include hazards such as fire and flooding during non-power operating states (AF-UKEPR-PSA-002).
- Initiating faults due to intentional mal-operation or sabotage are not considered.
- Also, terror attacks such as an intentional aircraft crash are not considered.

Limitation of the PSA 2

An UK-EPR specific containment structural analysis has to be performed which addresses all potential modes of containment failure, including penetration and leakage failures (AF-UKEPR-PSA-042).

Practical elimination Practical elimination of large or early releases

There is an international expectation that large or early releases can be practically eliminated for new reactors. The Nuclear Safety Directive of the European Union, as amended in 2014, demands that new nuclear installations be designed with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding early radioactive releases and large radioactive releases. (EU 2014) Principle 1 in the Vienna Declaration on Nuclear Safety formulates the same objective for new nuclear power plants.

According to the Western European Nuclear Regulators Association (WENRA) report on the safety of new NPP designs, accidents with core melt which would lead to early or large releases have to be practically eliminated. The report further states that "for accidents with core melt that have not been practically eliminated, design provisions have to be taken so that only limited protective measures in area and time are needed for the public and that sufficient time is available to implement these measures. (WENRA 2013)

WENRA has not undertaken to state quantitatively what they mean by "practically eliminated". WENRA cites requirements from the IAEA to the effect that accidents with a large or early release can be considered to have been practically eliminated if it is physically impossible for the accident sequence to occur, or if the accident sequence can be considered with a high degree of assurance to be extremely unlikely to arise.

This situation leads to arguments from project proponents and stakeholders about what "practically eliminated" actually means. What is a "high degree of assurance"? What does "extremely unlikely to arise" mean? Is extremely unlikely less than 1×10^{-6} per year, or 1×10^{-7} per year, or 1×10^{-8} per year?

A study published by the Institute for Safety and Risk Research at the University of Vienna, concluded that severe accidents for the EPR are not practically eliminated. (ISR 2015) This study found that EDF Energy appears to be using a frequency of 1×10-6 per year to constitute the required high degree of assurance to be extremely unlikely to arise in order that the accidents and accompanying phenomena are practically eliminated. Evaluations of other Generation III and Generation III+ designs use much lower values, ranging from1×10-8 per year to 1×10-7 per year. However, as noted earlier, all of these values are merely suggestions or arguments from the designers since there is no quantitative guide value for what is meant by "practically eliminated". The only safety target cited in the Pre-Construction Safety Report (PCSR) of the UK EPR™ is a target for core damage frequency of ≤1×10-5 per year

A recently published WENRA report provides a common understanding of the approach to demonstrate the avoidance of early releases and large releases by using the notion of practical elimination. (WENRA 2019)

According to WENRA (2019), demonstrating practical elimination via “extreme unlikeliness with a high degree of confidence” has to be based on the two pillars of deterministic and probabilistic considerations. For the deterministic part of the demonstration, practical elimination should be primarily based on design provisions, supported by operations provisions. Attention has to be paid to the human factor. The need for human actions should be limited to the extent practicable. The validity of underlying assumptions should be adequately controlled. Uncertainties have to be taken into account; sensitivity studies should cover the whole spectrum of possible conditions. Also, these provisions should withstand events caused by external hazards in a way that demonstration of practical elimination remains valid. For the probabilistic part of the demonstration, practical elimination of a scenario can be considered successful by achievement of a target value.

There are various kinds of scenarios to which the notion of practical elimination can be applied. In order to get an overview over all relevant cases, it is useful to classify the scenarios into three types:

- Type I -- scenarios with an initiating event that leads directly to severe fuel damage and early failure of the confinement function.
- Type II -- severe accident scenarios with phenomena that induce early failure of the confinement function.
- Type III -- severe accident scenarios that result in late failure of the confinement function.

All WENRA countries apply the notion of practical elimination to types I and II; some countries also apply it to type III. (WENRA 2019)

Flood Risk Assessment

Site-specific factors (in particular possible danger of flooding, climate change effects) could endanger the plant. Flooding can be catastrophic to a nuclear power plant because it can damage its electrical systems, disable its cooling mechanisms and lead to overheating with a possible meltdown and a dangerous release of radioactivity. The Fukushima accident highlighted the hazard of flooding events for nuclear power plants. One of the main questions the Fukushima accident highlighted was the predictability of the wave height of the tsunami.

In 2012 the ENSREG peer review team concluded that the currently available design basis flood (DBF) assessments in the UK did not take into account recent tsunami research work. It was noted that ONR doubts that these studies would lead to a significant change in understanding of maximum credible tsunami heights. (ENSREG 2012c)

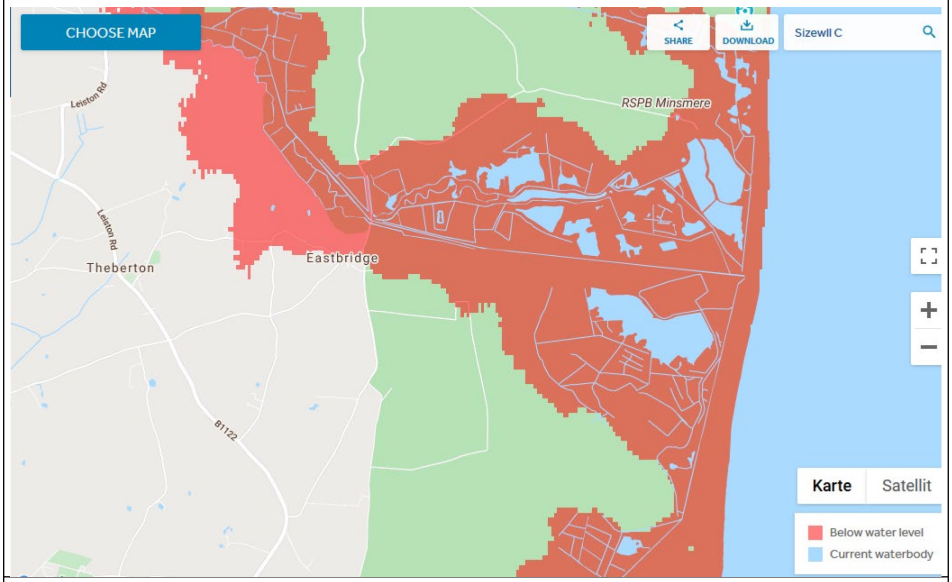
A number of recently published scientific papers suggested that climate change will impact coastal nuclear plants earlier and harder than industry, governments or regulatory bodies have expected, and that safety standards set by national nuclear regulators and the International Atomic Energy Agency (IAEA) are outdated and do not sufficiently take into account the effects of climate change on nuclear power. (BECKER 2020)

On top of sea-level rise, the additional impact of flooding from storm surges must be taken into account. The results of the Global Extreme Sea Level Analysis project showed that the magnitude and frequency of extreme sea levels (ESLs, a factor of mean sea level, tide and storm-induced increases), which can cause catastrophic flooding, have increased throughout the world since 1970. All new satellite studies by the U.S. government's National Oceanic and Atmospheric Administration (NOAA), NASA, and other leading scientific institutions show mean sea level rising and an increase of the frequency and severity of ESLs. (ENSIA 2018)

An example in the UK illustrated this issue: By the time Hinkley Point C will be completed, presumably in 2028, the concrete seawall will be 12.5 meters high, 900 meters long, and according to the UK regulator and French engineers sufficient to withstand the strongest storm surge, the biggest tsunami, and the highest sea-level rise. The independent nuclear consultant Pete Roche, a former adviser to the UK government and Greenpeace, points out that the new seawall does not adequately take into account sea-level rise due to climate change. The wall is strong, but the plans were drawn up in 2012, before the increasing volume of melting of the Greenland ice cap was properly understood and when most experts thought there was no net melting in the Antarctic. Now estimates of sea level rise in the next 50 years have gone up from less than 0.3 to 1 m, well within the operating lifespan of Hinkley Point C. (HAKAI 2018)

The Sizewell C site is prone to flooding events. This is illustrated by the following pictures, created by the Coastal Risk Screening Tool, which illustrates the land projected to be below the annual flood level in 2050. The Climate central sea-level maps are based on peer-reviewed science in leading journals. Improved elevation data indicate far greater global threats from sea level rise and coastal flooding than previously assumed. (CCC 2020)

Land projected to be below annual flood level in 2050



Source: Ccc (2020)

Figure 1: Land projected to be below annual flood level in 2050 around Sizewell C site.

Prevention of liquid radioactive releases

Liquid radioactive releases during and after an accident can only be prevented if the waste system and release routes are guaranteed to be safe. Otherwise, the radioactive liquid will first flow into the reactor building sump and then overflow. In the worst case, the liquid enters into the floors of the building. From there it flows outside the building into rain-water sewers or sinks into the bottom layer of the sea water draining tunnel. Via the sea water cooling outlets the radioactive release will flow into the sea.

ENSREG pointed out that conceptual solutions for post-accident fixing of contamination and the treatment of potentially large volumes of contaminated water should be addressed (ENSREG 2012b). This important issue highlighted by the Fukushima accident should be addressed in the EIA documents.

5.3 Conclusions, questions and preliminary recommendations

With regard to possible accidents, reference is made to the Generic Design Assessment (GDA). The ES states that a detailed assessment of safety, security and environmental risks associated with the UK EPR^{TM} design has been undertaken as part of the GDA process. However, this assessment was concluded eight years ago. Since this evaluation, the state of science and technology has underwent further development. This is reflected in new international and European regulations and guidelines.

In the specific PSA of the UK EPR^{TM}, many factors are not included, because they are out of scope or not addressed appropriately (for example, Common Cause Failure (CCF)).

Generally, PSA results should only be taken as rough indicators of risk. All PSA results are beset with considerable uncertainties, and there are factors contributing to NPP hazards which cannot be included in the PSA.

Therefore, for rare events, the probability of occurrence as calculated by a PSA should not be taken as an absolute value, but as an indicative number only. Hence, it is problematic in practice to reliably demonstrate the fulfilment of a probabilistic goal by PSA.

The claimed "practical elimination" of a large early release is not sufficiently demonstrated by the UK EPR™ PSA yet. To practically exclude the occurrence of severe accidents requires a deep knowledge of the specific situation. It is important to note that a recently published WENRA report provides a common understanding of the approach to demonstrate the avoidance of early releases and large releases by using the notion of practical elimination. (WENRA 2019)

Site-specific factors (in particular possible danger of flooding, climate change effects) could endanger Sizewell C. Flooding can be catastrophic consequences for a nuclear power plant. The EIA documents explain that a detailed assessment of site-specific nuclear safety and security risks would be undertaken as part of the nuclear site licensing regime. The authorities accepted that with this regulatory process in place regarding the safety of the UK EPR™ reactors and the EIA does not need to present a detailed assessment of nuclear safety risks.

All in all, a conservative worst-case release scenario should have been included in the EIA. As mentioned above, a source term, for example for an early containment failure or containment bypass scenario, should have been analysed as part of the EIA – in particular because of the results of the analysis of trans-boundary effects of a potential severe accident at the Sizewell NPP site indicate that significant transboundary effects cannot be excluded.

Questions

1. *When will be evaluated whether the UK EPR™ meets the safety goal of practical elimination of accident sequences leading to large or early releases of radioactive substances according to the approach of WENRA 2019? What could be the consequences for the Sizewell C Project if SZC Co. fails to meet this important safety objective for European NPPs?*
2. *Is it planned to review whether the UK EPR™ design meets the recent European safety standards/requirements by WENRA?*
3. *According to WENRA (2019), all WENRA countries apply the notion of practical elimination to types I and II; some countries also apply it to type III. For which types of scenarios should the concept of practical elimination be applied in the UK?*
4. *Which of the assessment findings of the ONR´s GDA step 4 assessment of Probabilistic Safety Analysis for the UK EPR™ are solved already? How were they solved and, if no solution has been found yet, when should they be solved?*
5. *Which recent national and international studies concerning external hazards (flooding risk, seismic hazard, tsunami and climate change) have to be taken into consideration to determine design basis requirements? Which margins against external hazards have to be implemented for the Sizewell C?*

Preliminary Recommendations

1. It is recommended to re-**assess external hazards** at the Sizewell C site before the design process for the NPP starts. The re-assessment should be based on the latest state-of-the-art methods and take into account most current data.
2. It is recommended to require the implementation of appropriate margins to external hazards in the design of the Sizewell NPP that are based on current scientific studies and data.
3. It is recommended to apply the **concept of practical elimination** consistently in the safety requirements for Sizewell C. Practical elimination of accident sequences has to be demonstrated with state-of-the-art probabilistic and deterministic methods, fully taking into account the corresponding publications of WENRA in 2019.
4. To achieve the safety goal of new nuclear power plants consisting in the requirement that accidents leading to early or large releases have to be practically eliminated, it is necessary to also consider hazard events with frequencies below $<<10^{-4}$ if their impacts reach beyond the design basis. For ensuring compliance with the safety goals, a comprehensive Probabilistic Safety Analysis (Extended PSA) is necessary, taking into consideration all relevant internal and external events and possible accident causes.
5. It is recommended to provide information in a transparent manner about the upcoming demonstration proving that the level of risk of Sizewell C is as low as reasonably practicable (ALARP).
6. It is recommended to include a conservative worst-case release scenario which should have been part of the EIA. A severe accident with a source term for e.g. containment failure or bypass scenario should be analysed as part of the EIA – in particular because of its relevance for impacts at greater distances.

6 ACCIDENTS WITH INVOLVEMENT OF THIRD PARTIES

6.1 Treatment in the EIA documents

According to the ES, malicious attacks and cyber security would be assessed in accordance with ONR's Security Assessment Principles (ONR 2017). The ONR Civil Nuclear Security Division is responsible for approving security arrangements within the civil nuclear industry. For instance, the ONR Civil Nuclear Security Division would require for its approval the submission of a Sizewell C site security plan, before the proposed development is brought into use.

It is explained that procedures and processes are required and are routinely audited by both internal and external regulators under the Nuclear Site Licence. (ES_V2_Ch27 2020)

6.2 Discussion

The terror threat to nuclear power plants has received considerable public attention in the last twenty years. This attention has – for obvious reasons – focused on the hazard of the deliberate crash of a large airliner. But already before September 11, 2001, numerous acts of terrorism have taken place. However, the terrorist threat appears to be particularly grave in the early 21st century.

There are numerous potential targets for terrorist attacks. Industrial plants, train stations or full sports stadiums can appear "attractive" for a terrorist group planning to kill as many people as possible in a single attack. Conducting an attack on a nuclear power plant on the other hand could be attractive for a terrorist group because of its immediate effect on power generation, its symbolic character, its double civilian/military character and the global attention it would receive. A successful attack on a nuclear power plant in one country is at the same time an attack on all NPPs around the world. Countries with a high de-pendency on nuclear power could face a real dilemma.

In recent years, the rise of well-funded terrorist groups combined with the spread of civil nuclear power has placed nuclear security high on the political agenda.

Nuclear power plants are vulnerable to a broad spectrum of possible pathways of attack, including attack from the ground, the air, water ways, and by insiders; as well as to a broad spectrum of possible means of attack, including bombs, aircraft, shelling, missiles, and application of explosives.

New possible means to support attacks emerge: unmanned flying objects, drones, can – such as in military application – be used for the preparation or support of terror attacks. Attention also needs to be devoted to newly emerged attack scenarios such as cyber-attacks.

The identification of terrorist threats against reactors and spent fuel pools is a necessary part of security planning at all nuclear power plants. There is also a pressing need to identify more systematically potential cyber, insider, and asymmetric security threats. More formalized processes for identifying and analysing threats – for example probabilistic risk assessment (PRA) – could help to improve security at nuclear power plants. (NAS 2016)

Terror attacks against Sizewell C

Terrorist attacks or acts of sabotage on Sizewell C may have significant impacts. However, in the Environmental Statement malicious acts of third parties against Sizewell C and their possible effects are not discussed. In comparable EIA procedures such events were addressed to some extent. (UMWELTBUNDESAMT 2018)

It is general consensus that the topic of terror attacks should not be treated publicly in a manner which would provide "useful" information to terrorists and saboteurs and/or provide them with new ideas for attack scenarios. It must be emphasized that this topic can be discussed if this is done in an appropriately general manner. Since the consequences of a terror attack are potentially very high, and many people can be affected, people have a right to be informed about these risks.

To help deciding to which extent the topic can be discussed in public, the "Criterion of the Technically Competent Attacker Group" can be applied (HIRSCH 2005): it does not appear problematic to openly discuss information which any group of attackers which is sufficiently competent to be able to plan and exe-cute an attack with some likelihood of "success" possesses anyway, or can acquire with minimal research effort. Indeed, the attempt to keep such information secret would serve no purpose whatsoever.

Information was provided for example that the UK EPR^{TM} will be designed to withstand a commercial airplane crash, but without mentioning the relevant airplane category.

It should be noted that, through an effective structural protection, which usually can also be shown publicly, a higher level of protection is achieved as by a non-disclosure of the technical, administrative and personnel protection measures.

6.3 Conclusions, questions and preliminary recommendations

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the planned Sizewell C reactors. Although precautions against sabotage and terror attacks cannot be discussed in detail in public in the EIA process for reasons of confidentiality, the necessary legal requirements should be set out in the EIA documents. Information regarding the issue of terror attacks would be of great interest to the Austrian side, considering the large consequences of potential attacks.

Questions

1. *What are the requirements with respect to the planned NPP design against the deliberate crash of a commercial aircraft?*
2. *Does the UK EPR^{TM} fulfil those requirements based on the present state of knowledge (not only relying on the data of the supplier but on the assessment of ONR)?*

Preliminary recommendations

1. Concerning the protection of the Sizewell C against aircraft crash it is recommended that the NPP should be designed in a way that vital safety functions can be fulfilled despite of the thermal and mechanical impacts corresponding to the assumed crash of passenger aircrafts of the largest class (Airbus A-380) and fast military jets.

7 TRANS-BOUNDARY IMPACTS

7.1 Treatment in the EIA documents

Volume 10 of the Environmental Statement (ES) presents details of the different cumulative effect assessments of the Sizewell C project. These take into account the following: inter-relationship effects; project-wide effects; effects with other plans, projects and programmes; and trans-boundary effects. (ES_Vol10_Ch1 2020)

Chapter 5 of this Volume deals with the possible trans-boundary effects of the Sizewell C project. It is stated: *"In line with policy and guidance, SZC Co. has considered whether the Sizewell C Project is likely to have significant trans-boundary effects during the construction, operation, and removal and reinstatement phases.*" (ES_V10_Ch5 2020, p. 1)

The ESPOO Convention signatory states closest to the Sizewell C project are Belgium, Netherlands, Germany and France. The nearest territorial waters of these states are approximately 112 km (to French territorial waters), 119 km (to Belgian territorial waters), 122.5 km (to Netherlands territorial waters) and 380 km (to German territorial waters) from Sizewell C.

In the EIA Scoping Opinion, the Planning Inspectorate acknowledged that the 2019 EIA Scoping Report did not indicate whether the Sizewell C Project is likely to have significant trans-boundary effects. It is requested that the Environmental Statement should identify whether the Sizewell C project has the potential to result in significant trans-boundary effects and, if so, which European Economic Area states would be affected.

By definition unmitigated major accidents and disasters (MA&D) hazards and threats could result in significant environmental effects and may result in trans-boundary effects. Following the implementation of the identified mitigation measures (including compliance with legislative and regulatory processes, as set out in Volume 2, Chapter 27 of the ES), all risks including any potential trans-boundary effects are considered to be tolerable or tolerable if as low as reasonably practicable and not significant (ES_V10_Ch5 2020)

The assessment of trans-boundary effects concluded: *"[i]t is predicted that there will be no significant transboundary effects"*. (ES-V10_Ch5 2020, p. 20)

7.2 Discussion

In the framework of the Environmental Statement, no severe accident was analysed. But severe accidents at Sizewell C with considerable Caesium-137 releases cannot be excluded, although their calculated probability is below 1E-7/a (see chapter 5). There is no reason to exclude those accidents from being covered in the Environmental Statement (ES). Quite to the contrary, it would appear rather evident that they should be included in the assessment since their effects can be widespread and long-lasting and Austria can be affected. The EIA for the planned Dukovany NPP (Czech Republic) assumed a maximal release of Cs-137 for a severe accident of 3.0E+13 Bq (30 TBq).

(UMWELTBUNDESAMT 2018) The EIA procedure for the Hanhikivi NPP (Finland) calculated possible trans-boundary effects of a Cs-137 release of 5.0E+14 (500 TBq). (UMWELTBUNDESAMT 2014)

For Sizewell C, a UK EPR™, a core-melt accident with containment failure or by-pass, resulting in the release of huge amounts of radioactive material in the environment, cannot be excluded. Thus, an analysis of possible trans-boundary effects is presented in the following chapter.

Possible source terms

In the following table, possible source terms are listed. Despite the calculated frequency being very low, large radioactive releases are possible. Note: As described in the chapter 5, the calculated frequencies are not fully confirmed yet.

Table 3: Calculated releases of severe accident at UK EPR™ (UK EPR 2012, 15.4)

Cs-137 release [PBq]	I-131 release [PBq]	Containment failure mode
44.5	471	Isolation failure in-vessel recovery without sprays (RC-201)
45.8	516	Isolation failure (debris not flooded) (RC-203)
46.8	533	Isolation failure (debris flooded) (RC-205)
40.6	384	SGTR unscrubbed (RC-702)
438.0	4,300	Large ISLOCA, unscrubbed (RC-802)
1,780.0	1,520	Spent fuel pool accident (RC SFP)

Analysis of trans-boundary effects

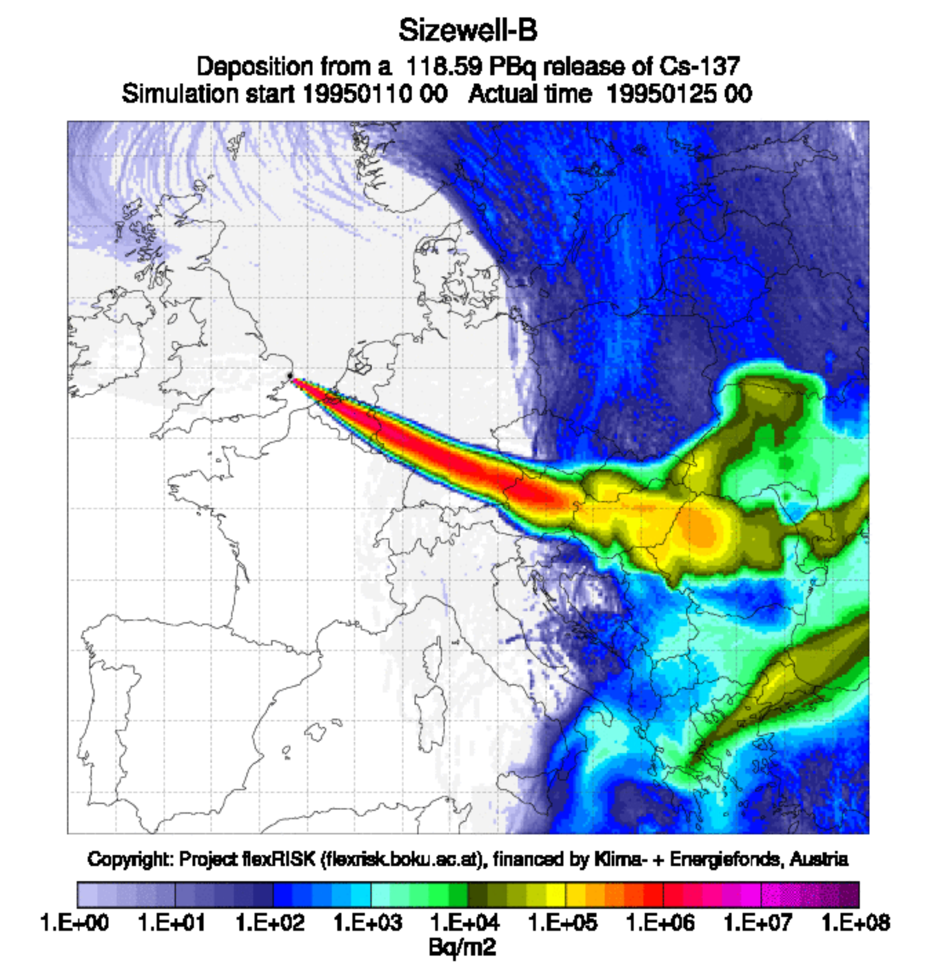
For the assessment of possible impacts of trans-boundary release of Sizewell C, flexRISK project calculations are used (FLEXRISK 2013). In the flexRISK research project, the geographical distribution of the risk due to severe accidents in nuclear power plants in Europe was investigated. For each reactor, an accident scenario with a large release of nuclear material was selected. Based on source terms and accident frequencies, a current dispersion model was used to calculate the ground contamination of Cs-137 and I-131 and doses for about 2,800 different weather situations. Furthermore, the Cs-137 deposition was determined for 88 real weather scenarios of a representative year (1995). The results were visualized in maps. The dispersion calculations were performed with the Lagrangian particle model FLEXPART. Data from the European Centre for Medium-Term Weather Forecasting (ECMWF) were used as meteorological input data.

FlexRISK used a release of 118.59 PBq Cs-137 and 925.74 PBq I-131 for the calculations. This source term is comparable with source terms of the EPR calculated in the PSA 2 (see table 3).

In the following some selected results from the flexRISK project are presented and discussed.

For Sizewell B, a release scenario has been evaluated for the above mentioned 88 weather situations in 1995. An evaluation of these results shows that a radioactive release in 31 of these 88 (about 35%) weather scenarios could result in a contamination of Austrian territory.

Figure 2 and 3 illustrate exemplarily the calculated Caesium-137 depositions after a possible severe accident at the Sizewell NPP site.



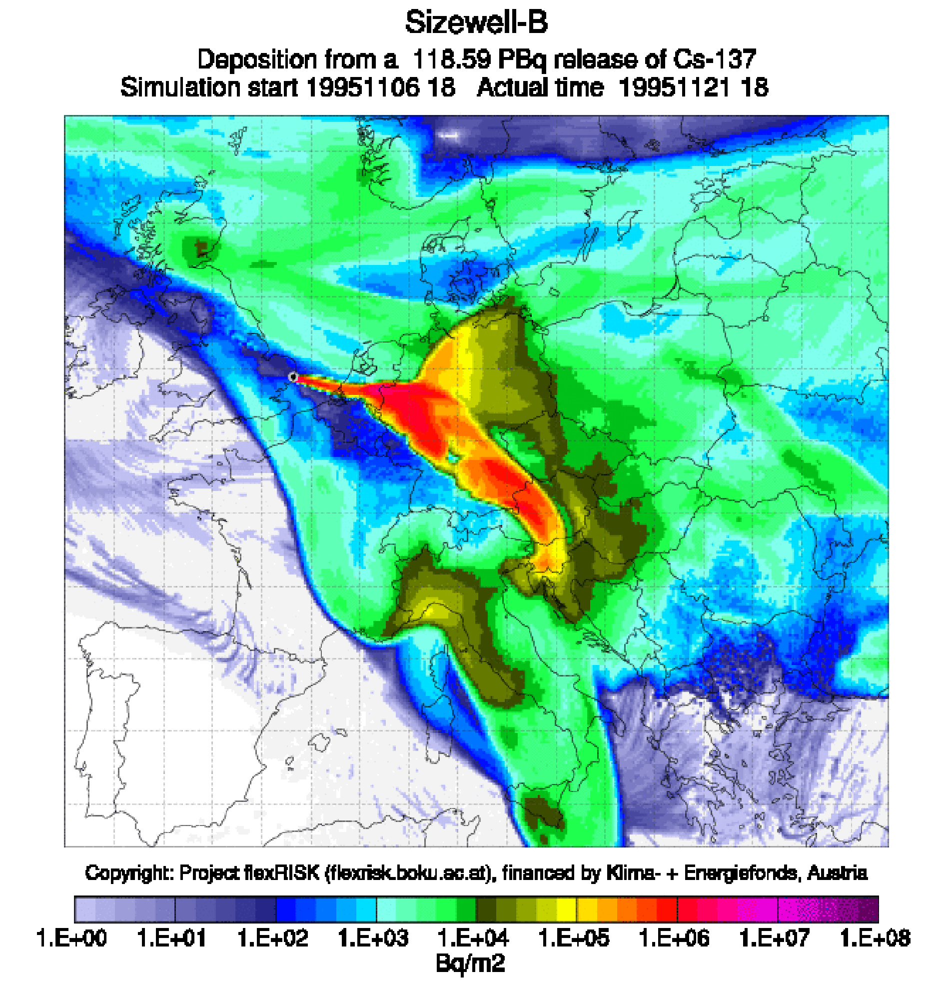
Source: http://flexrisk.boku.ac.at/ umweltbundesamt

Figure 2: Deposition of Cs-137 after a severe accident at the Sizewell site, weather situation of 10 Jan 1995.

Under weather conditions similar to those on 10 Jan 1995, large parts of the territory of Austria would be significantly affected by an accident at the Sizewell site. Contaminations in Austria could reach up to a few 100 kBq Cs-137/m^2(orange and red scale, up to 1E+06 Bq/m^2 = 1,000 kBq/m^2).

Areas with such contamination are considered contaminated according to IAEA classification, since the population in these areas can expect an effective dose of more than 1 mSv in the first year (LELIEVELD et al. 2012).

Figure 3: Deposition of Cs-137 after a severe accident at the Sizewell site, weather situation of 6 Nov 1995.



Source: http://flexrisk.boku.ac.at/ umweltbundesamt

A considerable contamination of the Austrian territory would result from a potential Caesium-137 release of 118.59 PBq at the Sizewell NPP site under conditions comparable to those on 6 November 1995. Almost all regions in Austria would receive depositions of more than 1,000 Bq/m² (1E+03 Bq/m²). In large areas the values could be above 1E+05 Bq/m², even up to 1E+06 Bq/m².

If the contamination of ground (and air) beyond certain thresholds can be expected, a set of agricultural intervention measures is triggered. These measures include earlier harvesting, closing of greenhouses and covering of plants, putting livestock in stables etc. A catalogue of countermeasures for radiological crisis situations is used (BMLFUW 2014), which requires the introduction of agricultural protection measures even in the case of low levels of contamination. This catalogue includes, among others, measure A07 ("Immediate harvesting of marketable products, in particular of storable products") with its associated (forecast) levels:

Table 4: Levels for the agricultural countermeasures A07 (BMLFUW 2014)

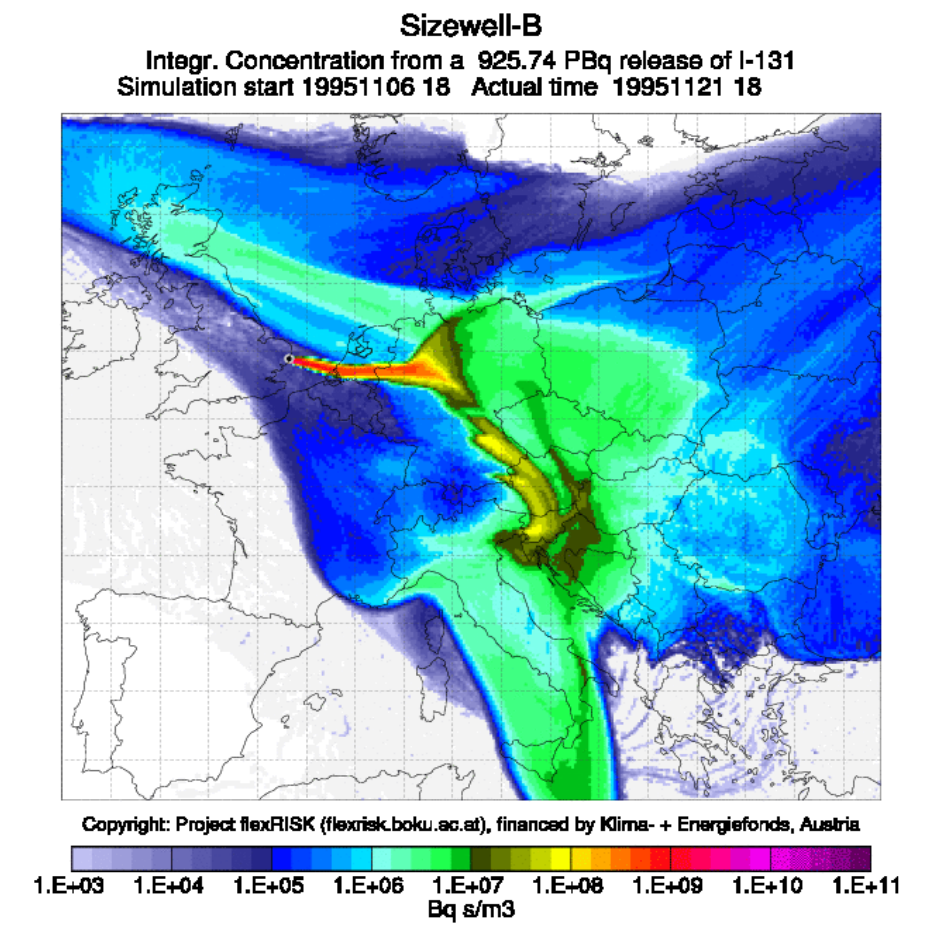
	I-131 Bq*h/m³	I-131 Bq/m²	Cs-137 Bq*h/m³	Cs-137 Bq/m²
Start of measure A07	170	700	350	650

Contaminations of several 100 kBq Cs-137/m² like in figure 2 or 3 are much higher than these levels, therefore agricultural countermeasures could be necessary on Austrian territory in case of a severe accident at the Sizewell site; Austria would be severely affected.

It is important, however, to keep in mind that accidents with much higher releases cannot be excluded.

Also a contamination with Iodine-131 can lead to significant impacts on Austrian territory, as is shown in figure 4.

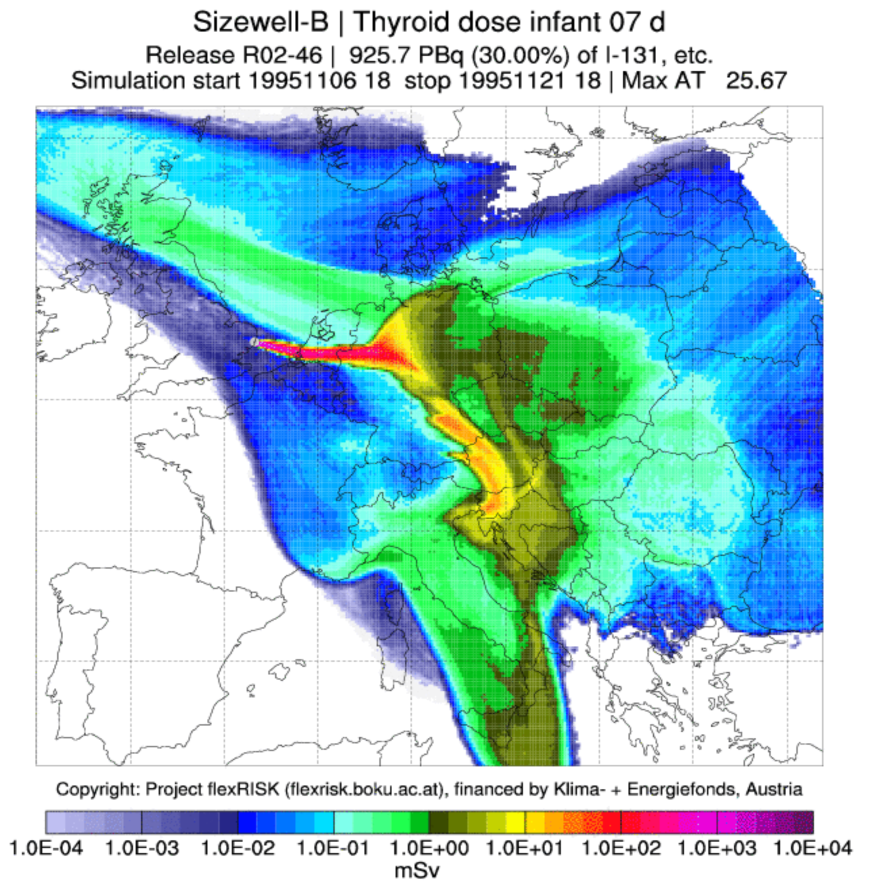
Figure 4: Integrated concentration of I-131 from a severe accident at the Sizewell site, weather situation of 6 Nov 1995.



Source: http://flexrisk.boku.ac.at/

Figure 4 shows a meteorological scenario for I-131. The highest concentration on Austrian territory can be up to several 1,000 Bq h/m³. Also this concentration is far above the above mentioned level which requires the start of agricultural countermeasures in Austria.

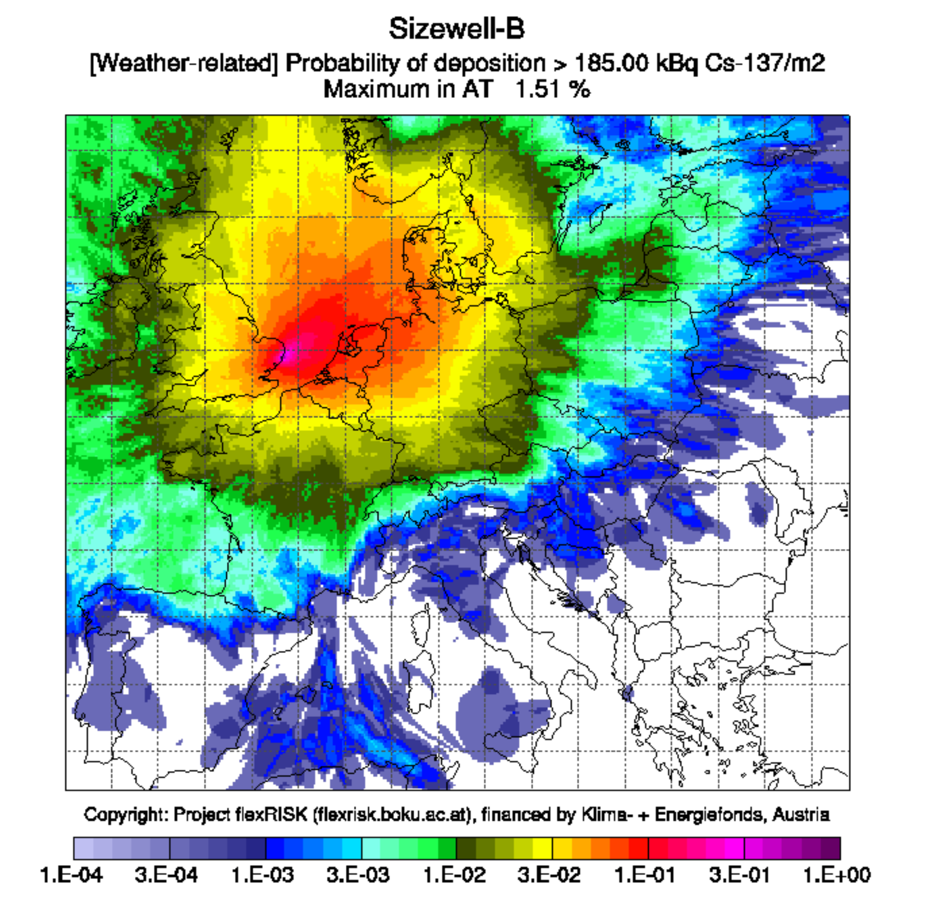
Figure 5: Possible thyroid dose for infants for a weather situation like on 6 June 1995; maximum dose for 7 days in Austria is 25.67 mSv.



Source: http://flexrisk.boku.ac.at/ umweltbundesamt

Figure 5 shows the maximum thyroid dose for infants resulting from an I-131 release in a weather situation like on 6 June 1995. Up to 25.67 mSv could be expected in 7 days. This could result in the intervention measure of iodine prophylaxis for risk groups.

When summarizing the weather-related probability of Austria being contaminated with more than 150 kBq Cs-137/m^2 by a severe accident in Sizewell, a maximum probability of 1.51% is calculated (see figure 6). Such a contamination would be comparable to the highest contaminations that occurred in Austria after Chernobyl (186 kBq Cs-137/m^2).



Source: http://flexrisk.boku.ac.at/ umweltbundesamt

Figure 6: Weather-related probability for a deposition of >185 kBq Cs-137/m2 due to a severe accident at the Sizewell site.

7.3 Conclusions, questions and preliminary recommendations

The results of the analysis of trans-boundary effects of a potential severe accident at the Sizewell NPP site indicate that significant transboundary effects cannot be excluded.

The results also indicate the need for intervention measures in Austria. Such measures include agricultural countermeasures, but also iodine prophylaxis for risk groups.

Moreover, the results emphasise the importance of a serious evaluation and discussion of the severe accident scenarios for Sizewell C in the framework of the trans-boundary EIA.

The information the EIA procedure provided so far does not permit a meaningful assessment of the effects that conceivable accidents at Sizewell C could have on Austrian territory. The analysis of a severe accident scenario would close this gap and allow for a discussion of the possible impacts on Austria. This should be taken into consideration before granting further permissions.

Preliminary recommendation

1. Because the source term used in the accident analysis of the Environmental Statement does not reflect a severe accident, it is recommended to calculate the consequences of a **severe accident with a large release** since the effects of severe accidents can be wide-spread and long-lasting and even countries in Central Europe, such as Austria, can be affected.

8 QUESTIONS AND PRELIMINARY RECOMMENDATIONS

8.1 Spent fuel and radioactive waste

Questions

1. *What is the timetable of the planned dry interim storage for spent fuel?*
2. *What is the status of the geological repository for spent fuel and HLW?*
3. *How can the safe storage of spent fuel be ensured in case the interim storage and final disposal will not be available in time?*
4. *Is it planned to use copper for the spent fuel canisters, and if yes, how will the copper corrosion problem be solved?*

Preliminary recommendation

1. To demonstrate the safe management of nuclear waste and spent fuel from Sizewell C detailed information on the interim storage and final disposal should be provided; also alternative nuclear waste management solutions in case these facilities will not be operable in time.

8.2 Reactor type

Questions

1. *Which of the assessment findings of the ONR´s GDA step 4 assessment of Severe Accidents for the UK EPR™ have already been solved? How were they solved and if not, when is a solution expected for those?*
2. *Does the UK EPR™ correspond to the EPR in Finland and/or France? If not, where does the design deviate?*

8.3 Accident analysis

Questions

1. *When will be evaluated whether the UK EPR™ meets the safety goal of practical elimination of accident sequences leading to large or early releases of radioactive substances according to the approach of WENRA 2019? What could be the consequences for the Sizewell C Project if SZC Co. fails to meet this important safety objective for European NPPs?*
2. *Is it planned to review whether the UK EPR™ design meets the recent European safety standards/requirements by WENRA?*
3. *According to WENRA (2019), all WENRA countries apply the notion of practical elimination to types I and II; some countries also apply it to type III. For which types of scenarios should the concept of practical elimination be applied in the UK?*

4. *Which of the assessment findings of the ONR´s GDA step 4 assessment of Probabilistic Safety Analysis for the UK EPR^{TM} are solved already? How were they solved and, if no solution has been found yet, when should they be solved?*
5. *Which recent national and international studies concerning external hazards (flooding risk, seismic hazard, tsunami and climate change) have to be taken into consideration to determine design basis requirements? Which margins against external hazards have to be implemented for the Sizewell C?*

Preliminary Recommendations

1. It is recommended to re-**assess external hazards** at the Sizewell C site before the design process for the NPP starts. The re-assessment should be based on the latest state-of-the-art methods and take into account most current data.
2. It is recommended to require the implementation of appropriate margins to external hazards in the design of the Sizewell NPP that are based on current scientific studies and data.
3. It is recommended to apply the **concept of practical elimination** consistently in the safety requirements for Sizewell C. Practical elimination of accident sequences has to be demonstrated with state-of-the-art probabilistic and deterministic methods, fully taking into account the corresponding publications of WENRA in 2019.
4. To achieve the safety goal of new nuclear power plants consisting in the requirement that accidents leading to early or large releases have to be practically eliminated, it is necessary to also consider hazard events with frequencies below $<<10^{-4}$ if their impacts reach beyond the design basis. For ensuring compliance with the safety goals, a comprehensive Probabilistic Safety Analysis (Extended PSA) is necessary, taking into consideration all relevant internal and external events and possible accident causes.
5. It is recommended to provide information in a transparent manner about the upcoming demonstration proving that the level of risk of Sizewell C is as low as reasonably practicable (ALARP).
6. It is recommended to include a conservative worst-case release scenario which should have been part of the EIA. A severe accident with a source term for e.g. containment failure or bypass scenario should be analysed as part of the EIA – in particular because of its relevance for impacts at greater distances.

8.4 Accidents with involvements of third parties

Questions

1. *What are the requirements with respect to the planned NPP design against the deliberate crash of a commercial aircraft?*
2. *Does the UK EPR^{TM} fulfil those requirements based on the present state of knowledge (not only relying on the data of the supplier but on the assessment of ONR)?*

Preliminary recommendations

1. Concerning the protection of the Sizewell C against aircraft crash it is recommended that the NPP should be designed in a way that vital safety functions can be fulfilled despite of the thermal and mechanical impacts corresponding to the assumed crash of passenger aircrafts of the largest class (Airbus A-380) and fast military jets.

8.5 Trans-boundary impacts

Preliminary recommendation

1. Because the source term used in the accident analysis of the Environmental Statement does not reflect a severe accident, it is recommended to calculate the consequences of a **severe accident with a large release** since the effects of severe accidents can be wide-spread and long-lasting and even countries in Central Europe, such as Austria, can be affected.

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12 GLOSSARY

ALARP .... As far as reasonably practicable

ASN .... French Nuclear Safety Authority

Bq .... Becquerel

CCF .... Common cause failure

CDF .... Core Damage Frequency

CGCS .... Combustible gas control system

CHRS .... Containment heat removal system

CMSS .... Core Melt Stabilisation System

Cs-137 .... Caesium-137

DAC .... Design Acceptance Confirmation

DBF .... Design basis flood

DCH .... Direct Containment Heating

DEC .... Design Extension Conditions

ECMWF .... European Centre for Medium Range Weather Forecasting

EDG .... Emergency Diesel Generators

EIA .... Environmental Impact Assessment

ENSREG .... European Nuclear Safety Regulators Group

EPR .... European Pressurised Reactors

ES .... Environmental Statement

EU .... European Union

FL3 .... Flamanville Unit 3

FMEA .... Failure Modes and Effects Analysis

FRA .... Flood Risk Assessment

GDA .... Generic Design Assessment

GDF .... Geological disposal facility

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

GW .... Giga Watt hour

HFT .... Hot functional testing

HLW .... High level waste

HPME .... High Pressure Melt Ejection

HRA .... Human Reliability Analysis

HVAC .... Heating, Ventilation and Air Conditioning

I&C .... Instrumentation & Control

I-131 .... Iodine-131

IAEA .... International Atomic Energy Agency

IDAC .... Interim Design Acceptance Confirmation

IE .... Initiating Event

ILW .... Intermediate level waste

ISFS .... Interim storage for spent fuel
IWRST................ In-containment refuelling water storage tank
JSW.................... Japan Steel Works
LLW.................... Low level waste
LOCA .... Loss of Coolant Accident
LOOP .... Loss of offsite power
MA&D................. Major Accidents and Disasters
MWh................... Mega Watt hour
MW..................... MegaWatt
NDA.................... Nuclear Decommissioning Authority
NFLA .... Nuclear Free Local Authorities
NOAA .... National Oceanic and Atmospheric Administration
NPP.................... Nuclear Power Plant
OL3 .... Olkiluoto Unit 3
PAR.................... Passive autocatalytic recombiners
PBq .... Peta Becquerel, E15 Bq
PCSR .... Pre-Construction Safety Report
PDS.................... Primary Depressurisation System
PRA.................... Probabilistic risk assessment
PSA.................... Probabilistic Safety Assessment
RCS.................... Reactor Cooling System
RPV.................... Reactor Pressure Vessel
RRC .... Risk Reduction Category
SBO.................... Station Black Out
SGTR .... Steam generator tube ruptures
SMA .... Seismic Margin Assessment
SoDA.................. Statement of Design Acceptability
Sr-90 .... Strontium-90
SZC Co. .... NNB Generation Company Ltd
SZC .... Sizewell C
TBq..................... Tera-Becquerel, E12 Bq
TVO.................... Teollisuuden Voima Oyj, Finnish NPP operator
TWh.................... Tera Watt hour
UDG .... Ultimate Diesel Generators
UNECE............... United Nations Economic Commission for Europe
VLLW .... Very low level waste
WENRA.............. Western European Nuclear Regulators´ Association

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