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6.1 INTRODUCTION

The Fundamental Purpose of the Generic Design Assessment (GDA) Safety, Security and Environmental Case (SSEC) is to demonstrate that the generic Small Modular Reactor (SMR)-300 can be constructed, operated, and decommissioned on a generic site in the UK to fulfil the future licensee's legal duties to be safe, secure and protect people and the environment, as defined in the SMR-300 GDA Preliminary Safety Report (PSR) Part A Chapter 1 [1].

The Fundamental Purpose is achieved through the Fundamental Objective of the PSR, which is to summarise the safety standards and criteria, safety management and organisation, claims, arguments and intended evidence to demonstrate that the generic SMR-300 design risks to people are likely to be tolerable and As Low As Reasonably Practicable (ALARP) [1].

Part B Chapter 6 of the PSR presents the Claims, Arguments and intended Evidence (CAE) for the electrical engineering topic.

Where design documentation is still being developed for the SMR-300, it has been necessary to make informed judgements on the use of SMR-160 design documentation. The Requesting Party (RP) intends to use a combination of SMR-160 and SMR-300 documents as included within the GDA Design Reference Point (DRP) for electrical systems [2] and focus on presenting the safety case for Class 1E Structures, Systems and Components (SSCs).

6.1.1 Purpose and Scope

The overarching SSEC claims are presented in Part A Chapter 3 [3].

This chapter (Part B Chapter 6) links to the overarching claim through Claim 2.2:

Claim 2.2: The design of the systems and associated processes are developed taking cognisance of relevant good practice and substantiated to achieve their safety and non-safety functional requirements.

As set out in Part A Chapter 3 [3], Claim 2.2 is further decomposed across several engineering disciplines which are responsible for development of the design of relevant SSCs.

This chapter presents the electrical engineering aspects for the generic SMR-300 and therefore directly supports a claim focused on the overall design and architecture of electrical SSCs, Claim 2.2.7.

Claim 2.2.7: The overall design and architecture of electrical SSCs ensures that safety functions and non-safety functions are delivered and faults arising from failures of the SSCs are minimised.

Further discussion on how the Level 3 claim is broken down into Level 4 claims and how the Level 4 claims are met is provided in Sub-Chapter 6.3.

This chapter (Part B Chapter 6 Electrical Engineering) presents:

- Descriptions of electrical engineering SSCs associated with the design (Sub-Chapter 6.2).
- Claims, Arguments and Evidence associated with the design (Sub-Chapter 6.3).
- Codes and Standards associated with the design of electrical SSCs (Sub-Chapter 6.4).
- The electrical architecture provided by the design of electrical SSCs (Sub-Chapter 6.5).
- Adaptation to the United Kingdom (UK) electrical transmission grid (Sub-Chapter 6.6).
- The Quality, Manufacturing and Installation approach (Sub-Chapter 6.7).
- The Verification, Validation (V&V) and Examination, Inspection, Maintenance and Testing (EIMT) approach (Sub-Chapter 6.8).

Finally, Sub-Chapter 6.9 provides a technical summary of how the claims for this chapter have been supported, together with a summary of key contributions from this chapter to the overall ALARP position. Sub-Chapter 6.9 also discusses any GDA commitments that have arisen.

Appendix E of the GDA Scope report [4] presents a list of SSCs which have been identified as in scope of the GDA i.e., those pertinent to Nuclear Safety. All SSCs outside of the GDA scope have been omitted to limit the scope of the GDA. The Medium Voltage AC Distribution System (MVE) and Low Voltage AC Distribution System (LVE) electrical systems are not formally claimed in the safety case or PFS, and the MVE is outside of the GDA scope, but a description is included in this chapter for completeness.

A non-exhaustive list of exclusions from the scope of v1 of this Chapter (Part B Chapter 6) includes:

- Operational Aspects: Specific operational procedures and maintenance plans for electrical systems.
- Emergency Power Systems: Detailed design and specifications for emergency power systems, such as those required to support Flexible (FLEX) Coping Strategies operations. The FLEX coping strategies will detail the mitigations for BDBAs.
- Electrical System Integration: The integration of electrical systems with other plant systems, including Instrumentation and Control, are not fully detailed in PSR v1.
- Electromagnetic Compatibility (EMC) Studies: Comprehensive EMC studies to ensure that electrical systems do not interfere with each other or with other plant systems.
- Detailed Cable Routing: Specific routing of electrical cables and conduits throughout the plant.
- Load Flow and Short Circuit Analysis: Detailed load flow and short circuit analysis for ensuring the stability and safety of the electrical distribution system.

These exclusions reflect areas of the design that are subject to further development or not yet available, and are judged not to be essential for the assessment at Step 2 of GDA

The electrical power distribution network within the SMR-300 performs a nuclear safety role through providing power to all SSCs that provide nuclear safety functions. The scope of the safety case under the current PSR focuses on the SMR’s safety-classified electrical systems.

There are no novel aspects to the electrical engineering SSCs, with respect to their application in the UK, identified within the scope of this document.

A master list of definitions and abbreviations relevant to all PSR Chapters can be found in Part A Chapter 2 [5].

6.1.2 Assumptions

No assumptions have been identified in relation to the Electrical Engineering topic. Any assumptions relevant to this topic that are identified in the future will be formally captured, following the Commitments, Assumptions and Requirements (CAR) process [6]. Further details of this process are provided in Part A Chapter 4 [7].

6.1.3 Interfaces with other SSEC Chapters

As electrical engineering is a broad topic that is applied across the plant, there are multiple important interfaces. The primary interfaces are driven by the safety claims and associated Safety Functional Requirements (SFRs).

The electrical engineering chapter interfaces with multiple plant systems and disciplines and thus interfaces with the PSR chapters described in this Sub-Chapter.

Electrical arguments will inform the overall ALARP claims in PSR Part A Chapter 5 [8].

Electrical SSCs are designed for the generic design aspects and site characteristics of the generic SMR-300. The general design aspects and site characteristics are reported in Part A Chapter 2, General Design Aspects and Site Characteristics [5].

Design basis faults are identified and analysed in Part B Chapter 14, Design Basis Analysis (Fault Studies) [9] (see Sub-Chapter 6.4.3 for the approach to safety categorisation and classification of electrical systems). Part B Chapter 14 presents the Design Basis Accident Analysis (DBAA) for reactor faults and at Revision 1, contains a Preliminary Fault Schedule (PFS), identifying classification requirements on SSCs required for fault mitigation. BDBAs are identified and analysed in Part B Chapter 15, BDBA, Severe Accidents Analysis and Emergency Preparedness [10].

Part B Chapter 16, Probabilistic Safety Assessment (PSA) [11] considers electrical supplies as support systems for front line systems; appropriate reliability figures will be used as the PSA is developed to demonstrate the risk is tolerable and ALARP.

Hazards are addressed in Part B Chapter 12, Nuclear Site Health and Safety and Conventional Fire Safety [12], and the methodologies for identification of relevant hazards are presented in Part B Chapter 21, External Hazards [13] and Part B Chapter 22, Internal Hazards [14].

The electrical architecture supports delivery of the safety features for those systems described in PSR Part B Chapter 1, Reactor Coolant System and Engineered Safety Features [15], Part B Chapter 5, Reactor Supporting Facilities [16] and Part B Chapter 19, Mechanical Engineering [17].

The electrical systems provide power to the Instrumentation & Control (I&C) systems that are described in Part B Chapter 4, Instrumentation & Control Systems [18].

Part B Chapter 20, Civil Engineering [19] considers impacts of electrical SSCs on structural requirements.

Electrical systems are considered within Part B Chapter 25, Construction and Commissioning [20] which provides the construction and commissioning approach of the generic SMR-300.

Part B Chapter 9, Description of Operational Aspects and Conduct of Operations [21] considers at a high level, safety requirements relating to electrical SSCs providing safe and reliable supplies to plant and the development of a maintenance schedule.

Part B Chapter 17, Human Factors (HF) [22] summarises key Human Factors Engineering (HFE) activities carried out in the design of the SMR-300 aimed at optimising its design for human performance, with comments on their applicability to the UK, including activities linked to electrical engineering such as maintenance, testing and inspection. The HFE process will continue to be applied throughout the development of the SMR-300.

Electrical systems are considered within Part B Chapter 26, Decommissioning Approach [23], which provides the decommissioning approach of the generic SMR-300.

6.1.3.1 UK Electrical Deployment Impacts Due to Cross-Cutting Topics

This Sub-Chapter identifies the main topics which could be impacted by the adaptation of the SMR-300 design to meet UK requirements.

6.1.3.1.1 Impacts Resulting From Other Topic Areas

During Step 1 of the SMR-300 GDA, it was identified that design modifications in other plant areas required for UK deployment could necessitate changes to the electrical systems and result in incoming impacts on the electrical architecture. Therefore, the electrical topic will need to manage the potential incoming impacts associated with design and safety case developments in other topics to maintain consistency across the SSEC. The main topics which could directly impact the electrical topic by the adaptation of the SMR-300 design to meet UK requirements are discussed in depth within Appendix C. The topics included are not yet sufficiently mature to make any firm decisions on changing the electrical architecture and are currently identified as risks within the CAR process [6]. However, the electrical topic will accommodate future modifications to the electrical architecture by following the Design Management process [24] and ensuring consistency with the SSEC.

A project-wide, UK-specific DBAA has been initiated during Step 2 of GDA and is described in Part B Chapter 14 [9]. Currently, this only covers certain SSCs within the SMR-300 design. It will be further developed post-GDA, and the final UK-specific DBAA may challenge the current classification and design of the parts of the electrical systems.

6.1.3.1.2 Outgoing Impacts from Electrical Systems on Other Topic Areas

During Step 1 of GDA, it was identified that adapting the design for the UK's electrical transmission grid and ensuring compliance with UK statutory requirements could necessitate changes to the electrical systems, potentially impacting the safety case. This could have a knock-on effect to other disciplines due to the electrical engineering chapter driving the consideration of several cross-cutting topics, including design adaptation from a design for 60 Hz transmission network to facilitate a 50 Hz network deployment (60/50 Hz), and the approach to Grid Code compliance. These topics are critical in maintaining overall system safety and must be appropriately managed to achieve a design that manages risks to ALARP. Therefore, the electrical topic will need to manage the potential outgoing impacts associated with 60/50 Hz and Grid Code compliance, to maintain consistency across the SSEC. The electrical engineering topic area introduces expected changes that include, but are not limited to, those associated with:

- Electrical RGP Codes and Standards (Sub-Chapter 6.4).
- Grid Code Compliance (Sub-Chapter 6.6.1).
- 60/50 Hz Adaptation (Sub-Chapter 6.6.2).

These are each discussed further within this Chapter, in the referenced Sub-Chapters.

6.1.4 Design Intent

The design intent of the electrical architecture is to provide reliable power supplies to safety and non-safety equipment during normal and shutdown operation, as well as during accident conditions, whilst complying with Grid Code requirements.

From the DBAA work undertaken to date, no offsite or onsite AC power sources are currently identified as being required to perform safety functions, due to the passive design of the SMR-300. However, completion of the DBAA for a comprehensive set of all faults will be required to confirm this position and also to demonstrate that no further claims on AC architecture are necessary to demonstrate that risk is reduced to ALARP. A loss of voltage, degraded voltage condition, or other electrical transient on the offsite or onsite non-safety AC power system does not affect the ability to achieve and maintain safe-shutdown conditions. A commitment has been raised in Part B Chapter 14 [9] to develop a detailed fault schedule, and the electrical topic will adapt accordingly to any new claims on supplies.

The design considers lessons learnt and Operating Experience (OPEX) from previous events, such as Fukushima, to ensure appropriate power supplies are maintained for 72 hours following a Station Blackout (SBO) event.

6.1.5 Design Reference Point

Part A Chapter 2 [5] presents the verified DRP [2] and this chapter (Part B Chapter 6) presents the electrical design which is consistent with the DRP. The reference design reflected in this DRP is for a dual-reactor unit plant.

As discussed in Section 6.1, it has been necessary to make an informed judgement about the use of SMR-160 design documentation, where the SMR-300 equivalents are still under development. The electrical design information contained in the DRP is split between SMR-300 documentation and SMR-160 documentation, as follows:

SMR-300: All safety-classified systems, consisting of:

- The Class 1E portion of the Direct Current Power Distribution System (DCE) distribution system.
- The Class 1E portion of the I&C Power Distribution System (ICE) distribution system.

SMR-160: All other systems, all of which are non-safety classified. These consist of:

- The non-Class 1E portion of the DCE distribution system.
- The non-Class 1E portion of the ICE distribution system.
- The entire LVE distribution system.
- The entire MVE distribution system.

The latest version of the electrical architecture for the LVE and MVE systems, from HI-2240077, SMR-300 Plant Overview [25], has been represented in a diagram contained in this chapter (Figure 2 in Sub-Chapter 6.5) to provide an up-to-date representation of the fundamental electrical design of these systems. This is an updated version of the diagram included in v0 of this PSR Chapter. The updated architectural design shown by this diagram does not contradict the information contained in the DRP, or any other submitted design document. Only non-safety systems (the MVE and LVE) are shown on this updated diagram.

The fundamental design/architecture of the non-safety classified portions of the ICE and DCE will be unchanged between the SMR-160 and SMR-300 designs.

The more detailed aspects of the design of these systems may be subject to further refinement as they mature.

6.2 DESCRIPTIONS OF ELECTRICAL ENGINEERING SSCS

[REDACTED]

6.2.1 DCE

[REDACTED]

6.2.1.1 Class 1E Portion

[REDACTED]

[REDACTED]

Figure 1: SMR-300 Class 1E DCE & ICE Architecture

[REDACTED]

6.2.1.2 Non-Class 1E Portion

[REDACTED]

6.2.2 ICE

[REDACTED]

6.2.2.1 Class 1E Portion

[REDACTED]

6.2.2.2 Non-Class 1E Portion

[REDACTED]

6.2.3 LVE

[REDACTED]

6.2.4 MVE

[REDACTED]

6.3 ELECTRICAL ENGINEERING CLAIMS, ARGUMENTS AND EVIDENCE

This chapter presents the electrical engineering aspects for the generic SMR-300 and therefore directly supports Claim 2.2.7.

Claim 2.2.7: The overall design and architecture of electrical SSCs ensures that safety functions and non-safety functions are delivered and faults arising from failures of SSCs are minimised.

Within this Chapter, Claim 2.2.7 has been further decomposed into four sub-claims, to provide confidence that the relevant requirements for all electrical SSCs will be achieved during all lifecycle phases:

Sub-claim 2.2.7.1: Electrical SSCs are designed using appropriate Codes and Standards.

This sub-claim shows that the design addresses the requirements in the appropriate Codes and Standards during the design phase and takes account of RGP in existing designs and OPEX.

Sub-claim 2.2.7.2: The electrical system architecture design incorporates Defence in Depth to protect against anticipated operational occurrences and accident conditions, whilst ensuring compliance with the UK Grid Code.

This sub-claim ensures that Defence in Depth (DiD) is provided at multiple independent levels, so that the failure of one of those levels is accommodated by other engineered safety features within the design. Although the project intent is to achieve full Grid Code compliance, ensuring DiD and the safe operation of the plant will take precedence.

Sub-claim 2.2.7.3: Electrical SSCs achieve the design intent through quality, manufacturing and installation processes.

This sub-claim describes electrical SSCs will achieve their design intent and that the electrical systems can provide the required functionality in the site environment, noting that the maturity of evidence for this claim will be limited at a PSR stage.

Claim 2.2.7.4: Functionality will be assured through Verification, Validation and Examination, Inspection, Maintenance and Testing regimes to provide confidence in the design and continued operation of the electrical systems for their design lifetime.

This sub-claim describes that the electrical systems will be initially tested appropriately at works and at site, including through electrical system commissioning, and subsequently, that they are examined, inspected, maintained and tested throughout their operational life to ensure they continue to provide the required safety functions. The maturity of evidence for this claim will be limited at a PSR stage.

Table 1 shows the breakdown of Claim 2.2.7 and identifies in which Sub-Chapter of this PSR the arguments and evidence to support the claims are demonstrated to be met to a maturity appropriate for PSR v1.

Table 1: Level 4 Claims Covered by Chapter B6

Claim No.	Claim	Chapter Section
2.2.7.1	Electrical SSCs are designed using appropriate Codes and Standards.	6.4 Electrical Engineering Codes, Standards and Methodologies
2.2.7.2	The electrical system architecture design incorporates Defence in Depth to protect against anticipated operational occurrences and accident conditions, whilst ensuring compliance with the UK Grid Code.	6.5 Electrical Engineering Architecture 6.6 Adaptation to the UK Grid
2.2.7.3	Electrical SSCs achieve the design intent through quality, manufacturing and installation processes.	6.7 Quality, Manufacturing and Installation Processes
2.2.7.4	Functionality will be assured through Verification, Validation and Examination, Inspection, Maintenance and Testing regimes to provide confidence in the design and continued operation of the electrical systems for their design lifetime.	6.8 Verification, Validation and Examination, Inspection, Maintenance and Testing

Appendix A provides a full Claims, Arguments and Evidence mapping for this Chapter (Part B Chapter 6), which includes any lower-level claims, arguments and evidence needed to support the Claims in the table above. This includes identification of evidence available at PSR v1 and aspects for future development of evidence to support these claims beyond PSR v1.

6.4 ELECTRICAL ENGINEERING CODES, STANDARDS AND METHODOLOGIES

Claim 2.2.7.1: Electrical SSCs are designed using appropriate Codes and Standards.

This Sub-Chapter outlines the Codes and Standards used in the design of SMR-300 electrical SSCs, taking into account relevant good practice and operational experience.

Claim 2.2.7.1 has been further decomposed into four arguments explaining how each subject area is addressed during the electrical design and subsequent lifecycle stages. The electrical systems have been designed using applicable US nuclear Codes and Standards (A1). These have been compared against UK RGP and any differences identified (A2) and these differences have been reviewed and sentenced (A3). The electrical design is informed by OPEX and utilises proven electrical equipment (A4). Evidence is provided to support these arguments in the following Sub-Chapters.

6.4.1 US Codes and Standards

Argument 2.2.7.1-A1: Electrical systems have been designed using applicable US nuclear Codes and Standards.

The key codes, standards and regulations used to develop the reference SMR-300 design are presented in HI-2240448, SMR-300 Project References for Design and Licensing [26].

These include the codes and standards endorsed by the NRC via relevant Regulatory Guides (RGs) as acceptable means of compliance with their electrical design requirements.

The codes and standards applicable to the design of each of the main electrical subsystems are identified in the relevant SDDs (the relevant SDD(s) for each subsystem are identified in Sub-Chapter 6.2). At present, compliance information detailing how the electrical design meets the US design standards is not complete. Later in the design process, the requirements captured in each electrical system SDD will be traced through the design lifecycle to confirm compliance.

In some cases, the NRC has endorsed an older version of a standard, where a newer version has since been issued. The SMR-300 Project References for Design and Licensing [26] states the preferred approach is to follow the latest revision where possible and justify deviations from the NRC endorsed version in safety analysis report content.

6.4.2 Comparison against UK Codes and Standards

Argument 2.2.7.1-A2: Gap analysis between US nuclear Codes and Standards, and applicable UK RGP was carried out to identify any gaps between the electrical design and UK RGP.

6.4.2.1 High-Level Gap Analysis

[REDACTED]

6.4.2.1.1 Codes and Standards Report – Process for Identification of Differences

[REDACTED]

Table 2: UK RGP Standards

[REDACTED]

Table 3: Identified UK Statutory Requirements

[REDACTED]

[REDACTED]

6.4.2.1.2 Codes and Standards Report – High-Level Findings & Sentencing of Gaps

[REDACTED]

6.4.2.1.3 Tracking of Identified Differences & Future Actions

[REDACTED]

6.4.2.1.4 GDA Design Management Process [24]

[REDACTED]

6.4.2.2 Relevant Good Practice, Operational Experience and Lessons Learnt

[REDACTED]

6.4.2.2.1 GDA Lessons Learnt

[REDACTED]

6.4.3 Safety Categorisation and Classification

6.4.3.1 Reference Design Approach to Classification

The RP has developed a procedure, HPP-8002-0012, SMR-300 Structures, Systems, and Components Classification Procedure [27], for classification of all SSCs according to their safety significance. This has been developed to ensure the reference design meets the NRC's classification requirements, particularly the applicable sections of Title 10 CFR Part 50 Appendix A [28] and IEEE 603-1991 [29].

Following HPP-8002-0012, electrical SSCs are classified according to their safety significance, as either safety-related or non-safety-related dependent on the design function(s) they support during and following Design Basis Events (DBEs). Safety-related electrical equipment is designated as "Class 1E". All other electrical equipment is designated as "non-Class 1E" [27]. Under this process, a separate seismic classification is also assigned; for electrical systems this is dependent on the supported function(s) and the postulated consequences of failure during a Safe Shutdown Earthquake (SSE). Electrical SSCs are designed in accordance with codes and standards appropriate for their classification.

Under HPP-8002-0012, safety-related and non-safety-related SSCs are further classified into one of six SMR Classes: A to F. Classes A, B and C are safety-related classes, whilst D, E and F are non-safety-related classes.

SMR Class D is applied to non-safety-related SSCs with requirements for "augmented quality". "Augmented quality" is a catch-all term used where non-safety-related SSCs require specific, additional requirements in some areas, beyond those normally applied to non-safety-related SSCs, to either comply with NRC regulations, or as determined by fault studies.

Table 4 below provides the classifications for the electrical systems within the scope of GDA, along with their corresponding seismic and Quality Assurance Program (QAP) [30] requirements. The SMR classes are described in the relevant SDDs. The seismic classification and QAP applicability are as described in the classification procedure, HPP-8002-0012 [27]. A further breakdown of each of the systems, and their corresponding safety and non-safety functions, is provided in Appendix B.

Table 4: Electrical Systems Classification

[REDACTED]

The non-safety SMR Class designations are subject to further review as the reference design matures, and fault studies are further developed. "Augmented quality" requirements may be identified for certain non-safety electrical SSCs, resulting in an associated change in SMR Class.

6.4.3.2 Classification for UK Deployment

The RP acknowledges that there are differences in the approach to safety categorisation and classification between the US NRC requirements and other national and international standards.

As mentioned in Sub-Chapter 6.2.1, a provisional, UK-specific DBAA has been initiated during Step 2 of GDA. This is described in Part B Chapter 14 [9]. This has provisionally identified that, following the UK RGP approach to classification, the Class 1E portion of the DCE would be classified as a Class 1 system. The associated PFS currently contains only a limited set of design basis faults, including limited electrical system faults (LOOP, Extended Loss of Grid (ELOG) and loss of DCE). Further development of the fault schedule will go beyond GDA Step 2 [9], to cover all SSCs. Of the electrical SSCs, only the DCE has been considered within Step 2 of GDA.

A commitment (C_Faul_103) to complete the necessary safety assessment work for the UK context, beyond Step 2 of GDA, is identified in Part B Chapter 14 [9].

It is recognised that as the DBAA and the PFS are further developed, there could potentially be impacts on the electrical system design resulting from the assigned safety classification of some systems (particularly the LVE and MVE). Beyond Step 2, as the plant design and fault analyses mature, the electrical systems design will be kept under review to ensure it is consistent with the development of the UK safety case.

A commitment (C_Elec_120) has been raised (see Sub-Chapter 6.9.3) to provide assurance that, following completion of a comprehensive UK-specific DBAA, potential design modifications to the AC electrical architecture are not foreclosed and can be accommodated within the future design.

6.4.4 Metrication

The overarching approach to Metrication is described in Part A Chapter 2 [5], however, there are no firm decisions yet on the detailed implementation for the electrical topic, such as cable sizing. An approach to metrication will be developed post-GDA.

6.4.5 CAE Summary

The SMR-300 electrical systems have been designed using applicable US nuclear codes and standards and NRC regulatory requirements. The standards recognised as UK RGP have been identified, and a proportionate comparison of the reference design standards against this UK RGP has been carried out as part of Step 2 of GDA, with identified differences reviewed and sentenced. Where gaps of higher significance are identified, or differences in application of standards confirmed, a mitigation strategy will be developed to facilitate a future UK deployment of the SMR-300, as set out in the GDA commitments (Sub-Chapter 6.9.3). Claim 2.2.7.1 has therefore been met to the extent consistent with the fundamental aims of Step 2 of GDA. The project methodology for safety categorisation and classification [27] will be developed beyond Step 2 of the GDA. This will address potential gaps identified in Revision 1 of the SSEC relating to categorisation and classification, to ensure UK regulatory expectations are addressed.

6.5 ELECTRICAL ENGINEERING ARCHITECTURE

Claim 2.2.7.2: The Electrical system architecture design incorporates defence in depth to protect against anticipated operational occurrences and accident conditions, whilst ensuring compliance with the UK Grid Code.

This Sub-Chapter describes the electrical architecture and argues that this incorporates sufficient Defence in Depth (DiD) against Anticipated Operational Occurrences (AOO), faults, Beyond Design Basis Accidents (BDBA) and transients while supporting compliance with the UK Grid Code. These arguments also demonstrate that the electrical architecture considers appropriate DiD to protect against AOOs and accident conditions.

Claim 2.2.7.2 has been further decomposed into nine arguments outlining the comprehensive measures taken to ensure the suitable implementation of DiD within the electrical system architecture design. The electrical system architecture delivers the required electrical performance to support the relevant SSCs identified in the UK PFS (A1). In addition, that faults originating within the electrical architecture will not compromise delivery of the main safety functions (A2). The electrical architecture incorporates appropriate levels of DiD (A3) and the electrical systems functional, non-functional, performance and reliability requirements have been specified (A4). The electrical systems are designed to meet their functional, non-functional and performance requirements for their specified operational life (A5). The Electrical system design takes internal and external hazards withstand requirements into account (A6), as well as the ageing and obsolescence of electrical systems and components (A7). The electrical architecture ensures that failure of non-classified electrical SSCs will not compromise classified SSCs (A8) and the electrical systems are designed to ensure compliance with the Grid Code and National Energy System Operator (NESO) requirements, including any site-specific requirements from NESO, in a 50 Hz transmission network (A9).

Each of these nine arguments and their supporting evidence are covered within Sub-Chapters 6.5 and 6.6.

6.5.1 Electrical Architecture

This Sub-Chapter supports Arguments 2.2.7.2-A1, 2.2.7.2-A2 and 2.2.7.2-A8.

Argument 2.2.7.2-A1: The electrical architecture delivers the required electrical performance to support the relevant SSCs identified in the Fault Schedule.

6.5.1.1 Overview

[REDACTED]

[REDACTED]

Figure 2: SMR-300 MVE & LVE Architecture

[REDACTED]

6.5.1.2 Modes of Operation

[REDACTED]

6.5.1.2.1 Normal Operation

[REDACTED]

6.5.1.2.2 Abnormal Operation

[REDACTED]

6.5.1.3 Minimising Fault Propagation

[REDACTED]

6.5.2 Defence in Depth

Argument 2.2.7.2-A3: The electrical architecture incorporates appropriate levels of Defence in Depth.

This Sub-Chapter demonstrates that the electrical architecture has sufficient levels of DiD, by demonstrating the design is based upon multiple independent levels where the failure of one of those levels is accommodated by the engineered safety features and safety margins within the design.

DiD is implemented primarily through the combination of consecutive and independent levels of protection, which would have to fail concurrently before harmful effects could be caused to people or to the environment. If one level of protection or barrier were to fail, the subsequent level or barrier would be available. The independent effectiveness of the different levels of defence is a necessary element of DiD.

The DiD philosophy of the SMR-300 design is defined in HI-2240251, Top Level Plant Design Requirements [31], as follows:

- **Level 1: Prevention of abnormal operation and failures by design:** Conservative design, construction, maintenance and operation in accordance with appropriate safety margins, engineering practices and quality levels.
- **Level 2: Prevention and control of abnormal operation and detection of failures:** Control, indication, alarm systems or other systems and operating procedures to prevent or minimise damage from failures.
- **Level 3: Control of faults within the design basis to protect against escalation to an accident:** Engineered safety features, multiple barriers and accident or fault control procedures.
- **Level 4: Control of severe plant conditions in which the design basis may be exceeded, including protecting against further fault escalation and mitigation of the consequences of severe accidents:** Additional measures and procedures to protect against or mitigate fault progression and for accident management.
- **Level 5: Mitigation of radiological consequences of significant releases of radioactive material:** Emergency control and on and off-site emergency response (See Part B Chapter 15 BDBA, Severe Accidents Analysis and Emergency Preparedness [10]).

The electrical architecture contributes to levels 1 and 2 of DiD by providing supplies to plant AC systems used in normal operation and for their monitoring and control. In addition, the Class 1E electrical architecture provides supplies to safety-classified loads of protection functions to support level 3 of DiD. The electrical architecture supplies systems for accident monitoring to support level 4 of DiD.

Following the completion of PSR v1, new evidence will be provided to support this argument. This will include a comprehensive fault schedule, which will be developed in accordance with industry standards and best practices. The fault schedule will detail the various types of faults identified, their potential impacts, and the corresponding mitigation strategies.

6.5.3 Safety Functional Requirements and Identification of Electrical SSCs

This Sub-Chapter supports Arguments 2.2.7.2-A4 and A5.

Argument 2.2.7.2-A4: Electrical system functional, non-functional, performance and reliability requirements have been specified.

Safety functions and non-safety functions have been identified and allocated to the appropriate electrical SSCs within the electrical architecture. The safety requirements / functions for the electrical SSCs are documented in the SDD for the Class 1E DCE Power Distribution System [32] and the SDD for the Class 1E ICE Power Distribution System [33]. Further evidence will be developed beyond GDA to demonstrate that the design of the electrical SSCs will be consistent with the reliability claimed in the PSA.

Electrical SSCs and their safety and non-safety functions, as identified to date, are presented in Appendix B.

HI-2240251, Top Level Plant Design Requirements [31] defines the design philosophy and high-level requirements for all SMR-300 systems. The SMR-300 Electrical Specification [34] builds on these high-level requirements; it presents the required general electrical characteristics and design philosophy of the electrical power system for the SMR-300, and the generic requirements that the electrical architecture will satisfy. The SDDs provide more detailed requirements for each particular electrical subsystem. Applicable codes and standards for the electrical systems are captured in HI-2240448, Project References for Design and Licensing [26].

Post-GDA, the SDDs will be updated to capture the requirements for the electrical systems (for example, classification, diversity, separation and segregation) from the fault studies. The electrical architecture will deliver the required performance to support safety critical SSCs identified within the fault schedule. Part B Chapter 14 [9] will reflect any further development of the PFS.

Argument 2.2.7.2-A5: Electrical systems are designed to meet their functional, non-functional and performance requirements for their specified operational life.

The electrical systems functional, non-functional, and performance requirements are provided in the comprehensive SDDs provided for various power distribution systems. The SMR-300 plant is designed for an 80-year operational life. As per the Top-Level Plant Design Requirements [31], equipment shall either be designed to last for the 80-year design life of the plant or shall be designed to be replaceable. Electrical equipment shall be specified for a minimum design life of 30 years, with the final design life to be determined by the manufacturer(s). This applies to all electrical systems within the SMR-300 design.

The electrical SDDs define that the electrical systems are engineered to fulfil both functional and non-functional requirements throughout their operational life. These define the applicable regulatory requirements from US NRC and the codes and standards that are partially or fully applicable for the design.

6.5.3.1 Functional Capability and Preliminary Engineering Schedule

The RP plans to develop an SMR-300 preliminary engineering schedule, and further details on the approach to development of the engineering schedule is provided in Part B Chapter 19 [17].

6.5.4 Hazards

The following Sub-Chapter describes how electrical system design takes into account hazard withstand requirements.

Argument 2.2.7.2-A6: Electrical system design takes Internal and External Hazards withstand requirements into account.

It is acknowledged that the electrical system must be resilient to various hazard conditions. At the time of writing this Sub-Chapter, the detailed hazard requirements have not been specified.

Beyond Step 2 of GDA, the electrical topic will provide substantiation for requirements identified as a result of safety analysis and engineering good practice. This includes implementing measures such as physical and electrical isolation, redundancy, and independence to ensure that the system can withstand internal hazards like fires, explosions, and electromagnetic interference. Additionally, external hazards such as extreme weather conditions, seismic events, and flooding will be considered to ensure the system's overall robustness and reliability during possible hazard conditions. Appropriate design, qualification, location, barriers, analysis and verification activities will demonstrate these requirements are met by SMR-300 design.

Internal and external hazards and their link to Electrical systems are discussed in the Sub-Chapters below.

6.5.4.1 Internal Hazards

The SMR-300 is designed to incorporate power cable routing arrangements to provide appropriate fire prevention, including ensuring the integrity of fire barrier seals is not affected by a loss of cable supports resulting from fire. Cables are appropriately designed for use in harsh environments and routed to minimise impact on the plant during replacement, whilst minimising the number of fire barrier penetrations needing to be breached.

In addition, as per the SMR-300 Design Standard for Grouping and Separation [35], the design follows industry good practice by ensuring only Class 1E cables associated with a given division shall be routed together within raceways and will not interfere with the other division or non-Class 1E cables. This standard also ensures appropriate methods of separation depending on safety class or hazard threat, using defined techniques to achieve electrical isolation. The segregation, separation and redundancy of electrical systems will ensure that should an internal hazard result in the failure of an SSC, there is another redundant SSC to fulfil the required safety functions.

The electrical systems need to be designed to withstand applicable internal hazards. Additionally, electrical equipment will be qualified and designed to minimise the risk of generating internal hazards. The following are the main internal hazards relevant to the electrical systems:

- Internal fires
- Internal flooding
- Internal explosions
- Internal Electromagnetic Interference (EMI)

Further detail on the hazard identification and analysis to be undertaken for internal hazards post-GDA is outlined within PSR Part B Chapter 22 [14].

[REDACTED]

6.5.4.2 External Hazards

The approach to external hazards is outlined within Part B Chapter 21 [13], which identifies applicable external hazards, including those that impact the SMR-300's electrical design, and discusses that further site-specific assessments are required.

The electrical systems are protected from the majority of external hazards by the civil / structural SSCs, e.g. the Containment Enclosure Structure (CES) and Reactor Auxiliary Building (RAB). These civil / structural SSCs provides a robust structure to protect electrical SSCs from the impacts of identified external hazards. However, the following external hazards cannot be fully isolated from electrical equipment and therefore, have the potential to impact upon the design of electrical equipment:

- Extreme Ambient Air Temperature.
- Lightning (and potential EMI).
- Seismic.
- External EMI.
- Electromagnetic Pulses.
- Space Weather.
- External Flooding.
- LOOP and ELOG .

6.5.4.2.1 Extreme Ambient Air Temperature

The design temperatures of the electrical system are defined to ensure their reliability and safety. HVAC systems are typically employed to maintain these design temperatures by mitigating the effects of extreme ambient air temperature, and Part B Chapter 5 [16] provides arguments and evidence to support the claim that the HVAC system design ensures the delivery of safety and non-safety functions.

[REDACTED]

6.5.4.2.2 Lightning

As stipulated within the Generic Site Envelope Report (GSER) hazard report [36], the SMR-300 Electrical Systems will contain earthing and isolation points, the requirements for which will be informed by site-specific design aspects, in addition to regulations and applicable codes and standards.

Requirements will include, but are not limited to, the need for a low impedance path to earth for fault currents and lightning discharges, protecting personnel from injury and the equipment from electrical shock hazards. The overall approach to ensuring the Earthing and Lightning Protection System is still in development.

6.5.4.2.3 Seismic

The SDDs contain requirements for all Class 1E equipment and support structures to be designed to meet the criteria for Seismic Category I SSCs. This requirement defines the seismic and safety classes required for safety grade equipment consistent with current practice.

6.5.4.2.4 External EMI

SMR-300 Electrical Specification [34] details requirements relating to external EMI, such as cable shielding, and these will be further developed post GDA.

6.5.4.2.5 Electromagnetic Pulse Resistance

The SMR-300 design features measures to improve protection against electromagnetic pulses. The SMR-300 Class 1E Electric Power system is isolated from the non-Class 1E system by qualified power isolation panels. The SMR-300 Class 1E control system is optically isolated from the non-Class 1E system, and fibre optic cables are used throughout the design to reduce the impact of electrical transients on the systems. The Class 1E containment penetrations on the side of the RAB are in dedicated cable spreading rooms, reducing electromagnetic pulses intrusion pathways.

6.5.4.2.6 Space Weather

The overall approach to ensuring protection against space weather is still under development.

6.5.4.2.7 External Flooding

The overall approach to ensuring protection against flooding is still under development.

6.5.4.2.8 LOOP and ELOG

There is a UK requirement to consider Extended Loss of Grid [37], the timescales of which are greater than the current 72-hour coping period. The impact of this will be evaluated and a coping strategy developed.

6.5.5 Ageing and Obsolescence

Argument 2.2.7.2-A7: Electrical system design takes into account the ageing and obsolescence of electrical systems and components.

The SMR-300 Top Level Plant Design Requirements document [31] defines the approach to operating life / replaceability of the electrical system architecture, which applies to all electrical systems and components. It specifies that all electrical equipment will be designed to be replaceable and be applicable to a two-division plant if they cannot meet the full 80-year plant design life. Such components shall consider Light Water Reactor (LWR) operating fleet experience for best available techniques for monitoring design life and service life extension of components.

A replacement strategy will be developed for all replaceable equipment beyond GDA, as part of the detailed SSC design. Replacement procedures for systems important to safety will be determined by probabilistic risk assessment, to ensure that at a system level, functions important to safety have a suitable level of reliability / redundancy even when some components are offline for maintenance.

During equipment replacement system reliability and redundancy will be maintained, with equipment renewal / replacement occurring during planned windows and appropriate shutdowns in place. Any unplanned equipment failures outside of these windows will constitute urgent maintenance. There will be a limit on what equipment can undergo renewal / replacement concurrently, to ensure that overall functions important to safety are maintained with appropriate redundancy, even during these conditions. The Class 1E power supply is not relied on to provide power to the cooling equipment used during a normal reactor shutdown.

6.5.6 CAE Summary

Safety and non-safety functions have been identified through the overall safety analysis and allocated to the electrical systems within the electrical architecture. This allocation will be reviewed and updated as the SMR-300 design progresses.

The electrical architecture provides electrical systems with DiD. Electrical supplies are provided to plant systems used in normal operation, which contribute to DiD Levels 1 and 2, including I&C systems used for monitoring and control. The electrical architecture supports Level 3 of DiD, by providing supplies to safety-classified loads to support plant protection functions and supports Level 4 of DiD by providing supplies to systems for accident monitoring. The design has been analysed for modes of operation; DiD associated with operation has been considered and has been implemented where appropriate.

Each safety and non-safety plant load will be identified and allocated to the appropriate electrical system. The electrical system requirements have been specified in project level specifications and in the relevant SDDs. Post-GDA, further evidence will be developed to demonstrate that the SSCs are consistent with the reliability claimed within the PSA.

The electrical topic will provide substantiation for hazard withstand requirements identified through safety analysis and engineering good practice. Ageing and obsolescence within the electrical system has considered the need for replaceable parts where the design life cannot meet the full 80-year plant design life.

6.6 ADAPTATION TO THE UK GRID

Claim 2.2.7.2: The Electrical system architecture design incorporates defence in depth to protect against anticipated operational occurrences and accident conditions, whilst ensuring compliance with the UK Grid Code.

The reference SMR-300 design has been developed for deployment in the North American electrical transmission grid. The design will be developed such that it can be safely operated, maintained, and supported within the UK, and this Sub-Chapter outlines how this will be achieved. There are two primary challenges associated with this: satisfying the requirements of NESO/Office of Gas and Electricity Markets (Ofgem) which are defined in the UK Grid Code [38], and modification of the design to enable operation in a 50 Hz electrical transmission network, rather than a 60 Hz network. The approach to mitigating these challenges is described in Sub-Chapters 6.6.1 and 6.6.2 below.

6.6.1 Approach to Grid Code Compliance

[REDACTED]

6.6.2 Approach to 50 Hz Deployment

Argument 2.2.7.2-A9: The electrical systems are designed to ensure compliance with the Grid Code, 60/50 Hz and National Energy System Operator requirements, including any site-specific requirements from National Energy System Operator.

6.6.2.1 [REDACTED] Design Challenge

[REDACTED]

6.6.3 CAE Summary

To facilitate the adaptation to UK Grid, both the 60/50 Hz Strategy [39] and Grid Code Compliance Strategy [40] documents have been developed, to provide a clear pathway to ensure compliance of the SMR-300 with the UK Grid Code, and to facilitate its adaptation for operation in a 50 Hz electrical transmission network. Both strategies ensure that the systems and associated processes are developed taking cognisance of RGP and are substantiated to achieve their safety and non-safety functional requirements. Post-GDA, it is envisaged that in-depth detailed analysis of the UK Grid Code will be initiated, and documentation produced to support Grid Code, 60/50 Hz and NESO requirements, including any site-specific requirements from NESO. The electrical design will be updated to reflect the outcomes of the 60/50 Hz design challenge.

6.7 QUALITY, MANUFACTURING AND INSTALLATION PROCESSES

Claim 2.2.7.3: Electrical SSCs achieve the design intent through quality, manufacturing and installation processes.

This Sub-Chapter sets out how electrical SSCs will in future be demonstrated to achieve their design intent and that the electrical systems can provide the required functionality in the site environment.

Claim 2.2.7.3 has been decomposed into two arguments to demonstrate that the electrical SSCs achieve the design intent through quality, manufacturing and installation.

The quality of electrical SSCs shall be ensured through stringent vendor selection and ongoing Quality Assurance (QA) and Quality Control (QC) measures throughout the manufacturing process (A1) and through the installation / commissioning process for the lifecycle of the SMR-300 (A2), which will be fully developed post-GDA. SMR-300 procedures for the selection of reputable and reliable contractors will be followed. Verification activities will demonstrate that the equipment has been manufactured correctly.

Electrical engineering is delivered in line with the SMR-300 Program Quality Plan [41], which is outlined in Part A Chapter 4 [7]. The RP have presented the arrangements for controlling the SMR-300 design and the arrangements to maintain Design Authority (DA).

The SSC classification methodology is defined in Part B Chapter 14 [9] and assigns safety requirements and design standards to Electrical SSCs. The SSC classification methodology is discussed in SMR-300 Systems, Structures, and Components Classification Procedure [27]. and describes the link between electrical systems safety class and corresponding quality class. The quality class for each of the electrical subsystems, as required under this process, is described in Table 4 of Section 6.4.3.1.

Part A Chapter 4 [7] presents the arrangements for the lifecycle Management of Safety and Quality Assurance (MSQA) of the generic SMR-300.

6.7.1 Manufacturing

Argument 2.2.7.3-A1: Quality of manufacturing of electrical SSCs is established through rigorous vendor selection and continuous Quality Assurance and Quality Control of the manufacturing process.

Electrical SSCs include bespoke components fabricated by Holtec International and their supply chain, and Commercial-Off-The-Shelf (COTS) items. These SSCs are subject to the SMR-300 Project Quality Plan [41], which includes procedures to select and maintain suppliers, conformance testing, QA records, and audits, among other Quality Procedures.

Procurement of safety significant scope of work from a supplier requires that either the supplier is on the Approved Vendors List (AVL), or that an additional / enhanced acceptance process (commercial grade dedication) is undertaken to provide reasonable assurance that a component not manufactured under a nuclear QA programme will fulfil its intended safety function.

Suppliers are approved based upon recommendations, certifications and experience, qualification of suppliers within the RP's QA program through auditing, or extension of the RP's QA program for performance of supplier scope. Further details are provided in Part A Chapter 4 [7].

Due to the current level of design information, the evidence of this claim is limited at the PSR stage, however the evidence intended to support this argument is planned for PCSR stage and includes but is not limited to:

- Stringent vendor selection procedures.
- Development and implementation of QA and QC plans.
- Manufacturing facilities inspections.
- Development and implementation of program for traceability of manufacturing process.

The QA arrangements provide a framework to ensure that the manufacturing of the systems achieves the design intent and meets the defined safety and non-safety requirements, including the requirements set out in US NRC Regulatory Guides [42] and IEEE standards.

6.7.2 Installation

Argument 2.2.7.3-A2: Quality of installation for electrical SSCs is established through rigorous contractor selection and continuous Quality Assurance and Quality Control of the installation and commissioning process.

The electrical systems will be installed by the equipment supplier or approved contractors, under the supervision of the overall construction QA arrangements to ensure that the equipment is not damaged as part of the shipping, unloading, storage and installation processes. The arrangements will confirm that the electrical systems have been installed correctly in accordance with the design intent, are safe to power up, and operate correctly in the site environment.

Due to the current level of design information, the evidence of this claim is limited at the PSR stage; the evidence intended to support this argument is planned for the PCSR stage and will include but not be not limited to:

- Rigorous contractor selection procedures.
- Development and implementation of QA and QC plans for installation works.
- Implementation of staff training, evaluation and assessment programme.
- Development and implementation of program for traceability of installation and commissioning works.

These arrangements will ensure the electrical systems are suitably prepared for electrical system commissioning tests, to then be carried out prior to the wider plant commissioning tests. Construction and commissioning are addressed in Part B Chapter 25 [20].

6.7.3 CAE Summary

The electrical systems will be manufactured and installed in accordance with appropriate QA arrangements to ensure that the design intent is implemented, and the electrical systems deliver the required supplies within the site environment.

Evidence is limited for PSR; QA and QC arrangements will be developed beyond GDA to support the claim that the SMR-300 project has controls in place to ensure that the design of the SMR-300 maintains high quality standards throughout the plant lifecycle and that QA and QC arrangements for electrical SSCs are defined and appropriate.

6.8 VERIFICATION, VALIDATION AND EXAMINATION, INSPECTION, MAINTENANCE AND TESTING

Claim 2.2.7.4: Functionality will be assured through Verification, Validation and Examination, Inspection, Maintenance and Testing regimes to provide confidence in the design and continued operation of the electrical systems for their design lifetime.

This Sub-Chapter outlines that the electrical systems will be initially tested appropriately at the manufacturer's works, commissioned at site and subsequently examined, inspected, maintained and tested throughout their operational life to ensure they continue to provide the required safety functions.

Claim 2.2.7.4 has been further decomposed into three arguments. The electrical systems safety and non-safety functional requirements will be demonstrated by appropriate verification and validation activities (A1). These activities are defined and performed to provide evidence that electrical systems provide their intended functionality (A2) and EIMT activities will be defined and implemented for the operational life of the electrical systems (A3). The overarching EIMT approach for the SMR-300 is described in Part B Chapter 9 [21]; detailed electrical EIMT requirements and procedures will be developed post-GDA as the design matures further. Elements of HFE will be integrated into the processes outlined in Claim 2.2.7.4 and will be applied and detailed as the electrical design progresses.

6.8.1 Verification and Validation

Argument 2.2.7.4-A1: Safety and non-safety functional requirements will be demonstrated by appropriate Verification and Validation activities.

V&V analysis will be developed post-GDA. This will typically include design review, design analysis, item tests, integration tests, works acceptance tests, site installation, site acceptance tests, electrical commissioning and plant commissioning.

Argument 2.2.7.4-A2: Verification and Validation activities are defined and being performed to provide evidence that the electrical systems provide their intended functionality.

The supporting evidence for this argument will be developed at a future stage.

6.8.2 EIMT

Argument 2.2.7.4-A3: Examination, Inspection, Maintenance and Testing for the operational life of the electrical systems will be defined as informed by the design activities.

Routine examination, inspection, maintenance and testing arrangements will be defined and documented in accordance with:

- Manufacturers' recommendations and the relevant standards and guides.
- The SMR-300 Top Level Plant Requirements document [31], which includes operability and maintainability requirements that are applicable for all SMR-300 SSCs and inform the design development of the plant.
- The SMR-300 Electrical Specification document [34] which provides more detailed requirements.

- The PSA, which includes assumptions on Test Intervals. These assumptions will be subject to further review post-GDA.

A SmartPlant 3D model of the SMR-300 is employed to inform the ongoing design and layout development of the plant and facilitate EIMT considerations. This model has been developed and is continuously updated in compliance with SmartPlant Standards [43], which provides the standard for modelling, communication and coordination of SmartPlant 3D in the design of the SMR-300.

6.8.3 CAE Summary

The SMR-300 will be subject to appropriate V&V and EIMT arrangements and processes, to ensure that electrical SSCs will continue to meet their design intent throughout the lifetime of the SMR-300.

The evidence supporting this argument will be developed in future submissions and will include both operational surveillance and maintenance requirements. These measures ensure that the electrical systems will be continuously monitored and maintained, providing reliability and safety throughout their operational life.

6.9 CHAPTER SUMMARY AND CONTRIBUTION TO ALARP

This Sub-Chapter provides an overall summary and conclusion of the electrical engineering chapter and how this chapter contributes to the overall demonstration of ALARP for the generic SMR-300. Part A Chapter 5 [8] sets out the overall approach for demonstration of ALARP and how contributions from individual chapters are consolidated.

This Sub-Chapter therefore consists of the following elements:

- Technical Summary.
- ALARP Summary:
  - Demonstration of RGP.
  - Evaluation of Risk and Demonstration Against Risk Targets.
  - Options Considered to Reduce Risk.
- GDA Commitments.
- Conclusion.

A review against these elements is presented below under the corresponding headings.

6.9.1 Technical Summary

Part B Chapter 6 aims to demonstrate the following Level 3 claim to a maturity appropriate for a PSR:

Claim 2.2.7: The overall design and architecture of electrical SSCs ensures that safety functions and non-safety functions are delivered and faults arising from failures of SSCs are minimised.

In support of Claim 2.2.7.1, the SMR-300 electrical design has been undertaken using best practice nuclear industry codes and standards by use of US NRC requirements, NRC Regulatory Guides and IEEE standards as described in Sub-Chapter 6.4. The Electrical Codes and Standards report [44] demonstrates the level of alignment of the SMR-300 design standards with IEC standards, recognised as UK RGP, that are relevant to the fundamental electrical design, and sets out a forward action plan to address identified differences.

The US/UK Regulatory Framework and Principles Report [38] provides a comparison between the UK and the US regulatory frameworks. An initial evaluation of the alignment of the design principles against the ONR SAPs [45] has also been performed. The electrical system design for the SMR-300 is informed by OPEX. Claim 2.2.7.1 is also supported by ongoing work to identify differences between the design codes and standards, and UK RGP, to be further substantiated beyond GDA.

The SMR-300 electrical architecture and electrical system design supports Claim 2.2.7.2, demonstrating that the overall DiD approach provides systems with a stable supply within normal operation which contributes to Levels 1 and 2 of DiD, providing supplies to Class 1E loads to support protection functions to support Level 3 of DiD and supplies to systems for accident monitoring to support Level 4 of DiD.

The key requirements for the electrical SSCs are to provide the required safety and non-safety functions at the required integrity, ensure that the electrical architecture is aligned with international RGP, and the electrical systems support safety category functions. The SMR-300 electrical system design does not rely on AC power sources and instead uses battery-backed DC power with a 72-hour coping period for all DBAs in the event of a loss of AC power. The design incorporates resilience to address potential hazard conditions. The electrical systems will be designed to address ageing and obsolescence. If the design life of the systems cannot meet the full 80-year plant design life, components will be designed for replaceability to ensure continued functionality.

The processes and procedures that the RP has established extend to manufacturing, installation and maintenance. These processes will ensure that electrical SSCs deliver their design basis throughout the design life of an SMR-300 unit. While several aspects of this are outside of scope at Step 2 of GDA (see Sub-Chapter 6.1.1), the high-quality standards required of the SMR-300 Program Quality Plan [41] and the relevant design processes supporting this provide evidence that Claim 2.2.7.3 can be achieved.

V&V activities and EIMT will demonstrate the fitness for purpose of electrical SSCs through V&V plans and electrical system commissioning tests prior to plant commissioning. Once in operation, ongoing EIMT throughout the operational life of the electrical systems will ensure the electrical systems continue to safely provide the required electrical supplies for the plant. As the design matures, detailed Electrical V&V and EIMT requirements will be developed to provide evidence that Claim 2.2.7.4 can be achieved.

At PSR v1, it is judged that the maturity of the safety justification presented in Part B Chapter 6 is appropriate for a PSR and that the proposed strategies confirm that the electrical SSCs provide the required functions at the required integrity levels and faults arising are minimised, to adequately support Claim 2.2.7. Post-GDA, there is sufficient confidence that once the strategies are applied, Claim 2.2.7 will be met in future safety submissions and risks evaluated as tolerable and ALARP.

6.9.2 ALARP Summary

This Sub-Chapter provides a summary of how the electrical engineering design has been used to reduce risks across the SMR-300 plant. This Sub-Chapter is informed from supporting GDA documents, primarily the electrical engineering 60/50 Hz Strategy [39], Grid Code Compliance Strategy [40] and the Electrical Topic Codes and Standards Analysis Report [44].

Part A Chapter 5 [8] considers the totality of the SMR-300 design against the ALARP principles. Part A Chapter 5 [8] also presents the methodology for demonstration of ALARP, which consists of two main elements:

- The design is informed by RGP.
- Options to reduce the risk have been / will be identified and implemented where the effort to do so is not grossly disproportionate to the benefit that would be realised.

The following Sub-Chapters present the ALARP considerations for electrical engineering and implement this ALARP methodology from the point of view of electrical engineering and their potential effects on SMR-300 systems.

6.9.2.1 Demonstration of RGP

This sub-chapter discusses the engineering processes used and identifies whether these meet the standard of RGP.

At this stage of the electrical engineering design, that the design reduces risk to ALARP is demonstrated mainly through showing that the design/engineering process has considered RGP and OPEX (Sub-Chapter 6.4.2.2). In addition, the electrical design development through Step 2 of GDA has included several strategy reports and an optioneering study to address the most significant challenges to implementation of the current reference electrical design in the UK. These include:

- Codes and Standards Gap Analysis (see Sub-Chapter 6.4.2).
- Grid Code Compliance Strategy [40] (see Sub-Chapter 6.6.1).
- 60/50 Hz Strategy [39] (and associated optioneering) (see Sub-Chapter 6.6.2).

These arrangements for considering RGP, OPEX and optioneering are embedded in the RP's arrangements and will be further progressed as the detailed design is developed.

Following the application of the electrical engineering optioneering strategies, provided the associated differences and potential design changes are clearly defined and managed, the approaches are considered to demonstrate relevant good practice.

Commitments will form the basis for setting out the process to justify any gaps from UK RGP. Commitments have been collated and are managed via the Commitments, Assumptions and Requirements process [6].

6.9.2.2 Evaluation of Risk and Demonstration Against Risk Targets

The numerical targets against which the demonstration of ALARP is considered can be found in PSR Part A Chapter 2 [5]. Electrical SSCs, through the defined safety functions, will contribute to the demonstration of ALARP by comparison against the risk targets in two ways:

- By fulfilling safety functions for normal operations (e.g., providing supply to plant equipment), and thereby contributing to achieving Targets 1-3.
- By achieving their safety classification as a duty system or a protection system (e.g. batteries operate during plant trip), where claimed, they will contribute to the achievement of accident risk, Targets 4-9.

Chapter A Part 2 [5] covers Basic Safety Objectives (BSOs) and Basic Safety Levels (BSLs).

Evaluation of nuclear safety risk is not directly applicable to electrical engineering SSCs, as these are supporting systems for the main systems performing nuclear safety functions. The safety assessment of the electrical SSCs will be associated with the probability of failure to perform their intended function, which is then used to calculate the overall comparison against the nuclear safety risk targets as described above. On completion, the PSA will provide insights as to the risk contributions from the electrical systems to the overall plant risk in various scenarios. This will allow a variety of options which will reduce the risk contribution to be identified.

Part A Chapter 5 [8] summarises the evaluation performed to date to provide confidence that the SMR-300 will meet Targets 1-9.

6.9.2.3 Options Considered to Reduce Risk

Risk reduction is core to SMR-300 reference design development. Two separate aspects contribute to risk reduction from the electrical engineering topic area: Design Decisions, and the Design Management Process, which are described within Chapter A Part 5 [8]. Part A Chapter 5 ALARP Summary also considers the holistic risk-reduction process for the generic SMR-300.

[REDACTED]

6.9.3 GDA Commitments

GDA commitments which relate to this chapter have been formally captured via the Commitments, Assumptions and Requirements process [6]. Further details of this process are provided in Part A Chapter 4 [7]. At Revision 1 of this Chapter, four GDA commitments have been raised for the electrical engineering topic; these are summarised in Table 5:

Table 5: GDA Commitments

Commitment ID	Commitment
C_Elec_071	The Holtec '60/50 Hz Design Strategy' (HI-2241517-R0.0) is based upon the fleet deployment approach and design stability objectives, and involved the investigation of available options to deploy the SMR-300 design into 50 Hz markets. The implementation of this strategy is delivered through the mechanism of the Design Challenge Paper '60/50 Hz Design Challenge' (HI-2241520-R0.0), which is with the Design Authority for Design Decision. A Commitment is raised to progress this Design Challenge through the Design Management process (HPP-3295-0017-R1.0) to completion. Target for Resolution – Issue of UK Pre-Construction SSEC.
C_Elec_072	Further detailed design information is required to develop the appropriate Grid Code compliance studies required to confirm UK compliance with the UK Grid Code. A Commitment is raised to develop the necessary studies required to confirm the SMR-300 Grid Code compliance and present them in a dedicated Grid Compliance assessment report. Target for Resolution - Issue of UK Pre-Construction SSEC.
C_Elec_118	During Step 2 of GDA, the requirements of UK RGP standards were compared against the standards used to develop the reference SMR-300 design. This exercise, documented in 'Electrical Codes and Standards Gap Analysis Report' (HI-2250205 R0.0), identified several differences between UK RGP expectations and the design. A Commitment is raised to develop a mitigation strategy to address the differences identified. Target for Resolution - Issue of UK Pre-Construction SSEC.

Commitment ID	Commitment
C_Elec_120	Due to the ongoing resolution of Design Challenges and developing safety analysis of the SMR-300, there is a possibility that the AC electrical architecture may require further development and justification to demonstrate alignment with UK expectations. A Commitment is raised to justify that the current AC electrical architecture continues to support reduction of risks to ALARP. Target for Resolution - Issue of UK Pre-Construction SSEC.

6.9.4 Conclusion

This chapter presents and discusses the claims supported by the electrical engineering topic area. As electrical engineering is a broad subject covering many aspects of the SMR-300, the claims focus on how the practice of electrical engineering has contributed to the design of the SMR-300 and how risks have been reduced across the design.

The primary claim for the chapter (Claim 2.2.7, a Level 3 claim) is supported by four Level 4 claims related to different aspects of electrical engineering and range from design processes, procedures and codes to assured quality in manufacturing and installation. At this stage of development, there are Claims, Arguments and Evidence supporting Claim 2.2.7, as shown in Appendix A.

This chapter and the supporting documents present the aspects of electrical engineering in the SMR-300 design. There are a number of areas in the electrical systems design where potential design changes have been identified. These risks include differences between the US and UK regulatory approaches and areas of development for the SMR-300. Project processes are available to identify and escalate these risks into design challenges and prospective design changes, if required, and have currently been used to raise one design challenge in the electrical engineering topic area, as well as further design challenges in interfacing topic areas.

There are four commitments raised at this stage, to address identified differences between the design and UK RGP codes and standards, incorporate requirements from 60/50 Hz adaptation and Grid Code compliance into electrical SSCs where appropriate, and to further develop the electrical architecture to demonstrate reduction of risk to ALARP.

The arguments and evidence presented to meet the generic SMR-300 at PSR v1 include:

- The Electrical SSCs' design is developed and evaluated in accordance with the established US design principles through the engineering processes, including design optioneering using RGP, to drive risk reduction to ALARP, and utilising BAT, secure by design and safeguards by design.
- The Electrical Power Systems architecture has been developed with appropriate DiD to provide suitably reliable and robust electrical power.
- The layout of the Electrical Power Systems includes separation provisions intended to achieve divisional independence. The plant layout activities are being developed to implement the required separation within the physical routing and separation design.
- The Electrical Power Systems design basis includes applicable codes and standards, which encapsulate over-arching non-functional system requirements derived from lessons learnt, RGP and OPEX.

- At Electrical Power System level, system functions are defined, along with functional and non-functional requirements. SSCs are categorised in accordance with the categorisation and classification methodology [5]. System lifecycle activities are also described such as EIMT.
- Design decisions are documented, to record the down-selection of options in accordance with criteria to ensure risks are reduced to ALARP.

The Design Challenges and Commitments will also be developed in accordance with the principles of ALARP; the ALARP considerations are discussed in the context of the overall SMR-300 design in an overarching ALARP summary statement in Part A Chapter 5 [8].

The information presented has included risk reduction activities across the SMR-300, which will be further developed in accordance with the principles of ALARP.

It is therefore judged that the safety of the SMR-300 relying on electrical engineering can be demonstrated, subject to resolution of the outstanding commitments, and that the Chapter claims identified have been met to a maturity aligned with the current version of the PSR. Further claims, arguments and evidence will be presented in due course as the design develops.

6.10 REFERENCES

[1] Holtec Britain, "HI-2240332, Holtec SMR GDA PSR Part A Chapter 1 Introduction," Revision 1, June 2025.

[2] Holtec Britain, "HI-2240648, GDA Design Reference Point," Revision 2, May 2025.

[3] Holtec Britain, "HI-2240334, Holtec SMR GDA PSR Part A Chapter 3 Claims, Arguments and Evidence," Revision 1, June 2025.

[4] Holtec Britain, "HI-2240121, Holtec SMR GDA Scope," Revision 1, May 2024.

[5] Holtec Britain, "HI-2240333, Holtec SMR GDA PSR Part A Chapter 2 General Design Aspects and Site Characteristics," Revision 1, June 2025.

[6] Holtec Britain, "HPP-3295-0013, Holtec SMR-300 Generic Design Assessment Capturing and Managing Commitments, Assumptions and Requirements," Revision 1, January 2025.

[7] Holtec Britain, "HI-2240335, Holtec SMR GDA PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance," Revision 1, June 2025.

[8] Holtec Britain, "HI-2240336, Holtec SMR GDA PSR Part A Chapter 5 Summary of ALARP and SSEC," Revision 1, June 2025.

[9] Holtec Britain, "HI-2240345, Holtec SMR GDA PSR Part B Chapter 14 Design Basis Accident Analysis," Revision 1, June 2025.

[10] Holtec Britain, "HI-2240346, SMR-300 GDA Part B Chapter 15 DBAA, Severe Accident Analysis, and Emergency Preparedness," Revision 1, June 2025.

[11] Holtec Britain, "HI-2240347, Holtec SMR GDA PSR Part B Chapter 16 Probabilistic Safety Assessment," Revision 1, June 2025.

[12] Holtec Britain, "HI-2240343, Holtec SMR GDA PSR Part B Chapter 12 Nuclear Site Health and Safety and Conventional Fire Safety," Revision 1, June 2025.

[13] Holtec Britain, "HI-2240350, Holtec SMR GDA PSR Part B Chapter 21 External Hazards," Revision 1, June 2025.

[14] Holtec Britain, "HI-2240351, Holtec SMR GDA PSR Part B Chapter 22 Internal Hazards," Revision 1, June 2025.

[15] Holtec Britain, "HI-2240337, Holtec SMR GDA PSR Part B Chapter 1 Reactor Coolant System and Engineered Safety Features," Revision 1, June 2025.

[16] Holtec Britain, "HI-2240777, Holtec SMR GDA PSR Part B Chapter 5 Reactor Supporting Facilities," Revision 1, June 2025.

[17] Holtec Britain, "HI-2240356, SMR-300 GDA PSR Part B Chapter 19 Mechanical Engineering," Revision 1, June 2025.

[18] Holtec Britain, "HI-2240338, SMR-300 GDA PSR Part B Chapter 4 Control and Instrumentation Systems," Revision 1, June 2025.

[19] Holtec Britain, "HI-2240357, Holtec SMR GDA PSR Part B Chapter 20 Civil Engineering," Revision 1, June 2025.

[20] Holtec Britain, "HI-2240354, Holtec SMR GDA PSR Part B Chapter 25 Construction and Commissioning Approach," Revision 1, June 2025.

[21] Holtec Britain, "HI-2240340, Holtec SMR GDA PSR Part B Chapter 9 Description of Operational Aspects and Conduct of Operations," Revision 1, June 2025.

[22] Holtec Britain, "HI-2240348, Holtec SMR GDA PSR Part B Chapter 17 Human Factors," Revision 1, June 2025.

[23] Holtec Britain, "HI-2240355, Holtec SMR GDA PSR Part B Chapter 26 Decommissioning," Revision 1, June 2025.

[24] Holtec Britain, "HPP-3295-0017, Design Management Process," Revision 1, December 2024.

[25] Holtec Britain, "HI-2240077, SMR-300 Plant Overview," Revision 1, April 2025.

[26] Holtec International, "HI-2240448, SMR-300 Project References for Design and Licensing," Revision 1, May 2024.

[27] Holtec International, "HPP-8002-0012, SMR-300 Structures, Systems, and Components Classification Procedure," Revision 0, February 2025.

[28] United States Nuclear Regulatory Commission, "10 CFR Part 50 Appendix A - General Design Criteria for Nuclear Power Plants".

[29] Institute of Electrical and Electronics Engineers, "IEEE 603, Standard Criteria for Safety Systems for Nuclear Power Generating Stations 1991 (NRC Endorsed) & 2018 (latest)".

[30] Holtec International, "HI-2230815, Topical Report on the Quality Assurance Program for Holtec International's Small Modular Reactor Design and Construction," Revision 2, June 2024.

[31] Holtec International, "HI-2240251, Top Level Plant Requirements," Revision 2, January 2025.

[32] Holtec International, "HI-2240964, System Design Description for Class 1E DCE Power Distribution System," Revision 0, September 2024.

[33] Holtec International, "HI-2240963, System Design Description for Class 1E ICE Power Distribution System," Revision 0, September 2024.

[34] Holtec International, "HI-2240910, Holtec SMR-300 Electrical Specification," Revision 0, September 2024.

[35] Holtec International, "HPP-8002-3017, SMR-300 Design Standard for Grouping and Separation," Revision 0, March 2024.

[36] Holtec Britain, "HI-2240069, Generic Site Envelope Report for SMR-300 UK GDA," Revision 2, January 2025.

[37] Office for Nuclear Regulation, "Holtec SMR300 - Step 2 - Letter Out - Information on Extended Loss of Grid Scenarios," August 2024.

[38] National Grid ESO, "The Grid Code," Issue 6, Revision 26, September 2024.

[39] Holtec Britain, "HI-2241517, Holtec SMR-300 60/50Hz Strategy," Revision 0, January 2025.

[40] Holtec Britain, "HI-2241442, Holtec SMR-300 Grid Compliance Strategy," Revision 0, January 2025.

[41] Holtec International, "HPP-8002-0002, SMR-300 Program Quality Plan," Revision 2, April 2025.

[42] United States Nuclear Regulatory Commission, "US NRC Regulatory Guides," [Online]. Available: https://www.nrc.gov/reading-rm/doc-collections/reg-guides/index.html#guides..

[43] Holtec International, "HPP-8002-0008, SmartPlant Standards," Revision 0, October 2024.

[44] Holtec Britain, "HI-2250205, Holtec SMR-300 GDA Electrical Topic Codes and Standards Analysis Report," Revision 0, April 2025.

[45] Holtec Britain, "HI-2241193, SMR-300 Safety, Security and Safeguards Principles Alignment Review," Revision 1, March 2025.

6.11 LIST OF APPENDICES

Appendix A PSR Part B Chapter 6 CAE Route Map

A summary of the SSEC claims for the Electrical engineering area is presented in Table 6. Evidence in tick bullet points indicates that these are available at PSR v1, and evidence with an open bullet indicates evidence is in development after PSR v1.

Table 6: PSR Part B Chapter 6 CAE Route Map

[REDACTED]

Appendix B High-Level, Safety and Non-Safety Functions for Electrical Engineering

Table 7: Electrical SSCs & Functional Requirements

[REDACTED]

Appendix C Detailed Impacts on Electrical Systems and other Discipline/Topic Areas

Table 8: Detailed Electrical Impacts

[REDACTED]