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ASSESSMENT REPORT

Civil Nuclear Reactors Programme

NNB GenCo: Hinkley Point C Pre-Construction Safety Report 2012 – Assessment Report for Topic Stream B8, Probabilistic Safety Analysis (PSA)

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EXECUTIVE SUMMARY

This assessment report reviews that portion of the Hinkley Point C pre-construction safety report 2012 (HPC PCSR2012) that falls within the scope of topic stream B8, probabilistic safety analysis (PSA). Most of this material lies in HPC PCSR2012 Chapter 15, related sub-chapters and key supporting references. The licensee, NNB Generation Company Limited (NNB GenCo), submitted HPC PCSR2012 to the Office for Nuclear Regulation (ONR) to provide the site-specific baseline safety justification to support the construction of a twin UK EPR™ power station at Hinkley Point C (HPC).

This assessment report also reviews that portion of the HPC PCSR2012 relevant to the demonstration that the Hinkley Point C design reduces risk as low as reasonably practicable (ALARP). Most of this material lies in HPC PCSR2012 Chapter 17.

A final version of the Generic Design Assessment (GDA) pre-construction safety report (PCSR) issued in November 2012 formed the basis for issue by the Office for Nuclear Regulation (ONR) on 13 December 2012 of a Design Acceptance Confirmation (DAC) for the UK EPR™ design. The GDA PCSR addressed only the key elements of the design of a single UK EPR™ unit (the generic features on ‘the nuclear island’) and excluded ancillary installations that a potential purchaser of the design could choose after taking the site location into account. Certain matters were also deemed to be outside the scope of the GDA PCSR.

In contrast, HPC PCSR2012 addresses the whole Hinkley Point C licensed site comprising the proposed twin UK EPR™ units and all ancillary installations. Some matters that were outside the scope of the GDA PCSR are also addressed in HPC PCSR2012. As the generic features were addressed in the GDA process, my focus is on site-specific documentation that has not been formally assessed by ONR previously. The remaining, generic, documentation has been copied into HPC PCSR2012 from an earlier March 2011 GDA PCSR, but this has now been superseded by the November 2012 GDA PCSR.

Based on my assessment of new material, not previously covered by the March 2011 GDA PCSR, I conclude that adequate progress has been made for the point in time of this PCSR. For PSA, the March 2011 GDA PCSR has been adequately updated to reflect the site-specific features, with those aspects identified as outside the generic site environmental and external hazards envelope, where relevant, being updated with site-specific information. However, HPC PCSR2012, and in particular the HPC PCSR2012 version of the PSA, will be insufficient to inform a future ONR decision on whether to permission construction of Hinkley Point C.

It is important to note that HPC PCSR2012 alone is not intended to inform a future ONR decision on whether to permission construction of Hinkley Point C. NNB GenCo intends to submit a major revision to HPC PCSR2012 before seeking consent for nuclear island construction which will fully integrate the final GDA PCSR and will be supported by other documentation.

A significant amount of work needs to be completed on the PSA for the next revision of the Hinkley Point C PCSR. I consider NNB GenCo has comprehensively identified the required further work and qualitatively assessed the impact of the PSA limitations as part of HPC PCSR2012. However, given the importance of having as comprehensive as possible PSA for the nuclear island safety related concrete milestone, NNB GenCo needs to develop the PSA model and supporting documentation to address those aspects identified in its HPC PCSR2012 PSA forward work plan and PSA limitations report. This should focus on those aspects that are relevant for risk informing the design to inform a future ONR decision on whether to permission construction of Hinkley Point C.

Regarding the demonstration that risk has been reduced ALARP, I consider, based on the ALARP assessments reviewed, there is evidence of continued consideration of design development and

optimisation, there is general consistency with a number of the principles outlined in ONR's ALARP assessment guidance and there is evidence that PSA has been adequately used to risk inform the design. However, there are a number of limitations in the presentation of the demonstration of ALARP in HPC PCSR2012.

In addition to the PSA limitations identified in ONR's GDA step 4 PSA assessment report, and those identified by NNB GenCo in HPC PCSR2012, I have identified a number of limitations. Such limitations where more significant have been recorded as issues within ONR's issues database, and will be covered through routine future regulatory work. Where less significant, and where captured within NNB GenCo's PSA forward work plan, the limitations are identified as expectations in the main body of this report. These expectations will be discussed with NNB GenCo as part of ongoing normal regulatory business.

Issues have been raised to address the following:

- The PSA model (and documentation), PCSR and reference design are not aligned.
- It is important for NNB GenCo to develop sufficient seismic PSA at an early stage so that it can risk inform the design of Hinkley Point C effectively. Further information is required on how its seismic PSA strategy will be implemented to ensure it meets this expectation.
- The current ALARP demonstration is not coherent. A Hinkley Point C specific overall ALARP assessment is required that includes, but is not limited to, the following: a summary of NNB GenCo's arrangements for ensuring risk is managed ALARP as the Hinkley Point C design and construction progresses; consideration of the insights from PSA; a comprehensive summary of the site-specific ALARP studies; and a summary of the GDA ALARP position.

I judge that a suitable and sufficient PSA can be developed for the next revision of the Hinkley Point C PCSR provided that adequate resolution of the following is achieved: relevant GDA assessment findings: the issues raised in this report; the expectations stated in this report; and the PSA limitations and gaps identified by NNB GenCo in HPC PCSR2012.

LIST OF ABBREVIATIONS

AF	Assessment Finding
ALARP	As Low As Reasonably Practicable
BMS	(ONR) How2 Business Management System
BSL	Basic Safety Level
BSO	Basic Safety Objective
C&I	Control and Instrumentation
CBA	Cost Benefit Analysis
CCF	Common Cause Failure
CDF	Core Damage Frequency
DAC	Design Acceptance Confirmation
DBA	Design Basis Analysis
FMEA	Failure Mode and Effects Analysis
GDA	Generic Design Assessment
HRA	Human Reliability Analysis
HSE	Health and Safety Executive
HPA	Health Protection Agency
HPC	Hinkley Point C
HPC PCSR2012	Hinkley Point C Pre-Construction Safety Report 2012
HVAC	Heating, Ventilation and Air Conditioning
IAEA	International Atomic Energy Agency
IPR	Intervention Project Record
ISFS	Interim Spent Fuel Store
LC	Licence Condition
LOOP	Loss Of Off-site Power
LUHS	Loss of Ultimate Heat Sink
NNB GenCo	NNB Generation Company Limited
NSDAP	Nuclear Safety Design Assessment Principle(s)
ONR	Office for Nuclear Regulation (an agency of HSE)
PCSR	Pre-construction Safety Report
pry	Per Reactor Year
PSA	Probabilistic Safety Analysis
RC1	Reference Configuration 1
SAP	(ONR) Safety Assessment Principle(s)

LIST OF ABBREVIATIONS

SDO	Safety Design Objective
SEC[ESWS]	Essential Service Water System
SEF	Coarse Filtration and Trash Removal System
SMA	Seismic Margins Assessment
SRU[UCWS]	Ultimate Sea Water Cooling System
SSC	System, Structure and Component
SSG	Specific Safety Guide
TAG	(ONR) Technical Assessment Guide(s)
WENRA	Western European Nuclear Regulators Association

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1 INTRODUCTION

1.1 Background

1 This report presents the findings of the assessment of that portion of the Hinkley Point C pre-construction safety report 2012 (HPC PCSR2012, Ref. 1) that falls within the scope of topic stream B8, probabilistic safety analysis (PSA), and as low as reasonably practicable (ALARP). The licensee, NNB Generation Company Limited (NNB GenCo), submitted HPC PCSR2012 to the Office for Nuclear Regulation (ONR) to provide the site-specific baseline safety justification to support the construction of a twin UK EPR^{TM} power station at Hinkley Point C (HPC).

2 Assessment was undertaken in accordance with the requirements of the ONR How2 Business Management System (BMS) process 'Produce assessments' (Ref. 2). The ONR Safety Assessment Principles (SAP), Ref. 3, together with supporting Technical Assessment Guides (TAG), Ref. 4, have been used as the basis for this assessment.

3 This assessment report has been written to support a summary assessment report that addresses whether HPC PCSR2012 demonstrates suitable progress towards meeting ONR's requirement for an adequate pre-construction safety report. To this end, this assessment report provides guidance through expectations and, where more significant, issues have been recorded within ONR's issues database on matters that need to be addressed in the next revision of the HPC pre-construction safety report (PCSR).

4 This assessment is carried out under the ONR intervention project record (IPR) NNB-HPC2-IPR-46 (Ref. 5) and in accordance with the 'Hinkley Point C construction intervention strategy for the UK EPR™' (Ref. 6).

1.2 Scope

5 The scope of this report covers topic stream B8, PSA, and the demonstration that the HPC design reduces risk ALARP. Most of the material assessed lies in HPC PCSR2012 Chapters 15 and 17, related sub-chapters and key supporting references.

6 A final version of the Generic Design Assessment (GDA) PCSR issued in November 2012 formed the basis for issue by ONR on 13 December 2012 of a Design Acceptance Confirmation (DAC) for the UK EPR^{TM} design. The GDA PCSR addressed only the key elements of the design of a single UK EPR^{TM} unit (the generic features on 'the nuclear island') and excluded ancillary installations that a potential purchaser of the design could choose after taking the site location into account. Certain matters were also deemed to be outside the scope of the GDA PCSR.

7 In contrast, HPC PCSR2012 addresses the whole HPC licensed site comprising the proposed twin UK EPR^{TM} units and all ancillary installations. Some matters that were outside the scope of the GDA PCSR are addressed in HPC PCSR2012. As the generic features were addressed in the GDA process, attention has been concentrated here on site-specific documentation that has not been formally assessed by ONR previously. The remaining, generic, documentation has been copied into HPC PCSR2012 from an earlier March 2011 GDA PCSR but this has now been superseded by the November 2012 GDA report. The generic documentation has only been revisited if recent developments have materially affected the case being made.

8 It is important to note that HPC PCSR2012 alone is not sufficient to inform a future ONR decision on whether to permission construction of HPC and NNB GenCo intends to submit other supporting documentation. Note also that HPC PCSR2012 will be

superseded by a further site-specific revision intended to fully reflect the final GDA PCSR and other design changes.

9 It should also be noted, the approach to safety function categorisation and safety system classification agreed during GDA is not fully reflected in HPC PCSR2012, which largely uses the approach employed on Flamanville 3. The integration of the methodology agreed during GDA will be demonstrated in the next revision of the HPC PCSR.

1.3 Methodology

10 The methodology for the assessment follows ONR How2 BMS step 1.4.1 ‘Produce assessments’, in particular the ‘Guidance on mechanics of assessment’ (Ref. 2).

2 ASSESSMENT STRATEGY

11 My assessment strategy is set out in this section. This identifies the standards and criteria that have been applied, the use of technical support contractors, the integration with other assessment topics and those areas outside the scope of my assessment.

2.1 Standards and criteria

12 The relevant standards and criteria adopted within this assessment are principally the Safety Assessment Principles (SAP), Ref. 3, internal ONR Technical Assessment Guides (TAG), Ref. 4, relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licensed sites. The key SAPs and relevant TAGs are detailed within this section. National and international standards and guidance have been referenced where appropriate within the assessment report. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.1.1 Safety Assessment Principles

13 The key SAPs applied within the assessment are included within Table 1 of this report.

2.1.2 Technical Assessment Guides

14 The following TAGs have been used as part of my assessment (Ref. 4):

- NS-TAST-GD-005 ONR guidance on the demonstration of ALARP
- NS-TAST-GD-030 probabilistic safety analysis

2.1.3 National and international standards and guidance

15 The following international standards and guidance have been used as part of my assessment (Refs 7 and 8):

- International Atomic Energy Agency (IAEA) Specific Safety Guide (SSG) on the development and application of level 1 PSA for nuclear power plants (SSG-3)
- Western European Nuclear Regulators Association (WENRA) reference levels

16 The above PSA related SAPs, IAEA standards and WENRA reference levels are embodied and enlarged on in ONR's Technical Assessment Guide (TAG) on PSA (Ref. 4) and it is this guide that provides the principal means for assessing the PSA in practice.

2.2 Use of technical support contractors

17 No technical support contractors have been used to inform this work.

2.3 Integration with other assessment topics

18 The nature of PSA means that there are interactions with other technical areas since aspects of the assessment in those areas constitute inputs to the PSA assessment. For the HPC PCSR2012 PSA assessment, because of the limited changes to the PSA, there have only been informal interactions across a number of technical areas.

2.4 Out-of-scope items

19 The following items are outside the scope of my assessment:

- Aspects of the PSA model and documentation that have remained unchanged since the March 2011 GDA PCSR are outside scope.

- Level 2 PSA (HPC PCSR2012 Sub-chapter 15.4, Ref. 1) – no significant changes have been made to the level 2 PSA compared to the GDA level 2 PSA. However, there are some changes to the level 2 PSA results (compared with the March 2011 GDA PCSR level 2 PSA results) due to changes in the level 1 PSA results feeding into the level 2 PSA and a small number of insignificant PSA model corrections. I have therefore considered the results of the level 2 PSA; see Section 4.9.
- Seismic margins assessment (HPC PCSR2012 Sub-chapter 15.6, Ref. 1) – this is identical to that reported in the March 2011 GDA PCSR, but is claimed to be bounding for HPC. Given there has been no change and this was assessed during GDA (Ref. 9), it is considered no further in this report.

3 LICENSEE'S SAFETY CASE

20 The licensee, NNB Generation Company Limited (NNB GenCo), submitted HPC PCSR2012 (Ref. 1) to ONR to provide the site-specific baseline safety justification to support the construction of a twin UK EPR™ power station at HPC.

21 The majority of material relating to topic steam B8, PSA, is located in Chapter 15 of HPC PCSR2012. The PSA is noted as contributing to a key safety objective ensuring that the risk of release of radioactive products into the environment is reduced to as low as reasonably practicable (ALARP). A summary of the overall ALARP assessment for the proposed twin reactor site at HPC is presented in Chapter 17 of HPC PCSR2012. The PSA is also noted as being used to demonstrate compliance with a number of numerical targets. The numerical targets used by the licensee are described in HPC PCSR2012 Sub-chapter 15.0.

22 The overall requirements for the production of all PSA related deliverables to support HPC PCSR2012 is presented in Ref. 10.

23 The PSA has been carried out at level 1, 2 and 3, consistent with the practice internationally.

24 The level 1 PSA considers both internal events (HPC PCSR2012 Sub-chapter 15.1) and internal and external hazards (HPC PCSR2012 Sub-chapter 15.2) 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. The level 1 PSA analysis includes consideration of all non-power operating states and an allowance for plant unavailability due to maintenance is modelled in the PSA.

25 HPC PCSR2012 Sub-chapter 15.3 addresses the likelihood of damage to fuel assemblies located in the spent fuel pool, or of boiling of the spent fuel pool water to the fuel building atmosphere.

26 The objective of the level 2 PSA (HPC PCSR2012 Sub-chapter 15.4) is to assess the response of the containment and its related systems to potential loads, and to assess the characteristics of radiological releases from core damage accidents. The level 2 PSA calculates the probability, composition, magnitude, and timing of fission product releases from the plant and assigns level 2 fault sequences into release categories. The analysis relies on a combination of deterministic and probabilistic considerations.

27 The PSA quantification for both level 1 and level 2 PSA is carried out using RiskSpectrum® Professional software, version 2.10.04. This software suite has been developed by the Swedish company Scandpower (part of Lloyd's Register Consulting). It enables the modelling of fault trees to be integrated with the event tree modelling. The code models sequence dependencies automatically. The use of RiskSpectrum® was considered during GDA and found to be adequate (Ref. 9); I have therefore not considered this as part of my assessment of HPC PCSR2012.

28 The level 3 PSA (HPC PCSR2012 Sub-chapter 15.5) evaluates both off-site consequences to determine both individual and societal risk to the public and the risk to workers on site during a fault.

29 HPC PCSR2012 Sub-chapter 15.6 presents a seismic margins assessment, which is unchanged from the March 2011 GDA PCSR; this is therefore not considered further in this report.

30 HPC PCSR2012 Sub-chapter 15.7 presents the overall results from the HPC PSA as well as analysis of the significant cutsets, importance factors and uncertainty analysis. A number of sensitivity studies are presented that provide additional insights into modelling conservatisms, design options, long term scenarios and potential improved data. It identifies the key insights from the HPC PCSR2012 PSA that are being used to risk inform the HPC design. PSA results are reported against a number of numerical targets; a range of these results are presented in Table 2.

31 In addition to HPC PCSR2012 Chapter 15, the following three documents provide key support to all aspects of the PSA:

- HPC PCSR2012 PSA assumptions (Ref. 11): all PSA assumptions (explicit and implicit) identified and collated in the PSA HPC PCSR2012 sub-chapters and main supporting references have been documented in an assumptions log. This also captures assumptions relating to the GDA PSA, where identified and obviously implicit in the March 2011 GDA PCSR sub-chapters. Assumptions from the GDA PCSR supporting references have not been identified. NNB GenCo intends that this assumptions log will be kept live and used as a tool to inform the project and designers for HPC.
- Assessment of the impact on risk from limitations in the HPC PCSR2012 PSA model (Ref. 12): NNB GenCo acknowledges throughout HPC PCSR2012 Chapter 15 that the PSA model does not yet cover the full scope of the risks at the HPC site due to omissions, conservatisms, optimisms and simplifications. The calculated risk is not yet best estimate. NNB GenCo has therefore identified the differences between the current HPC PCSR2012 PSA model and a judgement on what it considers a full scope PSA (known as limitations). Each of these limitations has been reviewed and the potential impact they could have on the calculated level of risk has been evaluated (mainly qualitatively).
- PSA forward work plan (Ref. 13): to support the overall HPC PCSR2012 forward work activities (Ref. 14), a PSA specific forward work plan has been produced. Together these provide a summary of the PSA activities required to be completed, as the HPC design matures, in order to develop the safety case.

4 ONR ASSESSMENT

32 This assessment has been carried out in accordance with ONR How2 BMS step 1.4.1 'Produce assessments', in particular the 'Guidance on mechanics of assessment' (Ref. 2).

4.1 Scope of assessment undertaken

33 HPC PCSR2012 Head Document, Section 15, (Ref. 1) states that the majority of the GDA PSA is unchanged and is applicable to HPC or judged bounding for the HPC site. I have therefore focused my assessment on sampling areas that are new, likely to be affected by site-specific features or that were outside the scope of GDA.

34 ONR's GDA step 4 PSA assessment report (Ref. 9) identified the following as being outside the scope of GDA:

- final updates of detailed GDA PSA documentation (in line with the last GDA PSA update);
- development of processes to consider PSA insights for any future use of the PSA beyond GDA;
- any requirement on the PSA modelling that needs detailed design information or site-specific data beyond the scope of GDA[1];
- failure modes and effects analysis (FMEA) for initiating event analysis; and
- test frequencies of key components.

35 HPC PCSR2012 Head Document, Section 15, states that for most of these outside scope items they have remained out-of-scope for HPC PCSR2012. Although HPC PCSR2012 does not give sufficient justification for why it is acceptable for these areas to remain outside scope, I do not consider this position to be a significant cause for concern for the point of time of HPC PCSR2012. Firstly, these areas are the subject of specific GDA assessment findings, discussed in Section 4.11, and are considered in NNB GenCo's discussion of the PSA limitations (see Section 4.10.4) and its PSA forward work plan (see Section 4.10.3). However, it is my expectation that these areas will be addressed within the next revision of the HPC PCSR.

36 The main changes to the PSA model supporting HPC PCSR2012 are summarised in Ref. 15. These include the following:

- Level 1 PSA (internal events):
  - The frequencies of loss of off-site power initiating events have been updated.
  - Detailed modelling of the ultimate heat sink as a support system has been added to the PSA.
  - A number of minor modelling corrections have been made.
  - The electrical modelling has been expanded.
- Level 1 PSA (internal and external hazards):

[1] The HPC PCSR2012 Head Document states there are a number of site-specific systems and conventional island systems that are not yet modelled in the PSA. The main exception to this is the inclusion of the heat sink, which is discussed in Section 4.7.

- The frequencies and risks associated with an accidental transport aircraft crash have been assessed.
- The impact due to turbine disintegration has been assessed.
- The frequencies of a combined snow and wind event for the HPC site have been assessed and incorporated within the level 1 PSA model as initiating events.
- The modelling of the loss of ultimate heat sink as an initiating event is now explicitly modelled and specific to the HPC site.

- Spent fuel pool modelling:
  - The frequencies of loss of off-site power initiating events have been updated, taking into account British operating experience.
  - Event trees to model loss of ultimate heat sink in the spent fuel pool PSA have been added.
- Level 2 PSA: changes have generally been limited to a small number of insignificant corrections.
- A number of new sensitivity studies have been carried out.

37 I have considered the following aspects in my assessment, which are summarised in Sections 4.2 to 4.12:

- whether the PSA aspects of HPC PCSR2012 and the supporting documentation have met the intent of the PSA specification for HPC PCSR2012 (see Section 4.2);
- safety requirements and PSA objectives (see Section 4.3);
- level 1 PSA for internal initiating events (see Section 4.4);
- level 1 PSA for internal and external hazards (see Section 4.5);
- PSA of accidents in the spent fuel pool (see Section 4.6);
- modelling of the ultimate heat sink (pumping station) as an initiator and as a support system (see Section 4.7);
- level 3 PSA (see Section 4.8);
- results and insights from the PSA (see Section 4.9);
- generic PSA topics, including PSA documentation, management of PSA assumptions, PSA limitations and PSA forward work plan (see Section 4.10);
- progress addressing GDA assessment findings (see Section 4.11); and
- demonstration of ALARP (see Section 4.12).

4.2 Specification for PSA aspects of HPC PCSR2012

38 Ref. 10 provides a specification for HPC PCSR2012, and includes a high level specification for PSA. This is supported by Ref. 16, which provides a PSA specific HPC PCSR2012 specification. I reviewed these documents as part of my assessment to support granting of a nuclear site licence (Ref. 17), and considered that the specification was capable of leading to the development of a suitable and sufficient PSA for HPC PCSR2012.

39 As part of my assessment of HPC PCSR2012, I considered whether the intent of the HPC PCSR2012 PSA specification had been met. Most of the items within the specification have been addressed and are discussed in this report. However, the following items have not been addressed by HPC PCSR2012:

- FMEA to support derivation of initiating events: this was noted as out-of-scope of GDA and assessment finding AF-UK EPR-PSA-003 (Ref. 9) was raised.
- Test frequencies for key components: this was noted as out-of-scope of GDA and assessment finding AF-UK EPR-PSA-021 (Ref. 9) was raised.
- Produce detailed level 1 PSA documentation: a number of supporting PSA documents were produced during GDA, but these were not updated to reflect the PSA model at the end of GDA. GDA assessment finding AF-UK EPR-PSA-010 (Ref. 9) relates to this issue. This is discussed further in Section 4.10.1.
- Implement a procedure to maintain the PSA and keep it living: this was noted as out-of-scope of GDA and assessment finding AF-UK EPR-PSA-047 (Ref. 9) was raised.

40 I consider that although four areas have not been addressed by HPC PCSR2012, NNB GenCo has delivered the main intent of its HPC PCSR2012 specification, and key site-specific features (namely loss of off-site power frequency, loss of ultimate heat sink frequency including circulation water filtration system modelling, and site-specific hazards screening) have been incorporated. These aspects are all discussed in the following subsections of this report. Notwithstanding this, it is my expectation that the remaining four areas shall be adequately addressed in the next revision of the HPC PCSR.

4.3 Assessment of safety requirements and PSA objectives (HPC PCSR2012 Sub-chapter 15.0)

41 HPC PCSR2012 Sub-chapter 15.0 outlines the purpose and scope of the HPC PSA and sets out the licensee’s numerical targets (discussed in Section 4.3.1) used to evaluate the HPC design.

42 I have assessed this sub-chapter, in terms of the scope of the PSA, against ONR’s SAPs and consider it meets the intent of SAP FA.12. This is because all sources of potential radioactive releases are identified, including from outside the reactor core, level 1, 2 and 3 PSA are carried out, all types of initiating events are considered, including internal events, internal hazards and external hazards, all plant operational states are considered, including full power, low power and shutdown, and maintenance states are considered. However, there remain gaps in the completeness of faults modelled in the PSA. These gaps are adequately captured by extant GDA assessment findings or adequately recognised and captured by NNB GenCo (Ref. 12). It is also noted that initiating events due to intentional mal-operation or sabotage and malicious events such as intentional aircraft crash are not considered in the PSA. This is consistent with my expectation.

43 Notwithstanding that all sources of potential radioactive release are identified, the PSA currently does not include releases from all buildings. I do not consider it a major gap that other sources of potential radioactive release, where applicable, are not yet included within the PSA. In some cases the design is only at the conceptual stage, and most of these currently excluded buildings are intended to contain limited amounts of potentially radioactive material. Section 14 of the HPC PCSR2012 Head Document (Ref. 1) notes that the design of both the interim spent fuel store (ISFS) and interim intermediate level waste store are at a conceptual stage, and states that safety cases will be submitted, including the design basis analysis (DBA) faults, at an appropriate time. It is my

expectation that suitable and sufficient PSA will also be submitted[2] as part of such safety cases (in line with SAP FA.1) and that PSA will be used to inform the design process (in line with SAP FA.14). HPC PCSR Sub-chapter 15.5, covering level 3 PSA, the PSA forward work plan (Ref. 13) and the PSA limitations report (Ref. 12) adequately recognise this gap and expectation. It is also noted that HPC PCSR2012 Sub-chapter 11.5 states that the approach to PSA for the interim intermediate level waste store will be determined before the nuclear island safety related concrete milestone and that PSA for the ISFS will follow a staged approach. I carried out a high level review of the outline plan for the staged approach (summarised in Ref. 18) and consider this should be capable of meeting the intent of SAPs FA.10, FA.12 and FA.14). Although I have not identified any areas of concern regarding the intended scope of the PSA within HPC PCSR2012, it is my expectation that the intended approaches for PSA to support the interim intermediate level waste store and ISFS will be further developed for the next revision of the HPC PCSR.

4.3.1 NNB GenCo's risk targets

44 NNB GenCo has assessed the numerical output from the PSA against targets (safety design objectives (SDO)) it has defined in its 'Nuclear Safety Design Assessment Principles (NSDAP)' (Ref. 19). I have therefore assessed the licensee's numerical targets relevant to PSA against those set out in ONR's SAPs, SAP NT.1:

- NNB GenCo's target SDO-4 relates to individual risk of death from on-site accidents to any person on the site. This target is consistent with the basic safety objective (BSO) of ONR's target 5 from SAP NT.1.
- NNB GenCo's target SDO-5 relates to frequency dose targets for any single accident to any person on the site. This is identical to ONR's target 6 from SAP NT.1.
- NNB GenCo's target SDO-6 relates to individual risk of death from on-site accidents to any person off the site. This target is consistent with the BSO of ONR's target 7 from SAP NT.1.
- NNB GenCo's target SDO-7 relates to frequency dose targets for accidents on a single reactor (individual facility) to any person off the site. This is identical to ONR's target 8 from SAP NT.1. The NSDAPs note that the design objective is to achieve a frequency in each dose category that is below the BSO.
- NNB GenCo's target SDO-8 relates to the risk of 100 or more fatalities, either immediate or eventual, from on-site accidents that result in exposure to ionising radiation. This target is consistent with the BSO of ONR's target 9 from SAP NT.1.
- NNB GenCo also set out two PSA intermediate design targets relating to core damage cumulative frequency and large early release frequency:
  - Core damage cumulative frequency shall be lower than 10^{-5} per reactor year.
  - Sequences potentially involving either the early failure of the primary containment or very large releases shall have a cumulative frequency well below 10^{-6} per reactor year.

[2] This is likely to be after the nuclear island safety related concrete milestone.

Although there are no directly equivalent targets within ONR's SAPs, I have compared these targets against international practice (Ref. 20). This shows that the targets adopted by NNB GenCo are generally consistent with those in use internationally for new plant.

45 Overall, I consider NNB GenCo's risk targets (relevant to PSA) are consistent with the numerical targets in ONR's SAPs and international practice, and in a number of cases more challenging as the focus is on the BSO of ONR's numerical targets.

4.4 Assessment of level 1 PSA for internal initiating events (HPC PCSR2012 Sub-chapter 15.1)

46 HPC PCSR2012 Sub-chapter 15.1 presents the methodology and results relating to the analysis of internal initiating events within the level 1 PSA.

47 Significant parts of this sub-chapter are the same as the relevant sub-chapter of the March 2011 GDA PCSR. I do not consider this as a shortfall, as many aspects of the internal faults and related systems are site independent and were within the scope of GDA.

48 The following changes have been made to the level 1 PSA and are discussed in this report:

- The frequencies of loss of off-site power initiating events have been updated to make them site-specific (see Section 4.4.5.1).
- Ultimate heat sink (circulation water filtration system) is modelled as a support system to the essential service water system and the ultimate cooling water system (see Section 4.7.1). Modelling of loss of ultimate heat sink as an initiating event has also been incorporated in the PSA (for external hazards and spent fuel pool accidents). The initiator aspect is discussed in Sections 4.7.2 and 4.7.3.

49 In addition to these explicit changes to the level 1 PSA, I have also considered aspects that have not changed but should have been considered for development within the site-specific PSA. This was based on limitations highlighted in the GDA step 4 PSA assessment report as areas needing further work and ONR's expectations set out in TAG 030.

4.4.1 Reference design for HPC PCSR2012

50 The reference design for HPC PCSR2012 is based on the Flamanville 3 design and the outcome of the GDA of the UK EPR^{TM}, plus site-specific features, corresponding to the state of development of the HPC reference design at the end of March 2011. The HPC reference design is currently subject to a further iterative engineering phase to address a number of potential design developments.

51 NNB GenCo has recognised (Ref. 12) that the HPC PCSR2012 PSA is not fully aligned with the HPC PCSR2012 reference design, particularly relating to system modelling, and that further work is required to improve the alignment between the design and the PSA model to support future activities. NNB GenCo has assessed the impact of this gap and considers it negligible. However, the basis for this assessment is not clear. It is noted that Ref. 21 claims the most significant difference from the GDA PSA model has been added, in that the HPC heat sink system is now modelled in the HPC PCSR2012 PSA model.

52 ONR's SAP FA.11, validity, expects that the PSA should be directly related to the current design. Given the gap noted by NNB GenCo, I do not consider that the PSA model supporting HPC PCSR2012 fully meets the intent of this SAP. However, the reference

design is currently evolving to capture the significant changes from the GDA process (via GDA issues and/or GDA assessment findings), lessons learned from the design and constructability of other EPRs (Flamanville 3, Olkiluoto 3, Taishan and United States EPRs), and lessons learned from the events at Fukushima). This will be captured in a reference design known as Reference Configuration 1 (RC1), which will be the reference for the design that NNB GenCo will request ONR permission to start nuclear island construction. Although I do not consider this as a significant issue for this PCSR, it is my expectation that the PSA model to support the nuclear island safety related concrete milestone should be aligned with the relevant reference design, RC1. I have therefore raised the following issue on ONR's issues database, which requires NNB GenCo to develop the PSA supporting the nuclear island safety related concrete milestone to be consistent with the relevant PCSR and reference design, that is RC1 (see Annex 1):

- NNB GenCo shall adequately align the PSA to be consistent with the relevant reference design and safety report. For the PCSR supporting start of nuclear island construction, the PSA shall be adequately aligned with RC1. Any gap between the PSA and reference design shall be identified and its impact (in terms of risk and risk insights) assessed.

4.4.2 Identification and grouping of initiating events

53 No new initiating events (reactor internal faults) have been identified or groupings changed since the GDA PSA (as assessed in the GDA step 4 PSA assessment report, Ref. 9). The GDA step 4 PSA assessment report noted that a number of initiating events relating to plant systems had not yet been included in the PSA due to a lack of design detail, and raised assessment finding AF-UK EPR-PSA-004 (milestone: mechanical, electrical and control and instrumentation (C&I) safety systems, structures and components (SSC) – delivery to site). The initiating events to be treated later were identified in Ref. 22; this is also the reference document used to support HPC PCSR2012.

54 In order to meet SAP FA.12, scope and extent, it is important for all relevant initiating events to be identified and, where necessary, included within the PSA. It is noted that this was assessed during GDA, although as a result of the design progressing, it is my expectation that the identification and grouping of initiating events will have been reviewed. However, no such review appears to have been carried out. Notwithstanding this, given the lack of specific design detail it is not my expectation that if any new initiating events had been identified, they would necessarily have been explicitly modelled in the PSA at this point in time.

55 As part of ONR's assessment of NNB GenCo's application for a Nuclear Site Licence in respect of the site at HPC (Ref. 23), ONR had learned that site-specific DBA for conventional plant faults would not be available in time for inclusion in HPC PCSR2012 and the conventional plant initiating fault list was not yet comprehensive. HPC PCSR2012 Head Document, Section 14, notes that faults in the conventional island and balance of plant are included in the GDA fault schedule, but they are only included at a functional level due a lack of specific design detail. The PSA also reflects this position.

56 I note that NNB GenCo has identified and qualitatively assessed the impact of initiating events missing from the PSA in its PSA limitations report (Ref. 12). However, this does not provide sufficient justification for their omission, for example due to the design not being sufficiently developed. It is my expectation that as the design evolves the initiating events included in the PSA model and the grouping of initiating events will be regularly reviewed. Furthermore, it is my expectation that any missing initiating events will be incorporated into the PSA where the design detail has sufficiently developed, with the

unincorporated initiating events adequately justified with respect to the state of design development and the reference design. This will be followed up with NNB GenCo through normal regulatory business including from oversight of NNB GenCo's resolution of relevant GDA assessment findings.

57 Within HPC PCSR2012 Sub-chapter 15.1 it is noted that FMEAs have been used to inform the identification of initiating events, but that these are not available to support the HPC PSA. It is further stated that this topic is going to be addressed in the framework of the GDA assessment finding AF-UK EPR-PSA-003 (milestone: nuclear island safety related concrete), which requires the licensee to provide FMEAs to support the derivation of initiating events. This aspect was agreed as out-of-scope for GDA and therefore is an expectation for any future licensee to provide the FMEAs. No progress on this aspect is reported in HPC PCSR2012.

58 IAEA SSG-3 (Ref. 7) states that a systematic process should be used to identify the set of initiating events to be addressed in the level 1 PSA. This should involve a number of different approaches including analytical methods such as hazard and operability studies, FMEA or other relevant methods for all safety systems to determine whether their failures, either partial or complete, could lead to an initiating event. It is therefore my expectation that FMEAs, or an equivalent analytical approach, are available to NNB GenCo, both for the initiating events identified within the GDA PSA and any new initiating events, and that they will be included as part of the supporting documentation for the PSA. As per assessment finding AF-UK EPR-PSA-003, it is expected that the FMEAs, or equivalent, will be provided prior to the nuclear island safety related concrete milestone.

4.4.3 System modelling

59 HPC PCSR2012 notes that a number of systems and support systems are not yet included in the PSA. There has been very little change in this area since the GDA PSA. The GDA step 4 PSA assessment report (Ref. 9) noted that a number of support systems were not included in the PSA model, for example loss of heating, ventilation and air conditioning (HVAC) and loss of the compressed air system, due to insufficient design information being available, and raised assessment finding AF-UK EPR-PSA-012 (milestone: mechanical, electrical and C&I safety systems, structures and components – delivery to site).

60 Within the HPC PCSR2012 PSA model the only changes that have been made are the expansion of the electrical system modelling and inclusion of the circulation water filtration system as a support system to the essential service water system (SEC[ESWS]) and the ultimate sea water cooling system (SRU[UCWS]). This latter aspect is considered in Section 4.7.1.

61 In order to meet SAP FA.13, adequate representation, it is important for all relevant systems and support systems to be identified and, where necessary, included within the PSA. Although it is not my expectation that these systems and support systems would necessarily have been incorporated into the HPC PCSR2012 PSA due to a lack of specific design detail, it is not clear whether the design has sufficiently evolved in any of the areas for such systems to be included. I note that NNB GenCo has identified and qualitatively assessed the impact of missing systems and systems modelled simplistically in its PSA limitations report (Ref. 12). However, this does not provide sufficient justification for their omission against the reference design, for example due to the design not being sufficiently developed. It is my expectation that as the design evolves the systems included in the PSA model, including support systems, will be regularly reviewed. Furthermore, it is my expectation that any missing systems will be incorporated into the

PSA where the design detail has sufficiently developed. I will follow this up with NNB GenCo through normal regulatory business and through NNB GenCo's resolution of the issue raised in paragraph 52 of this report, relating to the reference design for the PSA.

62 As regards the modelling of C&I in the PSA, there have been minimal changes since the GDA PSA. Given no significant issues were noted in the GDA step 4 PSA assessment report and no change to the C&I design reported in HPC PCSR2012, I consider it reasonable that the PSA modelling of C&I has not changed at this point in time. I note that there are two GDA PSA assessment findings associated with C&I (AF-UK EPR-PSA-015 and AF-UK EPR-PSA-016) that require the C&I modelling to be amended, if required, as the C&I systems evolve. Furthermore, NNB GenCo has recognised several aspects of the C&I modelling to be in need of improvement and that this may have a notable impact on indicated risk once the C&I initiating faults and system modelling is improved (Ref. 12).

63 A small number of changes have been made to the electrical system modelling in the PSA model. This is related to expansion of the electrical modelling to include additional busbars and related transformers required for modelling the circulation water filtration system. These have been simplistically modelled, for example failure of some intermediate boards and associated cabling has not been considered. Based on my inspection of the fault tree models and documentation of the changes (Refs 24, 25 and 26), I consider these changes are adequate for the purpose of HPC PCSR2012, as the modelling is consistent with the earlier electrical modelling and the simplifications will only have an insignificant impact on the risk insights from the PSA. Notwithstanding this, it is my expectation that the electrical modelling within the PSA is further developed consistent with GDA assessment finding AF-UK EPR-EE-31; this assessment finding is discussed further in Section 4.4.5.1.

4.4.4 Human reliability analysis

64 The human reliability analysis (HRA) supporting the HPC PCSR2012 PSA has not been changed since the March 2011 GDA PCSR. However, HPC PCSR2012 recognises that several aspects of the operator action modelling need to be improved and that this may have a notable impact on indicated risk (Ref. 12). The GDA step 4 PSA assessment report (Ref. 9) noted a number of limitations in the modelling of human failure events in the PSA, but it was judged that the numerical probabilities used in the PSA were adequate for the purpose of GDA. Furthermore, a number of human factors GDA assessment findings were raised (Refs 27 and 28) that may have an impact on the PSA; progress on these is discussed in the HPC PCSR2012 human factors assessment report (Ref. 29).

65 Given the status of the HPC design, I consider the position reached in GDA, that the numerical probabilities used in the PSA were adequate for the purpose of GDA, remains acceptable for the HPC PCSR2012 PSA. However, it is my expectation that the operator action modelling, and supporting HRA, is improved in future updates of the PSA. This improvement should be consistent with extant GDA assessment finding AF-UK EPR-PSA-017 and relevant human factors GDA assessment findings.

4.4.5 Initiating event frequencies

66 With the exception of loss of ultimate heat sink (LUHS), where a fault tree model is used to derive the initiating event frequency (see Section 4.7), and loss of off-site power (LOOP) (see Section 4.4.5.1), all other initiating event frequencies, for internal plant faults, remain unchanged (compared to the GDA PSA). I consider that the use of the GDA initiating event frequencies to remain suitable for the HPC PCSR2012 PSA for the

majority of internal event faults, as these are generally site independent and relate to the intrinsic EPR™ design. For the HPC PCSR2012 PSA, I consider it is reasonable that the derivation of site-specific initiating event frequencies has been focused on LOOP and LUHS. This is consistent with ONR's expectations in TAG 030 (Table A1-2.6.1). Notwithstanding this, as the design evolves, it is my expectation that some initiating event frequencies will change, and eventually these will be derived from site-specific or fleet design / operational data where available. Additionally, as the conventional island and balance of plant system designs evolve it is my expectation that, where appropriate, the initiating event frequencies will explicitly account for failure of the specific systems (rather than be based on a generic loss of function, as currently assumed). NNB GenCo should periodically review the assumed initiating event frequencies as the design evolves to ensure their basis remains valid, which should be documented with major PSA updates. Such a review should ensure that the contribution to the frequencies from faults originating on the conventional island and balance of plant systems are explicitly included, where necessary, in the PSA. This will be followed up with NNB GenCo through normal regulatory business.

4.4.5.1 Loss of off-site power (LOOP) frequency

67 The LOOP initiating event frequency has been updated to take account of UK operational experience. Ref. 30 provides the derivation of a site-specific LOOP frequency that has been incorporated into the HPC PCSR2012 PSA. This shows that the short LOOP (for up to 2 hours) frequency assumed within GDA is bounding for HPC, but that the long LOOP (2 to 24 hours) frequency is not. I have reviewed the derivation of the site-specific LOOP frequencies against the expectations in TAG 030 (Table A1-2.6.1) and make the following observations regarding their derivation[3]:

- LOOP frequencies (short LOOP and long LOOP) have been derived using predominantly UK operational experience. I consider the use of UK operating experience to be reasonable, but note there is significant uncertainty in the long LOOP frequency.
- There is no task procedure referenced that would ensure initiating event frequencies are derived in a consistent manner. It is my expectation that such a task procedure would clearly set out criteria for the selection / precedence of data sources and when a Bayesian approach should be adopted. Such a task procedure should be implemented as part of the resolution of GDA assessment finding AF-UK EPR-PSA-045.
- It is noted that the operational experience has been filtered based on specific features of the events which have occurred, the different arrangement of the EPR™ grid connections, and HPC having more grid lines compared to existing reactors. Whereas the filtering applied generally appears reasonable, insufficient evidence is presented to support the exclusion of Scottish LOOP events.
- The derivation of the short and long LOOP initiating event frequencies is clearly documented.
- No change has been made to the consequential LOOP probability, or the ratios used for long and short duration LOOP. However, as this is consistent with the

[3] The risk implications of the revised LOOP frequencies are discussed in Section 4.9.

probability and ratios used at Sizewell B, I consider this is acceptable in the short term. Notwithstanding this, I expect appropriate site-specific values to be ultimately utilised consistent with GDA assessment finding AF-UK EPR-PSA-020.

68 HPC PCSR2012 Sub-chapter 2.1 (Ref. 1) also presents an analysis of grid reliability, which is focused on the connection design at HPC and is largely based on equipment reliability. This excludes the impact of weather events. Although this data is not used in the PSA, given it excludes weather events, it provides a misleading picture of the likelihood of a LOOP event. It is therefore my expectation that only the overall frequency of LOOP (including all contributions) is presented in the next revision of the HPC PCSR.

69 It is noted that there are three GDA assessment findings related to LOOP and one GDA assessment finding related to the electrical modelling that are relevant to PSA:

- AF-UK EPR-PSA-019: the licensee shall ensure that the generic LOOP frequency is confirmed to be bounding in comparison to a site-specific value or demonstrate that a site-specific frequency is acceptable in risk terms. (Milestone: nuclear island safety related concrete)
- AF-UK EPR-PSA-020: the licensee shall ensure that the PSA uses an appropriate LOOP frequency for the site and justified ratios used for long and short duration LOOP, both in terms of initiating event and conditional LOOP. (Milestone: fuel load)
- AF-UK EPR-EE-30: the licensee should perform sensitivity studies for LOOP. This should include sensitivity studies to the frequencies of all defined LOOP durations and a sensitivity study to the assumed maximum period of the LOOP, assuming LOOP for significantly greater than 192 hours, but taking where necessary appropriate account of repair and recovery actions (where likely to be supported by documented procedures). This should identify the dominating contributions to the risk, any system vulnerabilities and any differences in the insights when compared with the base cases, and should be used as part of demonstrating a balanced design, without over-reliance on external sources of power, to demonstrate that the proposed design is ALARP. To risk inform the development of the design using PSA an iterative approach should be used. A preliminary study should be developed to support electrical design activities including the preparation of equipment purchase specifications. (Milestone: nuclear island safety related concrete)
- AF-UK EPR-EE-31: the licensee should develop the PSA model to reflect the design and operation, and provide an adequate representation of the electrical system reflecting the design and operation based on site-specific data and features. To risk inform the development of the design using PSA an iterative approach should be used. A preliminary study should be developed to support electrical design activities including the preparation of equipment purchase specifications. (Milestone: mechanical, electrical and C&I safety systems – before delivery to site)

It is my expectation that GDA assessment findings AF-UK EPR-PSA-019 and AF-UK EPR-EE-30 are adequately addressed within the PSA model supporting the next revision of the HPC PCSR. Furthermore, it is my expectation that adequate progress is made on assessment finding AF-UK EPR-EE-31, such that the PSA for the next revision of the HPC PCSR (supporting the nuclear island safety related concrete milestone) adequately reflects the electrical system within the relevant reference design.

70 For the purpose of HPC PCSR2012, I consider that the updated LOOP frequencies are fit-for-purpose. This is because the generic frequencies (for short and long LOOP) have been updated to take account of UK experience. However, due to the uncertainty

associated with their derivation and because the reliability of the electrical grid system is outside the control of the licensee, it is important that a comprehensive sensitivity study, including use of significantly higher failure frequencies, is carried out in line with assessment finding AF-UK EPR-EE-30. Consistent with ONR's expectation in Ref. 31, this should include examining the situation where the grid is assumed not to be present following a reactor trip. A comprehensive sensitivity study is required to demonstrate adequate resilience in the design to loss of off-site power.

4.4.6 Summary

71 Regarding the level 1 internal faults PSA model, changes have been made to the frequency of loss of off-site power and the ultimate heat is now explicitly modelled as a support system. I have also assessed aspects that have not changed but should have been considered for development within the site-specific PSA, based on limitations highlighted in the GDA step 4 PSA assessment report as areas needing further work and ONR's expectations set out in TAG 030. The following conclusions are raised regarding the level 1 internal faults PSA:

- There should be closer alignment between the PSA model and documentation with the relevant reference design.
- It is not clear whether new initiating events should have been identified and considered within the PSA as a result of development to the design since the March 2011 GDA PCSR.
- No progress is reported in HPC PCSR2012 on producing FMEAs to inform the identification of initiating events. FMEAs, or an equivalent analytical approach, need to be available to NNB GenCo, both for initiating events identified within the GDA PSA and any new initiating events, and these need to be included as part of the supporting documentation for the PSA.
- It is not clear whether further systems and support systems should have been included within the HPC PCSR2012 PSA model as a result of development to the design since the March 2011 GDA PCSR.
- As regards the modelling of C&I in the PSA, there have been minimal changes since the GDA PSA. Given no significant issues were noted in the GDA step 4 PSA assessment report and no change to the C&I design reported in HPC PCSR2012, I consider it reasonable that the PSA modelling of C&I has not changed at this point in time.
- A small number of changes have been made to the electrical system modelling in the PSA model. Although I consider these changes are adequate for the purpose of HPC PCSR2012, it is my expectation that the electrical modelling within the PSA is further developed for the next revision of the HPC PCSR.
- The human reliability analysis (HRA) supporting the HPC PCSR2012 PSA has not been changed since the March 2011 GDA PCSR. Given the status of the HPC design, I consider the position reached in GDA, that the numerical probabilities used in the PSA were adequate for the purpose of GDA, remains acceptable for the HPC PCSR2012 PSA.
- With the exception of loss of ultimate heat sink (LUHS), where a fault tree model is used to derive the initiating event frequency, and loss of off-site power (LOOP), all other initiating event frequencies, for internal plant faults, remain unchanged (compared to the GDA PSA). I consider this to be reasonable for the HPC

PCSR2012 PSA. However, NNB GenCo should periodically review the assumed initiating event frequencies as the design evolves (particularly as the conventional island and balance of plant system designs evolve), to ensure their basis remains valid, which should be documented with major PSA updates.

- For the purpose of HPC PCSR2012, I consider that the updated LOOP frequencies are fit-for-purpose. However, due to the uncertainty associated with their derivation and because the reliability of the electrical grid system is outside the control of the licensee, it is important that a comprehensive sensitivity study, including use of significantly higher failure frequencies, is carried out in line with assessment finding AF-UK EPR-EE-30.

72 Overall, for the point in time of HPC PCSR2012, I consider the level 1 internal events PSA is fit-for-purpose. Those aspects of the PSA most affected by site-specific features have been updated to the extent that the available information allowed. However, notwithstanding this, a number of areas are identified in this report where improvements are required for the next revision of the HPC PCSR. Such improvements, where significant, are identified by an entry within ONR's issues database, and where less significant, and where captured within NNB GenCo's PSA forward work plan, are identified as expectations in the text.

4.5 Assessment of level 1 PSA for internal and external hazards (HPC PCSR2012 Sub-chapter 15.2)

73 HPC PCSR2012 Sub-chapter 15.2 (Ref. 1) presents the results from the site-specific level 1 PSA carried out for the internal and external hazards that are considered to be applicable for the HPC site. The PSA developed for HPC PCSR2012 has evolved from the PSA that was developed for GDA.

74 HPC PCSR2012 Sub-chapter 15.2 identifies the internal and external hazards that have been deemed appropriate for probabilistic analysis. It also contains the results of the studies undertaken to analyse the frequency of core damage associated with those hazards for the UK EPR™.

75 The areas of PSA hazard assessment that have changed since the GDA PSA include the following:

- Aircraft crash: the frequencies and risks associated with an accidental transport aircraft crash for the HPC site have been assessed.
- Turbine disintegration: the impact due to turbine disintegration has been assessed. This takes into account two turbines associated with the proposed twin EPR™ reactors on the HPC site, and also the two turbines on the existing Hinkley Point B site.
- Loss of ultimate heat sink (LUHS): LUHS has been modelled as an initiating event that is specific to the HPC site. The initiating event is no longer just considered as a point value. An assessment of the PSA for LUHS is covered in Section 4.7.2 of this report.
- Combined snow and wind: the frequencies of a combined snow and wind event for the HPC site have been assessed and incorporated within the level 1 PSA model as initiating events. New event trees have been implemented into the model.
- Seismic analysis: the current seismic analysis has been developed using the seismic margins assessment (SMA) technique. This has not changed since GDA.

However, a seismic PSA strategy has been produced as part of HPC PCSR2012, which defines how a full seismic PSA is planned to be developed in the future.

76 In addition, a site-specific hazards screening exercise has been carried out.

77 The following subsections summarise my assessment of those aspects that have changed since the March 2011 GDA PCSR:

- Section 4.5.1 discusses hazards screening;
- Section 4.5.2 discusses initiating event frequencies;
- Section 4.5.3 discusses the seismic PSA strategy;
- Section 4.5.4 discusses the modelling of a combined hazard of snow and wind;
- Section 4.5.5 discusses other combined and consequential hazards; and
- Section 4.5.6 provides a summary.

4.5.1 Hazards screening

78 HPC PCSR2012 Sub-chapter 15.2 summaries a site-specific hazards screening exercise, which was carried out to determine which hazards should be included in the HPC PCSR2012 PSA model. A workshop process was undertaken that included a panel of subject matter experts; the output from the workshop is reported in Ref. 32. The workshop considered all potentially relevant internal and external hazards, that are known to affect nuclear power plants and other high-hazard industries, and determined those which should be studied in the HPC PSA.

79 Within the GDA step 4 PSA assessment report (Ref. 9) assessment finding AF-UK EPR-PSA-032, which relates to the adequacy of the hazards screening process, was raised. This stated: “The licensee shall ensure that the screening criteria used in the GDA PSA are confirmed to bound specific site hazard characteristics and include in the PSA any hazards and combination of hazards that have been screened in.” (Milestone: nuclear island safety related concrete)

80 I have assessed the hazards screening process against ONR’s guidance in TAG 030 (Table A1-2.7.1) and also IAEA guidance in SSG-3 (Ref. 7). I consider that a comprehensive list of hazards, compiled from a range of international sources, was considered, which I consider is reasonable.

81 The selection of hazards for inclusion in the PSA was based upon: the hazard initiating frequency, the hazard consequence severity, the lines of protection or defence in depth available to prevent or protect against the event and also the value of including the hazard in order to gain an insight into the plant design, operation or maintenance. Ref. 32 summarises the hazard screening process in a process flow diagram.

82 Within Ref. 32, the reasons why some hazards are excluded from the analysis are clear and justified. The judgments made are also clearly recorded, which is consistent with ONR’s expectations (TAG 030, Table A1-2.7.1). Therefore, I consider the hazards screening process is adequate at this point in time.

83 I note that, although I am satisfied with the hazards screening process followed, not all of the hazards planned to be included (screened in) in the HPC PSA are currently modelled. NNB GenCo has identified where screened in hazards have not yet been modelled in the PSA. Those hazards are also identified in the PSA forward work plan (Ref. 13) as requiring completing in the future. The list of screened in hazards that are not yet modelled in the PSA include:

- failure of tanks, pipework and pressurised components leading to consequences other than internal flooding;
- internal missiles from sources other than rotating equipment, for example valve components, control rod drive mechanisms;
- failure of high speed rotating equipment, including turbines;
- dropping of heavy equipment;
- internal explosions;
- accidental ship collision;
- accidental aircraft impact;
- earthquake induced ground motion;
- external flooding; and
- frazil ice.

84 It is also noted that, of the screened in hazards that are modelled within the HPC PCSR2012 PSA, the following sub-sets of the hazards have not yet been addressed:

- internal fire during shutdown states;
- internal flooding during shutdown states; and
- infrequent loss of ultimate heat sink (LUHS) (for example, infrequent massive ingress of marine bodies).

85 In addition, I recognise there are two potential events from Hinkley Point B that could impact the HPC site, which have been captured since the original screening exercise: turbine disintegration and radiological release at Hinkley Point B.

86 NNB GenCo has defined several internal and external hazards as ‘unscreened’. These represent hazards for which there is insufficient information to determine whether they should be screened in or out at this time. NNB GenCo stated (Ref. 13) it will be revisiting these hazards during the development of the HPC PSA. This includes the following hazards:

- internal corrosive, toxic, radioactive and asphyxiant substances;
- internal electromagnetic interference;
- internal transportation;
- frequency or voltage fluctuations in supply;
- high air temperature;
- tornadoes;
- lightning; and
- solar flare.

87 Some hazards have already been screened out and so will not require modelling now or in the future. Where this is the case, the assumptions made to inform the rationale appear reasonable and have been clearly documented. This is consistent with ONR’s expectations (TAG 030, Table A1-2.7.1), and therefore I consider it is adequate.

88 I note that in Ref. 33, NNB GenCo has undertaken a review of the PSA commitments made within HPC PCSR2012. In terms of the commitments relating to the hazards PSA (HPC PCSR2012 Chapter 15.2, Ref. 1), NNB GenCo implied it would include further hazards modelling in the PSA models supporting the next revision of the HPC PCSR (Ref. 13). However, NNB GenCo has since clarified (Ref. 33) that it will not be incorporating additional hazards modelling within the HPC PSA model for the next revision of the HPC PCSR. Although I do not consider that complete hazards PSA is necessarily required for this stage in the design process, it is my expectation that adequate hazards PSA analysis is carried out (potentially with specific probabilistic analyses separate to the HPC PSA model). NNB GenCo needs to demonstrate that it has performed sufficient hazards PSA modelling to enable it to adequately risk inform the design and release relevant hold points associated with the HPC project.

89 In terms of the GDA assessment finding relating to hazards screening (AF-UK EPR PSA-032), I consider that reasonable progress has been made towards addressing the intent of the finding. However, to adequately address the assessment finding on the nuclear island safety related concrete milestone timescale, it is my expectation that NNB GenCo:

- sets out its approaches for how hazards will ultimately be represented in the PSA and the interim probabilistic hazards analysis that is to be carried out to risk inform the design prior to the complete hazards PSA being developed;
- carries out adequate hazards PSA to risk inform the design; and
- provides a demonstration of the adequacy of the proposed approaches and programmes to implement them.

I will review the resolution plan for this assessment finding when provided by NNB GenCo and influence any necessary improvements as part of normal regulatory business.

90 Overall, given the analysis of hazards starts from a comprehensive list of internal and external hazards, and the approach and criteria for the screening of hazards are auditable and justified, I consider that the approach taken for hazards screening is adequate at the point in time of HPC PCSR2012. Furthermore, based on ongoing interactions with NNB GenCo I am aware that the hazards screening is being kept under review and up-to-date as more information becomes available.

4.5.2 Update to hazard initiating event frequencies

91 My assessment of HPC PCSR2012 is targeted on areas that have changed since the March 2011 GDA PCSR. The frequency of the following hazards have been reassessed, taking account of site-specific features, and their impact on risk assessed:

- aircraft crash (see Section 4.5.2.1)
- turbine disintegration (see Section 4.5.2.2)
- LUHS (see Section 4.7)

92 The frequencies for other internal and external hazards previously screened in and modelled within the GDA PSA have not been changed since the March 2011 GDA PCSR. I consider that, for the purpose of HPC PCSR2012, the frequencies assigned to these hazards are fit-for-purpose as I do not expect the site-specific features to have a large impact on the analysis.

4.5.2.1 Aircraft crash

93 The frequencies and risks associated with an accidental aircraft crash have been assessed for the HPC site (Ref. 34). The risks have been divided into several categories: LOOP, LUHS, level 3 PSA and total loss of a safety function. HPC PCSR2012 assumes the reliability of the aircraft crash protection shell is high and, therefore, if a building has aircraft crash protection then it is assumed there are no radiological consequences associated with any occurrence. It is therefore not modelled in the PSA. An assessment of the adequacy of the derivation of the frequencies (Ref. 34) for accidental aircraft crashes (for the five categories of aircraft considered) is outside scope of my assessment. This aspect is within scope of the external hazards topic stream.

94 In terms of the integration into the PSA for each of the LOOP, LUHS and level 3 PSA scenarios, the contribution to the frequency (of the relevant initiating event or effective dose range) as a result of an accidental aircraft crash is quantified to be very small. Therefore, the frequency of LOOP, LUHS, and level 3 PSA scenarios that are induced by accidental aircraft crashes are considered to be bounded by the existing frequency assessments. I consider that the approach used, and the decision to bound the aircraft crash frequencies, is appropriate for HPC PCSR2012 and is consistent with ONR's expectations (TAG 030, Table A1-2.7.1).

95 In terms of the integration into the PSA for the loss of a safety function scenario, HPC PCSR2012 Sub-chapter 15.2 states there is only one building per unit, the fire fighting water building, that contains safety functions (fire fighting capability and back-up water to the emergency feedwater system) that are not protected by an aircraft crash protection shell and are not geographically redundant. The analysis shows that the contribution to the 'loss of a safety system' frequency as a result of accidental aircraft crash is negligible compared to the values for common cause failure already assigned to these safety systems. Further analysis is proposed to be conducted (Ref. 13) to assess the impact of the loss of fire fighting equipment in terms of the impact on PSA. I consider this is acceptable for HPC PCSR2012.

4.5.2.2 Turbine disintegration

96 A detailed assessment of turbine missile impact frequencies on HPC safety related targets from both Hinkley Point B and HPC turbine missiles has been undertaken as part of HPC PCSR2012 (Ref. 35). An assessment of the adequacy of the derivation of the frequencies for a turbine missile impact is outside scope of my assessment. The derivation of the frequency for turbine missiles is within scope of the internal and external hazards topic streams.

97 HPC PCSR2012 Sub-chapter 15.2 provides a summary of the analysis carried out. The analysis considers the trajectories of the turbine blades and derives a frequency for which each of the safety related buildings at HPC could expect to be struck. It has been assumed that buildings that are protected with an aircraft shell are shielded against the consequences of turbine missile impact.

98 The radiological consequences of turbine missile impacts on HPC buildings that are important to safety are not yet known. HPC PCSR2012 Sub-chapter 15.2 conservatively assumes all releases equate to an effective dose of greater than 1000 mSv (to a person off-site). It is stated in the PSA forward work plan (Ref. 13) that further work is required on the turbine missile study in the future. It is also noted in the PSA limitations report (Ref. 12) that the risk from turbine disintegration may affect the HPC core damage frequency (CDF), but that this has not yet been included within the HPC PSA. Ref. 12 assesses this limitation as having a minor impact on CDF (less than 1%).

99 HPC PCSR2012 Sub-chapter 15.2 includes a conservative assumption that all releases from HPC generated turbine missiles will lead to an effective dose of greater than 1000 mSv (to a person off-site). Given the frequency of missile impacts is currently quantified as being below the BSO of target 8 of ONR's SAP NT.1, I consider the lack of integration into the PSA is adequate for the point in time of HPC PCSR2012.

100 I am satisfied, based on TAG 030 (Table A1-2.7.1), this hazard analysis reflects the HPC site-specific features appropriately and assumptions regarding the generic site are stated and justified. Therefore, in terms of the impact on PSA, I consider that the turbine disintegration analysis is suitable for the purpose of the HPC PCSR2012 submission. It is also positive to note that NNB GenCo has identified the requirement for further radiological consequence assessment relating to the impacts of missiles on buildings.

4.5.3 Seismic PSA strategy

101 The seismic hazard analysis incorporated in HPC PCSR2012 Sub-chapter 15.6 has not changed since the March 2011 GDA PCSR. This is based on a seismic margins assessment (SMA). This was assessed during GDA, where it was concluded that (Ref. 9):

- "The SMA shows a significant margin between the design basis event and the expected capability of the plant. Although this was encouraging, the risk gap analysis does point to the need for further confirmatory work. To gain real insights into the plant from earthquakes, a seismic PSA would be needed."

As an outcome of the GDA assessment, GDA assessment finding AF-UK EPR-PSA-037 was raised (Ref. 9): "The licensee shall provide a seismic PSA for the site. The seismic analysis should take account of consequential hazards that might be caused by a seismic event, such as fire or flooding, and if appropriate include them in the PSA." (Milestone: mechanical, electrical and C&I safety SSCs – delivery to site)

102 Within HPC PCSR2012, NNB GenCo stated that it intends to assess the seismic capacity of HPC with an integrated seismic PSA, which will be implemented through a staged process throughout the permissioning stages of HPC (for example the PCSR and pre-operational safety report). Ref. 36 outlines the seismic PSA strategy which defines the approach proposed to be adopted for developing a full seismic PSA in the future.

103 Although no seismic PSA has been produced for HPC PCSR2012, I have carried out an assessment of the seismic PSA strategy against ONR's expectations (TAG 030, Table A1-2.7.4). I consider that, based on the strategy, the proposed approach to evaluate the impact of earthquakes on nuclear power plant structures and components should ultimately lead to an adequate seismic PSA being developed.

104 It is important for NNB GenCo to develop sufficient seismic PSA at an early stage so that it can risk inform the design of HPC effectively. I consider NNB GenCo's proposal to deliver the seismic PSA in a phased approach to be positive, as it should meet this expectation. However, further information is required on how this strategy will be implemented to ensure it meets this expectation. It is my expectation that the initial stage(s) of the seismic PSA will be developed prior to the nuclear island safety related concrete milestone and included in the next revision of the HPC PCSR. I have therefore raised the following issue on ONR's issues database (see Annex 1):

- NNB GenCo shall develop a programme for its seismic PSA strategy, and implement the initial stage(s) of its seismic PSA strategy, such that suitable and sufficient seismic PSA is performed to risk inform the design.

105 I consider, on the assumption that the seismic PSA is developed in accordance with the information in the strategy, the seismic PSA should ultimately be consistent with ONR's expectations (TAG 030 Table A1-2.7.4) and therefore address GDA assessment finding AF-UK EPR-PSA-037. However, further confidence is required in NNB GenCo's plans to implement this strategy, to ensure sufficient seismic PSA is developed at an early stage to enable risk informing of the design prior to significant construction.

4.5.4 Combined snow and wind modelling

106 There is the potential for internal and external hazards to occur simultaneously or for one hazard to cause another. The combined hazard of snow and wind is the only combined set of hazards that has been explicitly modelled within the HPC PCSR2012 PSA. Other combined and consequential hazards have not been considered for inclusion in the HPC PSA at this time.

107 The analysis of the combined snow and wind hazard has been developed since the March 2011 GDA PCSR. Specific event trees are now included within the level 1 PSA. For the purpose of this combined hazard, it has been assumed that wind disrupts the off-site power lines (main grid and auxiliary grids) and that snow inhibits the air intakes for the diesel generators. The diesel generators at HPC will be located in two separate buildings and, due to the plant layout and the sheltering effect from other buildings, it has been claimed that the blockage of air intakes for the diesels (both emergency diesel generators and station black-out diesels) could only affect one diesel building at a time. I consider this to be a reasonable assumption and note that it is captured within the PSA assumptions log (Ref. 11). I consider (based on TAG 030, Table A1-2.7.1) this hazard analysis appropriately reflects facility specific and site-specific features.

108 The event trees that have been used to model the combined snow and wind event are based on those developed for LOOP events. I consider the PSA modelling approach taken to be reasonable for the purpose of HPC PCSR2012. I note that the modelling assumes that the diesel generators (affected by snow) are lost on a separate electrical division to the one where maintenance is modelled. This is positive as it allows insights to be gained in the effects of maintenance. However, I note that this is not the case for the station black-out diesels, where maintenance is modelled on the station black-out diesel in the same electrical division as the one that is assumed to be lost due to the hazard. The insight of the effect of maintenance in this particular circumstance is therefore lost. While this is not ideal, I note that HPC PCSR2012 Sub-chapter 15.2 states the modelling of maintenance will be correctly reflected when a symmetric PSA is eventually developed. For the purpose of HPC PCSR2012, I consider the current approach is adequate.

4.5.5 Other combined and consequential hazards

109 HPC PCSR2012 Sub-chapter 15.2 states that combined and consequential hazards will be identified during the production of the PSA and the development of the deterministic hazards safety case. Such hazards will be determined through another hazards screening process. This commitment is captured in the PSA forward work plan (Ref. 13). I consider this aspect of the PSA to be an important area, in that it will improve the comprehensiveness of the PSA.

110 Despite the shortcomings of the current PSA regarding a comprehensive hazard analysis for combined and consequential hazards, I consider the level of analysis for combined hazards to be adequate at this time. This is based on the commitment by NNB GenCo that it will perform further analysis of combined and consequential hazards as the HPC

project develops, and the extant GDA assessment findings AF-UK EPR-PSA-002 and AF-UK EPR-PSA-032 (Ref. 9).

4.5.6 Summary

111 HPC PCSR2012 Sub-chapter 2.2 (Ref. 1) includes an assessment of the HPC site environmental and external hazards envelope against the generic envelope defined in GDA. In most cases (with the exception of extreme high air temperature, extreme high seawater temperature and grid reliability) the generic envelope has been shown to be bounding. I have considered the impact on the HPC PSA of the hazards not bounded by the generic envelope. For grid reliability, HPC site-specific data has been used (see Section 4.4.5.1). For other areas outside the generic envelope, these were not included within the GDA hazards PSA, and have been screened out of the HPC PSA. I therefore consider where the site envelope is not bounded by the generic envelope this has either been appropriately addressed within the HPC PCSR2012 PSA or has a negligible impact on the PSA.

112 Although there has only been a very limited development to the hazards PSA (internal and external hazards) since the March 2011 GDA PCSR, I consider it is adequate for the point in time of HPC PCSR2012. Notwithstanding this, a significant amount of hazards PSA development is required to ultimately produce a suitable and sufficient hazards PSA. Aspects requiring development are clearly captured in NNB GenCo's PSA forward work plan (Ref. 13), which appears comprehensive.

113 In terms of the next revision of the HPC PCSR, it is not my expectation that detailed hazards PSA will be complete and fully integrated within the PSA. However, sufficient hazards PSA will need to developed at an early stage to risk inform the design. In terms of seismic PSA, a new issue has been raised within ONR's issues database. For other expectations regarding hazards PSA for the next revision of the HPC PCSR, I consider this is adequately captured by the extant GDA assessment finding AF-UK EPR-PSA-032.

4.6 Assessment of PSA for accidents in the spent fuel pool (HPC PCSR2012 Sub-chapter 15.3)

114 HPC PCSR2012 Sub-chapter 15.3 presents the analysis of the likelihood of damage to the fuel assemblies located in the spent fuel pool, or of boiling of the spent fuel pool water to the fuel building atmosphere.

115 Significant parts of this sub-chapter are the same as the relevant sub-chapter of the March 2011 GDA PCSR. I have therefore only assessed those aspects that have changed.

116 The following changes (since the March 2011 GDA PCSR) have been made to the PSA of the spent fuel pool:

- The frequency of LOOP initiating events have been updated, taking into account British operating experience.
- New event trees have been added to the PSA model to represent the impact of loss of the ultimate heat sink on the spent fuel pool.

117 As regards LOOP, the frequency of this initiating event has been updated based on the analysis presented in Ref. 30. This is the same source as for the reactor PSA LOOP, which is discussed in Section 4.4.5.1. I have therefore only checked that this has been derived appropriately for the defined operating states and incorporated correctly within the PSA model. I identified no issues as regards these aspects.

118 For LUHS, the assessment of the changes made to the PSA model is discussed in Section 4.7.3.

119 Overall, I consider the GDA spent fuel pool PSA model has been adequately updated for HPC PCSR2012.

120 Notwithstanding this, I note that the scope of the fuel pool PSA is limited to the fuel pool and not to loading activities. During the GDA step 4 fault studies assessment it was noted that faults associated with the cask loading pit and the despatch of fuel from the spent fuel pool had not been considered (Ref. 37). Subsequently GDA issue GI-UK EPR-FS-03 was raised (Ref. 38). In response to this GDA issue a probabilistic analysis of potential initiating events linked to the spent fuel cask loading process was produced (Ref. 39). This study was not reviewed in detail during the closeout of this GDA issue (Ref. 40) as it did not include the design modifications being proposed to the spent fuel pool adjacent compartments and the fuel route, and the procedural changes. A new assessment finding was therefore raised to enable closeout of the GDA issue:

- AF-UK EPR-FS-85: the licensee shall develop and update the spent fuel pool PSA (including cask loading pit faults) considering all the relevant modifications and any other update of the deterministic safety case and provide a full scope, modern and well documented spent fuel pool PSA for the UK EPR™ plant (including evaluation of fuel damage, radioactive releases and consequences). (Milestone: mechanical, electrical and C&I safety systems, structures and components – delivery to site)

121 It is my expectation that the spent fuel pool PSA to support the next revision of the HPC PCSR will, where the detailed design allows, be updated to reflect the design within RC1 and, where possible by this milestone, the expectations set out in GDA assessment finding AF-UK EPR-FS-85.

4.7 Modelling of the ultimate heat sink (circulation water filtration system)

122 One of the most significant modelling changes in the HPC PSA (compared with the GDA PSA) has been the explicit modelling of the ultimate heat sink, specifically the circulation water filtration system of the pumping station. The pumping station supplies filtered sea water to a number of systems in both normal operation (cooling for the turbine condensers and auxiliary cooling water system) and for safety systems (ultimate cooling water system and essential service water system). Failure of the circulation water filtration system leads to a loss of ultimate heat sink (LUHS) fault.

123 Within the HPC PCSR2012 PSA the circulation water filtration system has been modelled as an initiator (both for the reactor building and for the spent fuel pool) and also as a support system (to supply water to the ultimate cooling water system and essential service water system). I have therefore assessed the adequacy of modelling of this system within the PSA. This aspect was outside scope of GDA as the design of the heat sink is site-specific. Within GDA, the ultimate sink was represented within the PSA as follows:

- In terms of a support system to supply water to the ultimate cooling water system and the essential service water system, failure of the pumping station was not modelled.
- Although LUHS was modelled as a reactor initiating event (for a number of operating states), the frequency was a point value, based on an assumption taken from the Flamanville 3 PSA and considered to be representative of the UK EPR™.

- For the spent fuel pool, LUHS was not modelled and it was claimed the corresponding fuel damage frequency would be small.

Each of these aspects are discussed in Sections 4.7.1 to 4.7.3.

124 The key references describing the development of the ultimate heat sink modelling within the HPC PCSR2012 PSA are as follows:

- Ref. 26: this documents a reliability study of the pumping station, describing the development of fault trees and quantifying the LUHS initiating event frequency for the reactor building and the spent fuel pool building. The same fault trees are used as a basis to represent the circulation water filtration system as a support system.
- Ref. 24: this describes the changes made to the GDA PSA model to create the HPC PCSR2012 PSA model.
- Ref. 25: this is the PSA logbook and living status document that tracks the detailed changes made to the final GDA PSA model to create the HPC PCSR2012 PSA model.

4.7.1 Ultimate heat sink as a support system

125 I have assessed how the circulation water filtration system has been modelled within the PSA as a support system to the ultimate cooling water and essential service water systems. The other systems supported by the circulation water filtration system are not directly involved with the reactor and are support systems on the conventional island. I therefore consider including the support system for just the ultimate cooling water and essential service water systems is reasonable.

126 Ref. 26 provides the system description, system boundaries, system interfaces, system dependencies, connected systems, support systems, operating states, simplified FMEA, description of the fault trees, common cause failures, component data, assumptions, and areas requiring further development. Although some of the information is relatively high level at this point in time and further substantiation is required for some aspects, given the stage of the design, I consider this adequately meets the intent of TAG 30, Table A1-2.4.2 (ONR’s expectations for specific system analysis). The following are noted from my assessment:

- The circulation water filtration system model is adequately documented relative to the design development at the point in time that HPC PCSR2012 was produced.
- The C&I and electrical supply to the circulation water filtration system are adequately described.
- Common cause failures (CCF) are considered, although they are modelled simplistically. The claim that CCFs between low pressure pumps is only considered between pairs of pumps as opposed to all four pumps because each pair operates differently needs further substantiation.
- Refs 24 and 25 adequately describe how the fault trees developed as part of the standalone reliability study have been incorporated into the HPC PSA model, and ensured that this is consistent with the remainder of the HPC model.
- The fault tree logic in the PSA model appears adequate, it is consistent with the documentation and I found no errors.

- Transfer gates to the new circulation water filtration system fault tree have been added at appropriate points within the ultimate cooling water and essential service water system fault trees.
- All assumptions are clearly identified in Ref. 26, and most are captured in an overall PSA assumptions log (Ref. 11); the assumptions log is discussed in Section 4.10.2.
- Areas requiring further development are clearly identified, and most are explicitly captured in the PSA forward work plan (Ref. 13); the forward work plan is discussed in Section 4.10.3.

4.7.2 Loss of ultimate heat sink (LUHS) – impact on the reactor building

127 For the HPC PCSR2012 PSA, the assumed initiating event frequency for LUHS, modelled by a basic event in the GDA PSA, has been replaced by a fault tree model. This is based on the fault tree developed to model the circulation water filtration system (as a support system to the ultimate cooling water and essential service water systems; this is discussed in Section 4.7.1).

128 I have sampled the changes made to the PSA model, and the associated documentation, and consider these have been adequately implemented. I consider the use of logical models to calculate initiating event frequencies is acceptable, in that dependencies between the failure leading to the initiating event and system unavailabilities for accident mitigation are explicitly modelled. Notwithstanding this, consistent with IAEA SSG-3 (Ref. 7), it is my expectation that the frequencies from the fault tree are demonstrated to be consistent with operating experience.

129 The HPC specific assessment of the LUHS goes some way to addressing the following two GDA PSA assessment findings:

- AF-UK EPR-PSA-029: the licensee shall ensure that the generic loss of ultimate heat sink frequency is confirmed as bounding in comparison to a site-specific value or demonstrate that a site-specific frequency is acceptable in risk terms.
- AF-UK EPR-PSA-030: the licensee shall ensure that the PSA uses an appropriate loss of ultimate heat sink frequency for the site.

The loss of ultimate heat sink frequency is now reduced (for all relevant operating states) compared to that assumed in GDA.

130 However, it is noted that there a number of omissions and simplifications in the assessment of this initiating event frequency:

- Only intrinsic failure of the circulation water filtration system or massive ingress of marine organisms (that simultaneously clog all water intake points of the pumping station) are considered.
- A less frequent but more severe massive ingress has not yet been considered.
- Other external hazards, for example clogging by frazil ice, ingress of a layer of hydrocarbons or ship collision, which could lead to the loss of the pumping station, have not been included.
- The impact of LOOP is not considered.

131 These omissions and simplifications are identified by NNB GenCo and tracked in its assumptions log (Ref. 11). NNB GenCo also argues in its limitations report (Ref. 12) that the impact on risk of most of these omissions and simplifications is likely to be small. The only exception is the less frequent but more severe massive ingress, that is judged to

have a more pronounced impact on risk. However, given the reduction in the LUHS frequency compared to GDA, it is my judgement that if all these omissions and simplifications were addressed that the GDA LUHS frequency will still bound the HPC specific frequency. Notwithstanding this, in order to close the relevant GDA assessment findings, it is my expectation that adequate consideration will need to be made of all contributions to LUHS.

132 I also note that the LUHS frequency is sensitive to the assumed massive ingress of marine organisms frequency. I have not assessed the derivation of this frequency, which is derived in HPC PCSR2012 Sub-chapter 2.1, as it is within scope of the ONR external hazards topic stream assessment. However, this assumption has been appropriately captured in the PSA assumptions log (Ref. 11).

4.7.3 Loss of ultimate heat sink (LUHS) – impact on spent fuel pool

133 Within the GDA PSA, LUHS initiating events were not modelled within the spent fuel pool PSA and it was claimed the corresponding fuel damage frequency would be small. For the HPC PCSR2012 PSA, new event trees have been added to the HPC PSA to model the consequences following a LUHS event.

134 The initiating event for the spent fuel pool LUHS is modelled as a fault tree, which is consistent with the approach adopted for the reactor building LUHS initiating event. This also considers failure of the circulation water filtration system to supply the ultimate cooling water system, including diversification of the supply to the ultimate cooling water system via the discharge pond, in addition to failure to supply any essential service water system train. I have assessed (through sampling) the changes made to the PSA model, and the associated documentation, and consider these are acceptable, given the state of the design development, and they have been adequately implemented. However, the same limitations noted for the reactor building LUHS analysis (see Section 4.7.2) are relevant here.

135 I have also assessed the event trees developed to represent the impact of LUHS events on the spent fuel pool. These event trees have been based on the GDA PSA event trees for the loss of cooling chain fault but modified to remove consideration of start-up of the standby cooling pump on train 1 or starting trains 2 or 3 of the spent fuel pool cooling system. This is appropriate as the LUHS, including failure of the diversification route, would affect all 3 trains of the spent fuel pool cooling system. The event tree then considers whether fuel pool make-up is initiated and successful, and whether the operator repairs failure of the make-up system prior to fuel uncovery and subsequent fuel damage. Although I have not assessed the basis of the loss of cooling chain events, as these are unchanged from the GDA PSA, I have considered their relevance to the LUHS fault. On this basis and given its low risk, I consider for the HPC PCSR2012 PSA this adequately represents the LUHS event. However, as discussed in Section 4.6, due to a number of design changes to the spent fuel pool, this modelling may need to be updated as per GDA assessment finding AF-UK EPR-FS-85.

4.7.4 Summary

136 Based on my assessment of the modelling of the circulation water filtration system, both as a support system and as part of the LUHS initiating events, I consider that the LUHS aspects of the GDA PSA have been adequately updated to reflect HPC site-specific features. Based on the reference design relevant to HPC PCSR2012, and notwithstanding a number of simplifications, the changes made meet the intent of ONR's SAP FA.13, adequate representation.

137 Good progress has been made towards addressing GDA assessment finding AF-UK EPR-PSA-033. This requires the licensee to ensure that the generic loss of ultimate heat sink frequency is confirmed as bounding in comparison to a site-specific value or demonstrate that a site-specific value is reasonable in risk terms. However, further work is required before this finding is closed by the licensee. All contributions to LUHS need to be included, not just massive marine ingress and intrinsic failures of the system.

138 Longer term, to support the operational PSA, NNB GenCo should consider modelling more of the ultimate heat sink within the PSA, including for example the intake and discharge tunnels and related SSCs, and the coarse filtration and trash removal system (SEF).

4.8 Assessment of level 3 PSA (HPC PCSR2012 Sub-chapter 15.5)

139 Level 3 PSA is addressed in HPC PCSR2012 Sub-chapter 15.5 (Ref. 1), and is significantly different from GDA in some aspects.

4.8.1 Off-site individual exposures and risks

140 As explained at the beginning of Section 3 of HPC PCSR2012 Sub-chapter 15.5, the methodology used in the GDA PCSR for calculation of individual risks off-site has not been updated for this version of the site-specific PCSR. I therefore do not consider it further here. Changes to the input accidents and their parameters arising from level 2 PSA for example are reflected in the numerical outcomes for comparison with the licensee's numerical targets SDO-6 and SDO-7 (see Section 4.3.1), which correspond to SAP NT.1 numerical targets 7 and 8. Section 4.9 of this report discusses the results against the SAPs numerical targets.

4.8.2 Societal risk

141 Level 3 PSA, including societal risk, was considered by ONR during GDA. It was concluded: "The level 3 PSA is not state of the art. However, in view of the assurance provided by the correspondence between the numerical outcomes and those from independent calculations performed for ONR, it is considered adequate for the purposes of GDA" (Ref. 9).

142 The associated GDA assessment finding (AF-UK EPR-PSA-044) was: "The licensee should ensure that the level 3 PSA is developed to modern standards, in particular by placing less reliance on design basis dose assessments and by fully incorporating probabilistic factors such as weather. For each new plant the site-specific level 3 PSA will need to incorporate site-specific analyses of frequency for relevant fault sequences, together with site-specific dispersion and consequence modelling parameters (such as weather data and distribution of population and agriculture) for all releases." The timescale for this assessment finding was fuel load.

143 The independent calculations referred to above were carried out as suggested in ONR's guidance. They were performed using the computer code PC COSYMA by the UK Health Protection Agency (HPA) as a technical support contractor to ONR. The results confirmed EDF and AREVA's analysis to the degree of accuracy that can be expected for a level 3 PSA. The broad agreement between HPA's calculated radiological consequences and those of EDF and AREVA was important in forming a judgement as to the acceptability of EDF and AREVA's case for the purposes of GDA.

144 For HPC PCSR2012 the licensee has moved to the use of PC COSYMA and appropriate population and other data. Its analyses appear robust, although I have not performed an in depth assessment for several reasons. Firstly the licensee is currently drawing up a

resolution plan covering the GDA finding above, the outcome of which I will need to assess in due course. Secondly the required completion is fuel load, which is a long way in the future during which the design and safety case will continue to evolve. Finally, the input data from the level 2 PSA is incomplete; the licensee has a forward work plan to close the gaps, but it will continue to evolve. In view of all of these it would clearly not have been proportionate, or well targeted at this stage for ONR to carry out an in depth review including independent confirmatory calculations for HPC PCSR2012. An additional benefit is that any in depth assessment some distance in the future will be able to cover individual risks (SAP NT.1, numerical targets 7 and 8) as well as societal risks.

145 I conclude that the treatment of societal risk in HPC PCSR2012 is a substantial improvement on the situation for GDA, and that I do not need to make any findings in this area.

146 The numerical outcome of the analysis in relation to numerical target 9 of SAP NT.1 is discussed in Section 4.9 of this report.

4.8.3 Persons on-site

147 During GDA, ONR considered radiation exposures of persons on-site as a result of accidents to a limited extent. The GDA step 4 radiological protection assessment report (Ref. 41) stated: “Potential doses to workers on the site during accidents were not assessed in detail and so were not compared with NT.1 targets 4 and 6 during GDA. In my opinion, from the evidence provided, this was not unreasonable at this stage in the design process.”

148 The associated GDA assessment finding regarding impacts of accidents to workers on the site, (AF-UK EPR-RP-15) was: “The licensee shall provide a safety case that demonstrates that the on site-specific radiological consequences analyses for accidents (including hazards) are ALARP and have taken due cognisance of usual UK methodology assumptions and have explicitly compared the results of those analyses against NT.1 target 5 in ONR’s SAPs regarding the risk impact to individuals from all the facilities on the site, and against NT.1 target 6 in ONR’s SAPs regarding the predicted single accident frequency versus dose to individuals on the site. This shall be complete before fuel on-site.”

149 Considerable progress has been made and HPC PCSR2012 and its supporting references contain a substantial assessment of worker risk. The methodology falls into three stages: identification of relevant accidents; allocation of these to a release category in terms of severity; and dose calculations to assign to frequency / consequence bands. The results are then compared with the licensee’s NSDAPs (Ref. 19) as explained in Section 4.3.1.

150 The first stage was collation of accidents that could result in a dose greater than 0.1 mSv from the level 1 and 2 PSA, design basis plant condition category accidents, the expert review, and additional faults identified that would only affect workers. Also included were worker actions in response to fault conditions which had the potential to lead to dose uptake significantly exceeding that of normal operations. The second stage was assigning the accidents to ‘worker release categories’ on the basis of the release source term, ventilation, worker location and exposure time. The worker release categories were then allocated to the appropriate worker dose band by calculating the dose received through inhalation of airborne activity, direct radiation dose due to exposure to gamma sources and direct radiation dose due to the airborne release of gamma emitting nuclides.

151 The outcome of this methodology allows comparison against the frequency / consequence matrix in the licensee's SDO-5 (see Section 4.3.1), which is identical to SAP NT.1, numerical target 6. In order to compare the results with the targets for worker annual risk of death in SDO-4 (see Section 4.3.1; which is consistent with SAP NT.1, numerical target 5) it was then necessary to ascribe occupancies against potential locations and sum the risks from all accidents weighted with these.

152 The results presented in HPC PCSR2012 show that the overall annual risk of fatality to any worker on site is about a factor of 3 below the BSO in SAP NT.1, numerical target 5. For a two unit site, accidents at the neighbouring unit produce only a small increase in risk to workers. The detailed comparison of frequencies against dose bands shows that the great majority of accidents fall below the relevant BSOs for single accidents in SAP NT.1, numerical target 6. There are only three cases where the BSO is exceeded, but these are well within the basic safety level (BSL), and conservative assumptions made in their assessment. This is a good outcome.

153 I have been following the development of the licensee's assessment of worker risks since 2011, and matters I have raised have been dealt with during its evolution. I consider the approach taken by the licensee to address this complex and difficult area to be innovative, and better developed than typical for nuclear industry safety cases. It is a significant step forward from GDA. I conclude that the treatment of exposures of persons on-site as a result of accidents involving release of radioactivity within HPC PCSR2012 is adequate for current purposes; in particular, it does not invalidate ONR's GDA conclusions. However, I have not carried out a detailed review of the complex supporting calculations and documentation, an intention that I have previously explained to the licensee (Ref. 42). As the licensee is currently preparing plans to close out the GDA assessment findings, and AF-UK EPR-RP-15 requires closure by fuel on site not first concrete, I do not propose to carry out such a review for some time yet. I therefore reserve my position for the present time. This has the benefit that since the design and the safety case will continue to develop (and in particular the underlying PSA), resources can be targeted on issues that emerge during the design process.

154 Given all of the above, I do not need to raise issues within ONR's issues database in this area.

4.9 Assessment of PSA discussion and conclusions (HPC PCSR2012 Sub-chapter 15.7)

155 HPC PCSR2012 Sub-chapter 15.7 presents the results and insights of the HPC PCSR2012 PSA and summarises the results of the analyses presented in HPC PCSR2012 Sub-chapters 15.1 to 15.6. I have assessed the presentation and interpretation of the results and overall conclusions from the PSA against the expectations in TAG 030 (particularly relevant aspects of Tables A1-2.9.1, A1-2.9.3, A1-3.6, A1-4.2 and A1-5).

156 Currently, the level 1 and level 2 PSA only consider a single unit site. However, certain aspects of the level 3 PSA (discussed in HPC PCSR2012 Sub-chapter 15.5) require total site risk to be calculated, that is taking account of the proposed twin reactors and other buildings with the potential to release radioactivity. A strategy to assess the impact of a twin reactor site on the PSA has been produced (Ref. 43); my assessment of this strategy is summarised in Section 4.10.5. Estimates of the site risk have been made by assuming this is a factor of two of the single reactor risk.

157 The results of the PSA are adequately summarised in HPC PCSR2012 Sub-chapter 15.7. In addition to the overall core damage frequency, the following level 1 PSA results are discussed:

- contributions to the core damage frequency by types of events, operating states and initiating events;
- the use of PSA importance measures to identify significant components, systems, operator actions, CCF events and C&I events; and
- the dominant core damage sequences.

158 Hourly CDFs for each plant operating state are also presented. This enables the relative instantaneous risk to be compared for each plant operating state. Based on this information and the plant operating state durations, the instantaneous frequencies can be estimated. This indicates that the intent of SAP NT.2 is met, in that none of the operating states give rise to an instantaneous level of risk indicative of the radiological hazards not being controlled.

159 The following level 2 PSA results are discussed:

- contributors to large release frequency; and
- contributors to large early release frequency.

Further detail is presented in the level 2 PSA specific sub-chapter (HPC PCSR2012 Sub-chapter 15.4), regarding results and insights. However, I have not assessed this due to only insignificant changes being made compared with the March 2011 GDA PCSR equivalent sub-chapter.

160 The following level 3 PSA results (and the dominant events) are discussed:

- individual off-site risk (risk of fatality and summated risk of an accident leading to an individual effective dose);
- societal risk (overall frequency of greater than 100 fatalities); and
- worker risk due to exposure to ionising radiation from potential accidents (risk of fatality and summated risk of an accident leading to an individual effective dose).

161 For all aspects of the PSA, the key assumptions and calculation of parametric uncertainty are discussed.

162 It is clearly stated in HPC PCSR2012 that an iterative process has been used to identify design improvements. Section 5 of HPC PCSR2012 Sub-chapter 15.7 discusses the use of PSA insights to identify improvements to the plant design. Whereas most of the improvements were the ones identified during GDA, the following example is provided of how PSA has improved the design of the plant since GDA:

- Diversity has been added to the C&I associated with the circulation water filtration system.

It is also clearly stated that the intent is for the PSA to continue to be used to risk inform the detailed design as the HPC design develops.

163 Sensitivity analyses for selected key issues are presented. This includes both the sensitivity studies that were presented in GDA and a number of new or updated sensitivity studies. For the GDA sensitivity studies these have not been reassessed using the updated PSA model and are therefore inconsistent with the remainder of the HPC PCSR2012 sub-chapters. NNB GenCo has clearly stated that these were GDA sensitivity

studies that have not been updated, and discusses the validity of them to HPC. Given the minor changes to the HPC PSA, I do not consider that this is of concern. However, it is my expectation that as the HPC PSA further deviates from the GDA PSA that sensitivity studies presented in a given safety report, for example the next revision of the HPC PCSR, are generally carried out using the up-to-date PSA model.

164 For the new or updated HPC sensitivity analyses, the studies and their results are clearly presented. Where risk has been identified as sensitive to certain features or assumptions, further consideration has been included in the PSA forward work plan.

165 HPC PCSR2012 states that the sensitivity studies have been selected where it is perceived that new insights can be obtained. Whereas this is reasonable, I would expect a structured and systematic approach to be followed to identify the required sensitivity studies; this is not clear from the HPC PCSR2012 documentation. It is my expectation for the next revision of the HPC PCSR, that the sensitivity studies carried out have clearly been selected based on a structured and systematic process.

166 Vulnerabilities in the design are identified, although generally not resolved at this stage. However, there is a clear link to NNB GenCo's PSA forward work plan (Ref. 13). It is my expectation that sufficient progress is made towards resolving these for the next revision of the HPC PCSR, with, where necessary, adequate demonstration that the level of risk has been reduced ALARP.

167 Throughout HPC PCSR2012 Chapter 15 the differences in the risk insights from the HPC PSA compared with the GDA PSA are clearly presented and discussed. The change to the overall CDF has arisen from the following:

- Modelling the circulation water filtration system as a support system has resulted in a small increase (less than 10 %) to the CDF for the following faults: loss of coolant accidents, induced steam generator tube rupture and loss of cooling chain.
- There has been a large increase to the steam generator tube rupture CDF due to the correction of an error in the PSA model. However, in absolute terms the CDF from this fault remains small.
- Secondary transient CDF has reduced due to a modelling change to better reflect the plant. That is, previous conservative assumptions have been removed.
- LOOP CDF has increased significantly due to adoption of site-specific initiating event frequencies, which is discussed in paragraph 170.
- There have been minor changes to the CDF of primary transient faults.

The changes seen are all adequately described in HPC PCSR2012.

168 The risk estimates from the PSA are summarised in Table 2. This shows that risk estimates are lower than BSOs for targets 7 and 8 from SAP NT.1.

169 For target 9 the risk estimate for the site, that is for two reactors, is slightly above the BSO and significantly below the BSL of target 9 from SAP NT.1. It is stated in Sub-chapter 15.7 of HPC PCSR2012 that this is believed to be a conservative result and will be addressed by further study and an ALARP assessment. It is noted that this is the result for the site, for two reactors, and has been estimated by simply multiplying the risk estimate for a single reactor by a factor of two. Ref. 44 presents an assessment of the dominant contributors to societal risk, identifies a number of conservatisms and discusses results of relevant sensitivity studies. This concludes that there is potential for significant reductions in the societal risk for HPC through removal of a number of conservative assumptions in

the PSA, and that NNB GenCo's societal risk target for the site would be met if these were addressed without the need for modifications to the design. Appropriate forward work plan items are identified and captured within the PSA forward work plan (Ref. 13). Given the risk estimate is only slightly above the BSO of target 9 from SAP NT.1, and on the basis of NNB GenCo's assessment (Ref. 44), I consider the level of risk to have been adequately demonstrated to be sufficiently low for the purpose of HPC PCSR2012. However, given the design changes currently being progressed, it is my expectation that societal risk will be reassessed for the next revision of the HPC PCSR, after the significant conservatisms have been explicitly addressed in the PSA. Given relevant items are captured in NNB GenCo's PSA forward work plan, I have not raised a specific issue on ONR's issues database here.

170 Notwithstanding the fact that the risk estimates from the PSA generally meet the BSOs of relevant risk targets, I note that LOOP is a significant contributor to the overall CDF. This contribution has increased significantly since the GDA PSA as a result of using a site-specific LOOP frequency (see Section 4.4.5.1). ONR's SAPs (paragraph 618) states: "The facility safety should be balanced, that is, no single class of accident should make a disproportionate contribution to the overall risk". I do not consider that the risk estimates from the PSA meet the intent of this guidance in the SAPs as LOOP, which is a single class of accident, makes a dominant contribution to overall risk. However, I note that: this issue is recognised by NNB GenCo; a number of relevant sensitivity studies are presented in HPC PCSR2012; and areas of potential conservatism within the PSA are identified. Notwithstanding this, it is my expectation that for the next revision of the HPC PCSR that more realistic modelling of LOOP is contained within the PSA, and consideration made of improvements to the design to demonstrate the level of risk is reduced ALARP. Given that relevant items are captured in NNB GenCo's PSA forward work plan and the extant GDA assessment finding AF-UK EPR-PSA-019 (nuclear safety related concrete milestone), which requires that the LOOP frequency is acceptable in risk terms, I have not raised an issue on ONR's issues database.

171 Use of PSA as part of an overall ALARP summary is discussed in Section 4.12.

172 My overall conclusions from assessment of the discussion and conclusions from the PSA, as presented in HPC PCSR2012, are:

- Risk insights are adequately presented.
- The results for comparison with targets 5, 6, 7, 8 and 9 from SAP NT.1 are clearly presented.
- The overall conclusions from the PSA are set out clearly.

4.10 Assessment of generic PSA topics

173 This section summarises my assessment of a number of generic PSA topics that are relevant to a number of the HPC PCSR2012 PSA sub-chapters or form key supporting references to HPC PCSR2012. The following aspects are discussed:

- the adequacy of the PSA documentation (Section 4.10.1);
- management of PSA assumptions (Section 4.10.2);
- the PSA forward work plan (Section 4.10.3);
- PSA limitations assessment (Section 4.10.4); and
- twin reactor PSA strategy (Section 4.10.5).

4.10.1 Documentation

174 The HPC PCSR2012 PSA model has not been documented in a standalone report. Instead a number of documents have been produced describing the changes made to the GDA step 4 UK EPR™ PSA model:

- Ref. 24 describes the main changes made to the model and provides an overview of the results.
- Ref. 25 is a logbook summarising each incremental change made to the PSA model.

175 The approach to documentation is consistent with that agreed during GDA, in response to regulatory observation RO-UK EPR-68, and discussed in the ONR GDA step 4 PSA assessment report (Ref. 9). For the HPC PCSR2012 PSA model, I am satisfied that this approach has been followed and is acceptable for this point in time. However, based on my sampling of the PSA model and its documentation as part of my assessment of HPC PCSR2012, I do not consider that this approach will be acceptable in the long term. This is because:

- the PSA model was not coherently documented at the end of GDA;
- significant changes to the PSA model will make it increasingly difficult to understand the basis of the model; and
- as a fundamental part of the overall safety justification, the basis of the PSA model needs to be coherently documented.

Even though it is NNB GenCo's stated intention that a new PSA model will be created in the long term (which I anticipate will be adequately documented), the current PSA model will be further developed and will form the basis of supporting the safety justification for start of construction of the nuclear island at HPC. For such a significant safety justification it is my expectation that the PSA supporting this is adequately documented.

176 I note that the following assessment finding was raised in the GDA step 4 PSA assessment report and consider this should be addressed for the PSA model supporting the next revision of the HPC PCSR:

- Assessment finding AF-UK EPR-PSA-010: the licensee shall ensure that the detailed level 1 PSA document is updated so that it is fully consistent with the current PSA model.

177 Consistent with TAG 030 (Table A1-5), it is my expectation that the PSA is documented thoroughly such that all fault tree and event tree model assumptions and quantification results are easily traceable to the design documentation, drawings, analyses and any other supporting information.

4.10.2 Management of PSA assumptions

178 Throughout HPC PCSR2012 Chapter 15, and the supporting references, PSA assumptions (explicit and implicit) are clearly identified. These have been gathered together and documented in an assumptions log. This also captures assumptions underlying the GDA PSA where identified and obviously implicit in the GDA PCSR sub-chapters. Assumptions from GDA supporting references have not been identified and gathered together. To support HPC PCSR2012, Ref. 11 presents a snapshot of the assumptions log. NNB GenCo intends that this assumption log will be kept live and used as a tool to inform the project and designers for HPC.

179 I consider the assumptions log goes someway to meeting the intent of TAG 030 where the expectation is that there is a process in place to ensure that assumptions are captured and assessed for validity as the design evolves. Notwithstanding this, based on my sampling of the assumption log, the basis of the assumptions are not always clear. Whilst this is not critical at the present time, it ultimately will be important that the basis of all remaining assumptions is adequately documented.

180 A GDA assessment finding, AF-UK EPR-PSA-014, was also raised relating to the management of PSA assumptions. Based on my review of the assumptions log (Ref. 11) and NNB GenCo's resolution plan (Ref. 45) for this assessment finding, I consider the approach taken for HPC PCSR2012 is acceptable and the longer term plans should be capable of fully meeting the intent of TAG 030 and GDA assessment finding AF-UK EPR-PSA-014.

181 I have also sampled that the assumptions in HPC PCSR2012 and supporting documentation are captured in the assumptions log. For the vast majority of assumptions that were sampled I found no issues. However, there were a few assumptions where I could not identify a corresponding entry in the assumptions log. For example, study assumptions 10–12 in Ref. 26 did not appear to be captured in Ref. 11, and there was no basis recorded for their omission. This is not a significant issue, but one I will follow-up with NNB GenCo under normal regulatory business.

4.10.3 Forward work activities

182 It is recognised that HPC PCSR2012 requires further development to fully develop the safety case. These activities are documented in the forward work activities report (Ref. 14). The key inputs to the safety case development come from:

- GDA issues[4];
- GDA assessment findings (discussed in Section 4.11);
- GDA out-of-scope items;
- Fukushima related recommendations; and
- other forward work activities.

183 For PSA, the following are stated as the most significant forward work activities:

- improving PSA scope by developing the extent of hazards modelling and by adding missing systems and initiating events where appropriate (for example, to risk inform the design);
- reducing current modelling conservatisms;
- addressing GDA assessment findings; and
- developing PSA related procedures and processes.

This is consistent with my own expectation.

184 The forward work activities are also supported by a PSA forward work plan (Ref. 13). This details PSA items which have not been addressed within the HPC PCSR2012 PSA, but

[4] No PSA issues were raised, although it is recognised that other GDA issues may impact the PSA and will need to be addressed for the next revision of the HPC PCSR.

will need to be considered in the longer term. I have reviewed this report and consider it provides an acceptable summary of the areas identified within Chapter 15 of HPC PCSR2012, GDA and elsewhere that require further development in the short term. However, there is no plan of when these activities will be carried out. I understand from interactions with NNB GenCo that a programme will be produced, which will be informed by this forward work plan. This programme is critical in gaining confidence that the PSA supporting the next revision of the HPC PCSR will be adequate. I will follow-up this aspect under normal regulatory business.

4.10.4 PSA limitations

185 Ref. 12 collates all known limitations (for example exclusions, conservatisms, assumptions, optimisms and insufficiently developed design) of the HPC PCSR2012 PSA model and presents a qualitative assessment of the impact of these limitations on the calculated level of risk. Based on HPC PCSR2012 and my expectation (informed by TAG 030) of a full scope PSA to represent HPC at operation, I consider this report provides an acceptable collation and description of the current PSA limitations.

186 For the assessment of the impact of the identified limitations, a qualitative approach has been taken. This has been informed by the importance of the item under consideration within PSAs for other reactors, risk gap analysis carried out by ONR for GDA (Ref. 9) and judgement. The basis of the impact of each limitation is clearly recorded in Ref. 12. I consider that assessment of the limitations, in terms of impact on risk, is fit-for-purpose for HPC PCSR2012. It gives confidence that the CDF is likely to be well below NNB GenCo’s target and that the BSO of relevant ONR’s numerical targets in SAP NT.1 are unlikely to be exceeded if all limitations were to be addressed in the PSA.

187 The assessment of the limitations forms a useful basis to inform prioritisation of PSA work activities.

188 Notwithstanding that I consider the consideration of the limitations is fit-for-purpose for HPC PCSR2012, I make the following observations:

- The limitations report needs regularly reviewing and, when necessary, updating to reflect improved understanding of the gap to a full scope PSA.
- Consideration should be made for carrying out a more quantitative risk gap analysis for the next revision of the HPC PCSR.
- It is important that limitations are not just considered as regards their impact on risk, but also their impact on risk insights. To prevent biased insights, it is my expectation that the PSA risk informed design processes adequately consider the impact of any relevant PSA limitations.
- NNB GenCo should ensure that relevant PSA processes include how the limitations are to be managed, including as part of risk informed design.

189 I will discuss these observations with NNB GenCo under normal regulatory business and ensure that adequate account is taken of the PSA limitations when the PSA is used to risk inform the design. Given the extant assessment finding on use of the PSA model (GDA-UK EPR-PSA-046), I do not consider that an issue on ONR’s issues database is required.

4.10.5 Twin reactor PSA strategy

190 The March 2011 GDA PCSR assessed the hazards and risks associated with a single EPR^{TM} unit. However, for HPC this will consist of two adjacent EPR^{TM} units with some shared services. The safety justification for the presence of two EPR^{TM} units can be found

in the twin reactor hazard study (Ref. 46). Regarding the HPC PCSR2012 PSA this considers a single EPR^{TM} unit, which is consistent with current international practice. However, my expectation is that interactions between the two units (for example shared systems, interconnections and hazards from one unit affecting the other) and global initiating events (for example loss of grid and external hazards) should be appropriately considered and modelled. Furthermore, given some of ONR's numerical targets, SAP NT.1 (targets 7 and 9), relate to the level risk from a site and not a single reactor, it is necessary for a licensee to estimate the site risk. The considerations required to capture the twin unit aspects within the PSA are presented in Ref. 43.

191 I have assessed Ref. 43 as regards the assessment of site risk within HPC PCSR2012, and have informed my views through consideration of Ref. 46. I have not carried out an assessment of Ref. 46, which is a key supporting reference to HPC PCSR2012 Sub-chapter 2.3; this aspect of the HPC PCSR is within scope of a separate ONR topic stream.

192 Ref. 43 provides a summary of the issues associated with the twin reactor (for example dependences and interactions), the approach used to provide an initial assessment of the site risk for HPC PCSR2012 and options to estimate the risk in the future. I consider that the identification of potential twin reactor specific issues that has been carried out and qualitative discussion of the potential PSA impact from these issues is adequate for the point in time of HPC PCSR2012.

193 Only a simplified assessment of the level of risk from the twin unit site has been carried out for HPC PCSR2012, by multiplying the single PSA risk results by a factor of two. For independent events I agree that the site risk for a twin unit is likely to be double that of a single unit. However, for common cause events, for example from external hazards, there will be an increase in risk (although this is expected to be less than double) as the frequency of the initiating event will be unchanged. Based on this and the other arguments presented in Ref. 43, I consider the use of a factor of two is adequate for the purpose of HPC PCSR2012.

194 Notwithstanding my judgement on the adequacy of the overall risk estimate for HPC PCSR2012, the insights from a multi-unit PSA are of more importance than the overall risk estimate. For example, this may highlight vulnerabilities as a result of dependencies between the units. It is therefore important that the PSA explicitly considers both reactors. I note that Ref. 43 presents outline options to model the twin units within the PSA, there is a plan by EDF Research and Development to propose a methodology and also an item is captured in the PSA forward work plan (Ref. 13). Given there is no clear approach within international guidance and standards, and this is subject of discussion within the international PSA community (Ref. 47), I consider that the outline strategy is reasonable for this point in time.

4.11 GDA assessment findings

195 Within the GDA step 4 PSA assessment report (Ref. 9), 46 GDA assessment findings were raised in the area of PSA, of which 12 are required to be addressed before the first nuclear island safety related concrete milestone. Furthermore, following the resolution of the GDA issues a further 8 assessment findings were raised that have a bearing on PSA, although these have a milestone after first nuclear island safety related concrete.

196 The HPC PCSR2012 forward work activities report (Ref. 14) identifies and discusses outline plans for each of the PSA GDA assessment findings with a milestone of nuclear island safety related concrete. I have reviewed these plans, as well as formal resolution

plans where provided (for six assessment findings, Ref. 45), and make the following observations:

- AF-UK EPR-PSA-003 (FMEAs to support derivation of initiating events): it is not clear that the response to this finding will be adequate as it appears that FMEAs will only be provided for analysis of new initiating events.
- AF-UK EPR-PSA-007 (procedure for traceability and alignment of success criteria), AF-UK EPR-PSA-011 (process for maintaining and developing PSA model configuration and documentation), AF-UK EPR-PSA-014 (process to capture assumptions), AF-UK EPR-PSA-027 (procedure for managing CCF assumptions), and AF-UK EPR-PSA-045 (living PSA procedure): I consider based on the outline plans in Ref. 14 for the development of PSA processes, the resolution plans and interaction with NNB GenCo that the proposals are capable of addressing the intent of these assessment findings.
- AF-UK EPR-PSA-010 (update of PSA documentation): as discussed in Section 4.10.1, I do not consider that logbooks alone will be sufficient to document the PSA for the next revision of the HPC PCSR.
- AF-UK EPR-PSA-019 (LOOP frequency): some progress has been made, which is discussed in Section 4.4.5.1, to adopt a site-specific LOOP frequency. However, further work is required that shows this is acceptable in risk terms.
- AF-UK EPR-PSA-021 (test intervals should be consistent with examination, maintenance, inspection and testing programmes): the outline plan, subject to the resolution plan being shared, appears reasonable.
- AF-UK EPR-PSA-029 (LUHS frequency): adequate progress has been made towards addressing this assessment finding for HPC PCSR2012, although further consideration of other external causes of LUHS is required for the next revision of the HPC PCSR in order to close this finding. This is discussed further in Section 4.7.
- AF-UK EPR-PSA-032 (hazards screening): site specific hazards screening has been carried out; this is discussed in Section 4.5.1. However, plans for how the screened in hazards will be incorporated into the PSA remain unclear.
- AF-UK EPR-PSA-046 (use of PSA procedure): adequate progress has been made towards addressing this assessment finding for HPC PCSR2012. A key enabling document, the interface specification on use of PSA in risk informed design (Ref. 48), has been produced. I have reviewed this interface specification and note no significant areas of concern.

197 For the point in time of HPC PCSR2012 I consider that reasonable progress has been made towards addressing these assessment findings. For the few areas I have concerns on the adequacy of the planned resolution I will continue to engage with NNB GenCo as part of normal regulatory business to influence any necessary improvements. It remains my expectation that the assessment findings discussed above will be adequately addressed prior to the first nuclear island safety related concrete milestone.

198 Notwithstanding that reasonable progress has been made towards addressing this small subset of assessment findings, there are a significant number of assessment findings that relate to later milestones. No clear information is presented in HPC PCSR2012 on how these will be addressed. Although it is not my expectation that these assessment findings will necessarily be fully resolved earlier than the milestone indicated during GDA, it is my expectation that sufficient progress is made towards addressing these assessment

findings, where relevant, in order to risk inform the design. It is my expectation that NNB GenCo reviews all the GDA assessment findings that are relevant to PSA and ensures these are progressed sufficiently, in order to adequately risk inform the design. Adequate progress on relevant GDA assessment findings will be expected for the next revision of the HPC PCSR.

4.12 ALARP assessment (HPC PCSR2012 Chapter 17)

199 HPC PCSR2012 Chapter 17 (Sub-chapters 17.1–17.3, 17.5 and 17.6), Ref. 1, presents a summary of the ALARP assessment for the proposed twin reactors at HPC. I have assessed those aspects that have changed since the GDA PCSR, or are new, against ONR's expectations, which are described in TAG 005, ALARP. HPC PCSR2012 Sub-chapters 17.1–17.3, 17.5 and 17.6 are identical to the March 2011 GDA PCSR and Sub-chapter 17.4 from the March 2011 GDA PCSR has been incorporated in HPC PCSR2012 Sub-chapter 15.5, level 3 PSA. I have therefore focused my assessment on the following:

- HPC PCSR2012 Head Document Section 17 and supporting references;
- a report summarising the ALARP assessments carried out for the site-specific design modifications (Ref. 49); and
- use of PSA to support a demonstration of ALARP.

200 It is noted that aspects of ALARP are discussed throughout HPC PCSR2012. However, given that it is a cross-cutting topic, this will also be covered by discipline specific assessments and reported in the specific assessment reports. I have therefore not assessed the entire HPC PCSR2012 with respect to ALARP. Furthermore, my assessment has focused on the approach to ALARP rather than the technical adequacy of given solutions; this latter aspect will also be covered, as necessary, by discipline specific assessments.

201 The overall conclusion from the assessment carried out during GDA (Ref. 50) was that for the matters considered within GDA and subject to satisfactory resolution of the GDA issues and the assessment findings, the UK EPR™ design had reduced risks to workers and the public ALARP.

202 Within HPC PCSR2012 the following ALARP assessments are presented that are new compared with the March 2011 GDA PCSR:

- whether the overall HPC configuration, with respect to twin reactors, is ALARP (HPC PCSR2012 Chapter 2.3, Ref. 1);
- design of the heat sink[5] (Ref. 51);
- justification of the HPC stack height (Ref. 52);
- justification of the installation of a site-wide groundwater drainage gallery (Ref. 53); and
- a number of studies in HPC PCSR2012 Chapter 11 (Ref. 1) relating to the management of radioactive waste and interim storage of solid waste and spent fuel.

[5] This considers the heat sink approach, for example open system, closed system, a combined open and closed system, the heat sink, for example air, sea or both, and the configuration of the chosen approach, for example the number of forebays, intake tunnels, intake heads and linking tunnels.

203 Furthermore, an assessment against NNB GenCo's NSDAPs has been presented that shows good compliance (Ref. 54). For any identified gaps I consider appropriate action is being taken.

204 I have reviewed a selection of the new ALARP assessments, through sampling, against ONR's expectations in TAG 005. The outcome of my review is as follows:

- Based on the ALARP assessments reviewed there is evidence of continued consideration of design development and optimisation.
- There is general consistency with a number of the principles outlined in TAG 005. For example, there is clear evidence of:
  - optioneering including consideration of options that are ruled out – the factors considered and decision making process are generally adequately presented;
  - relevant good practice, which features prominently and appropriately in the decision making process;
  - cost benefit analysis (CBA) being used appropriately, that is it is used sparingly and then only to inform the overall decision; and
  - the level of risk is low and in most cases lower than the BSO of the relevant SAP NT.1 numerical targets, even when taking account of limitations in the current PSA model. The exception is societal risk which is discussed in Section 4.9.
- There is evidence in HPC PCSR2012 Sub-chapter 15.7 that PSA has been used appropriately to risk inform the design.
- However, a number of limitations in the ALARP presentation in HPC PCSR2012 are noted:
  - It is not always clear that the safest option that is reasonably practicable is selected.
  - Some factors considered are outside those relevant to health and safety, for example visual impact and planning. However, in this case these factors do not affect the overall decision.
  - There is evidence of consideration of additional marginal improvement that a design improvement would give, rather then whether a specific option reduces risk ALARP. For example, the risk reduction from an incremental increase in the HPC stack height is considered as opposed to whether the stack height at Flamanville 3 (a reasonable base case) is reasonably practicable.
  - The overview of the ALARP assessment (Ref. 49) is limited to a summary of three ALARP assessments, which is a limited number compared with discussed elsewhere in HPC PCSR2012. It provides a high level summary of these three ALARP assessments and a signpost to further information, and provides some evidence of the application of ALARP within the design development. However, this requires further development to support the next revision of the HPC PCSR, particularly the scope and depth.
  - Given Chapter 17 has not been updated since the March 2011 GDA PCSR, the number of ALARP studies discussed and key PSA insights are not

discussed, I do not consider a coherent demonstration that risk has been reduced ALARP is presented. However, considering the information dispersed throughout HPC PCSR2012, relevant supporting references, the position at GDA and taking cognisance of the forward work activities (Ref. 14), it is my judgement that NNB GenCo will be able to demonstrate that risk is reduced ALARP in future revisions of the HPC PCSR. For the purpose of HPC PCSR2012, I consider the current position is acceptable.

- Although HPC PCSR2012 Chapter 15 highlights key insights from the PSA, these are not discussed within the context of ALARP. For example, there is little consideration of what additional measures could be implemented and whether implementation of such measures would be reasonably practicable. However, there are relevant items within the PSA forward work plan (Ref. 13) to consider this for future HPC PCSR updates.
- There is no coherent statement on how NNB GenCo's arrangements contribute to the demonstration that the level of risk is reduced ALARP and will continue to as the design develops.
- Although Responsible Designer guidance is available on ALARP assessments to support the HPC project (Ref. 55), which is referenced in HPC PCSR2012 Head Document Section 17, this has not been updated to reflect comments previously sent to NNB GenCo (Ref. 56). However, based on discussion with NNB GenCo, I understand that NNB GenCo specific ALARP guidance is being produced. Once complete, I will review this against TAG 005, consider whether the previous comments have been addressed and influence any necessary improvements as part of normal regulatory business.

205 For the next revision of the HPC PCSR it is my expectation that a more coherent overall ALARP demonstration is presented. I have therefore raised the following issue on ONR's issues database (see Annex 1):

- NNB GenCo shall provide a HPC specific overall ALARP assessment that includes, but not limited to, the following: a summary of NNB GenCo's arrangements for ensuring risk is managed ALARP as the HPC design and construction progresses; consideration of the insights from PSA; a comprehensive summary of the site-specific ALARP studies; and a summary of the GDA ALARP position.

206 Notwithstanding my expectation for improvements for the next revision of the HPC PCSR and the limitations noted in the ALARP assessments, for the point in time of HPC PCSR2012, I consider there is sufficient evidence within the PCSR to demonstrate that, subject to satisfactory resolution of the forward work activities (Ref. 14) including resolution of the GDA assessment findings, NNB GenCo will be able to demonstrate that the HPC EPR™ has reduced the level of risk to workers and the public ALARP at a global level. I will discuss the limitations in the ALARP assessments with NNB GenCo as part of its resolution of the issue (see paragraph 205) on ONR's issues database, and normal regulatory business.

4.13 Comparison with standards, guidance and relevant good practice

207 In assessing Chapters 15 and 17 of HPC PCSR2012 I have considered relevant SAPs, TAGs and relevant good practice. Any shortfalls identified against this guidance are discussed at the relevant point within this report.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

208 This report presents the findings of my assessment of NNB GenCo's pre-construction safety report 2012 for the Hinkley point C site (HPC PCSR2012, Ref. 1). I have focused predominantly on assessing Chapter 15 of HPC PCSR2012 (PSA), with the exception of Sub-chapter 15.6, seismic margins assessment (which is unchanged from the March 2011 GDA PCSR). A number of changes have been made to the PSA model, mainly relating to site-specific features. These changes have been the focus of my assessment. This report also presents the findings of my assessment of HPC PCSR2012 Chapter 17 (ALARP).

209 Limited progress has been made relating to PSA aspects agreed as outside of scope of GDA. I do not consider this position to be a significant cause for concern, for the point in time of HPC PCSR2012, as these areas are the subject of specific GDA assessment findings, and are considered in NNB GenCo's discussion of the PSA limitations and its PSA forward work plan. However, it is my expectation that these areas will be addressed within the next revision of the HPC PCSR.

210 Overall, for the point in time of HPC PCSR2012, I consider that the level 1 PSA is fit-for-purpose. Those aspects of the PSA most affected by the site-specific features have been updated to the extent that the available information allowed. However, notwithstanding this, a number of areas are identified in this report where improvements are required for the next revision to the HPC PCSR.

211 The treatment of individual risks off-site has not been updated, however the treatment of societal risk and worker risk in HPC PCSR2012 are significant improvements on the situation for GDA.

212 In terms of the discussion and conclusions from the PSA, as presented in HPC PCSR2012, I conclude the following:

- Risk insights are adequately presented.
- The results for comparison with targets 5, 6, 7, 8 and 9 from the numerical targets of ONR's SAPs (NT.1) are clearly presented.
- The overall conclusions from the PSA are set out clearly.

213 For the point in time of HPC PCSR2012, I consider that reasonable progress has been made towards addressing the assessment findings with a nuclear safety related concrete milestone. However, in a few areas I am not yet satisfied by the adequacy of the planned resolution. For these areas I will continue to engage with NNB GenCo as part of normal regulatory business to influence any necessary improvements. Furthermore, there are a significant number of assessment findings that relate to later milestones. No clear information is presented in HPC PCSR2012 on how these will be addressed. Although it is not my expectation that these assessment findings will necessarily be fully resolved earlier than the milestone indicated during GDA, it is my expectation that sufficient progress is made towards addressing these assessment findings, where relevant, in order to risk inform the design.

214 Regarding the demonstration that risk has been reduced ALARP, I consider, based on the ALARP assessments reviewed, there is evidence of continued consideration of design development and optimisation, there is general consistency with the principles outlined in TAG 005 and there is evidence that PSA has been used to risk inform the design. However, a number of limitations in the ALARP presentation in HPC PCSR2012 were

noted. For the next revision to the HPC PCSR it is my expectation that a more coherent overall ALARP demonstration is presented.

215 Notwithstanding my expectation for improvements for the next revision of the HPC PCSR and the limitations noted in the ALARP assessments, for the point in time of HPC PCSR2012, I consider there is sufficient evidence within the PCSR to demonstrate that, subject to satisfactory resolution of the forward work activities, including resolution of the GDA assessment findings, NNB GenCo will be able to demonstrate that the HPC EPR™ design has reduced the level of risk to workers and the public ALARP at a global level.

216 In addition to the PSA limitations identified in the GDA step 4 PSA assessment report (Ref. 9) and those identified by NNB GenCo in HPC PCSR2012, I have identified a number of limitations in this report. Such limitations where more significant have been recorded as either level 4 or level 3 issues within ONR's issues database (see Annex 1), and will be covered through routine future regulatory work. Where less significant, and where captured within NNB GenCo's PSA forward work plan, the limitations are identified as expectations in the main body of the report. These expectations will be discussed with NNB GenCo as part of ongoing normal regulatory business.

217 Based on my assessment of new material, not previously covered by the March 2011 GDA PCSR, I conclude that adequate progress has been made for the point in time of this PCSR. For PSA, the March 2011 GDA PCSR has been adequately updated to reflect the site-specific features, with those aspects identified as outside the generic site environmental and external hazards envelope, where relevant, being updated with site-specific information. However, I do not consider that HPC PCSR2012, and in particular the HPC PCSR2012 version of the PSA, will be sufficient to support an ONR consent for start of construction of the nuclear island. A significant amount of work needs to be completed on the PSA for the next revision of the HPC PCSR. I consider NNB GenCo has comprehensively identified required further work and qualitatively assessed the impact of the PSA limitations as part of HPC PCSR2012. However, given the importance of having as comprehensive as possible PSA for the nuclear island safety related concrete milestone, it is my expectation that NNB GenCo develops the PSA model and supporting documentation to address those aspects identified in its HPC PCSR2012 PSA forward work plan and PSA limitations report that are relevant for risk informing the design to support a request to ONR for consent to start construction of the nuclear island.

218 This submission should be recorded in the Integrated Intervention Strategy (IIS) database with a rating of 3 (green), adequate. This is in recognition that the PSA aspects in HPC PCSR2012 have, for the point in time of this PCSR, been updated to reflect the site-specific features. However, a number of issues and limitations have been raised that are required to be addressed in the next revision of the HPC PCSR.

5.2 Recommendations

219 With the exception of a number of issues raised within ONR's issues database (see Annex 1), no other recommendations have arisen following my assessment of HPC PCSR2012.

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Table 1

Relevant Safety Assessment Principles considered during the assessment

SAP No.	SAP Title	Description
FA.10	Need for PSA	Suitable and sufficient PSA should be performed as part of the fault analysis and design development and analysis.
FA.11	Validity	PSA should reflect the current design and operation of the facility or site.
FA.12	Scope and extent	PSA should cover all significant sources of radioactivity and all types of initiating faults identified at the facility or site.
FA.13	Adequate representation	The PSA model should provide an adequate representation of the site and its facilities.
FA.14	Use of PSA	PSA should be used to inform the design process and help ensure the safe operation of the site and its facilities.
NT.1	Assessment against targets	A safety case should be assessed against numerical targets and legal limits for normal operation, design basis faults, and radiological accident risks to people on and off the site.
NT.2	Time at risk	There should be sufficient control of radiological hazards at all times.

Table 2

PSA results for Hinkley Point C

Item	NNB GenCo target	Result
Total core damage frequency	$1x10^{-5}$ pry	$8.6x10^{-7}$ pry
Off-site dose 0.1-1 mSv	$1x10^{-2}$ pry	$1.43x10^{-3}$ pry
Off-site dose 1-10 mSv	$1x10^{-3}$ pry	$1.32x10^{-5}$ pry
Off-site dose 10-100 mSv	$1x10^{-4}$ pry	$1.35x10^{-6}$ pry
Off-site dose 100-1000 mSv	$1x10^{-5}$ pry	$2.39x10^{-7}$ pry
Off-site dose >1000 mSv	$1x10^{-6}$ pry	$1.84x10^{-7}$ pry
Worker fatality	$1x10^{-6}$ per year	$4.1x10^{-7}$ per year
Individual risk of fatality (off-site)	$1x10^{-6}$ per year	$5.6x10^{-7}$ per year
>100 fatalities	$1x10^{-7}$ per year	$1.4x10^{-7}$ per year
Large release frequency	$1x10^{-6}$ pry	$1.8x10^{-7}$ pry
Large early release frequency	N/A	$4.9x10^{-8}$

Annex 1

Issues raised as part of the assessment reported in this assessment report

Probabilistic Safety Analysis – HPC PCSR2012

Issue No.	Issue title	Issue	Milestone (by which this item should be addressed)
2031	PSA reference design	NNB GenCo shall adequately align the PSA to be consistent with the relevant reference design and safety report. For the PCSR supporting start of nuclear island construction, the PSA shall be adequately aligned with RC1. Any gap between the PSA and reference design shall be identified and its impact (in terms of risk and risk insights) assessed.	Nuclear island safety related concrete
2032	Seismic PSA programme and implementation	NNB GenCo shall develop a programme for its seismic PSA strategy, and implement the initial stage(s) of its seismic PSA strategy, such that suitable and sufficient seismic PSA is performed to risk inform the design.	Nuclear island safety related concrete
2033	HPC ALARP assessment for HPC PCSR	NNB GenCo shall provide a HPC specific overall ALARP assessment that includes, but not limited to, the following: a summary of NNB GenCo's arrangements for ensuring risk is managed ALARP as the HPC design and construction progresses; consideration of the insights from PSA; a comprehensive summary of the site-specific ALARP studies; and a summary of the GDA ALARP position.	Nuclear island safety related concrete