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| **Assessment Report** | | | |
| **Unique Doc. ID:** | ONR-NR-AR-22-003 | **Issue No.:** | 1.1 |
| **Record Reference:** | 2023/24586 | | |
| **Project:** | Sizewell C Licensing | | |
| **Site:** | Sizewell C | | |
| **Title:** | Mechanical Engineering assessment of an application by NNB GenCo (SZC) Ltd for a Nuclear Site Licence. | | |
| **Nuclear Site Licence No.:** | N/A | | |
| **Licence Condition(s):** | LC 10, LC 12 and LC 20 | | |
| **ONR Assessment Rating:** | Green | | |

Table 1: Step-based document review

| Step | Description | Role | Name | Date | Revision No.[[1]](#footnote-1) |
| --- | --- | --- | --- | --- | --- |
| 1 | Initial Draft, including identification and mark-up of SNI/CCI | Author |  | 14/04/22 | 1 |
| 2 | Main editorial review | Author |  | 19/04/22 | 2 |
| 3 | Peer Review in accordance with  NS-PER-GD-016 | Peer Reviewer |  | 25/04/22 | 3 |
| 4 | Assessor update / sentencing of comments and return to Peer Reviewer | Author |  | 04/05/22 | 4 |
| 5 | Final editorial / clean draft review | Author |  | 05/05/22 | 5 |
| 6 | Acceptance review in accordance with  NS-PER-GD-016 | Professional Lead |  | 17/05/22 | 6 |
| 7 | Report Sign-off (Issue 1) | Author Peer Reviewer Professional Lead |  | 23/05/22 | 7 |
| 8 | Publication review comments addressed | Author |  | 21/04/23 | 1 (new CM9 reference) |
| 9 | Report Sign-off (Issue 1.1) | Author  Professional Lead |  | 21/04/2023 | 2 |

Table 2: Document acceptance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Role | Name | Position | Signature | Date | CM9 reference for review |
| Author |  | Inspector |  | 21/04/23 | N/A |
| Peer Review[[2]](#footnote-2) |  | - | - | - | Not required due to minor update. |
| Acceptance[[3]](#footnote-3) |  | Superintending Inspector |  | 21/04/23 | N/A |

Table 3: Revision history

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Issue No.: | Date | Author(s) | Reviewed By | Accepted By | Description of Change |
| 1 | 24/05/22 |  |  |  | First formal issue |
| 1.1 | 28/04/23 |  |  |  | Minor non-technical update following ONR publication review. |

Table 4: Circulation list

|  |  |
| --- | --- |
| Organisation | Name |
| Office for Nuclear Regulation |  |
| Environment Agency |  |
| NNB GenCo (SZC) Ltd |  |

**Sizewell C Licensing**

**Mechanical Engineering assessment of an application by NNB GenCo (SZC) Ltd for a Nuclear Site Licence**

Assessment Report Ref.: ONR-NR-AR-22-003

Issue No.: 1.1

Date: 21 April 2023

# Executive Summary

This report presents the findings of my Mechanical Engineering assessment of the application for a nuclear site licence by NNB GenCo (SZC) Ltd. My assessment is aligned to ONR’s assessment strategy for Sizewell C, which focusses on six safety case claims made by NNB GenCo. My assessment sampled specific areas related to Mechanical Engineering and which impacted upon nuclear safety.

My assessment concludes that NNB GenCo has provided sufficient evidence that:

It can develop an adequate safety demonstration for the heat sink;

The safety related ventilation systems can be adequately designed to meet safety case requirements; and,

The geology of the site should not significantly challenge the seismic qualification of systems or components.

My assessment also sampled NNB GenCo’s implementation of relevant Licence Condition arrangements:

Licence Condition 10: Training

Licence Condition 12: Duly authorised and other suitably qualified and experienced persons

License Condition 20: Modification to design of plant under construction

It concludes that NNB GenCo has demonstrated that its personnel are appropriately trained and competent for their roles and that it adequately implements its design modifications arrangements.

My assessment identifies areas, relating to my sample, where further work is needed post licensing. I have captured these as observations, which I reviewed against Assessment Findings from the UK EPR™ Generic Design Assessment. Where I judged my observation is not suitably captured, I raised a Regulatory Issue. I will track these to completion post granting of a nuclear site licence.

My assessment recommends that:

From a Mechanical Engineering perspective NNB GenCo should be granted a nuclear site licence for Sizewell C Nuclear Power Plant.

Post granting of a nuclear site licence, the observations raised in this report should be progressed via Level 4 Regulatory Issues (normal regulatory business).

# List of Abbreviations

AF Assessment finding

ALARP As low as reasonably practicable

AOD Above ordnance datum

APC Aeroplane crash

BOP Balance of Plant

BSL Basic Safety level (in SAPs)

BSO Basic Safety Objective (in SAPs)

CI Conventional Island

C&I Control and instrumentation

CNI Chief Nuclear Inspector

CNS Civil Nuclear Security (ONR)

CRF Circulation / Cooling Water System

DBE Design basis earthquake

DEL Safety Chilled Water System

ENSREG European Nuclear Safety Regulators Group

EQ Equipment qualification

FEM Finite element model

FRS Floor response spectra

GDA Generic Design Assessment

HCA Outfall pond building

HGX Technical galleries

HL Safeguards Building

HM Turbine Hall

OC Organisational Capability

HOW2 ONR’s Management System Platform

HP Pumping Station

HPF Forebay

HSE Health and Safety Executive

HSSR Heat Sink Summary Report

HVAC Heating, ventilation and air conditioning

IAEA International Atomic Energy Agency

IC Intelligent customer

JSSR Justification of Site Suitability Report

LC Licence Condition

LUHS Loss of ultimate heat sink

MSR Modifications Summary Report

NCC No Change Committee

NEA Nuclear Energy Agency

NI Nuclear Island

NNB GenCo NNB Generation Company (SZC) Ltd - nuclear site licence applicant

NOAK Next of a kind

NSL Nuclear site licence

OC Organisational Capability

ONR Office for Nuclear Regulation

PAR Project Assessment Report

PCSR Pre-construction Safety Report

PSA Probabilistic Safety Assessment

PSR Preliminary Safety Report

RC Reference Configuration

RGP Relevant good practice

RH Relative humidity

SAP Safety Assessment Principle(s)

SDSR Site Data Summary Report

SME Subject matter expert

SOC Signature of contract

SQEP Suitably qualified and experienced personnel

SSC Structure, system and component

SSSI Structure soil structure interaction

SZB Sizewell B Nuclear Power Plant

SZC Sizewell C (proposed site)

TAG Technical Assessment Guide(s) (ONR)

TIG Technical Inspection Guide(s) (ONR)

TSC Technical Support Contractor

WENRA Western European Nuclear Regulators’ Association

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Introduction

NNB Generation Company (SZC) Ltd (NNB GenCo) applied to the Office for Nuclear Regulation (ONR) on 30 June 2020 for a nuclear site licence. This was to construct and operate a nuclear power station comprising two UK EPR™ reactors at Sizewell C (SZC) in Suffolk.

The outcome of ONR’s activities from the nuclear site licence (NSL) assessment will be a Project Assessment Report (PAR). This will draw together the views of ONR’s specialist assessors on NNB GenCo’s readiness to become a nuclear site licensee.

The result will be a recommendation to the Chief Nuclear Inspector (CNI) on whether to grant a licence. My Mechanical Engineering licensing assessment report is one of a number that will inform the PAR.

ONR’s licensing assessment has followed the guidance in ‘Licensing Nuclear Installations’[1]*.* The approach to this assessment project was elaborated in the ‘SZC Assessment Strategy’[2], with guidance on the production of licensing assessment reports set out in the ‘SZC Assessment Framework’ [3].

Background

This report presents the findings of my Mechanical Engineering assessment of NNB GenCo’s claims, arguments and evidence. These are presented in NNB GenCo’s ‘Justification of Site Suitability Report’ (JSSR) [4] and supporting documentation.

My assessment was done in accordance with the Office for Nuclear Regulation (ONR) Management System. I used ONR’s Safety Assessment Principles (SAPs) [5] and supporting Technical Assessment Guides (TAGs) [6], as the basis for my assessment.

The JSSR and supporting documents provide the basis of NNB GenCo’s confidence that:

* The SZC site represents a suitable location from a nuclear safety perspective; and,

An adequate safety case can be developed in the future.

Scope

The scope of this report covers the following aspects:

* The adequacy of the cooling capability under all normal and fault conditions;
* Whether the geology of the site provides secure long term support to the necessary structures, systems and components (SSCs);
* The adequacy of NNB GenCo’s implementation of arrangements ensuring safety related work in respect to Mechanical Engineering is undertaken by suitably qualified and experienced personnel (SQEP);
* Whether NNB GenCo has a credible plan in place to continue to resource its project from a Mechanical Engineering perspective; and,
* The adequacy of NNB GenCo’s implementation of arrangements for the control and management of design modifications.

My assessment of these aspects is presented in Section 4.

Methodology

The methodology for assessment follows ONR’s ‘Guidance on the Mechanics of Assessment’ NS-TAST-GD-096 [6].

This assessment has been focussed primarily on NNB GenCo’s review of its Hinkley Point C (HPC) design and any further modifications that are necessary for the SZC site.

For licensing, this has targeted the claims made within the JSSR [4] that are relevant to my Mechanical Engineering assessment.

Assessment Strategy

The assessment strategy for Mechanical Engineering is set out in this section. This identifies the scope of the assessment and the standards and criteria that have been applied.

Standards and Criteria

The relevant standards and criteria adopted within this assessment are principally the:

* SAPs [5]
* internal TAGs [6]
* relevant national and international standards
* relevant good practice informed from existing practices adopted on GB nuclear licensed sites

I have also referenced ONR’s Technical Inspection Guides (TIGs) [7] where these were relevant to interventions undertaken. The key standards and guidance have been referenced where appropriate within my assessment report. I have also cited relevant good practice (RGP), where applicable, within the body of my assessment.

Safety Assessment Principles (SAPs)

The ONR SAPs [5] constitute the regulatory principles against which ONR judges the adequacy of safety cases. The ONR 2006 edition of the SAPs were benchmarked against the International Atomic Energy Agency’s (IAEA) Safety Standards. These SAPs have been updated to reflect subsequent changes in these standards since 2006.

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

These cover the following areas:

* FP Fundamental principles
* MS Leadership and management for safety
* EKP Key principles
* ECS Safety classification and standards
* EDR Design for reliability
* ECV Containment and ventilation
* EHT Heat transport systems

Technical Assessment Guides (TAGs)

The following TAGs have been used to inform my assessment [6]:

* ONR-TAST-GD-005 Guidance on the Demonstration of ALARP (As Low As Reasonably Practicable)
* ONR-TAST-GD-022 Ventilation
* ONR-TAST-GD-027 Training and Assuring Personnel Competence
* ONR-TAST-GD-049 Licensee Core Safety and Intelligent Customer Capabilities
* ONR-TAST-GD-065 Function and Content of the Nuclear Baseline

National and International Standards and Guidance

ONR’s guidance to inspectors recognises developing advice and guidance from:

The IAEA;

Western European Nuclear Regulators Association (WENRA);

European Nuclear Safety Regulators Group (ENSREG);

International Nuclear Regulators Association;

Organisation for Economic Cooperation and Development’s Nuclear Energy Agency (NEA); and,

Other relevant organisations.

WENRA safety reference levels are included as RGP within ONR’s technical assessment guides.

The following international standards and guidance have been used as part of this assessment:

* IAEA SSG-30 Classification of Structures, Systems and Components in Nuclear Power Plants [8]
* IAEA SSR\_2/1 Safety of Nuclear Power Plants: Design [9]
* IAEA NS-G-2.8 Recruitment, Qualification and Training of Personnel for Nuclear Power Plants [10]

Use of Technical Support Contractors

No Technical Support Contractors were used in my Mechanical Engineering assessment.

Integration with Other Assessment Topics

During my assessment, I have engaged with other topic areas for the following scope:

* Adequacy of cooling capability

External Hazards: extreme air temperatures, high and low sea levels and temperatures.

* The geology of the site provides secure long term support to the necessary SSCs

External Hazards and Civil Engineering: seismic floor response spectra.

* Safety related work is undertaken by SQEP and a credible plan in place to continue to resource its project from a Mechanical Engineering perspective

Organisational Capability (OC): SQEP, intelligent customer capability and nuclear baseline.

I refer to the judgements made by the interfacing topic areas in my report.

I attended and undertook specific Mechanical Engineering related Level 4 (technical) meetings with NNB GenCo during my assessment. These are referred to and summarised within my assessment report.

Out of Scope Items

All licensing aspects identified within the ‘SZC Assessment Framework’ [3], where I have not been involved, are outside the scope of my assessment.

NNB GenCo Submission

NNB GenCo’s primary submission is the JSSR [4]. For the Mechanical Engineering assessment, this was supported by the following documents:

* Heat Sink Summary Report (HSSR) [11]
* Site Data Summary Report (SDSR) [12]
* Justification of Extreme High (Air) Temperature Design Basis Value at Sizewell C [13]
* Modifications Summary Report (MSR) [14]

NNB GenCo’s strategy for SZC is to derive value from a ‘Next of a Kind’ (NOAK) series effect. NNB GenCo’s strategy is to duplicate, wherever possible, the HPC plant and adopt a systematic approach to capturing, quantifying and applying lessons learned to SZC.

Justification of Site Suitability Report

ONR has developed its assessment strategy [3] based on an interpretation of ‘Licencing Nuclear Installations’ [1] and ONR’s SAPs [5]. NNB GenCo has addressed this in its JSSR [4] as specific claims.

Previous versions of the JSSR were shared with ONR to facilitate early engagement. For licencing, Revision 3 was submitted. This captured the latest work that had been undertaken.

The JSSR is split into sections, each addressing a specific claim and pointing to further supporting “primary references”. The sections are as follows:

* Section 2 - Claim 1: The site is of sufficient size to accommodate all necessary systems to ensure safe operation.
* Section 3 - Claim 2: The site can be connected to electricity grid supplies.
* Section 4 - Claim 3: Adequate cooling capability can be provided for all normal and fault conditions.
* Section 5 - Claim 4: There are no external hazards that would preclude the use of the site (including the external hazards presented by SZB to SZC).
* Section 6 - Claim 5: The geology of the site provides secure long term support to the necessary SSCs.
* Section 7 - Claim 6: Operations on the SZC site will not adversely affect the ability to maintain an adequate Safety Case for the adjoining Nuclear Licensed Site (SZB).

Column Diagram to show how NNB GenCo's safety case is formed and how the various submissions to ONR for assessment make up the safety case.Figure 1 is taken from the JSSR which shows the layout of the claims and the key primary references.

Figure 1: Diagram taken from JSSR summarising the claims, and primary references.

Key Primary References

My Mechanical Engineering assessment has focussed upon the five documents identified above [4, 11, 12, 13, 14].

The JSSR [4] content is explained in Section 3.1. From a Mechanical Engineering perspective, this identifies Claim 3, which is linked to the cooling system designs and Claim 5 linked to the geology of the SZC site.

Heat Sink Summary Report

The HSSR [11] provides specific arguments and evidence. This aims to:

* Substantiate Claim 3 that relates to the role played by the “open circuit” seawater cooling systems, referred to as the ‘heat sink’[[4]](#footnote-4).
* Demonstrate that the SZC heat sink design changes will not materially impact the ability to fulfil the safety functional requirements associated with Claim 3.

Site Data Summary Report

The SDSR [12] summarises the characterisation of site-specific external hazards. This is in terms of magnitude and associated frequency of each external hazard. It also considers suitable Design Bases for each external hazard applicable to the SZC site.

Justification of Extreme High (Air) Temperature

The ‘Justification of Extreme High (Air) Temperature Design Basis Value at Sizewell C’ report [13]:

* provides site specific estimates of extreme high air temperature that could occur at SZC;
* considers the present climate conditions and future climate change; and
* analyses the information from other studies and defines the SZC site challenge values for extreme high air temperature.

It also provides some sensitivity studies related to the site challenge.

Modifications Summary Report

The MSR [14] describes the design change process in a qualitative manner. It is intended to support design changes and their significance to the SZC safety case. The MSR will inform the development of the SZC Pre-Construction Safety Report (PCSR). Of note, it:

* Provides a holistic view of design changes in development of the SZC design from the HPC Reference Configuration (RC) 2 Design to the SZC RC1 baseline design;
* Describes the processes by which the design changes have been developed and approved; and,
* Presents a review of the ‘in-scope’ design changes.

ONR Assessment

Scope of Assessment Undertaken

ONR’s licensing guidance [1] sets out expectations for a Nuclear Site Licence applicant. ONR’s SZC assessment strategy [3] identifies assessment topics, of which Mechanical Engineering is one.

To align the assessment strategy to ONR’s guidance, a set of licensing ‘features’ were developed within the strategy [3]. These align to the expectations within [1]. In each case, ONR’s SZC assessment strategy asks the question “Does the applicant’s proposal meet the expectation?” Hence, these are referred to as the ‘Licensing Questions’ within the strategy.

NNB GenCo then based the claims in its JSSR [4] to address these. To ensure full assessment coverage, but to also be targeted and proportionate, the ‘questions’ were linked to specific topic streams. This assessment report therefore addresses only those claims (related to the ONR licensing questions) relevant to the Mechanical Engineering topic steam.

Table 5 shows these licensing questions and their alignment to the relevant topic streams.

Table 5: Licensing Questions

| Does the applicant’s proposal meet requirement | | Topic Stream |
| --- | --- | --- |
| 1 | The site is of a sufficient size [to accommodate all necessary systems to ensure safe operation] | Civil Engineering  External Hazards  Internal Hazards |
| 2 | The site can be connected to [electricity] grid supplies. | Electrical |
| 3 | There is adequate cooling capability for all normal and fault conditions | Mechanical Engineering  Civil Engineering  Internal Hazards  External Hazards |
| 4 | The environmental conditions would not preclude the use of the site with respect to external hazards. | External Hazards |
| 5 | The geology of the site will provide a secure long term support to the necessary structures, systems and components. | Civil Engineering  External Hazards  Mechanical Engineering |
| 6 | The [NSL] submission would also need to provide a schedule for submission of further PCSR updates or revisions to support subsequent construction milestones | Safety Case |
| 7 | That operations of the site will not adversely affect the safety case for any adjoining nuclear licensed site | Internal Hazards (main)  External Hazards |

I focussed on the following:

* Claim 3: There is adequate cooling capability for all normal and fault conditions. I sampled:

The SSCs related to the heat sink and the design changes necessary for SZC;

How the sea water levels and temperatures had been considered and any impacts upon the design;

How the heating, ventilation and air conditioning (HVAC) systems had been impacted by the site location; and,

Whether there was sufficient margin in the design.

I also undertook a limited scope of assessment the following:

* Claim 5: The geology of the site will provide a secure long term support to the necessary structures, systems and components.

I sampled NNB GenCo’s de-risking studies for the floor response spectra[[5]](#footnote-5) for both the nuclear island and conventional island buildings. These studies being necessary due to changes in design basis earthquake for SZC compared with those considered for HPC.

My assessment has considered SSCs within the Nuclear Island, Conventional Island and Balance of Plant. I have only targeted those systems and components which are safety classified. For example:

Within the Conventional Island, there are mechanical components that are safety classified, for example turbine stop valves. These are important in the mitigation of events such as turbine disintegration. From a Mechanical Engineering perspective, I considered this within sub-section 4.3 in relation to the seismic floor response spectra and its impact upon equipment within the buildings. Turbine disintegration is discussed further within the Internal Hazards and External Hazards assessment reports [15, 16].

Balance of Plant structures include the pumping station, which provides a nuclear safety related function in support of the heat sink. I have considered this within sub-section 4.2 in relation to the supply of sea water and sub-section 4.3 in relation to the seismic floor response spectra and its impact upon equipment within the buildings.

Regulatory Issues

My assessment makes ‘observations’ that I have reviewed against existing Assessment Findings (AFs). These AF’s relate to the Generic Design Assessment (GDA) of the UK EPR™.

Where I judge an observation is not already captured within and AF, I have raised a Level 4 Regulatory Issue that will require closure post site licensing. This will enable me to track progress to completion.

The observations and associated issue references are captured in Appendix A of this report.

Assessment of Claim 3: Adequate Cooling Capability

The JSSR [4] claims:

* There is adequate cooling capability for all normal and fault conditions

I have assessed the adequacy of NNB GenCo’s claims by sampling two key areas:

* the heat sink
* the HVAC systems

Heat sink

The heat sink comprises both:

* The safety classified cooling water systems, performing nuclear safety functions; and,
* Non-classified cooling water systems associated with power production (e.g. turbine condenser cooling).

The HPC heat sink design is being replicated, as far as possible, in line with the SZC replication strategy [17, 18]. However, the amount of replication is limited by local conditions and the characterisation of external hazards at SZC.

The key driver for change is the lower lying position (and hence platform height[[6]](#footnote-6)) of SZC. Additionally, when compared to HPC, there are differences between this platform height and the extreme sea water levels (both high and low) for SZC. These are calculated in the SDSR [12] at the intended end of operations (2110).

The sea water levels are lower than the SZC platform height. However, for SZC there is reduced margin between the platform height and the maximum sea water height.

Higher sea water levels can lead to more frequent faults associated with the heat sink design. This affects ability of the heat sink to reliably perform its safety function.

I considered whether there is sufficient confidence, at this stage of the project, in the proposed SZC heat sink design. This concerns whether the design can achieve the required nuclear safety functional cooling requirements.

Site characterisation was undertaken with respect to sea levels and temperature. It is summarised in the Site Date Summary Report (SDSR) [12]. The adequacy of the data is assessed by ONR’s External Hazards inspectors [16] and is not considered further within my assessment.

HVAC systems

There are several safety classified HVAC systems within the SZC design. Environmental conditions may limit the ability of NNB GenCo to replicate the HPC HVAC system designs.

I sampled the design of the HVAC systems important to nuclear safety. I assessed whether site specific conditions for extreme high air temperature are adequately considered within the SZC design.

I targeted the Safeguard Building (HL) as it contains important nuclear safety related equipment and has been the focus of several design modifications at HPC. I consider this relevant as:

* The safety related equipment is qualified to operate within specific environmental conditions;
* External air temperature is an important factor; and,
* Ensuring that the HVAC systems provide adequate cooling in normal, fault and accident conditions is important to nuclear safety.

Relevant Parts of NNB GenCo’s Safety Case

As well as the JSSR [4], I also reviewed the following documents (relevant to the design changes to the heat sink SSCs):

* SZC Heat Sink Summary Report (HSSR) [11]
* Modifications Summary Report (MSR) [14]

I have considered the following documents (relevant to the HVAC systems design for SZC):

* SZC Heat Sink Summary Report (HSSR) [11]
* SZC Site Data Summary Report (SDSR) [12]
* SZC Justification of Extreme High (Air) Temperature Design Basis Value [13]

Comparison with Standards, Guidance and Relevant Good Practice

Heat sink

I consider the following RGP appropriate to my assessment of the adequacy of the SZC cooling capability:

* ONR SAPs [5]:

EHT.1 Heat transport systems, design: this considers the capacity of systems to remove or add sufficient heat at an adequate rate as required.

EHT.2 Heat transport systems, coolant inventory and flow: this considers quantifying heat sources in normal and design basis fault conditions. Uncertainties should be estimated and sufficient margin to failure stated and justified.

EKP.4 Safety function: this considers the identification of all safety functions to be delivered by a facility. They should be identified via a structured fault analysis, identifying fault sequences arising from all possible initiating events. It should also consider both internal and external hazards.

ELO.4 Minimisation of the effects of incidents: this considers how the design of the site layout, facilities and services minimise the effects of faults and accidents. This too should consider both internal and external hazards.

EHA.12 Flooding: this considers how facilities should be shown to withstand flooding conditions up to an including the design basis event. Severe accidents involving flooding should also be analysed.

I also considered NNB GenCo’s implementation of its arrangements under Licence Condition 20: Modification to design of plant under construction [19]. Although not “under construction” the heat sink design is closely related to that of HPC, which is. Therefore I consider it sensible to include this in my assessment.

The HSSR [11] notes that there would be a benefit in terms of replicating the HPC heat sink structures and equipment layout by adopting a higher platform height than the +7.3 m above ordnance datum (AOD) value selected. However, since design changes relative to HPC would still be required because of the narrower SZC tidal range the +7.3 m AOD value has been retained.

I consider this reasonable given the disadvantages of an increased platform height. For example, an increase in the platform height results in a reduced available area for buildings because the sides of the platform (which need to slope) would take up more of the available land. The reduced space for buildings would require significant reconfiguration of the major buildings and technical galleries, with closer spacing of facilities increasing the risks associated with hazards.

Due to the altimetry changes at SZC, there is an increased potential for internal flooding within the pumping station. This is following the tripping of CRF pumps and the resultant surge or swell of water[[7]](#footnote-7). This flooding has the potential to affect multiple cooling trains. The HSSR [11] notes that preliminary SZC hazards analysis provides confidence that the surge level remains below the level of the volumetric protection provided. I consider this position to be acceptable for the granting of the nuclear site licence, noting that further studies will be necessary as the detailed design is developed.

Any further design changes necessary to support the internal flooding safety case will be managed through normal business and assessed by ONR as considered appropriate as part of future regulatory oversight.

The principal design change, relative to HPC, is the removal of a 5 m ‘slice’ from the pumping station and forebay[[8]](#footnote-8) structures (HP-HPF). This raises the level (altimetry) of the water intakes in relation to the rest of the building. This design change requires various changes to the pumping station equipment Along with other site-specific factors, this has led to changes to the following structures:

* Outfall pond building (HCA)
* Some technical galleries[[9]](#footnote-9) (HGX)
* Elements of the CRF in the turbine hall
* Marine works

Despite these changes, the safety functional requirements for the heat sink buildings are the same for SZC as for HPC. I am content that the method of delivering these requirements will fundamentally be the same. Even if full replication of layout, dimensions, positioning and sizing of SSCs is not possible.

The HSSR [11] presents qualitative assessments for the more significant of those design changes proposed, to meet safety functional requirements. The report [11] aims to provide confidence in the ability to make an adequate safety case and demonstrate that the risk is reduced as low as reasonably practicable (ALARP). NNB GenCo concludes that none of the changes will materially undermine the ability of the heat sink systems to deliver their required nuclear safety functions. I consider this conclusion to be reasonable, and aligns with my expectations regarding ONR SAPs:

* EKP.4 (Safety function)
* ELO.4 (Minimisation of the effects of incidents)
* EHA.12 (Flooding)

I am satisfied that, where appropriate, NNB GenCo has conducted optioneering studies to identify preferred design changes to heat sink SSCs. For example, options to reduce the likelihood of the outfall pond building overflowing at very high seawater levels were considered.

Such overflow could increase the pumping station forebay seawater temperature. This may exceed the maximum permitted input temperature for the classified cooling water systems.

I consider the selected option of a manual, preventative trip of a CRF pump to reduce overflow based on forecasted exceptional meteorological and sea conditions to be appropriate. I note that NNB GenCo has raised an Open Point (HCA-OP-047) to include this into its Operating Rules.

I focused on the design change proposed for SZC to address reverse flow of heated seawater. This relates to water moving from the outfall pond to the pumping station forebay following CRF pump trip at high tide levels. In certain situations, the reverse flow can lead to a ‘loss of ultimate heat sink’ (LUHS) event. This results from the increase in temperature of the inlet water to the safety classified pumps.

The single CRF pump trip case adopt a similar mitigation as HPC. To prevent recirculation, CRF isolation valves will close on detection of CRF pump trip. Should these valves fail to close the reactor will trip on elevated inlet temperature for the safety classified pumps.

If both CRF pumps trip on a single unit (leading to reactor trip of that unit), the concern relates to reverse flow of warm water from the operational unit back through the CRF lines of the tripped unit. Within a CRF recirculation paper presented at No Change Committee No. 27 [20], NNB GenCo proposed to present two possible weir height options:

One to reduce the event frequency to a 1 in 200 year event (this is the estimated end of station life); and,

One to eliminate the problem.

Preventative shutdown of one CRF pump on each unit with the de-loading of both reactors addresses the fault for HPC. These pre-emptive measures will be taken when tide levels and sea water temperatures are forecast to exceed defined values (limits and conditions for operation).

At SZC the unmitigated frequency of the water levels reaching those at which reverse flow would occur is higher. This means that relying on preventative shutdown measures alone is not operationally feasible. As such, SZC proposes to have an elevated weir in the outfall pond.

The HSSR [11] notes that the final height of the weir will be determined. Within a paper presented at the No Change Committee No. 28 in July 2021, NNB GenCo endorsed the option for a +6 m AOD weir crest height to be used [21]. It states that this height will reduce the frequency of the recirculation hazard to 5.1 x 10-3 pry rather than eliminate it. I have reviewed the Gate 3 paper [21] and consider the chosen option to provide an ALARP position with respect to the likelihood of reverse flow and an LUHS event.

I consider the selected option for SZC to be acceptable. I note that the elevated weir is a robust and passive structure that can be designed to minimise the likelihood of failure. Hence, the elevated weir combined with the preventative CRF pump shutdown measures, should allow an LUHS safety case to be developed similar to that for HPC. This aligns with my expectations regarding ONR SAPs EHT.1 (Design) and EHT.2 (Coolant inventory and flow).

**Licence Condition 20: Modification to design of plant under construction**

My assessment considered whether NNB GenCo company guidance for SZC design changes [22] has been followed. This is relevant to my assessment of its implementation of LC 20 (Modification to design of plant under construction) arrangements. The guidance sets out a stage-gate structure of review and challenge implemented by the No Change Committee (NCC).

I have sampled the Gate 2 design change review linked to the CRF reverse flow. Gate 2 involves the NCC validating the preferred option and approving the start of more detailed feasibility studies. This is prior to the preferred option being included in the SZC reference configuration.

I have reviewed the following documents and am satisfied that in this instance NNB GenCo has adequately implemented its guidance [22]:

* Optioneering paper produced for the Technical Decision Committee (TDC) [23];
* Minutes from the TDC meeting that supported the preferred option [24]. The meeting attendees noted that the weir crest height would need to be decided in accordance with safety case and ALARP considerations;
* CRF Recirculation NCC Gate 2 paper [25]; and,
* Meeting minutes from the NCC Gate 2 review [26] that validated the selected option.

I noted that whilst the preferred option was validated, there remains a question over the location of the isolation valves in the CRF lines.

Replicating the HPC configuration at SZC introduces operational constraints. This is due to difficulties in isolating the turbine condensers’ water boxes for maintenance activities. I understand that provision has been made to install pipe spools upstream of the condensers. These spools should permit the potential installation of additional isolation valves. These would be used to reduce the operational constraints should this be considered necessary. I consider this to be an acceptable position at this stage of the project.

HVAC systems

I consider the following RGP appropriate to my assessment of the HVAC system designs:

* IAEA Specific Safety Requirements SSR-2/1 Safety of Nuclear Power Plants: Design [9]: this identifies requirements related to ventilation systems, for example within Requirements 65, 73, 79 and 81.
* ONR TAG NS-TAST-GD-022 Ventilation [6]: this provides guidance to inspectors and identifies expectations upon the design and operation of ventilation systems and components in nuclear facilities
* ONR SAPs [5]:

ECV.6 Monitoring devices: this considers that suitable and sufficient means of monitoring should be provided to detect and assess changes in the materials and substances held within the containment. Alarms should also be provided to alert operators. In addition, the guidance considers the need to monitor environmental conditions important to safety.

ECV.9 Containment and ventilation system design: this considers that a design should ensure that controls on fissile content, radiation levels and overall containment and ventilation standards are suitable and sufficient.

ECV.10 Ventilation system safety functions: this considers that the safety functions of ventilation systems should be clearly identified and the safety philosophy for the system in normal, fault and accident conditions defined.

EQU.1 Qualification procedures: this considers that qualification procedures should be applied to confirm that SSCs perform their safety functions in normal, fault and accident conditions for the duration of their operational lives.

EHA.7 ‘Cliff-edge’ effects: this considers how a small change in design basis fault or event assumptions should not lead to a disproportionate increase in radiological consequences.

EHA.11 Weather conditions: this considers that facilities should be shown to withstand weather conditions that meet design basis event criteria. It also states that weather conditions beyond the design basis that have the potential to lead to a severe accident should also be analysed.

To understand the impact of the SZC site challenge upon the HVAC systems, I sampled the Safeguard Building. These systems have previously been the focus of considerable work undertaken on the HPC project. Thus, I targeted the Safeguard Building to understand how NNB GenCo is assessing the impact of any change and to consider whether this might challenge delivery of the safety function of these systems.

I sampled the Safety Chilled Water System (DEL) as it is important to nuclear safety and has seen challenges in the HPC project. The system operates on four duty and four back-up trains.

The SZC SDSR [12] and Justification of Extreme High (Air) Temperature Design Basis Value report [13] discuss the values of extreme high air temperature at SZC. The specific justification document [13] provides a comparison of values at HPC and SZC. Table 6 summarises this data.

Table 6: HVAC Design Basis Values at HPC and Site Challenge at SZC

|  |  |  |  |
| --- | --- | --- | --- |
|  | HPC Design Basis | SZC Site Challenge | Change |
| Extreme External Air Temperature\* | 44 °C | 45.7 °C | +1.7 °C or 4% |
| Instantaneous Extreme Enthalpy | 83 kJ/kg | 78.9 kJ/kg | - 4.1 kJ/kg or 5% |

\* For SZC this temperature is recorded inland. Thus, NNB GenCo has assumed the equivalent temperature on the coastal site when determining the Design Basis.

The associated margins for the SZC DEL system design are based on the HPC design basis of 44 °C. NNB GenCo argues with its justification report [13], that the inland temperatures at Wattisham are conservative as those at the coastal site of SZC would likely be lower. I sought confirmation from ONR’s External Hazards inspector that this is acceptable.

The External Hazards assessment [16] judges that the SZC site challenge for enthalpy is bounded by the HPC design basis, but not the extreme air temperature.

The DEL system provides cooling to several other HVAC systems. These are sized using enthalpy rather than temperature. Therefore I accept that this may compensate for the increased temperature challenge at SZC. However, further work is needed by NNB GenCo to demonstrate the adequacy of the HVAC system design.

Section 5.4.1.2 and Figure 5 in Reference [13] provide some confidence that the design’s margins may cope with additional demand. However, in some cases the DEL trains cannot always deliver the required cooling capacity.

The sensitivity studies [13] show that:

* Adequate margin existed for the duty and back-up trains only at the 46 °C temperature. However, the additional challenges to the HPC HVAC design may further challenge this margin; and,
* At 48 °C and 50 °C, Reference [13] indicates there is a challenge placed upon the back-up trains of the DEL as well as reductions in margin available for the duty trains.

As such, it may not be possible to guarantee adequate cooling for the safety related equipment under these conditions. However, in this case I accept that it may be appropriate to trip the reactor if this scenario is realised. Should NNB GenCo determine that a limit be placed on extreme high air temperature, then I expect this to be captured within an appropriate limit or condition for safe operation (LC 23 Operating Rules).

Table 12 within Reference [13] states that there is at least a 12% margin within the DEL system. However, NNB GenCo’s analysis uses the 44 °C value for the design basis. As can be seen in Table 6, the recorded site challenge is higher than the current design basis. I do though concur with ONR’s External Hazards assessment [16] that the difference between the design basis and site challenge should not preclude the use of the SZC site.

I understand that the details of the HPC Safeguard Building design are still being finalised along with the sizing calculations. Several modifications / open points still need to be completed. These may impact the replicability of HPC at SZC and the corresponding design of SZC HVAC systems.

I held a technical meeting with NNB GenCo in April 2022 [27]. The aim was to understand the current status of the HPC HVAC designs and any implications on the SZC design. This included whether safety margins had been impacted together with the sensitivity studies within the SZC justification document [13].

This meeting confirmed that:

* The SZC HVAC margins in Reference [13] were based on HPC Reference Configuration (RC)1.2 thermal modelling. This information was circa. 2018;
* Updated information in November 2021 indicated that the HPC DEL margins within [13] could not be maintained. The main DEL lines in Division 1 and 4 are predicted to have -5% margin;
* NNB GenCo noted that the HPC thermal modelling is currently based on a flat temperature profile rather than a more representative sinusoidal heat wave profile. This combined with several other factors provides NNB GenCo with confidence that the HVAC design can be justified for HPC;
* Work is ongoing with the HPC HVAC design and sizing and will need to conclude before the impact can be fully understood for SZC; and,
* NNB GenCo noted that the lower enthalpy at SZC (see Table 6) will provide increased margin. This is due to enthalpy being the dominant sizing factor for the DEL system rather than temperature.

Following the technical meeting [27], it was apparent that NNB GenCo has not demonstrated adequate design margins for SZC safety related HVAC systems. This assumes that the HPC design is replicated for SZC. This does not meet my expectations regarding ONR SAP ECV.9 (Containment and ventilation system design).

However, NNB GenCo is still undertaking work in relation to the HPC Safeguard Building HVAC systems design. This will form the basis for the SZC design. I am confident in the work NNB GenCo is undertaking for the sizing of HPC HVAC systems. This is not yet concluded and the impact on the SZC design is not fully understood. The SZC site does not appear to pose any significant additional challenge to the HVAC systems [12].

Due to the items identified during my assessment and that of ONR’s External Hazards, I raise the following observation:

|  |
| --- |
| **Observation 1:** NNB GenCo should demonstrate that the HVAC designs for safety related systems are sufficient to meet the site challenge. NNB GenCo shall also demonstrate that adequate margins of safety exist.  This should include an update to any relevant safety case or supporting documentation.  The demonstration shallinclude a justification for any limits and conditions for safe operation that may be needed (LC 23 Operating rules). |

I have reviewed the following documentation in relation to the UK EPR™ GDA AFs:

* SZC GDA Assessment Findings Impact Analysis [28]
* ONR Assessment Report - NNB Generation Company (HPC) Limited - Start of Bulk MEH Installation on Unit 1 Nuclear Island [29]

I conclude that Observation 1 is within the scope of the following:

* AF-UKEPR-ME-20
* AF-UKEPR-FS-101

NNB GenCo’s Impact Analysis [28] notes that AF-UKEPR-ME-20 was closed for HPC. ONR accepted closure in October 2018 [30], before the challenges to the DEL system were noted. Equally, AF-UKEPR-FS-101 was closed for HPC in October 2021 [31] prior to ONR permitting on Start of Bulk MEH Installation on HPC Unit 1 Nuclear Island. These AFs are not yet closed for SZC.

Whilst Observation 1 is closely linked to the closure of other UK EPR™ AFs, they do not specify all of my findings and closure will be closely linked to NNB GenCo’s finalisation of the HPC design. Hence, I judge that Observation 1 should be raised as a Level 4 Regulatory Issue. I consider that raising it should provide me with an appropriate means to ensure all aspects are adequately addressed and should not increase the existing regulatory burden on NNB GenCo.

I judge that for licensing, NNB GenCo has sufficient evidence to provide confidence that:

* Site specific data for SZC [12] does not appear to present particularly onerous challenges in relation to HVAC systems that cannot be managed;
* It should be able to provide an adequate HVAC design and safety case for SZC post site licensing;
* The safety related ventilation systems can be analysed to determine whether sufficient margin exists for normal and fault conditions; and,
* It is able to undertake sensitivity studies analysing the impact of increases in design basis values to determine whether cliff edges exist.

This meets my expectations in relation to EHA.7 (‘Cliff edge’ effects) and EHA.11 (Weather conditions).

Should NNB GenCo place a safe limit upon the extreme high air temperature, I expect that suitable monitoring and alarms to be in place to enable this, in line with ONR SAP ECV.6 (Monitoring devices). This would also be relevant to the internal temperatures within the buildings serviced by ventilation systems, where these support delivery of a safety function or qualified parameter.

NNB GenCo must ensure that the equipment placed within the buildings and rooms serviced by ventilation systems can operate safely. This includes qualifying equipment to operate within defined temperature boundaries, with suitable margin of conservatism to allow for unknowns.

This topic is not yet concluded for SZC in relation to the design and sizing of HVAC systems. Work is ongoing for the HPC design, which may impact upon the SZC design. Therefore I intend to pursue this post site licensing in line with ONR SAPs ECV.9 (Containment and ventilation system design), ECV.10 (ventilation system safety functions) and EQU.1 (Qualification procedures).

Interface with other topic areas

During my assessment, I have interfaced with External Hazards on the applicability and adequacy of extreme high (air) temperatures and tidal ranges. The assessment of this is in the External Hazards assessment report [15].

During my assessment, I have engaged in technical meetings with NNB GenCo. These were in relation to the Heat Sink Topic Stream [32, 33, 34, 35] and specifically on the SZC HVAC challenge [27].

Summary

In relation to the heat sink:

* As a result of the differences in site challenge, NNB GenCo has implemented several design changes. These are summarised in its Modifications Summary Report [14] and the HSSR [11].
* I am content that the analyses and modifications in relation to the heat sink design for SZC, mitigation of the LUHS fault and raising of the weir crest height are appropriate. This meets my expectations, from a Mechanical Engineering perspective, in relation to ONR SAPs:

EHT.1 (Design)

EHT.2 (Coolant inventory and flow)

EKP.4 (Safety function)

ELO.4 (Minimisation of the effects of incidents)

EHA.12 (Flooding)

* As there is ongoing work in this area involving External Hazards, it is an area that I will pursue further post site licensing.

In relation to NNB GenCo’s analysis of the SZC HVAC systems:

* The claims, arguments and evidence in the submissions assessed appear reasonably constructed.
* The high air temperature justification report [13] identified conservatisms in the HPC HVAC sizing studies and provides sensitivity studies for the profile at 46 °C, 48 °C and 50 °C.

This meets my expectations regarding ONR SAPs:

EHA.7 (‘Cliff edge’ effects)

EHA.11 (Weather conditions)

However, NNB GenCo has confirmed that the data used for the SZC justification are superseded and the HPC design and sizing is not yet finalised. This is likely to have an impact on the SZC design.

The evidence provided for SZC HVAC systems is not sufficient to demonstrate that adequate margin exists for normal and fault conditions. This does not meet my expectations regarding ONR SAPs:

ECV.9 (Containment and ventilation system design)

ECV.10 (ventilation system safety functions)

There is work ongoing in this area. Developments in the HPC HVAC design and sizing may impact upon the ability to replicate this for SZC. I have made Observation 1 relating to NNB GenCo’s justification that SZC HVAC systems are adequately designed to meet the site challenge.

I will continue to engage with NNB GenCo in respect to the heat sink and HVAC system designs post site licensing.

I have identified a single Claim 3 related ‘observation’ to be followed up post site licensing. However, I have not identified any significant Mechanical Engineering issues preventing ONR from granting a nuclear site licence for SZC.

Conclusion

I am satisfied that the work to support site licensing provides sufficient confidence that NNB GenCo can develop an adequate safety demonstration for:

* The SZC heat sink
* HVAC systems

I am satisfied that NNB GenCo has undertaken modifications in line with its own arrangements. This meets my expectations in relation to LC 20 (Modification to design of plant under construction) for those sampled.

Further detailed design work and safety case studies are required, post site licensing. This should demonstrate delivery of safety functional requirements and will be subject to:

* Routine regulatory engagement;
* Closure of the Level 4 Regulatory Issue linked to Observation 1; and,
* Assessment of relevant safety case documentation.

Assessment of Claim 5: Geology of the site

The JSSR [4] claims that:

* The geology of the site provides secure long term support to the necessary structures, systems and components.

Within ONR, the Mechanical Engineering specialism has led on the assessment of seismic floor response spectra. Hence, it is reported here. This has been done with support from both External Hazards and Civil Engineering inspectors.

From an equipment perspective (mechanical, electrical, control and instrumentation (C&I) and HVAC) the floor response spectra (FRS) are key input data for both design and equipment qualification (EQ). The FRS generation depends on the:

* Design basis earthquake (DBE);
* Aeroplane crash (APC); and,
* Characteristics of the building hosting the equipment and the interaction of its structure with the soil.

Due to the site-specific nature of these characteristics, it cannot be assumed that the HPC safety demonstration can be replicated. Hence, I have sampled this for my assessment of Claim 5.

Ahead of signing contracts for SZC, NNB GenCo detailed its original strategy to de-risk equipment contracts with respect to seismic and APC FRS [36]. It is noted that on HPC no ‘structure soil structure interaction’ (SSSI) amplification was assumed and a structural damping of 7% was considered. For SZC, early results suggest that more onerous assumptions need to be considered. This is because SSSI effects are not negligible and a 4% structural damping is considered more appropriate.

Version 2 of the SDSR [12] provided data on the seismic DBE for SZC. However, ONR External Hazards raised concerns and a Regulatory Issue (RI-8992). Consequently, NNB GenCo undertook work to review the DBE. NNB GenCo’s position was provided to ONR in a position note [37] and a letter [38] in March 2022. This noted the adoption of a new, hybrid SZC DBE. ONR External Hazards raised additional concerns related to the vertical spectra, which were addressed in April 2022 and communicated to ONR in a further letter [39] and a revision to its ‘SZC DBE Definition’ document [40].

The updated DBE definition document [40] states the horizontal and vertical DBE spectra for the SZC site. The assessment of this and the modified SZC DBE is discussed within the External Hazards assessment report [16].

Relevant Parts of NNB GenCo’s Safety Case

The following documents provide data that NNB GenCo has considered in its design for SZC:

* Sizewell C Site Data Summary Report (SDSR) [12]
* Sizewell C specific DBE and APC - Strategy to de-risk equipment contracts to SOC [36]
* Sizewell C Position Note [37] and Letter [38] March 2022
* Sizewell C Letter [39] and updated ‘SZC DBE Definition’ document [40] April 2022

The final SZC FRS are not yet quantified. This is not required for the granting of a nuclear site license, given the equipment design and/or qualification could change to meet the revised FRS. Still, I would expect NNB GenCo to have undertaken limited analysis in advance of site licensing. This would provide confidence that differences in geology at the sites are not likely to cause significant changes to the design or preclude the use of the SZC site.

Comparison with Standards, Guidance and Relevant Good Practice

I consider the following RGP relevant to my assessment of the SZC nuclear site licence application:

* ONR TAG NS-TAST-GD-013 External Hazards [6]: this provides guidance to inspectors related to external hazards including seismic events.
* ONR SAPs [5]:

EKP.4 Safety function: this considers the identification of all safety functions to be delivered by a facility. They should be identified via a structured fault analysis, identifying fault sequences arising from all possible initiating events. It should also consider both internal and external hazards.

ELO.4 (Minimisation of the effects of incidents): this considers how the site layout, facilities and services design minimises the effects of faults and accidents. The design and layout should minimise the direct effects of initiating events from internal and external hazards.

EHA.5 (Design basis event operating states): this considers that the analysis of design basis events should apply engineering, deterministic and probabilistic methods to:

* + - Understand the behaviour of the facility in response to the hazard; and,
    - Confirm a high level of confidence in the facility’s design basis.

EHA.7 (‘Cliff-edge’ effects): this considers how a small change in design basis fault or event assumptions should not lead to a disproportionate increase in radiological consequences.

EQU.1 (Qualification procedures): this considers that qualification procedures should provide a level of confidence commensurate with the safety classification of a structure, system or component. They should address all operational, environmental, fault and accident conditions identified in the safety case.

Original de-risking studies

NNB GenCo’s original strategy [36] explains the assumptions and approach adopted for the original de-risking studies in terms of both seismic and APC FRS. The aim being to demonstrate, as far as possible, that FRS used to qualify equipment at HPC can be used directly at SZC, This is despite the different ground conditions and seismic hazard level at SZC.

Where the HPC FRS is demonstrated to bound SZC, I accept that there should be no need to carry out any additional equipment qualification for SZC. Where this is not possible an assessment of design margins, potentially some additional analysis, or requalification, may be needed in specific cases.

I consider the approach adopted to be reasonable. This notes that de-risking is aimed at providing confidence in advance of more detailed studies following signature of contracts with equipment suppliers.

Nuclear Island seismic floor response spectra

Most of the Nuclear Island (NI) equipment has already been qualified for HPC against a more onerous UK fleet seismic spectra. Whilst these spectra provide margin to the SZC FRS, considered at the time of the de-risking studies, there is uncertainty regarding their sensitivity to SSSI. However, I understand that the initial studies provide reasonable confidence that the HPC qualification will remain valid.

I consider this to be appropriate because NNB GenCo’s work to date has considered guidance within ONR SAPs EHA.5 (Design basis event operating states) and EHA.7 (‘Cliff-edge’ effects). NNB GenCo is undertaking confidence studies, which should provide appropriate justification for the chosen floor response spectra and the sensitivity to SSSI. A summary report is expected mid-2022, which should provide confidence in the chosen design.

Conventional Island and Balance of Plant seismic floor response spectra

The Conventional Island and balance of Plant (CI & BOP) equipment, along with a limited amount of NI equipment (most notably the primary circuit loop), has been qualified against the HPC site specific seismic FRS. For the SZC de-risking studies, FRS were generated using pessimistic DBE spectra defined by the project’s Hazards Expert Panel. In certain instances, these FRS exceeded those used for HPC resulting in the need for further consideration of impacted equipment.

During the heat sink technical meeting in March 2022 [35] an update was provided. This detailed the ongoing work and progress with FRS de-risking activities for SZC.

The information presented indicates that in the limited number of cases where the SZC seismic CI & BOP FRS have been shown to exceed those for HPC, the risk is considered low. The exceedances are small and in the higher frequency range, which is of less concern to installed equipment.

I expect this to be considered within the confidence studies that are currently ongoing. A summary report is expected mid-2022, which should provide confidence in the chosen design. At this stage, I judge NNB GenCo’s progress to be aligned with ONR SAPs EHA.5 (Design basis event operating states), EHA.7 (‘Cliff-edge’ effects) and sufficient for licensing.

Aeroplane Crash seismic floor response spectra

The pumping station is the only CI & BOP building which needs to be designed to withstand APC. The building will experience an FRS associated with this.

During the technical meeting in March 2022 [35], NNB GenCo explained that initial studies show the HPC APC FRS are exceeded at the higher frequencies at many levels within the pumping station. The higher frequencies are typically of concern to electrical equipment. It is understood that no sensitive electrical equipment has been identified in these areas. Although there is likely to be a potential impact on other aspects such as supports or anchoring and band screen motors.

Further studies are required for certain equipment in the pumping station (including the band screens and trash rakes) that are now expected to be subjected to more onerous APC FRS. This is because they have been relocated to a higher level in the building to address the different SZC sea levels.

I consider this to be appropriate as it aligns with ONR SAPs EHA.5 (Design basis event operating states) and EQU.1 (Qualification procedures). Conclusion of this is not a pre-requisite for nuclear site licensing.

New SZC hybrid design basis earthquake

During the technical meeting held in March 2022 [35], NNB GenCo summarised the FRS areas likely to be impacted by the new SZC Hybrid DBE. This has been defined following recent discussions with ONR.

The areas likely to be impacted are generally limited to those where the UK fleet spectra have been used for HPC. This includes:

* the Turbine Hall (HM) structure (this houses some safety classified mechanical systems and components)
* fuel assemblies
* radwaste tanks
* the crane in the Intermediate Level Wastes Building
* technical gallery piping

I understand that ‘confidence studies’ are to be completed by NNB GenCo with a summary report expected mid-2022.

The work completed by NNB GenCo aligns with my expectations regarding ONR SAPs:

* EHA.5 (Design basis event operating states);
* ELO.4 (Minimisation of the effects of incidents); and,
* EQU.1 (Qualification procedures).

I also recognise that NNB GenCo will continue to undertake work post site licensing in order to justify its design.

**Derivation of seismic floor response spectra**

Prior to commencement of HPC unit 1 nuclear island concrete, there was extensive discussion around how the seismic FRS had been derived and some of the associated assumptions [41].

Recognising this, at the technical meeting in March 2022 [35], the ONR Civil Engineering inspector made several observations. NNB GenCo will need to address these post site licensing. These include:

* Evidence to demonstrate that the finite element model (FEM) used for generating the FRS is appropriately verified and consistent with the FEM used for the civil engineering analysis.
* The design basis inputs used for the generation of FRS need to be the agreed inputs, confirmed by ONR’s External Hazards inspector.
* For structural damping, the value chosen should be appropriate for the stress state of the structure. As margins within the structure are expected to be high due to replication, 4% damping would seem appropriate unless it is demonstrated otherwise by the structure’s stress state.
* The structural stiffness assumptions relating to either cracked or uncracked section properties should also be validated based on the structure’s stress state in the model. Evidence should be provided to substantiate assumptions made.
* The decoupling assumptions relating to larger plant and equipment should be validated. This is to ensure the appropriate response is being captured in the development of the FRS.

I advised NNB GenCo to document its methodology being used for:

* defining the SZC FRS
* the damping sensitivity studies
* the basis for comparing SZC / HPC spectra

I advised that this should then be discussed with ONR to help de-risk this aspect post site licensing. This work should allow me to further judge NNB GenCo’s work in this area in respect to ONR SAPs:

* EKP.4 (Safety function)
* EHA.7 (‘Cliff-edge’ effects)
* ELO.4 (Minimisation of the effects of incidents)
* EHA.5 (Design basis event operating states)
* EQU.1 (Qualification procedures)

I have captured this in the following observation:

|  |
| --- |
| **Observation 2:** NNB GenCo should firstly advise ONR of a timescale for production of a methodology for:  defining the SZC floor response spectra  the damping sensitivity studies  the basis for comparing SZC and HPC spectra  NNB GenCo should then produce this methodology for the SZC floor response spectra analysis for NI and CI & BOP structures, systems and components. |

I have reviewed the following document relating to the UK EPR™ GDA Assessment Findings:

* SZC GDA Assessment Findings Impact Analysis [28]

I have not identified any AFs that deal with my observation. Therefore, I judge that it should be raised as a Level 4 Regulatory Issue. This should provide me with an appropriate means to ensure all aspects are adequately addressed. I also judge that raising the Regulatory Issue should not increase the regulatory burden on NNB GenCo, as it is only to enable me to track existing submissions.

Interface with other topic areas

During my assessment I have interfaced with External Hazards. This is in relation to assessment of the environmental conditions and DBE used as the SZC design basis. This is discussed in the External Hazards assessment report [16].

I have also interfaced with Civil Engineering in relation to the adequacy of NNB GenCo’s methodology to de-risk the FRS for SZC. The inspector has engaged with NNB GenCo during the relevant technical meetings held.

Summary

In relation to NNB GenCo’s analysis of the SZC site geology:

* NNB GenCo has provided sufficient confidence that the impact of the revised DBE on FRS for NI, CI & BOP buildings is being assessed. At present the risk to the SZC design is considered low.
* ONR has advised NNB GenCo to provide early sight of its studies, to provide confidence in the methodology adopted.
* NNB GenCo has identified where the aeroplane crash FRS has exceeded that for the design basis values (HPC).
* Work is ongoing with the production of a de-risking paper related to APC. ONR has advised NNB GenCo that early sight of this too would assist in providing confidence in the work undertaken.
* I have made Observation 2 relating to NNB GenCo documenting its methodology for the SZC FRS analysis for NI, CI & BOP SSCs. This will inform further discussions with ONR.

In relation to seismic floor response spectra, I have identified Observation 2, which I will follow up post site licensing. However, I have not identified any significant Mechanical Engineering issues preventing ONR from granting a nuclear site licence for SZC.

Conclusion

I am satisfied that NNB GenCo’s work relating to de-risking the SZC floor response spectra is being appropriately managed. I am also satisfied that the methodology it is using to provide confidence in the SZC design, identifying areas where this is challenged, is in line with ONR’s guidance.

I have identified the need for NNB GenCo to document its methodology. This is to ensure that it has been appropriately challenged internally (via NNB GenCo’s own processes) and allow ONR to agree its adequacy. This should provide NNB GenCo with further confidence in its approach.

Further work is required post site licensing to define the SZC floor response spectra. This will be subject to ONR oversight via:

* Routine regulatory engagement;
* Closure of the Level 4 Regulatory Issue linked to Observation 2; and,
* Assessment of the relevant safety case documentation.

Licence Condition Compliance

During my assessment I targeted the following Licence Conditions:

* LC 10: Training
* LC 12: Duly authorised and other suitably qualified and experienced persons
* LC 20: Modification to design of plant under construction

My LC 20 assessment can be found in sub-section 4.2.2 of this report.

My LC 10 and LC 12 assessment of NNB GenCo’s implementation of its arrangements is summarised below.

When granting a nuclear site license, ONR seeks assurance that the licence applicant has suitable and sufficient organisational structures, resources and competencies to lead and manage safety effectively [1]. It assesses this using the ‘Leadership and management for safety’ (MS) series of SAPs and supporting TAGs [6].

From a Mechanical Engineering perspective, I have engaged with NNB GenCo in the following areas:

* Core capability including design authority and intelligent customer capabilities
* Suitably qualified and experienced personnel and associated training

I consider the following SAPs relevant:

* MS.2 Capable organisation: this considers how the organisation ensures it has the capability to secure and maintain the safety of its undertakings.

I also consider guidance within the following TAGs [6] to be RGP:

* Appendix A of TD-HOD-GD-002 (this replaces NS-TAST-GD-093) on Leadership and Management for Safety.
* NS-TAST-GD-027 on Training and Assuring Personnel Competence.
* NS-TAST-GD-049 on a Licensee’s Core Safety and Intelligent Customer Capabilities.
* NS-TAST-GD-065 on the Function and Content of the Nuclear Baseline.
* NS-INSP-GD-010 concerning Licence Condition 10: Training.
* NS-INSP-GD-012 concerning Licence Condition 12: Duly Authorised and other Suitably Qualified and Experienced Personnel.

Interventions

I participated in two, multi-disciplinary interventions during February 2022 [42] and March 2022 [43]. These are discussed in more detail within the Organisational Capability (OC) assessment report [44]. This sub section summarises my Mechanical Engineering related findings.

The first intervention [42] assessed the adequacy of NNB GenCo’s design authority and intelligent customer (IC) capability.

The second intervention [43] assessed how NNB GenCo implements its arrangements within specialist areas. These related to how it ensures its workforce is suitably qualified and experienced, competent and appropriately trained.

A summary of my Mechanical Engineering findings is:

* NNB GenCo’s arrangements provide assurance that only competent staff perform work. This includes authoring and verifying documentation. This aligns with ONR SAP MS.2 (Capable organisation) and guidance within ONR’s inspection guidance on LC 12 (Duly authorised and other suitably qualified and experienced persons) [7].
* Work has been undertaken on safety significant mechanical SSCs, specifically in respect to the heat sink. However, no mechanical resource has been identified on the nuclear baseline or as an IC / IC practitioner. I judge this to be a gap in the implementation of SZC’s arrangements [45].
* I judge that NNB GenCo’s current ‘reliance’ on HPC SQEP undertaking SZC roles is not currently an area of Mechanical Engineering significance. However post licensing, as the project increases in size, NNB GenCo must address this matter. It should ensure personnel are demonstrably SQEP for SZC specific work. NNB GenCo’s work with the Nuclear Skills Alliance and EDF Nuclear Generation Limited to define common competencies may support this (the OC assessment report [44] provides more information).
* The role and competencies that are associated with specialist areas should be reviewed and revised. These should enable a competence assessor to consistently confirm a variety of requirements that relate to roles and competence.
* The arrangements for using subject matter experts (SMEs), whether internal or external, requires improvement. Instances where SMEs should be used to undertake formal SQEP assessment requires clarification and consistent implementation.
* Assessment of technical competence should be undertaken by a competent person. This aligns with NNB GenCo’s arrangements but not their implementation in the areas sampled.

I consider the above to be gaps in NNB GenCo’s arrangements related to MS.2 (Capable organisation) and LC 12 (Duly authorised and other suitably qualified and experienced persons).

Assessment of NNB GenCo Organisation and Systems

ONR also undertook a detailed assessment of NNB GenCo’s organisation and systems in place to manage it. ONR held a series of technical meetings with NNB GenCo, reported on within the OC assessment report [44].

NNB GenCo’s organisation does require further development as the SZC project advances. Its processes and procedures largely mirror those used within the HPC project, with specific changes relating to SZC. It includes learning from HPC in its organisational development. I consider this positive and demonstrates that, in line with ONR SAP MS.4 (Learning), NNB GenCo is a learning organisation.

I have sampled NNB GenCo’s organisational structure. I focused on how it has considered those within mechanical topic areas on the nuclear baseline. I identified issues in relation to this, which NNB GenCo has now addressed.

At this stage, I have no significant Mechanical Engineering concerns relating to NNB GenCo’s organisation and systems.

This area will be assessed further as part of normal regulatory business post granting of a nuclear site licence.

Summary

From a Mechanical Engineering perspective, I have not identified any issues that would prevent the granting of a nuclear site licence. This is in relation to NNB GenCo’s training, intelligent customer and SQEP arrangements and capabilities.

NNB GenCo’s process demonstrates personnel have appropriate level of competence associated with their role. It allows for personnel to demonstrate competence through assessment of knowledge and skills. This aligns with ONR’s expectations in respect to MS.2 (Capable organisation) and guidance on assessment of competence, training and SQEP [6, 7].

However, there are areas where I judge improvement necessary. These are already captured within the OC assessment report [44]. Hence, I have not raised any observations or Regulatory Issues in my assessment report.

Conclusion

NNB GenCo’s arrangements provide assurance that competent persons can assume SQEP roles. This aligns with ONR’s guidance despite some findings concerning their implementation.

NNB GenCo has updated its nuclear baseline and IC roles to include those related to the heat sink and, more importantly, the CI & BOP areas.

I have identified aspects of NNB GenCo’s arrangements, and their implementation, that require improving. I judge that these aspects can be addressed post site licensing, under normal regulatory business.

ONR Assessment Rating

Following my Mechanical Engineering assessment, I judge that an assessment rating of Green is appropriate.

The reasons for this are:

* Relevant good practice is generally met in the areas I sampled;
* My sample only identified relatively minor deficiencies in Licence Condition compliance arrangements; and,
* I did not identify any significant shortfalls in the design that are related to the delivery of safety functions.

Conclusions and Recommendations

Conclusions

This report presents the findings of my Mechanical Engineering assessment of NNB GenCo’s application for a nuclear site licence. To conclude, I am satisfied with the claims, arguments and evidence presented in my sample of the Licensee’s submissions. From a Mechanical Engineering perspective, the evidence provided is sufficient for licensing in respect to:

* Claim 3 regarding the design’s cooling capacity; and,
* Claim 5 regarding the impact of modified seismic floor response spectra for mechanical systems and components.

I have identified two areas where further work is required to provide an adequate safety case. However, I am satisfied that these can be addressed post granting of a nuclear site licence.

My assessment of NNB GenCo’s compliance with relevant Licence Conditions concludes that:

* For LC 10 and LC 12, there are no issues that would impact upon the granting of a nuclear site licence. Whilst some deficiencies require improvement, I am satisfied that these can be addressed post granting of a nuclear site licence.

For LC 20, NNB GenCo has demonstrated that its arrangements to assess the nuclear safety impact of design modifications are adequately implemented.

I have assigned an assessment rating of Green.

I have made two observations, listed in Table 8 within Appendix A to this report. I intend to follow these up once ONR has granted a nuclear site licence. I intend to progress these through the associated Level 4 Regulatory Issues.

Recommendations

My recommendations are as follows:

**Recommendation 1:** from a Mechanical Engineering perspective NNB GenCo should be granted a nuclear site licence for Sizewell C Nuclear Power Plant.

**Recommendation 2:** post granting of a nuclear site licence, the observations raised in this report should be progressed via Level 4 Regulatory Issues (normal regulatory business).

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Table 7: Relevant Safety Assessment Principles (SAPs) considered during the assessment

| SAP No. | SAP Title | Description |
| --- | --- | --- |
| FP.2 | Leadership and management for safety | Effective leadership and management for safety must be established and sustained in organisations concerned with, and facilities and activities that give rise to, radiation risks. |
| FP.4 | Safety assessment | Dutyholders must demonstrate effective understanding and control of the hazards posed by a site or facility through a comprehensive and systematic process of safety assessment. |
| FP.6 | Prevention of accidents | All reasonably practicable steps must be taken to prevent and mitigate nuclear or radiation accidents. |
| MS.2 | Capable organisation | The organisation should have the capability to secure and maintain the safety of its undertakings. |
| MS.4 | Learning | Lessons should be learned from internal and external sources to continually improve leadership, organisational capability, the management system, safety decision making and safety performance. |
| EKP.2 | Fault tolerance | The sensitivity of the facility to potential faults should be minimised. |
| EKP.3 | Defence in depth | Nuclear facilities should be designed and operated so that defence in depth against potentially significant faults or failures is achieved by the provision of multiple independent barriers to fault progression. |
| EKP.4 | Safety function | The safety function(s) to be delivered within the facility should be identified by a structured analysis. |
| EKP.5 | Safety measures | Safety measures should be identified to deliver the required safety function(s). |
| ECS.1 | Safety categorisation | The safety functions to be delivered within the facility, both during normal operation and in the event of a fault or accident, should be identified and then categorised based on their significance with regard to safety. |
| ECS.2 | Safety classification of structures, systems and components | Structures, systems and components that have to deliver safety functions should be identified and classified on the basis of those functions and their significance to safety. |
| EQU.1 | Qualification procedures | Qualification procedures should be applied to confirm that structures, systems and components will perform their allocated safety function(s) in all normal operational, fault and accident conditions identified in the safety case and for the duration of their operational lives. |
| EDR.1 | Failure to safety | Due account should be taken of the need for structures, systems and components to be designed to be inherently safe, or to fail in a safe manner, and potential failure modes should be identified, using a formal analysis where appropriate. |
| EDR.2 | Redundancy, diversity and segregation | Redundancy, diversity and segregation should be incorporated as appropriate within the designs of structures, systems and components. |
| ELO.4 | Minimisation of the effects of incidents | The design and layout of the site, its facilities (including enclosed plant), support facilities and services should be such that the effects of faults and accidents are minimised. |
| EHA.5 | Design basis event operating states | Analysis of design basis events should assume the event occurs simultaneously with the facility’s most adverse permitted operating state |
| EHA.7 | ‘Cliff-edge’ effects | A small change in design basis fault or event assumptions should not lead to a disproportionate increase in radiological consequences. |
| EHA.11 | Weather conditions | Facilities should be shown to withstand weather conditions that meet design basis event criteria. Weather conditions beyond the design basis that have the potential to lead to a severe accident should also be analysed. |
| EHA.12 | Flooding | Facilities should be shown to withstand flooding conditions up to and including the design basis event. Severe accidents involving flooding should also be analysed. |
| ECV.6 | Monitoring devices | Suitable and sufficient monitoring devices with alarms should be provided to detect and assess changes in the materials and substances held within the containment. |
| ECV.9 | Containment and ventilation system design | The design should ensure that controls on fissile content, radiation levels, and overall containment and ventilation standards are suitable and sufficient. |
| ECV.10 | Ventilation system safety functions | The safety functions of the ventilation system should be clearly identified and the safety philosophy for the system in normal, fault and accident conditions should be defined. |
| EHT.1 | Design | Heat transport systems should be designed so that heat can be removed or added as required. |
| EHT.2 | Coolant inventory and flow | Sufficient coolant inventory and flow should be provided to maintain cooling within the limits (operating rules) derived for normal operational and design basis fault conditions. |

# Appendix A – Regulatory Issues

Table 8: Observations identified in the Mechanical Engineering Assessment

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Details | Section | Ref. |
| 1 | NNB GenCo should demonstrate that the HVAC designs for safety related systems are sufficient to meet the site challenge. NNB GenCo shall also demonstrate that adequate margins of safety exist.  This should include an update to any relevant safety case or supporting documentation.  The demonstration shall include a justification for any limits and conditions for safe operation that may be needed (LC 23 Operating rules). | 4.2.2 | RI - 10802 |
| 2 | NNB GenCo should firstly advise ONR of a timescale for production of a methodology for:  defining the SZC floor response spectra  the damping sensitivity studies  the basis for comparing SZC and HPC spectra  NNB GenCo should then produce this methodology for the SZC floor response spectra analysis for NI and CI & BOP structures, systems and components. | 4.3.2 | RI - 10803 |

The above Regulatory Issues are captured on ONR’s Regulatory Issues database. They are to be closed post granting of a nuclear site licence, as part of normal regulatory business.

1. CM9 revision to be identified upon completion of activity and incorporation of any changes to document. [↑](#footnote-ref-1)
2. Where required in accordance with [NS-PER-GD-016](https://how2.prod.onr.gov.uk/CtrlWebIsapi.dll/D2B97868F9C04F9F97117C7B56DFC8B7.cwl?__id=webFile.save&doc=3B55AFB1AFAC46B48A5EF6D7C306666C&dpt=1&save=1). [↑](#footnote-ref-2)
3. Hard-copy of document signed-off, CM9 version updated with authors / approver / acceptor names and dates and record finalised. [↑](#footnote-ref-3)
4. Heat Sink refers to the SSCs involved in the transmission, use, and return of seawater in an open circuit seawater cooling system. [↑](#footnote-ref-4)
5. Floor response spectra present the vibrational exposure that equipment experiences during a seismic or aircraft crash event. They are used to define the procurement and qualification requirements for systems and components that are required to withstand such events. [↑](#footnote-ref-5)
6. Sizewell C will be built on a platform to help protect the site from flooding. [↑](#footnote-ref-6)
7. “surge / swell” refers to the temporary increase in water depth in the forebay. This is due to the momentum of the water in the intake tunnels following CRF pump trip (i.e. water removal from the forebay is reduced because of CRF pump trip, but the water the tunnels continues to arrive in the forebay for a short period of time). [↑](#footnote-ref-7)
8. The forebay provides the normal source of intake water for all the cooling water systems. It consists of an open-topped concrete structure which receives water from the intake tunnel before it is drawn into the associated pumping station. [↑](#footnote-ref-8)
9. The technical galleries are the underground concrete structures that connect essential services (for example, cooling water, gases and electricity) between the two reactor units and other buildings. [↑](#footnote-ref-9)