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6.1 INTRODUCTION

The Fundamental Purpose of the Generic Design Assessment (GDA) Safety, Security and Environment 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 United Kingdom (UK) to fulfil the future licensee's legal duties to be safe, secure and protect people and the environment as defined Preliminary Safety Report (PSR) PART A Chapter 1 Introduction [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).

Part B Chapter 6 of the PSR presents the Claims, Arguments and intended Evidence (CAE) for the design of Electrical Engineering Structures, Systems and Components (SSCs) that underpin the design of the generic SMR-300.

Note the maturity of the Holtec SMR-300 design information presented in Rev 0 SSEC is evolving and currently is based on the significantly more mature design definition associated with the SMR-160 design.

6.1.1 Purpose & Scope

The overarching SSEC Claims are presented in PSR Part A Chapter 3 Claims, Arguments and Evidence [2].

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 have been 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 [2] 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 ensure 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 subchapter 6.3.

This chapter will address all areas within the GDA Scope as defined in PSR Part A Chapter 2 General Design Aspects and Site Characteristics [3].

This chapter covers the codes and standards associated with the design of these SSCs (subchapter 6.4), the defence-in-depth (DiD) provided by the design of the SSCs (subchapter 6.5), adaption to UK Grid (subchapter 6.6), the quality manufacturing and installation approach (subchapter 6.7) and Examination, Inspection, Maintenance and Testing (EIMT) (subchapter 6.8). Finally, a summary of considerations against the ALARP principle is provided, together with any forward actions or commitments that have arisen (subchapter 6.9).

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

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

A master list of definitions and abbreviations relevant to all PSR Chapters can be found in PSR Part A Chapter 2 General Design Aspects and Site Characteristics [3].

6.1.2 Assumptions

There are no assumptions in this PSR chapter.

6.1.3 Interfaces with other PSR Chapters

The Electrical discipline interfaces with multiple plant systems and disciplines. The Electrical architecture supports delivery of the safety features for those systems described PSR Part B Chapter 1 (Reactor Coolant System and Engineered Safety Features) [4], Part B Chapter 5 (Reactor Supporting Facilities) [5] and, Part B Chapter 19 (Mechanical Engineering) [6].

Faults associated with the Electrical systems will be identified and analysed in Part B Chapter 14 (Safety/Design Basis Accident Analysis) [7]. Electrical systems providing power to Instrumentation & Control (I&C) systems are described in Part B Chapter 4 (Instrumentation & Control Systems) [8]. Part B Chapter 17 Human Factors (HF) [9] programme will review the electrical system interfaces to the operational and maintenance staff.

Hazards are addressed in chapters Part B Chapter 12 (Health and Safety and Conventional Fire Safety) [10], Part B Chapter 21 (External Hazards) [11] and Part B Chapter 22 (Internal Hazards) [12]. Part B Chapter 16 (Probabilistic Safety Assessment (PSA)) [13] considers electrical supplies as support systems for front line systems and appropriate reliability figures will be used as the PSA is developed.

Part B Chapter 9 (Description of Operational/Conduct of Operations) [14] considers safety requirements relating to electrical SSCs providing safe and reliable supplies to plant. Part B Chapter 20 (Civil Engineering) [15] considers impacts of electrical SSCs on structures. Electrical arguments will inform the overall ALARP claims in PSR Part A Chapter 5 [16].

6.1.4 Design Intent

The overall SMR-300 design intent is for the plant to operate safely and reliably within the UK grid and the design intent of the electrical architecture is to provide reliable power supplies to safety and non-safety equipment during normal operation and accident conditions. Offsite or onsite Alternating Current (AC) power sources are not required to perform safety functions due to the passive design of the SMR-300 and therefore loss of AC power does not impact the ability to perform safety functions. Safety functions are powered by the Class 1E portion of the Direct Current Power Distribution System (DCE) and Instrumentation & Control Power Distribution System (ICE) only. A loss of voltage, degraded voltage condition, or other electrical transients on the offsite or onsite non-safety AC power system does not affect the ability to achieve and maintain safe-shutdown conditions.

The plant electrical safety systems are designed to US (United States) NRC (Nuclear Regulatory Committee) requirements and IEEE (Institute of Electrical and Electronic Engineers) requirements to ensure high reliability and compliance with the Single Failure Criterion (SFC). The design considers lessons learnt and OPEX (Operating Experience) from previous events such as Fukushima, to ensure supplies are maintained for 72 hours following a Station Blackout (SBO) Event.

The SMR-300 electrical design will be based on System Design Descriptions (SDDs) documents listed below, which define the functional requirements and design basis for the individual SSCs. As the design is transitioning from SMR-160 to SMR-300, the current PSR chapter presents information relevant to SMR-160. Those referenced below are the latest approved versions:

- System Design Description for Class 1E DCE Power Distribution System [17].
- System Design Description for Non-Class 1E DCE Power Distribution System [18].
- System Design Description for Class 1E ICE Power Distribution System [19].
- System Design Description for Non-Class 1E ICE Power Distribution System [20].
- System Design Description for Medium Voltage Power Distribution System (MVE) [21].
- System Design Description for Low Voltage Power Distribution System (LVE) [22].

6.2 (REDACTED)

REDACTED

Figure 1: Redacted

6.3 ELECTRICAL ENGINEERING CLAIMS, ARGUMENTS AND EVIDENCE

The primary purpose of a CAE approach is to capture the golden thread of a safety case narrative demonstrating how plant and operational evidence is brought together to justify that a high-level or fundamental claim is true. In the context of the GDA of the generic SMR-300, this is how the Fundamental Purpose of the SSEC [1] is achieved.

The CAE provides a golden thread from the Fundamental Purpose through the SSEC via the objectives set out for each of the PSR, Preliminary Environmental Report (PER) and Generic Security Report (GSR). The overarching SSEC claims, and the philosophy of their architecture are presented in Part A Chapter 3 [2]. This chapter links to the overarching claims through Claim 2 and Claim 2.2:

Claim 2: The design and safety assessment shows that the Generic Holtec SMR-300 can be constructed, commissioned, operated and decommissioned on a generic site in the UK with risks that are tolerable and As Low As Reasonably Practicable (ALARP).

This chapter contributes directly to Claim 2.2, which is focused on the demonstration of the design and that the SSCs that form the design, are developed to ensure they meet the relevant safety requirements and appropriate codes and standards.

Claim 2.2: The design of the systems and associated processes have been 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 [2], 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 structures, 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.

Claim 2.2.7 has been further decomposed within Part B Chapter 6, across the design lifecycle, to provide confidence that the relevant requirements for all electrical SSCs will be achieved during all lifecycle phases. This has been done by breaking down Claim 2.2.7 into four further sub-claims as follows:

Sub-Claim 2.2.7.1: Electrical SSCs are designed using appropriate Codes and Standards, taking cognisance of Relevant Good Practice (RGP) and Operational Experience (OPEX).

This sub-claim shows that the design addresses the requirements in the appropriate codes and standards during the design phase and takes account of relevant good practice in existing designs and operational experience.

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

The sub-claim ensures that defence in depth 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.

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

This sub-claim ensures electrical SSCs 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: Examination, inspection, maintenance and testing regimes provide confidence in the design and continued operation of the Electrical systems for their design lifetime.

This sub-claim ensures that the Electrical systems are initially tested appropriately 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 in which subchapter of this PSR chapter these claims are addressed.

Table 1: CAE Subchapter Locations:

Claim No	Claim	Subchapter Location
2.2.7.1	Electrical SSCs are designed using appropriate Codes and Standards, taking cognisance of Relevant Good Practice (RGP) and Operational Experience (OPEX).	6.4 Codes, Standards & Methodologies
2.2.7.2	The Electrical system design incorporates Defence in Depth (DiD) to protect against anticipated operational occurrences and accident condition, whilst ensuring compliance with the UK Grid Code.	6.5 Defence in depth
2.2.7.3	Electrical SSCs achieve the design intent through quality manufacturing and installation processes.	6.7 Quality Manufacturing and Installation
2.2.7.4	Examination, inspection, maintenance and testing regimes provide confidence in the design and continued operation of the Electrical systems for their design lifetime.	6.8 Examination, Inspection, Maintenance & Testing

The current CAE route map for Part B Chapter 6 is provided in Appendix A and a further update on claim decomposition, argument development and evidence maturity will be provided in PSR Revision 1 at the end of GDA Step 2.

6.4 CODES, STANDARDS AND METHODOLOGY

Claim 2.2.7.1: Electrical SSCs are designed using appropriate Codes and Standards, taking cognisance of Relevant Good Practice (RGP) and Operational Experience (OPEX).

This subchapter outlines the codes and standards used in the design of SMR-160 Electrical SSCs, the relevant good practice considered, and the operational experience taken into account.

6.4.1 Codes and Standards

This subchapter identifies the codes, standards and regulations that have been used for the development of the electrical system architecture contained within the SMR-160 and the key codes, standards and regulations are presented in HI-2240126 Rev 0, Holtec SMR-300 Generic Design Codes and Standards Report [23]. The full list of codes and standards that have been applied in the design of the electrical systems of the SMR-160 are covered in SDDs [17], [18], [19], [20], [21], [22].

The codes and standards have been selected in accordance with the SSC safety classification outlined in subchapter 6.5.2. The codes and standards identified reflect the functional reliability requirements of the SSCs.

The US/UK Regulatory Framework and Principles Report [24] has identified Office for Nuclear Regulation (ONR) Safety Assessment Principles (SAPs) [25], which can be compared against the NRC General Design Criteria (GDC) 17 & 18 [26] and provides a comparison between US/UK regulatory frameworks. During step 2, a high level codes and standards gap analysis will be performed as part of the GDA ensuring appropriate gaps are identified, sentenced and tracked with a forward action plan developed.

Pre-identified gaps will be subject to optioneering which will include consideration of ALARP.

In some cases, the NRC has endorsed an older version of some standards and a newer version has been issued. The intention of the Requesting Party (RP) is to comply with both the NRC endorsed version and latest version. Table 2 identifies the key UK / International nuclear standards which will be used to inform GDA Step 2.

The RP will review the design against UK RGP. Documents that are currently available will be used to identify where additional work may be required to demonstrate compliance with UK expectations.

Table 2: Identified Applicable Standards Relevant to the Electrical Topic Within the UK Context.

Title of the Code/Standard/Legislation	Code/Standard Reference:	Date:
Nuclear power plants – Electrical power system – General requirements	BS EN IEC 63046	2021 [27]
Nuclear power plants – Electrical power systems – Electrical power systems analysis	BS EN IEC 62855	2016 [28]

Title of the Code/Standard/Legislation	Code/Standard Reference:	Date:
Nuclear power plants – Instrumentation, control, and electrical power systems important to safety – Separation	BS IEC 60709	2019 [29]
IAEA – Design of Electrical Power Systems for Nuclear Power Plants	SSG-34	2016 [30]

Although primarily for the use of the regulator, due account will also be taken of the relevant ONR SAPs [25] and Technical Assessment Guides (TAGs) available on the ONR website.

6.4.2 UK Statutory Regulations

The electrical design identifies potential applicable statutory regulations for the development of the electrical system architecture contained within the SMR-160/SMR-300 and is presented below. These statutory regulations will be analysed in greater detail during Step 2.

The following relevant UK statutory regulations are identified for the Electrical Systems:

- British Standard 7671 Requirements for Electrical Installations. IET Wiring Regulations [31].
- Electrical Safety, Quality and Continuity Regulations 2002 (as amended) [32].
- The Building Regulations 2000 (as amended) for England and Wales [33].
- The Electricity at Work Regulations 1989 (as amended) [34].
- The Supply of Machinery (Safety) Regulations 1992 (as amended) [35].
- The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 [10].
- The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 [36].
- Construction (Design and Management) Regulations 2015 described in Chapter B12 [10].

6.4.2.1 Relevant Good Practice and Operation Experience

See also 6.9.2.1 for information about the use of RGP and OPEX.

Several sources for lessons learnt have been reviewed, these include both from within GDA Guidance [37] and from previous GDA Submission Regulatory Observations (ROs), Regulatory Issues (RIs) and Regulatory Queries (RQs).

As part of the current GDA process the experience of previous GDAs and the relevant challenges made by the ONR to other Requesting Parties (RPs) have been reviewed and the relevant Electrical related issues identified. This has informed the gap analysis and the process of how forward action plans are managed already identified and discussed in subchapter 6.9.2.

The ONR identified lessons learned from previous GDAs for Electrical as follows:

A summary of the common lessons learnt related to Electrical Engineering is provided below from ONR-GDA-GD-007, New Nuclear Power Plants: Generic Design Assessment Technical Guidance [38]:

- The RP should fully understand the expectation for substantiation of the safety role of the electrical distribution system in a claims, arguments and evidence format to support the safety case head document. As the role of the electrical power distribution system is to support safety systems the claims on the electrical system should be established from the claims on the supported safety systems which should primarily be derived from the fault schedule. Claims should also be established for the capability of the electrical distribution system to withstand disturbances such as lightning strikes, loss of grid and electrical faults with no adverse impact on its capability to support the safety systems.
- The RP should fully understand the requirements for meeting the requirements of the UK Grid Code in order to establish a grid connection agreement. Grid Code requirements are generally for generators to remain connected during grid disturbances in order to support the grid and it is not acceptable for plants to be shut down in order to protect the plant. Full Grid Code compliance is the expectation for connection to the UK National Electricity Transmission System with any non-compliances requiring derogations from the UK electricity regulator, Office of gas and electricity markets (Ofgem). Derogation requests will generally require a supporting ALARP presentation.
- ONR requires the development of a comprehensive computer based model of the electrical system in order to verify the capability of the system to support plant loads and to withstand a range of plant disturbances. Development should start at an early stage of the GDA process. A range of studies should be performed in line with IEC 62855. The GDA model can be based on existing Office for Nuclear Regulation ONR-GDA-GD-007 Revision 0 Page 54 of 149 designs but ONR expects the capability of the design to be demonstrated in all cases.
- In demonstrating the integrity of the electrical system design particularly with regard to resilience to common cause failure the RP needs to take account of maintenance requirements. This should address under what operating conditions maintenance can be performed and definition of conditions for taking equipment out of service in order to perform maintenance activities. It is important that there is a clear distinction between maintenance surveillance activities and maintenance activities which require equipment to be taken out of service.
- The RP should define where smart devices are to be used in the electrical system and should define its approach to protect against the risk of common cause failure where smart devices are implemented. Where a claim is made that analogue technology will be used then the availability of such technology for long term applications should be substantiated.
- The GDA assessment should be based on a generic design. Site-specific design features should not be taken into account.

The lessons learnt which are summarised above are being considered and will be responded to in Rev. 1 of this chapter. We are confident that the design of the generic SMR-160 addresses these issues.

These have been taken into consideration in identifying the forward actions, which are managed as set out in subchapter 6.9, and will be more fully addressed in revision 1 of this chapter. The lessons from existing nuclear UK projects are being reviewed to identify potential improvements to the design where they are deemed to be ALARP.

6.4.3 Safety Categorisation and Classification

The safety categorisation and classification methodology currently defined for SMR-300 utilises the US NRC Regulatory Guide 1.26, Revision 6 [39] and related guidance documents.

The RP acknowledges the existence of differences in the approach to safety categorisation and classification between the NRC regulatory guides and other national and international standards.

The differences in the approach to safety categorisation and classification have been identified via the Gap Analysis [40] and the US/UK regulatory framework and principles report [24].

The project methodology for safety categorisation and classification will be developed during Step 2 of the GDA. This will address potential gaps identified in the SSEC Revision 0 relating to categorisation and classification to ensure UK regulatory expectations are addressed. The appropriate safety classification strategy for Electrical systems will be presented within Part B chapter 6 in Step 2 of the GDA.

6.4.4 Codes, Standards & Methodology Summary

The previous subchapters show that the Electrical design has been undertaken using appropriate nuclear codes and standards required in the US such as NRC and IEEE requirements. Relevant UK standards have been identified, and a proportionate comparison against these standards will be carried out as part of step 2 of GDA. RGP and OPEX have been used to inform the gap analysis and identify forward actions. The codes and standards claim will be demonstrated on that basis.

6.5 DEFENCE IN DEPTH

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

DiD is implemented primarily through the combination of a number of consecutive and independent levels of protection that would have to fail 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.

These levels are defined in the International Atomic Energy Agency (IAEA) document 'Safety of Nuclear Power Plants: Design SSR-2/1 [41] and developed in the ONR Safety Assessment Principles for Nuclear Facilities [25] 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.

The following subchapter describe how DiD is demonstrated for the electrical topic.

6.5.1 (REDACTED)

REDACTED

Figure 2: Redacted

6.5.2 Safety Functional Requirements and Identification of Electrical SSCs

Safety functions and non-safety functions have been identified and allocated to the appropriate electrical SSCs within the electrical architecture. Electrical engineering has been applied to ensure that SSCs deliver their assigned requirements. This subchapter presents the requirements that are relevant to the electrical systems. The requirements for the electrical SSCs are documented in the electrical system SDDs [17], [19] and [22].

Electrical SSCs and their safety and non-safety functions, as identified to date are presented in Table 3 below. These have been identified by following the US categorisation process leading to the safety / non safety categorisation. These are based on the SMR-160 design and will be reviewed and updated as the SMR-300 design is further developed.

Table 3: Electrical SSCs links with SFRs

System Envelope	Safety Functions	Comments (Safety)	Non-Safety Functions	Comments (Non-Safety)
LVE	The LVE has no safety functions.	N/A	• To Receive MV AC power from the MVE • To distribute LV AC power to the DCE & ICE, MG sets and LV AC loads • To sense and isolate electrical faults in the system. • To notify plant operators of abnormal conditions via control room alarms. • To permit electrical isolation to support maintenance activities.	N/A
DCE	Provide Normal Source of Power for the Class 1E 250 VDC Loads.	The DCE system is designed to provide nominal 250 VDC power to the plant's Class 1E 250 VDC loads via the Class 1E battery chargers and associated Tier 3 power distribution components.	Provide Equipment Protection.	The DCE system is designed to provide automatic fault clearing to prevent equipment or property damage resulting from electrical transients due to a malfunction of the electrical system itself or the components fed by the electrical system.
	Provide Normal Source of Power for the Class 1E ICE System.	The DCE system is designed to provide an uninterrupted supply of Tier 3, nominal 250 VDC power to the ICE system via the Class 1E UPS'. The ICE system converts the nominal 250 VDC power to nominal 120 VAC power for those Class 1E loads that require this voltage level. [19] provides the SDD for the ICE system.	Provide Means of Electrical De-energisation.	The DCE system is designed to provide a means to allow circuits to be manually deenergized as necessary for worker protection during the performance of maintenance activities, and in support of plant evolutions requiring specific components to be de-energised.
	Maintain the Station Batteries in a Fully Charged State.	The Class 1E battery chargers are designed to provide a constant float charge or equalizing charge, as required, in order to maintain the Class 1E station batteries in a fully charged state.	Provide Means of System Monitoring.	The DCE system is designed to allow monitoring of system status including voltage levels, current (amperage) levels, breaker status, and alarms.

System Envelope	Safety Functions	Comments (Safety)	Non-Safety Functions	Comments (Non-Safety)
	Provide Uninterrupted Backup Power to All Class 1E Loads Assuming a Single Failure.	The DCE system is designed to provide an uninterrupted supply of Tier 3, nominal 250 VDC power to all Class 1E loads following a DBA such as a fire, flooding event, earthquake, or other DBA. Following a SBO where all AC power is lost (including loss of the N1E standby diesel generators), the DCE system is designed to provide, via the fully charged station batteries, an uninterrupted supply of power to all Safety Related loads for the duration of time necessary to prevent or mitigate the consequence of an accident.		
ICE	Provides isolation between Class 1E and non-Class 1E portions of the electrical distribution.	The Regulating Transformer provides the required isolation between the non-Class 1E and Class 1E portions of the electrical distribution.	Provide Equipment Protection.	The ICE system is designed to provide automatic fault clearing to prevent equipment or property damage resulting from electrical transients due to a malfunction of the electrical system itself or the components fed by the electrical system.
	Provides power to the Class 1E ICE components and loads.	The Class 1E UPS or the Regulating Transformer provide constant AC power to each Class 1E PPL and AC loads.		
	Provides Two Redundant Power Sources to All Class 1E Loads.	The ICE system is designed to have uninterrupted power to all Class 1E loads in all conditions. Under normal operation the Class 1E UPS feeds all the Class 1E loads, Under SBO the batteries from the DCE system feeds the Class 1E loads. When the UPS itself is not in operation due to failure or if its undergoing maintenance, then the Regulating Transformer feeds all the Class 1E loads and components.	Provide Means of Electrical De-energisation.	The ICE system has the functionality to provide a means to de-energize the UPS manually for worker protection during maintenance or plant evolutions activities for specific components.
			Provides Means of System Monitoring.	The ICE system is designed to allow monitoring of system status including voltage levels, load on inverter and static bypass switch, current levels, breaker status and alarms.
	Maintain the Station Batteries in a Fully Charged State.	The Class 1E battery chargers are designed to provide a constant float charge or equalizing charge, as required, in order to maintain the Class 1E station batteries in a fully charged state.	Provide Means of System Monitoring.	The DCE system is designed to allow monitoring of system status including voltage levels, current (amperage) levels, breaker status, and alarms.

6.5.3 Electromagnetic Pulse Resistance

The SMR-300 design is protected from electromagnetic pulses (EMPs). The SMR-300 Class 1E system is electrically isolated from the non-Class 1E system. The Class 1E containment penetrations are in isolated rooms, reducing Electromagnetic Pulse Resistance intrusion pathways. The Containment Enclosure Structure (CES) is a several foot-thick concrete structure with a steel-lined interior that can effectively block electromagnetic interference.

6.5.4 Earthing, Lightning Protection & Electromagnetic Compatibility

The Holtec SMR-300 Electrical Systems will contain earthing and isolation points, the requirements for which will be informed by the design in addition to regulations and applicable codes and standards. These will include but are not limited to a need for a low impedance path to ground for fault currents and lightning discharges, protecting the personnel from injury and the equipment from electrical shock hazards.

The Earthing and Lightning Protection System, and the overall approach to ensuring electromagnetic compatibility is still in development.

6.5.5 (REDACTED)

6.5.6 Defence in Depth Summary

The electrical architecture provides electrical systems that contribute to DiD levels. Stable electrical supplies are provided to plant systems used in normal operation including I&C systems used for monitoring and control that contribute to DiD levels 1 and 2. The architecture supports level 3 of DiD by providing supplies to class 1E loads to support protection functions and ensures level 4 of DiD by providing supplies to systems for accident monitoring.

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 grid code has been identified and a strategy to address the requirements in the UK grid code will be developed. Further information is provided in subchapter 6.6.

EMP within the electrical system as well as Earthing, Lightning Protection & Electromagnetic Compatibility is being considered to reduce the risk of system failure or any faults that could jeopardise safety of plant equipment. The design has been analysed for modes of operation and the DiD associated with operation has been considered. The DiD claim will be demonstrated on that basis.

6.6 ADAPTION TO UK GRID

To satisfy the requirements of Ofgem which are defined in the UK Grid Code [42] a design will be developed that can be safely operated, maintained, and supported within the UK. Two strategies are in production to demonstrate that the generic SMR-300 will support highly reliable operation of the grid system as stated within IAEA SSG-34 [30] in compliance with the grid code [42].

6.6.1.1 (REDACTED)

6.6.1.2 (REDACTED)

6.7 QUALITY MANUFACTURING AND INSTALLATION PROCESSES

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

The manufacturing and installation processes are controlled as part of the quality assurance arrangements for the electrical systems.

6.7.1 Manufacturing

The electrical engineering described in this chapter topic follow Holtec SMR-300 procedure for selection of reputable and reliable contractors with appropriate Quality Assurance (QA) and Quality Control (QC) arrangements that are aligned with the classification of the electrical system. Verification activities will demonstrate that the equipment has been manufactured correctly. Further information to support the quality of manufacture claim will be presented in PSR Rev 1.

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 [43] and IEEE standards.

6.7.2 Installation

The electrical systems will be installed by the equipment supplier or approved contractors in accordance with their approved QA arrangements under the supervision of Holtec 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.

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 PSR Part B Chapter 25 [44].

The HPP-160-3004, SMR-160 Systems, Structures and Components Classification Standard [45] describes the link between electrical systems safety class and corresponding quality class. Further information to support the quality of installation claim will be presented in PSR Rev 1.

6.7.3 Manufacturing and Installation Process 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.

QA arrangements aligned with the safety of the electrical systems will be used to ensure that suppliers are selected, equipment is manufactured and installed in accordance with the design intent. The quality manufacturing and installation claim will be demonstrated on that basis.

6.8 EXAMINATION INSPECTION MAINTENANCE AND TESTING

Claim 2.2.7.4: Examination, maintenance, inspection and testing regimes provide confidence in the design and continued operation of the Electrical systems for their design lifetime.

EIMT is generically addressed in PSR Part B Chapter 9 Conduct of Operations [46]. However, for electrical systems there are specific requirements.

As part of the overall lifecycle development the electrical systems will be subject to a number of verification and validation activities as set out in a verification and validation plan, including testing at various stages. These will typically include item tests, integration tests, works acceptance tests, site installation, site acceptance tests, electrical commissioning and plant commissioning.

Electrical systems will be subject to commissioning tests that will demonstrate that the electrical systems perform safely, reliably and efficiently.

Vendor guidance for equipment procured will provide assurance that the electrical systems remain operable within the design life and to ensure defects will be detected before becoming a threat to the life cycle of plant.

Routine examination and maintenance arrangements will be defined and documented in accordance with manufacturers recommendations and the relevant standards and guides.

6.8.1 EIMT Summary

Electrical systems will be commissioned in isolation to ensure stable functioning of electrical supplies prior to further testing as part of the plant commissioning. In operation, EIMT arrangements will ensure that the electrical systems continue to provide the required functions throughout their life. The EIMT claim will be demonstrated on that basis.

6.9 CHAPTER SUMMARY AND CONTRIBUTION TO ALRAP

This subchapter 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. PSR Part A Chapter 5 [16] sets out the overall approach for demonstration of ALARP and how contributions from individual Chapters are consolidated.

This subchapter therefore consists of the following elements:

- Technical Summary;
- ALARP Summary
  - Review against Relevant RGP;
  - Demonstration against risk targets
    - Evaluation of Risk (where applicable);
  - Risk Reduction Options
  - GDA Commitments and Forward Actions (FAs).
- Conclusion.

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

6.9.1 Technical Summary

PSR Part B Chapter 6, Revision 0 demonstrates that the Electrical Engineering SSCs within the scope of this report will meet the high-level Claims of the SSEC and that the SSCs can be substantiated at Pre-Construction Safety Report (PCSR) stage. This is demonstrated through the following claim and associated sub-claims:

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.

The SMR-160 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 this chapter. Relevant good practice and operational experience has been considered and will be further reviewed as part of step 2 of the GDA.

The SMR-160 electrical architecture and electrical system design supports the overall defence in depth approach by providing systems with a stable supply within normal operation which contributes to levels 1 & 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 SMR-300 electrical systems, based on SMR-160 design, will be manufactured and installed in accordance with appropriate quality assurance arrangements to ensure the design intent is achieved and the systems operate adequately in the site environment.

EIMT will demonstrate the fitness for purpose of electrical SSCs through electrical system commissioning tests prior to plant commissioning. Once in operation, ongoing examination, inspection, maintenance and testing throughout the operational life of the electrical systems will ensure the electrical systems continue to safely provide the required electrical supplies for the plant.

The key requirement of the electrical SSCs is to provide the required safety and non-safety functions at the required integrity.

PSR Revision 1 will demonstrate through further arguments and evidence that the electrical SSCs provide the required functions at the required integrity levels and faults arising are minimised.

6.9.2 ALARP Summary

The preceding subchapters outline the system descriptions, functional requirements, and high-level claims relating to Electrical Engineering.

Part A Chapter 5 of this PSR [16] considers the totality of the SMR-300 design against the ALARP principles. This subchapter presents the ALARP considerations specific to this topic area. The methodology for this is discussed in Part A Chapter 5 [16] and consists of two main elements:

- The design complies with 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 subchapters 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.

The overall safety case of the RP aims to consider that all potential risks associated with activities on site are captured and measures have been identified and will be implemented to mitigate the risk to staff and public to a level that is ALARP. Therefore, any gaps that have been identified are summarised, and a forward action plan has been created.

(REDACTED)

6.9.2.1 Demonstration of RGP

The design of the SMR-160 Electrical SSCs complies with NRC requirements applicable in the US where the present electrical design follows codes and standards endorsed by the USNRC and internationally recognised bodies such as the IAEA.

The principal codes and standards identified within subchapter 6.4 are considered RGP by the UK nuclear industry. This is based on existing practices adopted on UK nuclear licensed sites, application in earlier and successful GDAs, as well as recognition as RGP by ONR SAPs [25] and TAGs.

6.9.2.2 Demonstration of Risk Targets

The numerical targets against which the demonstration ALARP is considered can be found in PSR Part A Chapter 2 [3]. 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.

6.9.2.2.1.1 Evaluation of Risk

Evaluation of nuclear safety risk is not directly applicable to electrical engineering SSCs, as they are supporting systems for the main systems performing nuclear safety function. 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.

At this time, the evaluation of the normal operations and accident risks against Targets 1-9 has not been provided. This information will be presented in PSR Part B Chapter 10 'Radiological Protection' [47] for normal operations, and PSR Part B Chapter 14 'Safety/Design Basis Accident Analysis' [7], Chapter 15 'Beyond Design Basis and Severe Accident Analysis, and Emergency Preparedness' [48], Chapter 16 'Probabilistic Safety Analysis' [13] for accident conditions.

6.9.2.3 Risk Reduction Options

This is a placeholder to identify and review relevant Position Papers and Design Decision Papers with a view to demonstrate which option(s) is/are ALARP.

It will summarise those option evaluations, and it will briefly explore if other risk reduction options have or could be considered and either:

- Present the ALARP argument for why those options have not been implemented.
- Present the ALARP argument for why those options will be implemented in future.
- Create a Forward Action to consider the option(s) at some future point (noting this still must be a point where a meaningful design improvement could be made).

The process for the assessment of risk reduction options is presented in HPP-3295-0017-R0, Holtec SMR-300 Generic Design Assessment Reference Design Process and GDA Prospective Design Change Register [49]. Part A Chapter 5 of this PSR 'ALARP Summary' [16] considers the holistic risk-reduction process for the generic SMR-300.

The 60/50Hz design transition and grid code compliance options will be presented as part of the design decision process that incorporates ALARP decision making.

6.9.2.4 GDA Commitments and Forward Actions

There are no GDA commitments identified for Part B Chapter 6, Electrical Engineering.

FAs will form the basis for setting out the process to justify any gaps from UK RGP. FAs have been collated and are managed via the process described in Holtec SMR GDA PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance [50].PSR Part A Chapter 5 'ALARP Summary' [16] describes the contribution of the FAs to the ALARP argument. The Gap's that have been identified and deemed relevant to Electrical Engineering and will be developed within Step 2 of the GDA process.

6.9.3 Conclusion

This chapter summarises the overall electrical architecture and electrical systems design. It identifies the claims and arguments that will form the basis of the safety case for the electrical topic throughout the lifecycle of SMR-160/SMR-300 to a maturity aligned to a PSR.

As the design and safety case are developed, evidence will be provided to substantiate these claims. It is recognised that there are different Codes, Standards, Methodologies and practices between the UK and US. FAs have been identified to review these different approaches. This will be carried out in accordance with the ALARP principle.

Similarly, FAs have also been identified to resolve the key technical differences between the US and UK justification for electrical systems, e.g. the production of strategies to define the approach to 60/50Hz frequency generation and grid code compliance. These activities will also be developed in accordance with the principles of ALARP and 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 [16].

It is therefore judged that the safety of the electrical design will be demonstrable subject to resolution of the outstanding items and future action plans.

6.10 REFERENCES

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6.11 LIST OF APPENDICES

Appendix A Electrical Engineering CAE Route Map

Table 4: Electrical Engineering CAE Route Map

Overarching SSEC Claim	Chapter Claim	Chapter Sub Claim
Claim 2.2 - System/Process Design and Substantiation The design of the systems and associated processes have been developed taking cognisance of relevant good practice and substantiated to achieve their safety and non-safety functional requirements.	**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.	**Sub-claim 2.2.7.1:** Electrical SSCs are designed using appropriate Codes and Standards, taking cognisance of Relevant Good Practice (RGP) and Operational Experience (OPEX).
		Sub-claim 2.2.7.2: The Electrical system design incorporates Defence in Depth to protect against anticipated operational occurrences and accident conditions, whilst ensuring compliance with UK grid code.
		Sub-claim 2.2.7.3: Electrical SSCs achieve the design intent through quality manufacturing and installation processes.
		Sub-claim 2.2.7.4: Examination, Inspection, Maintenance and Testing regimes provide confidence in the design and continued operation of the Electrical systems for their design lifetime.