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CIVIL NUCLEAR REACTOR PROGRAMME

Electrical Engineering Assessment

NNB Genco Hinkley Point C Licensing

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EXECUTIVE SUMMARY

Background

This report presents the findings of the assessment of the electrical engineering aspects of the NNB Genco application for a Nuclear Site Licence to construct and operate two EPR reactors at Hinkley Point C.

Assessment Work carried out by ONR

The scope of the assessment undertaken covers the following activities:

- Assessment of NNB Genco's documentation that provides justification that the site can be connected to grid supplies.
- Sampling of NNB Genco's progress in developing the safety case within the PCSR covering the electrical systems.
- Sampling the development of NNB Genco's organisation and systems

Matters arising from ONR's Work

I have assessed a sample of NNB Genco activities which have been carried out with National Grid in establishing a connection to the Grid. I am satisfied that a process has been developed and is in the process of implementation to provide a sufficient level of confidence that a Grid connection can be established to Hinkley Point C. I am also satisfied that the impact on nuclear safety arising from the requirements for Grid Code compliance are being addressed by NNB Genco in conjunction with National Grid. I am satisfied NNB Genco have demonstrated a compliance process for Hinkley Point C power plant that will result in full compliance with the Grid Code.

I am content with the Batch 6 submission Hinkley Point C Grid Connection Justification which is based on the PCSR Chapter 8.1.

I have sampled the development of NNB Genco's organisation and systems and am satisfied that a robust organisation and systems to support nuclear safety are being developed.

Conclusions

I am broadly satisfied from an electrical engineering perspective that the reactor can be connected to the Grid and that the NNB Genco organisation and systems are suitable to undertake the design activities.

Recommendation

My recommendation from the assessment of the connectability of the station to the grid and the capability of the NNB Genco electrical engineering organisation is that a Nuclear Site Licence should be granted.

LIST OF ABBREVIATIONS

BMS	(ONR) How2 Business Management System
EPR	European Pressurised-water Reactor
EDF	Electricité de France SA
GIS	Gas Insulated Switchgear
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
LOOP	Loss of Offsite Power
NGL	EDF Energy Nuclear Generation Ltd
ONR	Office for Nuclear Regulation (an agency of HSE)
PCSR	Pre-construction Safety Report
PSA	Probabilistic Safety Assessment
PSS	Power System Stabiliser
SAP	Safety Assessment Principle(s) (HSE)
TAG	Technical Assessment Guide(s) (ONR)
TSC	Technical Support Contractor

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Tables

1 INTRODUCTION

1.1 Background

1 This report presents the findings of the assessment of the electrical engineering aspects of the NNB Genco application for a Nuclear Site Licence to construct and operate two EPR reactors at Hinkley Point C.

2 Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) procedure AST/001 (Ref. 1). The ONR Safety Assessment Principles (SAP) (Ref. 2), together with supporting Technical Assessment Guides (TAG), Ref. 3) have been used as the basis for this assessment.

1.2 Scope

3 The scope of this report covers the electrical engineering aspects of the assessment of NNB Genco's application for a Nuclear Site Licence.

1.3 Methodology

4 The methodology for the assessment follows ONR BMS document AST/001, Assessment Process (Ref. 1), in relation to mechanics of assessment within the Office for Nuclear Regulation (ONR).

5 This assessment has focussed primarily on a review of submissions provided by the prospective licensee, NNB Genco, which have been supplemented by several Level 4 technical meetings.

2 ASSESSMENT STRATEGY

6 The intended assessment strategy for electrical engineering is set out in this section. This identifies the standards and criteria that have been applied to the assessment.

2.1 Standards and Criteria

7 The relevant standards and criteria adopted within this assessment are principally the Safety Assessment Principles (SAP) (Ref. 2), internal ONR Technical Assessment Guides (TAG), (Ref. 3), relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licensed sites. The key SAPs and relevant TAGs are detailed within this section. National and international standards and guidance have been referenced where appropriate within the assessment report. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.2 Safety Assessment Principles

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

2.2.1 Technical Assessment Guides

9 The following Technical Assessment Guides have been used as part of this assessment (Ref. 3):

- T/AST/019 Essential Services

2.2.2 National and International Standards and Guidance

10 The following international standard has been used as part of this assessment:

- IAEA NG-T-3.8 Electric Grid Reliability and Interface with Nuclear Power Plants (Ref. 5.)

2.3 Use of Technical Support Contractors

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

2.4 Integration with other Assessment Topics

12 This assessment interfaces with the PSA assessment on the probabilistic assessment of grid reliability.

2.5 Out-of-scope Items

13 There are no out of scope items for this assessment.

3 NNB GENCO SUBMISSION

14 The NNB Genco submission for connectability to the Grid is based on the following documents:

HPC-NNBOSL-UO-000-000044-RES – Hinkley Point C Pre Construction Safety Report – Sub Chapter 8.1 – External Power Supply (Ref.6)

HPC-NNBOSL-U0-000-ASS-000002 – Electricity Network Investment System Technical Performance (Ref.7)

ENCFI110004A – Frequency of loss of off-site power (LOOP) for use in HPC PCSR PSA (Ref. 8)

4 ONR ASSESSMENT

15 This assessment has been carried out in accordance with ONR How2 BMS document AST/001, “Assessment Process” (Ref. 1).

4.1 Scope of Assessment Undertaken

16 The scope of the assessment undertaken covers the following activities:

- Assessment of NNB Genco’s documentation justifying that the site can be connected to grid supplies.
- Sampling of NNB Genco’s progress in developing the safety case within the PCSR covering the electrical systems.
- Sampling the development of NNB Genco’s organisation and systems.

4.2 Assessment of Connectability to the Grid

4.2.1 NNB Genco Submission

17 The NNB Genco submission identifies three main areas covering the feasibility of the connection of an EPR to the grid which are:

- The Grid Connection technical design
- The Grid Code compliance process
- The Grid reliability at the connection point

18 NNB Genco states that the grid connection for each unit meets international standards for nuclear plants and follows the redundancy and independency connection principles recommended by IAEA with two independent connections. NNB Genco explains that high reliability of this connection is achieved by applying the independence and redundancy principles to the main items of the grid connection.

19 The requirement for a Bilateral Connection Agreement between NNB Genco and National Grid is explained. This defines the responsibilities of both parties at the interface between the Generator and the Transmission System Operator including the following:

- National Grid to update the Grid, if necessary, to accommodate connection of the units to the National Grid substation, taking into account every aspect of transmission system security as defined in the National Electricity Transmission System Security and Quality of Supply Standards (Ref.9)
- NNB Genco to design and develop its own Grid Connection assets to be connected to the National Grid substation
- NNB Genco to ensure that each unit is fully compliant with the generic and site specific UK Grid code requirements
- National Grid and NNB Genco to liaise as necessary throughout the project phases to ensure that an appropriate level of coordination is met.

20 The reliability of the grid as an external source of power supply is described in EDF document Frequency of Loss of Offsite Power for use in HPC PCSR PSA (Ref.8) and National Grid document HPC-NNBOSL-U0-000-ASS-000002 (Ref.7) assessing the risk of loss of offsite power to Hinkley Point C.

4.2.2 Basis of ONR Assessment

21 I have assessed the NNB Genco Batch 6 submission Hinkley Point C PCSR Chapter 8.1 External Power Supplies (Ref 6). In undertaking the assessment I have also considered the electrical design aspects of the submissions on grid reliability. The assessment of the probabilistic aspects of grid reliability will be covered by the PSA report.

4.2.3 Grid Connection Technical Design

22 NNB Genco has advised (Ref. 10) that they have carried out a review of compliance with IAEA document NG-T-3.8 – Electrical Grid Reliability and Interface with Nuclear Power Plants (Ref.5). This document defines a high level strategy covering the issues to be considered when connecting new nuclear power plants to the Grid. I support the findings of the NNB Genco review that the design of Grid connection for Hinkley Point C complies with the IAEA document.

23 Discussions have been held in Level 4 electrical meetings where NNB Genco has presented details of their approach to Grid connection and their interfaces with National Grid. Details have been presented to ONR of the steps taken to achieve compliance with the UK Grid Code (Ref. 4).

24 A meeting was held between National Grid, NNB Genco and ONR (Ref.10) to gain a common view of the grid connection developments for the Hinkley Point C site and to enable ONR to assess the interactions between NNB Genco and National Grid on the Grid Connection design and UK Grid Code compliance.

25 National Grid presented an overview of the grid developments proposed to accommodate the connection to two EPR reactors at Hinkley Point C. This will consist of a new 400kV Grid Substation (Shurton) with double circuit connections to Taunton and Melksham and a double circuit interconnector to the existing Hinkley Point B substation. A new double circuit connection will be made from Hinkley Point B to Seabank and the existing lines to Melksham will have conductors replaced.

26 The Shurton substation will be located off the nuclear licensed site and will consist of an indoor 400kV Gas Insulated Switchgear (GIS). The switchgear will be in a single room with separate gas zones to prevent a fault spreading between zones. This is at variance with the description in the Batch 6 PCSR submission (Ref. 6) which describes an outdoor switchyard. However, I consider that the arrangement of GIS switchgear proposed by NNB Genco and National Grid provides a Grid connection of sufficient integrity to support nuclear safety.

27 The Hinkley Point C PCSR Chapter 8.1 (Ref 6) describes the design basis of the system as follows:

- A connection from the main alternator to the Grid through a main power transformer
- A connection from the High Voltage side of the Main Power Transformer to two unit step down transformers supplying the main connection to the station power supply boards
- An auxiliary Grid connection, independent of the main connection, through a step down transformer to supply certain loads on the station power supply boards during

shutdown in normal or accident conditions. This connection is adequately sized to shut down the reactor from normal power operation.

- The use of two unit transformers each with two secondary windings connected by separated cables to provide electrical independence to the four electrical divisions of the nuclear island
- Provision to connect the main alternator to the Grid during normal operation
- Provision to disconnect the main alternator from the Grid whilst keeping the station power supply boards supplied by the Grid through the main connection
- Provision to disconnect from the Grid with the power supply boards fed from the main alternator

28 The potential for common cause faults in the substation relay room has been addressed by NNB Genco and National Grid by a design which splits the room into two separate fire segregated sections.

29 I consider that the interactions between National Grid and NNB Genco are working well with a good level of understanding and cooperation. I consider that the technical design and the processes in place meet all international and national standards required for the Grid connection.

4.2.4 Grid Code Compliance Process

30 Details were presented of the process which was followed by NNB Genco and National Grid to develop the design of the Grid connection to Hinkley Point C with associated developments to enhance the power transfer capability of the Grid. The process commenced in 2006 with a feasibility study by National Grid. A connection application was then submitted by NNB Genco to National Grid who then undertook a high level optioneering study prior to making a connection offer. A Bilateral Connection Agreement was then made between National Grid and NNB Genco specifying technical requirements and obligating NNB Genco to meet the UK Grid Code (Ref.4). A series of studies and analyses of the Grid incorporating the Hinkley Point C connection were then undertaken by National Grid.

31 As part of the connection agreement with National Grid compliance of the EPR with the UK Grid Code (Ref.4) is required. The responsibility to demonstrate compliance lies with NNB Genco as the generating unit owner. This compliance will be assessed by National Grid for each individual EPR unit connected to the Grid.

32 The technical data required to be submitted is required at four stages of the construction process which are:

- At connection application after acceptance of the connection offer
- Before back energisation of the nuclear power plant
- Before the first synchronisation
- Before the final operation notification

33 The process followed by NNB Genco to demonstrate UK Grid Code compliance is described in NNB Genco Batch 6 submission Hinkley Point C Grid Connection Justification (Ref 6). An initial review was undertaken of the Flamanville 3 EPR design

compliance with the UK Grid Code (Ref 4). This identified 29 points where there was a possible impact on design.

34 Interactions then took place between NNB Genco and National Grid to reach agreement on compliance. A number of items were clarified in initial discussions with seven non compliances remaining to be mitigated by design changes or modifications to the Grid Code (Ref. 4). These non compliances and the mitigation measures taken are summarised in Table 1.

Table 1: Summary of Grid Code Non-Compliances

Title	Grid Code Requirement	Mitigation Adopted
Short Circuit	Remain stable on fault and restore Active Power at Minimum Q	Contract specification changed to become grid code compliant
Excitation system	Maximum time to reach ceiling voltage	Contract specification changed to become grid code compliant
Power System Stabiliser	Standard Power System Stabiliser (PSS) switched off for tests	Contract specification changed to become grid code compliant
Step up Transformer	700 MVA rating & on load tap changer	Contract specification changed to become grid code compliant
Frequency Range	Grid Code modified to require range 49-51 Hz	RCC-E (Ref. 11) Project Data Book to be modified
Short Circuit Ratio	Grid Code modified to >0.4 for units >1600MVA	Design compliant with modified Grid Code
Voltage Dips	Consideration being given to Grid Code modification	Contract specification changed to become grid code compliant

35 For the capability to withstand voltage dips NNB Genco are seeking technical solutions with manufacturers based on current UK Grid Code requirements. Technical solutions are being sought in consultation with manufacturers. In the event that compliance is not achievable then NNB Genco proposes to initiate a UK Grid Code clarification and modification process.

36 I am content that the Grid Compliance process which is being followed is appropriate to achieve full UK Grid Code compliance.

4.2.5 Grid Reliability at the Connection Point

37 I have considered the technical aspects of the reports on grid reliability and consider that they adequately represent the technical aspects. The assessment of the probabilistic claims in these reports is covered in the PSA assessment report (Ref. 15).

4.3 Assessment of NNB Genco Organisation and Systems

4.3.1 NNB Genco Submission

38 The assessment is based on interactions between ONR and NNB Genco at Level 4 meetings and assessment of the following NNB Genco documents:

- NNB GENCO-OSL-SPE-000005 Competency Framework (Ref.12)
- NNB GENCO-OSL-PRO-000018 Competency Procedure (Ref.13)
- NNB GENCO-OSL-PRO-000035 Design Review and Acceptance (Ref. 14)

39 An intervention was carried out by ONR to review the implementation of these procedures by the electrical design team. During this intervention the profiles for a number of roles within the electrical team were submitted to ONR with the procedures for assessing the competency of duty holders for these roles.

40 NNB Genco demonstrated the operation of their Design Review and Acceptance procedure (Ref. 14). This is being applied to work by the Responsible Designer. The procedure is being refined to take account of initial NNB Genco experience with implementation of the process. Examples were provided of surveillance plans which will be the basis of NNB Genco undertaking their role of Design Authority with the Architect Engineer. Technical matters are resolved in a series of Topical Meetings. Examples were provided of recording of discussions and actions in Topical Meetings to demonstrate the implementation of the process.

4.3.2 Basis of ONR Assessment

41 I have carried out an assessment of the procedures for assessing the competencies of the NNB Genco electrical design team. NNB Genco has presented details of their organisational structure for the electrical design activities together with their proposals for increasing the team to meet the future design programme. Details were provided of the anticipated staffing requirements in each area of electrical design.

42 The NNB Genco design activities can be supplemented by the use of contract staff under framework contracts which are currently in place. The EDF Energy Nuclear Generation Ltd (NGL) Central Engineering capability can be used for specific tasks. NNB Genco explained that all contract staff, including NGL staff, have the status of external contractors providing technical support to the Design Authority. The responsibility will always rest with the Design Authority rather than the supporting contractors.

43 I have sampled the application of the NNB Genco procedure for assessing the competency of electrical design staff. This has been applied to assess the competencies of individuals to perform specific roles. It is based on self assessment which is then subject to approval by the supervisor. Any areas requiring further training are identified. I consider that the procedure is robust and is being implemented effectively to ensure that all staff possess the required competencies to fulfil specific roles.

44 I have assessed the Design Review and Acceptance (DR&A)(Ref.14) procedure applied by the NNB Genco Electrical team to design and procurement activities being undertaken by the Architect Engineer. NNB Genco is currently improving this procedure as a result of their experience from its implementation. A number of examples of good practice were

observed such as improvement following self assessment and adoption of independent challenge. I expect that NNB Genco will now complete and update surveillance plans to maintain effective monitoring of the Architect Engineer activities. I conclude that I am broadly satisfied with the implementation of the DR&A procedure.

45 The Electrical Topic Meetings held in accordance with the DR&A procedures are working effectively in providing a forum for technical discussions between NNB Genco and the Architect Engineer. I assessed the recording of the discussions in these meetings together with the arrangements for recording and following up on actions. I am content that these meetings are achieving their objectives and are being conducted in accordance with procedures.

4.3.3 Assessment of SAPS Compliance

46 I have assessed the NNB Genco Electrical Engineering organisation for compliance with ONR's Safety Assessment Principles (SAP) covering Leadership and Management for Safety. My assessment is that the requirements of the SAPs are fully met. The assessment of compliance against specific SAPs is discussed below:

4.3.3.1 MS.1 – Leadership and Management for Safety – Leadership

47 The managers and leaders in the electrical engineering discipline have shown a clear commitment to meeting the requirements of this SAP in their establishment of strategies and standards for safety and their dedication to establishing and meeting the requirements of all company procedures and standards to ensure nuclear safety.

4.3.3.2 MS.2 – Leadership and Management for Safety - Capable Organisation

48 NNB Genco has provided evidence of a capable organisation in the electrical engineering discipline. Plans have been developed which establish the organisation and staffing levels throughout the project. The competencies required in each post have been determined and a procedure has been developed and implemented for assessing the competencies and training requirements for duty holders to meet these requirements.

49 There are structures in place covering the use of contractors and maintenance of the intelligent customer capability.

50 The interfaces with the Architect Engineer which are key to maintaining nuclear safety have been assessed and I am satisfied that the processes and their implementation are maintaining the intelligent customer relationship.

4.3.3.3 MS.3 – Leadership and Management for Safety – Decision Making

51 NNB Genco has shown decision making processes where nuclear safety has been given a high priority. Evidence has been provided of active challenge, of due consideration of available data and consideration of all views in reaching decisions.

4.3.3.4 MS.4 – Leadership and Management for Safety – Learning from Experience

52 NNB Genco has provided evidence of a culture of learning from experience with examples provided of self assessments identifying improvements to be adopted in processes. The results of reviews against international standards and practices have been provided and evidence has been provided of design decisions influenced by lessons from investigations by other organisations.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

53 This report presents the findings of the ONR assessment of the electrical aspects of NNB Genco's application for a Nuclear Site Licence to construct and operate two reactors at Hinkley Point C.

54 I have assessed whether the reactors can be connected to the Grid. This assessment has covered the following aspects:

- The Grid connection technical design
- The Grid Code compliance process
- The Grid reliability at the connection point

55 My conclusion is that the technical design basis is sound and that the process of achieving compliance with the UK Grid Code is well advanced to achieving full compliance. The report on grid reliability is technically sound to support the development of probabilistic claims.

56 I have undertaken an assessment of the competencies of the NNB Genco electrical team and the implementation of systems to support the electrical design of Hinkley Point C. I am satisfied with the competencies demonstrated and the systems in place to ensure that the required competencies are held to meet the requirements for specific design functions.

57 My review of the compliance with SAPs covering Leadership and Management for Safety has determined that compliance has been adequately demonstrated by NNB Genco.

58 To conclude, I am broadly satisfied from an electrical engineering perspective that the reactor can be connected to the grid and that the NNB Genco organisation and systems are suitable to undertake the design activities

5.2 Recommendations

59 My recommendation from the assessment of the connectability of the station to the grid and the capability of the NNB Genco electrical engineering organisation is that a Nuclear Site Licence should be granted.

6 REFERENCES

1 *ONR How2 Business Management System. Assessment Process.* AST/001 Issue 4. HSE. April 2010. www.hse.gov.uk/nuclear/operational/assessment/index.htm.

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5 *Electric Grid Reliability and interface with Nuclear Power Plants.* International Atomic Energy Agency (IAEA). Safety Standards Series No. NG-T-3.8. IAEA. Vienna. 2012. www.iaea.org.

6 *Hinkley Point C Pre Construction Safety Report – Sub Chapter 8.1 – External Power Supply.* HPC-NNBOSL-UO-000-000044-RES

7 *Electricity Network Investment System Technical Performance.* HPC-NNBOSL U0-000-ASS-000002 National Grid Electricity Transmission. July 2011

8 *Frequency of loss of off-site power (LOOP) for use in HPC PCSR PSA*. ENCFI110004A EDF Septen. November 2011

9 *National Electricity Transmission System Security and Quality of Supply Standards.* NETS SQSS Issue 2.2 National Grid Electricity Transmission. March 2012

10 *Level 4 meeting notes-Hinkley Point grid connection.* NNB-OSL-NOT-000250. NNB Genco 12 March 2012

11 *RCC-E: Design and Construction Rules for electrical components of PWR nuclear islands.* AFCEN. December 2005

12 *Company Specification: Competency Framework.* NNB-OSL-SPE-000005. NNB Generation Company Ltd. January 2011

13 *Company Specification: Competency Procedure*. NNB-OSL-PRO-000018 NNB Generation Company Ltd January 2011

14 *Company Specification: Design Review and Acceptance.* NNB-OSL-PRO-000035. NNB Generation Company Ltd March 2011

15 *PSA workstream assessment to inform nuclear site licensing of Hinkley Point C.* ONR-CNRP-AR-12-056. ONR. January 2013

Table 2

Relevant Safety Assessment Principles Considered During the Assessment

SAP No.	SAP Title	Description
MS.1	Leadership and Management for Safety - Leadership	Directors, managers and leaders at all levels should focus the organisation on achieving and sustaining high standards of safety and on delivering the characteristics of a high reliability organisation
MS.2	Leadership and Management for Safety – Capable Organisation	The organisation should have the capability to secure and maintain the safety of its undertakings
MS.3	Leadership and Management for Safety – Decision Making	Decisions at all levels that affect safety should be rational, objective, transparent and prudent
MS.4	Leadership and Management for Safety – Learning from Experience	Lessons should be learned from internal and external sources to continually improve leadership, organisational capability, safety decision making and safety performance

…