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**Sizewell C Licensing**

**Electrical engineering assessment of an application by NNB Generation Company (SZC) Ltd for a nuclear site licence**

Assessment Report Ref.: ONR-NR-AR-22-001

Issue No.: 1

Date: 31 January 2023

Executive Summary

This report presents the findings of the assessment of the electrical engineering aspects of the NNB Generation Company (SZC) Ltd (NNB GenCo (SZC)) application for a nuclear site licence to construct and operate two UK EPR™ reactors at Sizewell C (SZC).

The scope of my assessment has been to consider whether:

* the site can be connected to electricity grid supplies;
* the site is of a sufficient size to accommodate all necessary systems to ensure safe operation;
* the environmental conditions would not preclude the use of the site with respect to external hazards; and
* NNB GenCo (SZC) is developing a competent organisation to support delivery of these technical activities.

From an assessment of NNB GenCo (SZC)’s documentation that provides the justification for these aspects, I consider that NNB GenCo (SZC) has provided an appropriately structured case to address each of these aspects. This case is underpinned by evidence appropriate for this stage of the project which gives confidence that the power station will be able to be connected to the Great Britain (GB) electricity transmission system and be constructed to meet robust deterministic and reliability claims. I am also satisfied that NNB GenCo (SZC) is working with relevant stakeholders to ensure the design of this connection does not compromise the electricity transmission connection to the neighbouring Sizewell B nuclear power station.

In respect of organisational capability, I am satisfied that the NNB GenCo (SZC) staff demonstrate the required level of competence for this current stage of the project.

I am satisfied that NNB GenCo (SZC) demonstrates its approach to design and management of safety is generally consistent with the expectations of the Office for Nuclear Regulation (ONR) Safety Assessment Principles. However, I note that the underpinning data used in its loss of offsite power analysis has not been reviewed for a number of years. While I consider the impact on this assessment and, consequently, risk to the safety case is low and it is not essential to resolve this prior to licensing, I have raised an ONR regulatory issue to ensure this is adequately resolved at the appropriate time.

To conclude, I am satisfied from an electrical engineering perspective that the power station can be connected to the GB transmission system without compromising the safety case for the adjoining nuclear licensed site and that the NNB GenCo (SZC) organisation and systems are suitable to develop the design.

I recommend that from an electrical engineering perspective a nuclear site licence should be granted to NNB GenCo (SZC) to construct and operate a nuclear power station at Sizewell C.

List of Abbreviations

A Ampere

EU European Union

ESO Electricity System Operator

GB Great Britain

GCDR Grid Connection Design and Contribution to Loss of Offsite Power Frequency Report

GDA Generic Design Assessment

GIC Geomagnetic Induced Current

HG\* Technical Gallery System

HPC Hinkley Point C

IAEA International Atomic Energy Agency

JSSR Justification for Site Suitability Report

kV Kilovolt

LOOP Loss of Offsite Power

NNB GenCo (SZC) NNB Generation Company (SZC) Ltd

NSL Nuclear Site Licence

Ofgem Office of Gas and Electricity Markets

ONR Office for Nuclear Regulation

p.a. per annum

PAR Project Assessment Report

PSA Probabilistic Safety Analysis

RI Regulatory Issue

SAP Safety Assessment Principle

SDSR Site Data Summary Report

SSG Specific Safety Guide (IAEA)

SZB Sizewell B

SZC Sizewell C

TAG Technical Assessment Guide

UK United Kingdom

UK EPR™ UK reference design of the European Pressurised water Reactor

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**Table(s)**

Table 1: Relevant Safety Assessment Principles (SAPs) considered during the assessment

**Annex(s)**

Annex 1: Regulatory Issues

# Introduction

1. NNB Generation Company (SZC) Ltd (NNB GenCo (SZC)) applied to the Office for Nuclear Regulation (ONR) on 30 June 2020 for a nuclear site licence to construct and operate a nuclear power station comprising two UK EPR™ reactors at Sizewell C (SZC) in Suffolk.
2. The outcome of ONR’s activities from the nuclear site licence (NSL) assessment will be a project assessment report (PAR), which will draw together the views of ONR’s specialist assessors on NNB GenCo (SZC)’s readiness to become a nuclear site licensee. This will result in a recommendation to the Chief Nuclear Inspector on granting a licence. This electrical engineering licensing assessment report is one of a number that will inform the PAR.
3. 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

1. This report presents the findings of the assessment of electrical engineering aspects of the NNB GenCo (SZC) application for a nuclear site licence to construct and operate two UK EPR™ reactors at SZC as presented in the Justification of Site Suitability Report [4] and supporting documentation provided by NNB GenCo (SZC). Assessment was undertaken in accordance with the requirements of the ONR Management System. The ONR Safety Assessment Principles (SAPs) [5], together with supporting Technical Assessment Guides (TAGs), have been used as the basis for this assessment.

## Scope

1. The scope of this report covers the assessment of the electrical engineering aspects of NNB GenCo (SZC)’s application for a licence for the SZC site.

## Methodology

1. The methodology for assessment follows ONR’s guidance on the mechanics of assessment, NS-TAST-GD-096 [6].
2. This assessment has been focused primarily on a review of the submissions provided by the prospective licensee, NNB GenCo (SZC), supplemented by several level 4 technical meetings.

# Assessment Strategy

1. The intended assessment strategy for electrical 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, relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licenced sites. The key SAPs and any 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.

### Safety Assessment Principles (SAPs)

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

### Technical Assessment Guides (TAGs)

1. The following TAGs have been used as part of this assessment:
* NS-TAST-GD-019 Essential Services [7]
* NS-TAST-GD-096 Guidance on Mechanics of Assessment [6]

### National and International Standards and Guidance

1. The following international standards and guidance have been used as part of this assessment:
* International Atomic Energy Agency (IAEA) Specific Safety Guide SSG-34 : Design of Electrical Power Systems for Nuclear Power Plants [8]
* Grid Code [9]

## Use of Technical Support Contractors

1. No Technical Support Contractors have been used in this assessment.

## Integration with Other Assessment Topics

1. I have worked closely with a number of other ONR inspectors to inform my assessment. The key interactions were with:
* ONR external hazards inspector on the assessment of the justification of the site from the risk of lightning and geomagnetic induced currents (GIC);
* ONR mechanical engineering inspector on the consideration of floor response spectra for the site; and
* ONR probabilistic safety analysis (PSA) inspector on the assessment of the derivation of a site frequency for a loss of offsite power (LOOP) event.

## Out of Scope Items

1. The following items are outside the scope of this assessment:
* replication strategy for the UK EPR™ design to SZC; and
* development strategy for the safety case for SZC.

# NNB GenCo (SZC) Submission

1. It is the intent of NNB GenCo (SZC) to replicate the Hinkley Point C (HPC) design at SZC as far as is reasonably practicable to reduce the risks to safety, schedule and cost.
2. NNB GenCo (SZC) has recognised that the specific characteristics or layout of the SZC site may lead to design changes, and that as part of its site licence application it needed to provide confidence that it recognised these potential changes; that design changes were feasible, and that the site represents a suitable location from a nuclear safety perspective for hosting a twin UK EPR™ reactor nuclear power station, and that an adequate safety case can be made. To support this need, NNB GenCo (SZC) produced the Justification of Site Suitability Report (JSSR) [4] underpinned by references.

## Justification of Site Suitability Report

1. ONR developed seven key questions based on an interpretation of Licensing Nuclear Installations [1] and ONR’s SAPs [5]. NNB GenCo (SZC) has addressed these questions in the JSSR [4] as specific claims.
2. Previous versions of the JSSR were shared with ONR in order to facilitate early engagement but for licensing, Revision 3 of the report was submitted which captured the latest work that had been undertaken.
3. The JSSR [4] is split into sections, each addressing a specific claim and pointing to further supporting ’primary references’. The sections applicable to this assessment 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 Sizewell B (SZB) to SZC)
* Section 6 - Claim 5: The geology of the site provides secure long term support to the necessary structures, systems and components
* 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)
1. The diagram below 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 the primary references

## Key Primary References

1. To underpin the electrically related aspects of the claims made in the JSSR, the following key references were submitted by NNB GenCo (SZC) with the JSSR:
* Arguments and Evidence supporting JSSR Claim 6 [10]
* Sizewell C Site Data Summary Report [11]
* SZC Project – Plot Plan Summary Report [12]
* SZC Grid Connection Design and Contribution to Loss of Offsite Power (LOOP) Frequency [13]
* Site Specific Short and Long LOOP Frequency Updates for HPC and SZC EPRs [14]

# ONR Assessment

1. This assessment has been carried out in line with the approach set out in the *Sizewell C* *Licensing ONR Assessment Framework* [3].

## Scope of Assessment Undertaken

1. In line with ONR’s framework [3], my scope of assessment considers two of the principal areas:
* design and safety case
* organisational capability
1. In addressing the first of these aspects, and as discussed in paragraph 19, above, ONR developed seven key questions which NNB GenCo (SZC) has then developed claims in their JSSR to address. To ensure full assessment coverage and to be targeted and proportionate, the questions were linked to specific topic streams. This alignment was outlined in the *SZC Licensing ONR Assessment Framework* [3]. This assessment therefore focuses on those questions relevant to this topic steam.
2. The table below shows the questions and their alignment to the relevant topic streams.

|  |  |
| --- | --- |
| Licensing Question | Topic Stream |
| The site is of a sufficient size [to accommodate all necessary systems to ensure safe operation] | Civil EngineeringExternal Hazards Internal Hazards |
| The site can be connected to [electricity] grid supplies | Electrical  |
| There is adequate cooling capability for all normal and fault conditions | Mechanical EngineeringCivil EngineeringInternal HazardsExternal Hazards  |
| The environmental conditions would not preclude the use of the site with respect to external hazards | External Hazards |
| The geology of the site will provide a secure long term support to the necessary structures, systems and components | Civil EngineeringExternal Hazards |
| The [NSL] submission would also need to provide a schedule for submission of further pre-construction safety report updates or revisions to support subsequent construction milestones | Safety Case |
| That operations of the site will not adversely affect the safety case for any adjoining nuclear licensed site | Internal Hazards (main)External Hazards |

1. NNB GenCo (SZC)’s claims in the JSSR [4] align with each of these questions. In my assessment, my primary focus has been on whether the site can be connected to the electricity grid supplies, which is addressed by Claim 2 of the JSSR. Given the potential for the SZC site environmental conditions to affect equipment design and site layout, I have also worked with the relevant ONR technical disciplines to gain confidence that NNB GenCo (SZC) has appropriately considered the implications on the electrical design of these aspects through the adequacy of Claims 1, 4 and 6 of the JSSR.
2. ONR’s assessment of the NNB GenCo (SZC) replication strategy of the HPC design [15] concluded that NNB GenCo (SZC) should ultimately be able to present a safety case showing that replication reduced risks so far as is reasonably practicable. However, it also highlighted three areas regarding electrical engineering where further work was required. Two of these relate to the grid connection and have been considered as part of my assessment of Claim 2:
* Agreement should be reached with the Office of Gas and Electricity Markets (Ofgem) regarding the granting of derogations to the grid code. If the derogations are not granted the implications should be fully assessed by NNB GenCo (SZC) and any necessary changes made to the replication strategy prior to its implementation.
* The SZC grid reliability figures should be established and the implications on overall site reliability figures assessed. Following this, any changes required to the replication strategy should be implemented.
1. The third area, about ensuring consistent basic assumptions for the replication strategy, is not related to either the ability to connect the site to the grid or site environmental conditions. It has therefore not been considered further in this assessment.
2. In the initial stages of my assessment, I requested selected references [16, 17, 18] to two of the key submissions, the *Sizewell C Site Data Summary Report* (SDSR)[11]and SZC *Grid Connection Design and Contribution to Loss of Off-Site Power Frequency* report (GCDR)[13], to gain confidence that the underpinning evidence supported the arguments being made in the JSSR [4]. In response, NNB GenCo (SZC) advised that these references were not yet available as they had not yet completed the review and approval process [19].
3. As well as being unable to review the judgements made by NNB GenCo (SZC), I was concerned that if the underpinning evidence was not yet approved then it was potentially subject to change, which could undermine the claims being made. To understand the scale of the issue, I requested that NNB GenCo (SZC): review the status of all the references [20] associated with the SDSR and GCDR reports [11, 13], how it intended to address those that had not completed due process and identify the implications on the JSSR [4].
4. NNB GenCo (SZC) completed reviews [21, 22] of the referencing to both the SDSR and GCDR reports, identifying a number of further reports that had not completed the approval process, assessed the significance of these and took action to resolve them. Ultimately, this review concluded that the completion of the document approvals did not result in changes to the content of them and therefore did not undermine the claims and arguments made in the site licensing justification. Recognising it had issued a significant report without the underpinning evidence having completed due process, NNB GenCo (SZC) initiated a learning report to investigate how its arrangements had allowed this to occur and to identify any changes that should be made to prevent it in future. I consider this to be an appropriate action by NNB GenCo (SZC). This investigation is ongoing and I consider the learning should be followed up as part of normal regulatory business.

### Licensing Question 1 – Site is of Sufficient Size to Accommodate All Necessary Systems for Safe Operation

#### Relevant Parts of NNB GenCo (SZC) Submission

1. In Claim 1 of the JSSR [4], NNB GenCo (SZC) set out how the SZC plot plan had been developed from that at HPC and whilst the size and position of certain buildings had changed the nuclear safety risks were still being managed so far as is reasonably practicable. NNB GenCo (SZC) set out that the detailed evidence to support this in the *Plot Plan Summary Report* [12], which formed the basis of my assessment.
2. In [12], NNB GenCo (SZC) set out that the Nuclear Island and Conventional Island/Balance of Plant buildings and footprint were identical to that at HPC.

#### Comparison with Standards, Guidance and Relevant Good Practice

1. In my assessment of this aspect, I have considered guidance including:
* IAEA Specific Safety Guide SSG-34: Design of Electrical Power Systems for Nuclear Power Plants [8]

#### Interface with other topic areas

1. In my assessment of this area, I have not needed to consult with any other technical disciplines.

#### Summary

1. In my initial assessment of [12], I noted that it stated “the plot plan for the majority of the technical galleries which connect the services of these facilities also remains largely unaffected, and where a small amount of re-routing may be needed as a part of the ongoing design work, there is high level of confidence that this can be achieved with respect to both safety and design requirements.”
2. Since these technical galleries (known as HG\* systems) provide the means of routing electrical cables between the various buildings on site, I was concerned that there was the potential for any changes in the design of the galleries to affect the ability to route all the required cables whilst meeting the cable separation requirements set out in the *RCC-E Design and Construction Rules* [23] applied by NNB GenCo (SZC) to the design for HPC. I, therefore sought clarity [17] on what was meant by “majority of the technical galleries … remains largely unaffected” and how NNB GenCo (SZC) had assured itself that the changes as a result of the SZC plot size would not compromise nuclear safety.
3. In response, NNB GenCo (SZC) submitted the *HG Gap Analysis Report* [24], which sets out to “identify main design changes on HG galleries from HPC scheme”. From my assessment of this report, I am satisfied that only relatively few technical galleries are affected by the changes to the plot plan and these are relatively minor galleries from an electrical cabling perspective. Additionally, where changes are identified, NNB GenCo (SZC) does not intend to change the cross-sectional area of the galleries and therefore affect the cable capacity. As a result, I consider that NNB GenCo (SZC) should be able to demonstrate that the design will accommodate all the necessary electrical cables in support of nuclear safety systems whilst meeting the separation principles set out in the *RCC-E Design and Construction Rules* [23]. I will expect NNB GenCo (SZC) to confirm this as it develops the cable routing, taking into account any design changes resulting from the SZC specific requirements, as part of detailed design and consider it is appropriate for this to be tracked as part of normal regulatory business.

### Licensing Question 2 – Site can be Connected to Electricity Grid Supplies

#### Relevant Parts of NNB GenCo (SZC) Submission

1. In Claim 2 of the JSSR [4], NNB GenCo (SZC) provided an overview of the grid connection concept design for SZC. It subsequently sets out through the following aspects to demonstrate how and why it considers that SZC can be provided with an offsite power supply through connection to the GB electricity transmission system [also known as the “grid”] and why that connection will provide appropriately robust supplies to the SZC site:
* A description of how the UK EPR™ is capable of being compliant with the UK grid code alongside an outline of how this programme of work at HPC will be replicated for SZC.
* The key differences between the SZC grid connection design and the HPC design and why they have no effect on the ability to demonstrate Claim 2.
* A demonstration that the SZC design has resilience with regards to the external and internal hazards that may be experienced at SZC, including the effects of future climate change on LOOP frequency.
* Analysis of the LOOP frequencies for SZC, the comparison with HPC LOOP and how these frequencies were derived.
1. In the JSSR [4], NNB GenCo (SZC) states that the arguments and evidence to support these aspects are provided in Revision 05 of the GCDR [13], which has formed the principal document for my initial assessment.

#### Comparison with Standards, Guidance and Relevant Good Practice

1. In my assessment of this aspect, I have considered the following guidance:
* IAEA Specific Safety Guide SSG-34: Design of Electrical Power Systems for Nuclear Power Plants [8]
* ONR-TAST-GD-019 Essential Services [7]
* GB Grid Code [9]

#### Interface with other topic areas

1. In my assessment, I have consulted with the following technical discipline to ensure the overall licensing assessment in this area is coherent and holistic:
* ONR PSA inspector to ensure the approach being taken in the derivation of LOOP frequencies is consistent with our expectations and previous UK EPR™ reactor assessments.

#### Summary

1. I consider that each of the aspects set out in paragraph 41, above, are relevant to demonstrating suitability for licensing. In addition, I also consider that changes to the local 400kV substation, which provides the connection point to the GB electricity transmission system to accommodate SZC could impact the security of supply to the adjoining SZB nuclear site; something I expected to be set out in Claim 6 of the JSSR.
2. In my assessment of the JSSR and supporting references, I have considered whether NNB GenCo (SZC) has adequately demonstrated each of these aspects.
3. However, during my initial assessment, I identified the following concerns:
* Many arguments appeared to be supported by subjective statements rather than either explicit evidence or reference to underpinning analysis.
* There was an implicit assumption that the closure of any gaps in achieving compliance with the GB Grid Code could be achieved through seeking derogations from Ofgem.
* Data provided to support LOOP reliability figures appeared to be generic with no consideration on why or how they should be considered for application to SZC.
* The implications for the SZB safety case from modifications to the grid connection did not appear to have been considered.
1. Without clarity of these aspects, I was concerned that NNB GenCo (SZC) may not be able to demonstrate in a future safety case that the SZC nuclear power station was capable of being connected to or operating with the offsite electricity transmission system or that it does not compromise the reliability of offsite supplies to the existing SZB nuclear site.
2. I discussed my concerns with NNB GenCo (SZC) [25] and raised a series of queries [16, 17, 18] setting out these concerns and to seek clarification on how the underpinning evidence would address these concerns. NNB GenCo (SZC) responded [19, 26] providing clarity to a number of the specific queries, giving additional supporting references and submitted a restructured, revision 06 of the GCDR [27] with the purpose of more clearly setting out the evidence and its reasoning to support Claim 2. I consider revision 06 more clearly sets out evidence and judgements which substantiate the claims in the JSSR. My assessment in the remaining sections of this report considers revision 06 of the GCDR unless specific reference is made to the initially submitted revision 05 for context reasons.
3. The following sub-sections of this report set out my consideration of each of the aspects.

Grid Code Compliance

1. It is necessary for a connection agreement to be in place between National Grid Electricity System Operator Limited, the GB electricity system operator (ESO), and the licensee of the SZC site to allow this to be connected to the GB electricity transmission system. An aspect of this agreement is for the plant to be compliant with the technical requirements for connection, defined in the GB Grid Code [9].
2. IAEA Safety Guide SSG-34 [8] recognises that:
* Electrical power systems that supply power to systems important to safety are essential to the safety of nuclear power plants. These electrical power systems include both on-site and offsite power systems. The on-site power systems and offsite power systems work together to provide necessary power in all plant conditions so that the plant can be maintained in a safe state. Offsite power systems are not plant equipment. They are, nevertheless, essential to the safety of a nuclear power plant, and they are important in the defence in depth concept.
1. Due to the important role offsite power plays in supporting nuclear safety, I have considered in my assessment whether NNB GenCo (SZC) is likely to secure a suitable connection agreement for the SZC site, and whether its design will meet the technical performance requirements of the GB Grid Code [28].
2. NNB GenCo (SZC) has confirmed that a connection agreement is already in place [29] and, therefore, I have focused on whether the plant design is compliant with the technical requirements of the GB Grid Code.
3. In [13], NNB GenCo (SZC) sets out its strategy for ensuring GB Grid Code compliance at SZC taking into account the work undertaken during the ONR Generic Design Assessment (GDA) of the UK EPR™ reactor design. As part of GDA [30], a review of the design against the GB Grid Code was undertaken by the requesting party. To support SZC licensing, NNB GenCo (SZC) had recognised [13] the introduction of additional requirements to the GB Grid Code for new generators as a result of *Commission Regulation (EU) 2016/631 on Establishing A Network Code On Requirements For Grid Connection Of Generators* [31] and undertaken a review of the impact of these requirements [32]. NNB GenCo (SZC) made an implicit assumption in its review that where the gaps to the code existed prior to the introduction of [31] and were applicable for both the HPC and SZC sites, these could continue to be managed through seeking compliance derogations to the relevant GB Grid Code clauses from the relevant regulatory body, Ofgem.
4. While the requesting party had engaged with the National Grid ESO, the transmission system operator, at the time of GDA, NNB GenCo (HPC) had not progressed the derogation requests for the HPC site since licensing of that nuclear site. Given the evolution in the energy market in the past decade, it was not clear to me if the affected clauses may now be more significant to National Grid, as the transmission system operator, and ultimately Ofgem, as the responsible regulatory body, in ensuring system stability and security.
5. Following discussions with NNB GenCo (SZC), it submitted a *Grid Code Compliance: Status Update report* [28]. The report set out its latest position on compliance and a strategy to improve its understanding of those gaps and develop a set of options to resolve them through a series of workstreams involving NNB GenCo (SZC), the responsible designer EDF, and liaison with National Grid. I consider this report provides an appropriate update and a clear way forward, noting that any resultant modifications will be managed through the NNB GenCo (SZC) design change process.
6. Following issue of the status update report, NNB GenCo (SZC) also advised that regarding two significant gaps that existed at the conclusion of GDA, it had submitted two grid code derogation requests [33, 34] to National Grid ESO and Ofgem in respect of the SZC connection. While these requests are still under consideration by these parties and unlikely to conclude prior to a decision on nuclear site licensing, I consider the application for derogations a positive action. Also, from discussions with National Grid ESO and Ofgem [35], I have gained confidence that NNB GenCo (SZC) have appropriately identified the issue and that National Grid ESO and Ofgem both concur that it is a technical non-compliance for which a derogation request is a reasonable approach to take.
7. I note that Revision 06 of the GCDR [27] includes an update to the strategy to make reference to the submission of derogation requests and the establishment of workstreams to manage the remaining gaps. I consider this reflects the current state of grid code compliance and is a reasonable approach to address the concern raised during the replication strategy assessment [15].
8. Based on my assessment, I am content for the purposes of nuclear site licensing that NNB GenCo (SZC) has identified the gaps against compliance with the GB Grid Code and is taking appropriate steps through derogations and further analysis. I consider it appropriate that progress in the management of grid code compliance and the closure of any remaining gaps can be monitored as part of normal regulatory business.

Connection Design

1. In my assessment of [27], I noted that NNB GenCo (SZC) intended to replicate the offsite connection arrangements of the UK EPR™ containing redundancy that were set out in the design considered during GDA [30] and are currently being constructed at HPC. I consider that this approach ensures the design is consistent with the relevant good practice as set out in IAEA Safety Guide SSG-34 [8] for the preferred power supply.
2. I note that the design principles for the 400kV substation which will connect SZC to the GB electricity transmission system are set out in the LOOP report [27] and a Construction Agreement [36]. Whilst these principles are based on the typical substation arrangement for the connection of a large power plant to enable National Grid to meet the operational requirements of the National Electricity Transmission System Security and Quality Supply Standard [37], I noted in the LOOP report [27] that NNB GenCo (SZC) envisages a similar design to that developed for the HPC connection and are engaging with both the licensee for SZB and National Grid to ensure the design of the substation meets the robust expectations of all affected parties. I consider this an important and appropriate consideration since significant effort was undertaken in the HPC connection to minimise the risk of common cause failures in the substation [38]; something which if it occurred at Sizewell could result in the loss of supplies to safety systems supporting three nuclear reactors. I consider this intent demonstrates how NNB GenCo (SZC) is considering the potential implications of its work on the electrical supplies to the SZB nuclear site and taking appropriate measures, demonstrating its consideration of Claim 6, which in turn demonstrates how it is considering ONR Licensing Question 7.
3. NNB GenCo (SZC) set out in the LOOP report [27] that whilst it intends to maintain the same diversity in overhead line and underground cables to connect the power plant to the 400kV substation as employed at HPC, due to the change in location of the substation in relation to the site, the routing cannot be finalised until the 400kV substation design is completed. I noted that NNB GenCo (SZC) had undertaken work to give itself confidence that the indicative changes would not compromise a site safety case or adversely impact on the reliability of these important connections to the offsite power source. I will expect that once the design is finalised, NNB GenCo (SZC) formally incorporate it into its safety case through its design change process and consider ongoing oversight of this should be managed by ONR as part of normal regulatory business.

LOOP Frequencies

1. Whilst the design for the local connection to the GB transmission system is not currently developed, NNB GenCo (SZC) has outlined in Revision 06 of the GCDR [27] and the Connection Agreement [36] principles for the design and how it intends to work with both the transmission system owner and SZB to ensure that the proposed substation will be robust and reliable.
2. I consider that in the updated LOOP report [27] NNB GenCo (SZC) has addressed the concerns I set out in paragraph 47, above. The report explains the basis for the event frequency derivations and any assumptions, referencing to the underpinning analysis, as required.
3. In respect of LOOP event frequency, I note that the frequencies for LOOP durations up to 24 hours are based on the analysis of historical data for all UK nuclear power stations combined with Sizewell specific data covering the last four decades. I consider this approach reasonable given the very low frequency of events and that there has not been a fundamental change in the way in which the electricity transmission system is designed or operated which could undermine the basis for those figures. The consideration of UK wide data for such low frequency events is consistent with ONR expectations for the conservative characterisation of external hazards as set out in ONR SAP EHA.4 [5].
4. I note that the underpinning analysis adopts a Bayesian approach [14] to defining the LOOP frequencies. The analysis presented was undertaken in 2016 and was also used to derive figures for the updated HPC pre-construction safety report and was considered reasonable by ONR as part of its assessment [39] for the release of the HPC First Nuclear Island Concrete regulatory hold point. The resulting LOOP figures for SZC remain broadly consistent with those used at HPC.
5. I note that the data for this analysis considers the period until December 2014. I am not aware of a significant number of LOOP events at UK nuclear facilities since this time, and certainly none that have affected the existing Sizewell sites which are likely to mean the frequencies are not substantially different. However, ONR SAPs FA.11 and AV.8 expect safety analysis and the underpinning data to be updated and reviewed periodically over the life of the facility. I consider that it would be appropriate for NNB GenCo (SZC) to review the LOOP frequencies using up to date information to ensure the detailed design of the connection to the offsite power supply achieves the required level of reliability as it develops the SZC safety case. I consider this to be of sufficient importance that I will maintain regulatory oversight of this work using ONR regulatory issue RI-10822.
6. I consider that resolution of this ONR regulatory issue will enable NNB GenCo (SZC) to establish LOOP figures for SZC with greater confidence and provide assurance that any implications these figures have on replication are addressed, thereby addressing the concern from the ONR replication assessment [15] and noted in Paragraph 29, above.

### Licensing Question 4 – The environmental conditions would not preclude the use of the site with respect to external hazards

#### Relevant Parts of NNB GenCo (SZC) Submission

1. In Claim 4 of the JSSR [4], NNB GenCo (SZC) sets out it has undertaken a hazard identification and screening review to derive a SZC site hazard design basis. The evidence of this process is reported in the SDSR [11], which has formed a key reference in my assessment.

#### Comparison with Standards, Guidance and Relevant Good Practice

1. In my assessment of this aspect, I have considered the following guidance:
* IAEA Specific Safety Guide SSG-34: Design of Electrical Power Systems for Nuclear Power Plants [8]
* ONR-TAST-GD-019 Essential Services [7]

#### Interface with other topic areas

1. In my assessment, I have consulted with the following technical disciplines to ensure the overall licensing assessment in this area is coherent and holistic:
* ONR external hazards inspector to ensure that the derivation of hazards by NNB GenCo (SZC) is consistent with our expectations.
* ONR mechanical engineering inspector to ensure that the derivation of floor response spectra is consistent with our expectations, and that the implications for all relevant equipment, mechanical or electrical, are appropriately recognised by NNB GenCo (SZC).

#### Summary

1. I have assessed if the environmental conditions identified from the site-specific hazards definitions for SZC are likely to adversely affect the ability of the electrical system to perform its required function.
2. The assessment of the SZC site-specific floor response spectra and external air temperatures in terms of the heating, ventilation and air conditioning systems ability to cool equipment important to safety has been led by the ONR mechanical engineering inspector. The consideration of these characteristics is important since inappropriate specification and qualification can result in the common cause failure of electrical equipment important to safety. I support the conclusions of this assessment [40] that the likelihood of significant layout, building or design changes is low and will expect that any resulting changes that arise to the equipment specifications of electrical equipment are managed by NNB GenCo (SZC) through its design change process during detailed design.
3. In support of the SDSR [11], NNB GenCo (SZC) has derived a design basis lightning characteristic. The consideration of lightning is important since a strike to, or in the vicinity of, any building can result in the common cause failure of electrical equipment. The ONR external hazards inspector has led this assessment and concluded [41] further work is required to characterise the lightning hazard at SZC but that this work does not preclude the issue of a site licence. I am satisfied that any resulting changes on the design of the lightning and earthing system following the characterisation can be managed by NNB GenCo (SZC) through its design change process during detailed design.
4. The remaining external hazard that I have considered in my assessment which can impact on electrical system design and operation is from GICs. Solar activity can affect equipment important to safety in one of two ways; either through solar energetic particles interacting with complex electronic equipment or through disturbances to the earth’s magnetic field resulting in GICs in the high-voltage power transmission system. The amplitude of GICs during strong geomagnetic storms can range from tens to hundreds of amps. GICs may give rise to half-cycle saturation of the power transformers, causing hot-spot heating, increased reactive power loss and harmonics injection of the transformers to the power system, which may threaten the operability and integrity of power equipment and the grid. Such GIC events risk permanently damaging transformers connected to the transmission system, leading to an extended LOOP scenario.
5. In my assessment, I have considered whether NNB GenCo (SZC) has adequately considered the risk of a GIC event and how it considers this risk can be mitigated through the design or operational arrangements. It is noted that an assessment finding, AF-UKEPR-EE-026, relating to this topic was raised on the UK EPR™ design during GDA. While NNB GenCo (SZC) will be expected to develop a plan and formally address this assessment finding during detailed design, since information has been provided in the JSSR [4], I sought confidence that its preliminary assessment is likely to address that assessment finding.
6. In respect of GIC, NNB GenCo (SZC) identified in the JSSR [4] that the SZC design basis for GIC is higher than that for HPC and expands on this statement by stating “The SZC Site Challenge has been conservatively defined by considering an event with a return period of 1 x 10-4 p.a. and by conservatively including the maximum level of uncertainty from both the electric grid and electric field models”.
7. ONR’s expectations in the respect of external hazards are set out in the EHA series of ONR SAPs. Specifically, the accompanying paragraph 239 to EHA.4 states:
* For external hazards, the design basis event should be derived conservatively to take account of data and model uncertainties. The thresholds set in FA.5 for design basis events are 1 in 10,000 years for external hazards and 1 in 100,000 years for internal hazards (see also paragraph 629).
1. Paragraph 629 states:
* Initiating fault frequencies should be determined on a best-estimate basis with the exception of natural hazards where a conservative approach should be adopted*, e.g. to reflect uncertainties in the underlying data used when defining the most extreme events.*
1. While I considered that NNB GenCo (SZC)’s approach of considering conservative assumptions in evaluating this hazard is consistent with ONR expectations. Although, I was concerned by a statement in the JSSR [4] that stated: “However, as a result of the time period of the event being equivalent for the two sites, and the conservative sizing of the potentially affected components, the increase in the site challenge at SZC does not have an effect on the design.”
2. This statement conflicts with the previous arguments made by NNB GenCo (SZC) about conservative decision making and depending on the design basis GIC current may be inconsistent with ONR’s expectations, as set out in paragraph 629 that supports ONR SAP FA.5 [5].
3. I therefore sought [16, 17] to assess two reports identified by NNB GenCo (SZC) in the JSSR [10] and SDSR [11] as underpinning its calculations and reasoning. A review of these two reports [42, 43] identified concerns with the case being made.
4. Firstly, the approach to the derivation of GIC current had been updated from that used for the HPC site to include an additional factor associated with soil conductivity, thereby reducing the final calculation by about 30% from that which would have been determined using the HPC method. It was not clear why NNB GenCo (SZC) considered this change justifiable and [42] states: “We also retain the factor related to the detailed soil conductivity model (0.69), although we have few results to judge its relevance.” It is clear from this statement that NNB GenCo (SZC) is unsure of the validity of this additional factor and I would expect it to undertake additional work to give itself that confidence.
5. Secondly, even when including this soil conductivity factor, the resultant GIC design basis current for the SZC grid connected is 94A, which is 74% higher than the design basis figure for HPC and above the 90A current identified in the equipment specification used for that site [44]. NNB GenCo (SZC) concludes that despite this it does not propose to amend the equipment specification for SZC as it considers analysis [43] to show there is sufficient thermal margin in the design of the HPC transformers.
6. Since the design basis analysis [42] uses different time profiles for a GIC event to that used in either the SZC analysis [43] or the HPC equipment specification [44], I do not share this confidence. Therefore, I consider NNB GenCo (SZC) will need to undertake further work to demonstrate that the design basis for a GIC event at SZC has been appropriately determined and that the equipment is specified and shown to be resilient to it.
7. Since GDA assessment finding AF-UKEPR-EE-026 is relevant to this aspect and will need to be addressed during detailed SZC design, I consider that this gap can be managed post-licensing through the resolution of the assessment finding.

## Assessment of NNB GenCo (SZC) Organisation and Systems

1. I have supported ONR’s assessment on organisational capability [45, 46] through two interventions [47, 48]. In line with the ONR guidance for licensing [1], I have considered how NNB GenCo (SZC)’s processes are ensuring it maintains technical oversight and control in development of the SZC design and safety case, focusing on where the project is delivering electrical engineering aspects.
2. During the initial intervention [47], I highlighted that since the electrical engineers involved in the development of the analysis in support of licensing were not recognised on the nuclear baseline organisational chart as key personnel who undertake nuclear significant roles, I was concerned it was not clear how NNB GenCo (SZC) could demonstrate confidence that the individuals were appropriately accountable or appropriately qualified and experienced to undertake the roles they were performing. NNB GenCo (SZC) acknowledged this and is in the process of including key individuals who will make decisions on electrical systems that could affect nuclear safety to the nuclear baseline [49] through its management of change process. I consider this an appropriate action.
3. In the follow-up intervention [48] I reviewed the training role profiles of electrical engineers identified as involved in both nuclear safety design aspects and non-nuclear safety aspects. I sampled individuals from the latter area to gain confidence that those individuals recognised the boundaries to their role to ensure that they do not inadvertently make decisions that could affect nuclear safety.
4. In the discussions I had with the individuals, I considered that they demonstrated they had a technical capability appropriate to their role and the work currently underway in the project, recognised the limitations in those roles and where they should obtain input when they were at risk of crossing them.
5. I identified a number of aspects, which I judge not essential for licensing, but I consider NNB GenCo (SZC) should improve its arrangements to ensure consistent and demonstrable competency of those involved in the development of SZC. By resolving these aspects, I consider NNB GenCo (SZC) should be able to demonstrate it fully meets the expectations of ONR SAP MS.2 [5] in the electrical engineering area. These aspects are captured as part of the wider organisational capability assessment [45, 46].

## ONR Assessment Rating

1. Based on my assessment of the electrical engineering aspects of the SZC licensing application, I have assigned an ONR assessment rating [6] of Green. This is in recognition of the structure of the case presented in the JSSR [4] and the evidence submitted to support this case.

# Conclusions and Recommendations

## Conclusions

1. This report presents the findings of my assessment of the electrical engineering aspects to inform and support ONR’s decision to grant a nuclear site licence to NNB GenCo (SZC) to construct and operate a nuclear power station at SZC.
2. In my assessment, I have considered from an electrical engineering perspective whether:
* the site is of a sufficient size to accommodate all necessary systems to ensure safe operation;
* the site can be connected to electricity grid supplies; and
* that operations of the site will not adversely affect the safety case for any adjoining nuclear licensed site.
1. I consider that NNB GenCo (SZC) has provided an appropriately structured case to address each of these aspects. This case is underpinned by evidence appropriate for this stage of the project which gives confidence that the power station will be able to be connected to the GB electricity transmission system and be constructed to meet robust deterministic and reliability claims. I am satisfied that NNB GenCo (SZC) is working with relevant stakeholders to ensure the design of this connection does not compromise the electricity transmission connection to the neighbouring SZB nuclear power station.
2. In support of the ONR assessment of organisation capability, I have undertaken an assessment of the competencies of NNB GenCo (SZC) electrical team. I am satisfied that the staff demonstrated the required level of competence for the current stage of the project.
3. I am satisfied that NNB GenCo (SZC) is demonstrating that its approach to design and management of safety is generally consistent with the expectations of the ONR SAPs [5]. However, I am concerned that NNB GenCo (SZC) has not reviewed the underpinning data used in its LOOP safety analysis for a number of years which could affect its conclusions on the frequencies of such events. This is not consistent with the expectations of ONR SAPs FA.11 and AV.8. Although, I consider the impact on this assessment and, consequently, risk to the safety case is low and not essential prior to licensing. I judge this sufficiently important to raise an ONR regulatory issue, RI-10822, which can be tracked following any licensing.
4. To conclude, I am satisfied from an electrical engineering perspective that the power station can be connected to the GB transmission system without compromising the safety case for the adjoining nuclear licensed site and that the NNB GenCo (SZC) organisation and systems are suitable to develop the design. Based on my assessment, I have assigned this assessment a rating of Green.

## Recommendations

1. My recommendation is as follows:
* I recommend that from an electrical engineering perspective a nuclear site licence should be granted to NNB GenCo (SZC) to construct and operate a nuclear power station at Sizewell C.

# References

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| 4.  | *Sizewell C - Justification of Site Suitability Report,* 100813434, Revision 3, September 2021, NNB GenCo (SZC). [CM9 Ref. 2021/72608] |
| 5.  | *Safety Assessment Principles for Nuclear Facilities,* 2014 Edition, Revision 1, January 2020, ONR. http://www.onr.org.uk/saps/saps2014.pdf |
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| 8.  | *Design of Electrical Power Systems for Nuclear Power Plants,* Specific Safety Guide SSG-34, March 2016, IAEA. www.iaea.org |
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| 15.  | *NNB GenCo: SZC Replication Strategy - Summary Assessment Report,* ONR-NR-AR-21-034, Issue 0, March 2022, ONR. [CM9 Ref. 2021/89864] |
| 16.  | *Sizewell C - Licensing - Grid Code and LOOP Frequencies,* November 2021, Email from ONR to NNB GenCo. [CM9 Ref. 2021/88623] |
| 17.  | *SZC - Licensing - Electrical Assessment of JSSR - email #002,* November 2021, Email from ONR to NNB GenCo. [CM9 Ref. 2021/88636] |
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Table 1: Relevant Safety Assessment Principles (SAPs) considered during the assessment

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| SAP No. | SAP Title | Description |
| AV.8 | Fault analysis: assurance of validity of data and models – Update and review | The safety analysis should be updated where necessary and reviewed periodically. |
| EHA.4 | Engineering principles: external and internal hazards - Frequency of initiating event | For natural external hazards, characterised by frequency of exceedance hazard curves and internal hazards, the design basis event for an internal or external hazard should be derived to have a predicted frequency of exceedance that accords with Fault Analysis Principle FA.5. The thresholds set in Principle FA.5 for design basis events are 1 in 10,000 years for external hazards and 1 in 100,000 years for man-made external hazards and all internal hazards (see also paragraph 629). |
| FA.5 | Fault analysis: design basis analysis – Initiating Faults | The safety case should list all initiating faults that are included within the design basis analysis of the facility. |
| FA.11 | Fault analysis: PSA – Validity | PSA should reflect the current design and operation of the facility or site. |
| MS.2 | Leadership and management for safety – Capable organisation | The organisation should have the capability to secure and maintain the safety of its undertakings. |

**Annex 1: Regulatory Issues**

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| Details | Regulatory Issue Reference |
| NNB GenCo (SZC) should demonstrate that when considering the latest data, the LOOP reliability figures of durations up to 24 hours for the Sizewell C site do not compromise the safety case replication strategy. | RI - 10822 |

The above Regulatory Issue has been raised as a result of this assessment and is captured on ONR’s Regulatory Issues database.

It is to be closed post-site licensing 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)