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REGULATORY OBSERVATION Resolution Plan

RO Unique No.:	RO-UKHPR1000-0038
RO Title:	Demonstration of the appropriate power rating and performance capability of the Electrical Power System
Technical Area(s)	Electrical Engineering
Revision:	0
Overall RO Closure Date (Planned):	2021-03-31
Linked RQ(s)	RQ-UKHPR1000-0628 [CM9 2020/43288] RQ-UKHPR1000-0629 [CM9 2020/43294] RQ-UKHPR1000-0630 [CM9 2020/43299] RQ-UKHPR1000-0640 [CM9 2020/56399] RQ-UKHPR1000-0672 [CM9 2020/75584] RQ-UKHPR1000-0689 [CM9 2020/90272]
Linked RO(s)	N.A.
Related Technical Area(s)	Related technical topic(s): 3. Control & Instrumentation 8. External Hazards 9. Fault Studies 12. Internal Hazards 14. Mechanical Engineering 19. Severe Accident Analysis
Other Related Documentation	N.A.

Scope of Work

The Requesting Parties (RPs) have understood ONR's expectation on electrical system equipment sizing and system study in this Regulatory Observation (RO), i.e.:

- The studies should be performed to include the full range of electrical fault analysis and considered for all operation modes. In addition the linkage between the operation modes and fault analysis should be explained. Bounding cases should be justified and demonstrated.
- The computer models should reflect the actual electrical power system, and the modelling data should represent the equipment parameters of equipment. The assumptions regarding the models and modelling data should be justified conservatively.
- The acceptance criteria of the studies should be defined and the linkage with other safety case documents illustrated. The analysis results should be compared with the acceptance criteria to identify any gaps in the current system design and configuration.
- The gaps should be addressed according to the ALARP process and the design modification process of

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the UK HPR1000.

To meet these expectations and improve the safety case of Electrical Engineering, first the strategy of the electrical power system studies will be developed, then the sizing and studies will be performed according to the strategy, and finally the ALARP and design modification process will be implemented to address the identified gaps.

The RPs have taken learning from the related Regulatory Queries (RQs). During the aforementioned work, the expectations in the related RQs will also be addressed in this RO.

Deliverable Description

RO-UKHPR1000-0038.A1 – Develop an appropriate UK HPR1000 Electrical System Sizing and Study Strategy


The RO Action 1 states that:

In response to this Regulatory Observation Action, the RP should:

- *Develop a strategy to establish the rating of electrical power supply (EPS) equipment and analyse the UK HPR1000 EPS against anticipated events and disturbances. The strategy should seek to:*
 - *Identify and justify how it is intended to structure the electrical system model(s) and analyse the EPS;*
 - *Identify how it is intended to demonstrate the verification and validation of any analytical tools (such as software) or methods it intends to use to support its analysis;*
 - *Identify and justify any assumptions to be made in the development of the model, underlying System, Structures and Components (SSC) parameters, and intended analysis;*
 - *Identify and justify the different ‘study conditions’ that it is intended to analyse; (The term “study condition” is used here to include, but not limited, to modes of operation, plant configurations, fault scenarios and environmental conditions)*
 - *Identify and justify the identification of any ‘bounding cases’ that are used to reduce the number of study conditions; and*
 - *Identify the acceptance criteria for each of the studies, explaining how these have been derived from the safety case requirements.*

In developing the strategy, the RP should consider:

- *How it is ensuring that where it uses different software or different models for different studies, it demonstrates that the representations of the EPS remain consistent and do not compromise any assumptions or the study results; and*
- *How it is demonstrating it is adopting a conservative approach when considering the design maturity of the overall UK HPR1000 design, SSC parameters and the supporting analysis.; and*

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- How in defining the “study conditions” it has shown traceability from the fault and hazard analyses.

Resolution Plan for Action 1

The RPs acknowledge that the current submitted sizing and study reports focus on the study results, but are lacking justification of the study conditions, bounding cases, modelling data, assumptions and acceptance criteria. The following reports will be updated or newly provided to address the shortfalls, and relevant assumptions will be identified and justified:

1. Update the *Electrical Power System Studies based on BS IEC 62855:2016* report by end of May 2020. The updated report will focus on the following aspects:
 - Briefly introduce the design logic of the EPS considering the safety case requirements;
 - Explain the process and logic for equipment sizing and system studies; and
 - Explain the process and strategy for developing the bounding case.
2. A new document titled *Electrical Power System Equipment Sizing and System Study Bounding Case Analysis* will be produced and submitted by end of June 2020. *Bounding Case Identification (RQ-UKHPR1000-0672)* and *Electrical - Power Balance Calculations (RQ-UKHPR1000-0689)* will be considered during the document development. The document will:
 - Identify the conditions for electrical equipment sizing and system studies taking account of the fault and hazard studies;
 - Justify and identify the bounding case in detail, based on the identified conditions; and
 - Consider the electrical aspects or condition rationalization to determine the bounding case for each of the sizing and studies.
3. A new document titled *Electrical Power System Modelling and Acceptance Criteria* will be produced and submitted by end of June 2020. This document aims to incorporate all the information for confirmatory studies to rebuild the model. *Electrical System Studies – Development of Models (RQ-UKHPR1000-0628)* and *Electrical System Studies – Assumptions and Acceptance Criteria (RQ-UKHPR1000-0629)* will be considered during the document development. The document will:
 - Define the scope of the EPS studies;
 - Define the applicable design reference and the detailed EPS architecture and loads allocation information;
 - Provide the modelling input data; and
 - Define the acceptance criteria for each study and the traceability in the safety case.
4. A new document titled *Qualification Report of Electrical Power System Software* will be produced and submitted by end of November 2020, to:
 - Identify the software used in the studies;
 - Justify why the software is applicable and suitable for the study; and
 - Verify typical functions of the software by hand calculation, site-test results, or classic cases to

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demonstrate confidence in the software output.

RO-UKHPR1000-0038.A2 – Analyse the UK HPR1000 Electrical Power System

The Regulatory Observation (RO) Action 2 states that:

In response to this Regulatory Observation Action, the RP should:

- *Using the strategy developed in response to RO-UKHPR1000-0038.A1:*
 - *Develop the system model(s);*
 - *Determine the minimum electrical ratings of the EPS equipment;*
 - *Analyse the performance of the UK HPR1000 EPS in response to the identified “study conditions”; and*
 - *Analyse the results against the acceptance criteria, identifying any gaps against the extant safety case and system design.*

In undertaking the sizing and analysis, the RP should consider the:

- *Justification for any changes to the assumptions or acceptance criteria that have been necessary during the sizing or analyses; and*
- *Sensitivity of the analysis findings to uncertainties in the model data or assumptions.*

Resolution Plan Action 2

1. To provide further information, the RPs will update and submit the following sizing reports in two steps:

Step 1: According to the strategy and bounding cases defined in ROA1, the power balance calculations of the electrical equipment will be updated in September 2020.

Step 2: The power balance calculation reports will be updated again and submitted in December 2020 to incorporate relevant UK HPR1000 design modifications.

The updated documents will be:

- Emergency Diesel Generator Power Balance Calculation Report, GHX05000020DEDQ45GN
- SBO Diesel Generator Power Balance Calculation Report, GHX05000021DEDQ45GN
- Mobile Diesel Generator Power Balance Calculation Report, GHX05000025DEDQ45GN
- Dry Transformer Power Balance Calculation Report, GHX05000023DEDQ45GN
- Regulating Transformer Calculation Report, GHX05000024DEDQ45GN
- 2h/24h Battery Power Balance Calculation Report, GHX05000022DEDQ45GN

2. In aspects of modelling and analysis, following the strategy defined in ROA1, the RPs will:

- Update the modelling of the EPS;
- Perform the analysis according to the updated model;

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- Assess the analysis results against the acceptance criteria and identify gaps;
- Assess the gaps to determine if the acceptance criteria and assumptions need to be changed, or if the gaps need to undergo further ALARP assessment.


The RPs will update and submit the following reports in two steps. During the document development the relevant RQs, *Electrical System Studies – Studies and Interpretation (RQ-UKHPR1000-0630)* and *House Load Operation Studies (RQ-UKHPR1000-0640)*, will be considered.

Step 1: the following reports will be updated and submitted in September 2020, this version will focus on the analysis results and assessment against the acceptance criteria without gap analysis and resolutions:

- Load Flow Studies for AC on-site Power System, GHX05000030DEDQ45GN
- Short-circuit and Earth Fault Studies for AC on-site Power System, GHX05000038DEDQ45GN
- AT/ST Transfer Studies, GHX05000031DEDQ45GN
- Motor Starting and Reacceleration Studies for AC On-site Power System, GHX05000032DEDQ45GN
- Voltage Disturbance Studies, GHX05000034DEDQ45GN
- Load Sequencer Studies, GHX05000037DEDQ45GN
- Loss of Phase Studies, GHX05000035DEDQ45GN
- Electrical Protection Coordination Report, GHX05000017DEDQ45GN
- Load Flow Studies for DC and AC UPS, GHX05000039DEDQ45GN
- Short-Circuit and Earth Fault Studies for DC and AC UPS, GHX05000041DEDQ45GN
- Transient Studies for DC and AC UPS, GHX05000040DEDQ45GN

Step 2: the following reports, as the final version of the analysis, will be updated and submitted in November 2020 to incorporate the gap analysis, gap resolution results, and relevant UK HPR1000 design modifications:

- Load Flow Studies for AC on-site Power System, GHX05000030DEDQ45GN
- Short-circuit and Earth Fault Studies for AC on-site Power System, GHX05000038DEDQ45GN
- AT/ST Transfer Studies, GHX05000031DEDQ45GN
- Motor Starting and Reacceleration Studies for AC On-site Power System, GHX05000032DEDQ45GN
- Voltage Disturbance Studies, GHX05000034DEDQ45GN
- Voltage Surge Studies, GHX05000036DEDQ45GN
- Load Sequencer Studies, GHX05000037DEDQ45GN
- Loss of Phase Studies, GHX05000035DEDQ45GN
- Ferroresonance Studies, GHX05000042DEDQ45GN
- Frequency Compliance Analysis Report, GHX05000029DEDQ45GN
- Electrical Protection Coordination Report, GHX05000017DEDQ45GN
- Load Flow Studies for DC and AC UPS, GHX05000039DEDQ45GN
- Short-Circuit and Earth Fault Studies for DC and AC UPS, GHX05000041DEDQ45GN

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- Transient Studies for DC and AC UPS, GHX05000040DEDQ45GN
- House Load Operation Studies, GHX05000033DEDQ45GN

RO-UKHPR1000-0038.A3 – Identify and manage any gaps resulting from the analysis of the UK HPR1000 Electrical Power System

The Regulatory Observation (RO) Action 3 states that:

In response to this Regulatory Observation Action, the RP should:

- *Based on the completion of the analysis undertaken in response to RO-UKHPR1000-0038.A2:*
 - *Identify the implications for any shortfalls against the extant safety case arising from the system studies;*
 - *Undertake optioneering studies to identify appropriate solutions to address those shortfalls;*
 - *Explain the implications of any modifications on the safety case, including the impact on the Electrical Power System design and the other electrical system studies; and*
 - *Explain how those modifications could be implemented and the UK HPR1000 GDA safety case updated.*

Resolution Plan Action 3

For the gaps identified in the analysis work in response to ROA2, ALARP assessment will be performed as input of associated modifications to:

- Perform risk assessment on the gaps to quantify the potential risks;
- Perform optioneering on the gaps to generate and evaluate options which can reduce the risk to ALARP; and
- Decide and justify the selected option to address the identified gap.

The *ALARP Demonstration Report of PCSR Chapter 9* will be updated and submitted in November 2020 to address the ALARP assessment work.

Impact on the GDA Submissions

Submissions related with ROA1:


- [1]. Electrical Power System Studies based on BS IEC 62855:2016, GHX05000009DEDQ45GN, Revision B, CGN, 31 May 2020
- [2]. Electrical Power System Equipment Sizing and System Study Bounding Case Analysis, TBD, Revision A, CGN, 30 June 2020
- [3]. Electrical Power System Modelling and Acceptance Criteria, TBD, Revision A, CGN, 30 June 2020
- [4]. Qualification Report of Electrical Power System Software, GHX05000044DEDQ45GN, Revision B, CGN,

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Submissions related with ROA2:

- [5]. Emergency Diesel Generator Power Balance Calculation Report, GHX05000020DEDQ45GN, CGN
- Revision B, 30 September 2020
 - Revision C, 31 December 2020
- [6]. SBO Diesel Generator Power Balance Calculation Report, GHX05000021DEDQ45GN, CGN
- Revision B, 30 September 2020
 - Revision C, 31 December 2020
- [7]. Mobile Diesel Generator Power Balance Calculation Report, GHX05000025DEDQ45GN, CGN
- Revision B, 30 September 2020
 - Revision C, 31 December 2020
- [8]. Dry Transformer Power Balance Calculation Report, GHX05000023DEDQ45GN, CGN
- Revision B, 30 September 2020
 - Revision C, 31 December 2020
- [9]. Regulating Transformer Calculation Report, GHX05000024DEDQ45GN, CGN
- Revision B, 30 September 2020
 - Revision C, 31 December 2020
- [10]. 2h/24h Battery Power Balance Calculation Report, GHX05000022DEDQ45GN, CGN
- Revision B, 30 September 2020
 - Revision C, 31 December 2020
- [11]. Load Flow Studies for AC on-site Power System, GHX05000030DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [12]. Short-circuit and Earth Fault Studies for AC on-site Power System, GHX05000038DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [13]. AT/ST Transfer Studies, GHX05000031DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [14]. Motor Starting and Reacceleration Studies for AC On-site Power System, GHX05000032DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [15]. Voltage Disturbance Studies, GHX05000034DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [16]. Load Sequencer Studies, GHX05000037DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020

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- [17]. Loss of Phase Studies, GHX05000035DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [18]. Electrical Protection Coordination Report, GHX05000017DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [19]. Load Flow Studies for DC and AC UPS, GHX05000039DEDQ45GN, CGN
- Revision C, 15 September 2020
 - Revision D, 30 November 2020
- [20]. Short-Circuit and Earth Fault Studies for DC and AC UPS, GHX05000041DEDQ45GN, CGN
- Revision C, 15 September 2020
 - Revision D, 30 November 2020
- [21]. Transient Studies for DC and AC UPS, GHX05000040DEDQ45GN, CGN
- Revision B, 15 September 2020
 - Revision C, 30 November 2020
- [22]. Voltage Surge Studies, GHX05000036DEDQ45GN, CGN, Revision C, 30 November 2020
- [23]. Ferroresonance Studies, GHX05000042DEDQ45GN, CGN, Revision C, 30 November 2020
- [24]. Frequency Compliance Analysis Report, GHX05000029DEDQ45GN, CGN, Revision B, 30 November 2020
- [25]. House Load Operation Studies, GHX05000033DEDQ45GN, CGN, Revision B, 30 November 2020
- The submissions related with ROA3:
- [26]. ALARP Demonstration Report of PCSR Chapter 9, GHX00100052KPGB03GN, Revision E, CGN, 30 November 2020

Timetable and Milestone Programme Leading to the Deliverables

A Gantt chart is attached to present the timetable and milestone of the RO resolution in APPENDIX A.

Reference

NA

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APPENDIX A RO-UKHPR1000-0038 Gantt Chart

Task and Schedule		20-Apr	20-May	20-Jun	20-Jul	20-Aug	20-Sep	20-Oct	20-Nov	20-Dec	21-Jan	21-Feb	21-Mar
RO Action 1													
1	Development of deliverable - [Electrical Power System Studies based on BS IEC 62855:2016 (Submission [1])]	█											
2	Submission of deliverable - [Electrical Power System Studies based on BS IEC 62855:2016 (Submission [1])]		▲										
3	Development of deliverable - [Electrical Power System Equipment Sizing and System Study Bounding Case Analysis (Submission [2])]		█										
4	Submission of deliverable - [Electrical Power System Equipment Sizing and System Study Bounding Case Analysis (Submission [2])]			▲									
5	Development of deliverable - [Electrical Power System Modelling and Acceptance Criteria (Submission [3])]		█										
6	Submission of deliverable - [Electrical Power System Modelling and Acceptance Criteria (Submission [3])]			▲									
7	Development of deliverable - [Qualification Report of Electrical Power System Software (Submission [4])]							█					
8	Submission of deliverable - [Qualification Report of Electrical Power System Software (Submission [4])]								▲				
RO Action 2													
9	Development of deliverable - [Electrical Power System Sizing Reports (Submission [5] – [10])]			█									
10	Submission of deliverable - [Electrical Power System Sizing Reports (Submission [5] – [10])]						▲						
11	Development of deliverable - [11 Electrical Power System Studies Reports (Submission [11] – [21])]			█									
12	Submission of deliverable - [11 Electrical Power System Studies Reports (Submission [11] – [21])]						▲						
13	Development of deliverable - [Electrical Power System Sizing Reports (Submission [5] – [10])]								█				
14	Submission of deliverable - [Electrical Power System Sizing Reports (Submission [5] – [10])]									▲			
15	Development of deliverable - [Electrical Power System Studies Reports (Submission [11] – [25])]							█					
16	Submission of deliverable - [Electrical Power System Studies Reports (Submission [11] – [25])]								▲				
RO Action 3													
17	Development of deliverable - [ALARP Demonstration Report of PCSR Chapter 9 (Submission [26])]						█						
18	Submission of deliverable - [ALARP Demonstration Report of PCSR Chapter 9 (Submission [26])]								▲				
Assessment													
19	Regulators Assessment			█									
20	Target RO Closure Date												▲