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General Nuclear System Ltd.

UK HPR1000 GDA Project

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Title:

Pre-Construction Safety Report

Chapter 1

Introduction

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MODIFICATION RECORD

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000	ALL	ALL	First Issue

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1.1 List of Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
CGN	China General Nuclear Power Corporation
DAC	Design Acceptance Confirmation
EDF S. A.	Électricité de France S. A.
ERIC	Eliminate, Reduce, Inform, Control
GDA	Generic Design Assessment
GNI	General Nuclear International
GNS	General Nuclear System Limited
GPP	General Principles of Prevention
GSR	Generic Security Report
HPR1000 (FCG3)	Hua-long Pressurised Reactor under construction at Fangchenggang nuclear power plant unit 3
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
MSQA	Management of Safety and Quality Assurance
NC	Non-classified
ONR	Office for Nuclear Regulation (UK)
PCER	Pre-Construction Environmental Report
PCSR	Pre-Construction Safety Report
PSR	Preliminary Safety Report
RP	Requesting Party
SSER	Safety, Security and Environment Report
UK HPR1000	UK version of the Hua-long Pressurised Reactor

1.2 Introduction

The Pre-Construction Safety Report (PCSR) is part of Safety, Security and Environment Report (SSER), which presents the safety aspects of the UK version of the Hua-long Pressurised Reactor (UK HPR1000), in its development from the Hua-long Pressurised Reactor under construction at Fangchenggang nuclear power

plant unit 3 (HPR1000 (FCG3)) which is designed, licensed and being constructed in China. The Pre-Construction Environmental Report (PCER) and Generic Security Report (GSR) present the environmental and security assessment of the proposed design respectively. Together, these documents aim to demonstrate that the design of the UK HPR1000 is suitable for its intended construction, commissioning, operation and ultimate decommissioning, on a generic site in the United Kingdom.

The Requesting Party (RP) for the UK HPR1000 Generic Design Assessment (GDA) process is constituted jointly by China General Nuclear Power Corporation (CGN), Éléctricité de France S.A. (EDF S. A.) and General Nuclear International (GNI). General Nuclear System Limited (GNS) is appointed by the above shareholders to act on behalf of the RP. The GNS Shareholder Agreement sets out the full specification of the governance arrangements and decision making processes for GDA. The structure and roles of RP are outlined in Chapter 20 of the PCSR.

This chapter corresponds to Preliminary Safety Report (PSR) Chapter 1.

This PCSR Chapter 1 is structured as follows:

a) Sub-chapter 1.1 List of Abbreviations and Acronyms:

   This sub-chapter lists the abbreviations and acronyms that are used in this chapter.

b) Sub-chapter 1.2 Introduction:

   This sub-chapter gives a brief introduction of the PCSR and this chapter.

c) Sub-chapter 1.3 Purpose of the PCSR:

   This sub-chapter briefly outlines GDA process and describes the purpose of the PCSR.

d) Sub-chapter 1.4 GDA Scope:

   This sub-chapter briefly describes the proposed scope for the UK HPR1000 design submitted for GDA.

e) Sub-chapter 1.5 Design Reference:

   This sub-chapter introduces the UK HPR1000 Design Reference which lists all the documents that describe the design of the reactor and associated plant that the GDA submissions refer to.

f) Sub-chapter 1.6 Safety Case Route Map:

   This sub-chapter presents the hierarchy of claims from the Fundamental Objective (defined in Section 1.6.2) through to the Claims presented in the chapters of the SSER.

g) Sub-chapter 1.7 Structure and Contents of the PCSR:

This sub-chapter presents a summary of the structure and contents for each PCSR chapter.

h) Sub-chapter 1.8 Concluding Remarks:

This sub-chapter gives conclusions of this chapter.

i) Sub-chapter 1.9 References:

This sub-chapter lists the supporting references of this chapter.

During the draft, review and use of the SSER and supporting documents, the correct understanding and proper usage of the terminology are necessary to be harmonised. In particular, the principles, requirements and design descriptions presented in all documents for GDA must be clearly expressed. For this purpose, Reference [1] defines and explains the terminology applied in GDA.

1.3 Purpose of the PCSR

The PCSR is a key reference that supports the UK HPR1000 GDA process. The GDA process is briefly outlined below to present the PCSR in context, which is based on the *Generic Design Assessment Guidance to Requesting Parties*, Reference [2]:

a) Preparation of the design, safety case and security submissions

Step 1 is the preparatory part of the design assessment process. This involves the RP setting up the management arrangements and technical teams for GDA. Preliminary discussions between the RP and the Office for Nuclear Regulation (UK) (ONR) are held to ensure an understanding of the requirements and processes that will be applied. During Step 1, submissions for Step 2, primarily the Preliminary Safety Report (PSR), and the supporting references are prepared.

b) Fundamental design, safety case and security claims overview

Step 2 is an overview of the acceptability, in accordance with the UK regulatory regime, of the design fundamentals, including review of key safety and security claims. Step 2 of the GDA process requires the RP to submit a PSR providing an outlined description of the plant systems and structures, the design and safety philosophy, the codes and standards applied in the design, the quality management systems applied by the designers, and security related information. The aim is to present the fundamentals of the design and provide a basis for planning subsequent, more detailed assessment.

c) Overall design, safety case and security arguments review

Step 3 is a primarily review of the arguments supporting the RP’s claims regarding the safety and related security aspects of the proposed design. The

intention in this step is to move from the fundamentals of the previous step to an analysis of the design, primarily at the system level and by analysis of the RP's arguments that support the safety and security claims.

d) Detailed design, safety case and security evidence assessment

Step 4 is an in-depth assessment of the safety case evidence, security case evidence and the generic site envelope. The intention of this step is to move from the safety arguments and system level assessment of Step 3 to a fully detailed examination of the available evidence given in the safety and security submissions. Step 4 of the GDA process requires the RP to provide further detailed information, including arrangements for ensuring construction quality, justification of operating limits, arrangements for developing plant operational, maintenance and testing procedures, and arrangements for supporting future licensees to put in place their site licensing arrangements. Additional evidence will become available during the nuclear site licensing phase, and will further support the claims and arguments made in the GDA.

Upon successful completion of Step 4, which marks the completion of the GDA process, a Design Acceptance Confirmation (DAC) will be issued to the RP by the ONR.

Version 0 of the PCSR has been prepared to provide an overall design and safety case arguments. The aim of this version of the PCSR is to demonstrate that UK requirements and expectations could be met as far as practicably by the proposed UK HPR1000 design. The PCSR will also act as a “route map” to detailed safety justifications for future operators.

1.4 GDA Scope

The proposed technical scope for the UK HPR1000 GDA project, and the limit of GDA scope, including items that are outside of the RP’s responsibility, are presented in *GDA Scope for UK HPR1000 Project*, Reference [3]. This PCSR provides provisional GDA scope that will be refined throughout the GDA process.

The proposed scope for the UK HPR1000 design submitted for GDA is briefly presented as follows:

a) Structures in Scope

Safety Class 1 and Class 2 structures and/or Seismic Category 1 and Seismic Category 2 structures that are independent of the site specific conditions have been considered in the scope of GDA for UK HPR1000. In addition, some site specific buildings that are important to nuclear safety and some Non-classified (NC) Buildings where collapse could affect Class 1 and Class 2 structures are included. But only generic information is provided for these site specific buildings and NC buildings in the PCSR.

b) Plant Systems in Scope

The scope for GDA comprises systems that perform or support any of the following function:

1) Reactivity control;

2) Containment of radioactive substances;

3) Heat transfer or removal;

4) Environmental protection;

5) Waste production or other environmental impact (e.g. water abstraction);

6) Security.

Only systems that have a role (direct or supporting) in ensuring nuclear safety, environmental protection or security are included in the GDA scope. If a system delivers more than one function, then only the functions listed above are in the GDA scope.

c) Components in Scope

The GDA scope comprises components whose failure could affect the safety margin. This includes components that directly handle nuclear materials or whose reliability or other characteristics are essential for the realisation of a safety function.

For the majority of the plant, the detailed design of components will be provided by the suppliers who are not determined in GDA phase. Hence, detailed information will not be included. The level of detail required for GDA will be justified for each case and some areas require more detail design to be established for GDA. There are some areas where the design of the components will be established at the GDA stage for reasons of high safety, or functionality, related to the reactor design. The principal examples will comprise the primary circuit components, including (for example), Reactor Pressure Vessel, Steam Generators, Reactor Coolant Pumps and Pressurisers.

d) Extent of Analysis

A preliminary indication of the limits of scope for each topic area is presented in Reference [3]. This scope may be expanded through GDA Steps 3 and 4 to support claims and arguments made in the safety case.

e) Limits of RP’s Responsibility for GDA

Reference [3] describes the limit of GDA scope, based on the principles governing extent of analysis and the extent of RP’s responsibility. The following reasoning is applied to determine the limit of scope based on the extent of RP’s

responsibility:

1) Structures, systems and components that are not required for nuclear safety, security or environmental justification will not be presented by RP for assessment during GDA;

2) Designs or processes that are licensee or site dependent are not presented by the RP for assessment during GDA. Methodologies for development may be presented if required and appropriate;

3) Where a design is supplier related and the supplier cannot be determined at the time of GDA, the design details are not presented by the RP for assessment during GDA. Design specifications may be presented if required and appropriate;

4) If the level of detail requested could not reasonably be provided during the time frame of GDA, then RP will present methodologies and/or principles and/or assumptions for development in order to build confidence during GDA and the detail will be submitted during site licensing phase.

1.5 Design Reference

Design Reference is part of the GDA project. It provides a clear statement of design that the SSER will be based on. The first version of UK HPR1000 Design Reference, which lists all the documents that describe the design of the reactor and associated plant that the GDA submissions refer to, has been established. Design changes will be made during GDA process if needed. This PCSR is produced based on the first version of UK HPR1000 Design Reference, Reference [4].

1.6 Safety Case Route Map

1.6.1 Methodology of Safety Case Route Map

The purpose of the Route Map is twofold:

a) To present the hierarchy of claims and set out the trail from the Fundamental Objective through to the Claims presented in the SSER and then down to the Arguments and Evidence;

b) To present and track the interfaces between chapters in the SSER, to ensure that these interfaces are properly managed and do not lead to omissions or gaps.

The following guidelines have been adopted:

a) Clarity: There are up to a maximum of 10 lower level claims supporting each claim at the level above. This allows the reader to gradually step through the hierarchy of claims, understanding each step in turn;

b) Accessibility: The Route Map is accessible to the authors of the SSER chapters,

so that they can interrogate and confirm the requirements on chapters and the links between chapters;

c) Up-to-date: The Route Map is intended to be kept alive and modified throughout the GDA process, to track and control changes to the scope and content of chapters and their interfaces, and to record the agreed wording of claims. As evidence is developed, it is acknowledged that the arguments, and therefore the claims may need to change. The Route Map will manage this process.

It should be noted that the Route Map sets out a "direction of travel" at the start of the development of the SSER. The Route Map will only be finalised when the last piece of evidence is developed that confirms the proposed arguments. However, using the Route Map to manage the development of the safety claims and arguments allows each person contributing to the SSER to see how their contribution supports the project's Fundamental Objective.

The Route Map includes the following:

a) Fundamental Objective (from the PSR);

b) A number of specific, high level objectives (Level 1 Claims) supporting the Fundamental Objective;

c) A number of Level 2 Claims supporting Level 1 Claims;

d) A number of chapter level claims and arguments[1] supporting Level 2 Claims.

A general overview of Route Map is showed in F-1.6-1.

1.6.2 Initial Development of Objectives

The UK HPR1000 has the following Fundamental Objective, which combines the consideration of nuclear and conventional safety, security and environment, in order to ensure an integrated and balanced design:

Fundamental Objective: *The Generic UK HPR1000 could be constructed, operated, and decommissioned in the UK on a site bounded by the generic site envelope in a way that is safe, secure and that protects people and the environment.*

The International Atomic Energy Agency (IAEA) presents their fundamental safety objective, which is to protect people and the environment from harmful effects of ionising radiation, Reference [5]. The UK HPR1000 Fundamental Objective is aligned with this safety objective, but includes a broader scope of security and environmental protection (which includes consideration of the radiological and non-radiological impacts). The Fundamental Objective is appropriate for the GDA phase of the UK HPR1000 project, and will be shown to be justified through the suite of documents provided in the SSER.

[1] Chapter level claims and arguments are not presented in Chapter 1, but addressed in chapters of SSER

The Level 1 Claims cover five areas of significance:

a) Claim 1: Site characteristics;

b) Claim 2: Design development and organisational arrangements;

c) Claim 3: Nuclear safety;

d) Claim 4: Environmental protection, security and conventional safety;

e) Claim 5: Decommissioning.

The Fundamental Objective and the five Level 1 Claims are also presented in F-1.6-2.

These Claims were previously presented in the PSR, and have been developed further in the PCSR.

1.6.3 Site Characteristics

The Level 1 Claim 1 covers the characteristics of the generic UK site. Some of the key parameters that are used in the design are drawn from the characteristics of the site. Claim 1 is as follows:

Site characteristics: *The generic site characteristics for UK HPR1000 design reflect a generic UK site that bounds suitable locations.*

Meeting this claim shows that the UK HPR1000 design characteristics are suitable for a generic UK site. The site characteristics affect the assumptions underpinning the external hazard assessment, the assessment of systems and of the civil structures, the environmental assessments and the calculations of the dose assessments. This Level 1 Claim is underpinned by two Level 2 Claims:

a) ***Claim 1.1:*** *The site characteristics are identified in a systematic method and the characteristics of the three potential UK sites produce an appropriate generic site envelope;*

b) ***Claim 1.2:*** *The characteristics adopted in the environmental assessment reflect those of the generic site.*

These Level 2 Claims are addressed in PCSR Chapter 3 (Generic Site Characteristics) and PCER.

The hierarchy of Level 1 Claim 1 and supporting chapters are presented in F-1.6-3.

1.6.4 Design Development and Organisational Arrangements

The Level 1 Claim 2 covers the organisational arrangements that are in place to successfully conduct the design review. Claim 2 is as follows:

Design development and organisational arrangements: *The UK HPR1000 design will be developed in an evolutionary manner, using robust design process, building on*

relevant good international practice, to achieve a strong safety and environmental performance.

Meeting this claim shows that the UK HPR1000 design has been developed and substantiated in an evolutionary manner and by using suitable processes. In addition, it shows that the work to support the UK HPR1000 GDA has been undertaken by a suitably competent team, working under suitable management arrangements. This Level 1 Claim is underpinned by seven Level 2 Claims:

a) ***Claim 2.1****: The historic development process of the HPR1000 (FCG3) was based on relevant good international practice;*

b) ***Claim 2.2****: Suitable organisational arrangements are in place for the development & substantiation of the UK HPR1000;*

c) ***Claim 2.3****: Suitable General Safety and Design Principles are in place to ensure the design meets the nuclear safety objective;*

d) ***Claim 2.4****: General Principles of Prevention (GPP) and Eliminate, Reduce, Inform, Control (ERIC) Principles are in place to ensure the design meets the Environmental Protection, Security and Conventional Safety Objective;*

e) ***Claim 2.5****: Suitable Security Principles are in place to ensure the design meets the Environmental Protection, Security and Conventional Safety Objective;*

f) ***Claim 2.6:*** *Suitable Environmental Principles are in place to ensure the design meets the Environmental Protection, Security and Conventional Safety Objective;*

g) ***Claim 2.7****: Suitable Decommissioning Principles are in place to ensure the design meets the Decommissioning objective.*

The hierarchy of Level 1 Claim 2 and supporting chapters are presented in F-1.6-4.

1.6.5 Nuclear Safety

The Level 1 Claim 3 covers the area of nuclear safety, protecting people (workers and the public) from the harmful effects of radiation. Claim 3 is as follows:

Nuclear safety: *The design and intended construction and operation of the UK HPR1000 will protect the workers and the public by providing multiple levels of defence to fulfil the fundamental safety functions, reducing the nuclear safety risks to a level that is as low as reasonably practicable.*

The UK HPR1000, in common with most nuclear power plants, has three fundamental safety functions, Reference [6]:

a) Control of reactivity;

b) Removal of heat from the reactor and from the fuel store;

c) Confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.

Meeting this Nuclear Safety Claim shows that the design and intended construction and operation of the UK HPR1000 have been developed to ensure that the nuclear safety risk is As Low As Reasonably Practicable (ALARP).

The Nuclear Safety Claim is consistent with the fundamental safety objective "to protect people and the environment from harmful effects of ionising radiation" as per the IAEA's *Fundamental Safety Principle,* Reference [5].

In order to meet the Nuclear Safety Claim, design principles are required that consider nuclear safety risk to workers and the public during commissioning, normal operation, faults and during decommissioning. This Level 1 Claim is underpinned by four Level 2 Claims:

a) ***Claim 3.1****: The plant design is sufficiently developed based on reference design;*

b) ***Claim 3.2****: A comprehensive fault and hazard analysis has been used to specify the requirements on the safety measures;*

c) ***Claim 3.3:*** *The design of the processes and systems has been substantiated and the safety aspects of operation and management have been substantiated;*

d) ***Claim 3.4****: The safety assessment shows that the nuclear safety risks are ALARP.*

The design reference configuration is presented in PCSR Chapter 2 (General Plant Description), and further details are provided in the suite of system chapters. Operating limits are derived from the system chapters and the fault analysis chapters, based on the approach to managing the operational envelope presented in PCSR Chapter 31 (Operational Management).

The fault and hazard analysis is presented in the following chapters:

a) PCSR Chapter 12 (Design Basis Condition), covering faults and accidents that are considered as design basis conditions;

b) PCSR Chapter 13 (Design Extension Conditions and Severe Accident Analysis), covering accidents that are considered as beyond the design basis conditions;

c) PCSR Chapter 14 (Probabilistic Safety Analysis), covering a summation of risk from design basis conditions and beyond design basis conditions, in order to understand the key contributors to risk, and to inform improvement options considered during the design review process;

d) PCSR Chapter 18 (External Hazards) and PCSR Chapter 19 (Internal Hazards), covering a comprehensive examination of the effects on safety of external and internal hazards.

From the work in the fault analysis chapters, it is then possible to identify the requirements on the systems and operators. The fault analysis identifies which systems and operations are claimed to arrest particular fault sequences, hence a comprehensive set of requirements are derived from the fault schedule and hazards schedule. These requirements are then substantiated in the various system chapters (including the Human Factors Chapter, as the operator has a role in reducing risk).

PCSR Chapter 33 (ALARP Evaluation) summarises the ALARP evaluation for UK HPR1000 supported by the detailed ALARP assessments presented in the system chapters and analysis chapters. PCSR Chapter 33 will incorporate the improvements that are reasonably practicable, thereby will demonstrate that the risk has been reduced to the level that is ALARP.

The hierarchy of Level 1 Claim 3 and supporting chapters are presented in F-1.6-5.

1.6.6 Environmental Protection, Security and Conventional Safety

The Level 1 Claim 4 covers the key areas of environmental protection, security and conventional safety. Level 1 Claim 4 is as follows:

Environmental Protection, Security and Conventional Safety: *The design, and intended construction and operation, of the UK HPR1000 will be developed to reduce, so far as is reasonably practicable, the health and safety risks to the workers and the public, and the impact on the environment.*

Meeting this Claim, in combination with Level 1 Claim 3, shows that the design of the UK HPR1000 is balanced, and the overall risks have been reduced so far as is reasonably practicable. This Level 1 Claim is underpinned by three Level 2 Claims:

a) ***Claim 4.1****: An optimal level of protection of the environment and the population is achieved and maintained;*

b) ***Claim 4.2:*** *Conventional safety and conventional fire safety are managed to ensure that the conventional health and safety risks, and fire safety risks to workers and the public are reduced so far as is reasonably practicable;*

c) ***Claim 4.3****: The security threat will be managed to protect the public and workers from the risks arising from a radiological event caused by the theft or sabotage of nuclear or other radioactive material and supporting systems or through the compromise of sensitive nuclear information.*

The environmental assessment is presented in the PCER which replaces PCSR Chapter 26. The conventional safety assessment is presented in PCSR Chapter 25 (Conventional Safety and Fire Safety). The security assessment is presented in the GSR, which replaces PCSR Chapter 27.

The hierarchy of Level 1 Claim 4 and supporting chapters are presented in F-1.6-6.

1.6.7 Decommissioning

The Level 1 Claim 5 covers decommissioning. Level 1 Claim 5 is as follows:

Decommissioning*: The UK HPR1000 will be designed, and is intended to be operated, so that it can be decommissioned safely, using current available technologies, and with minimal impact on the environment and people.*

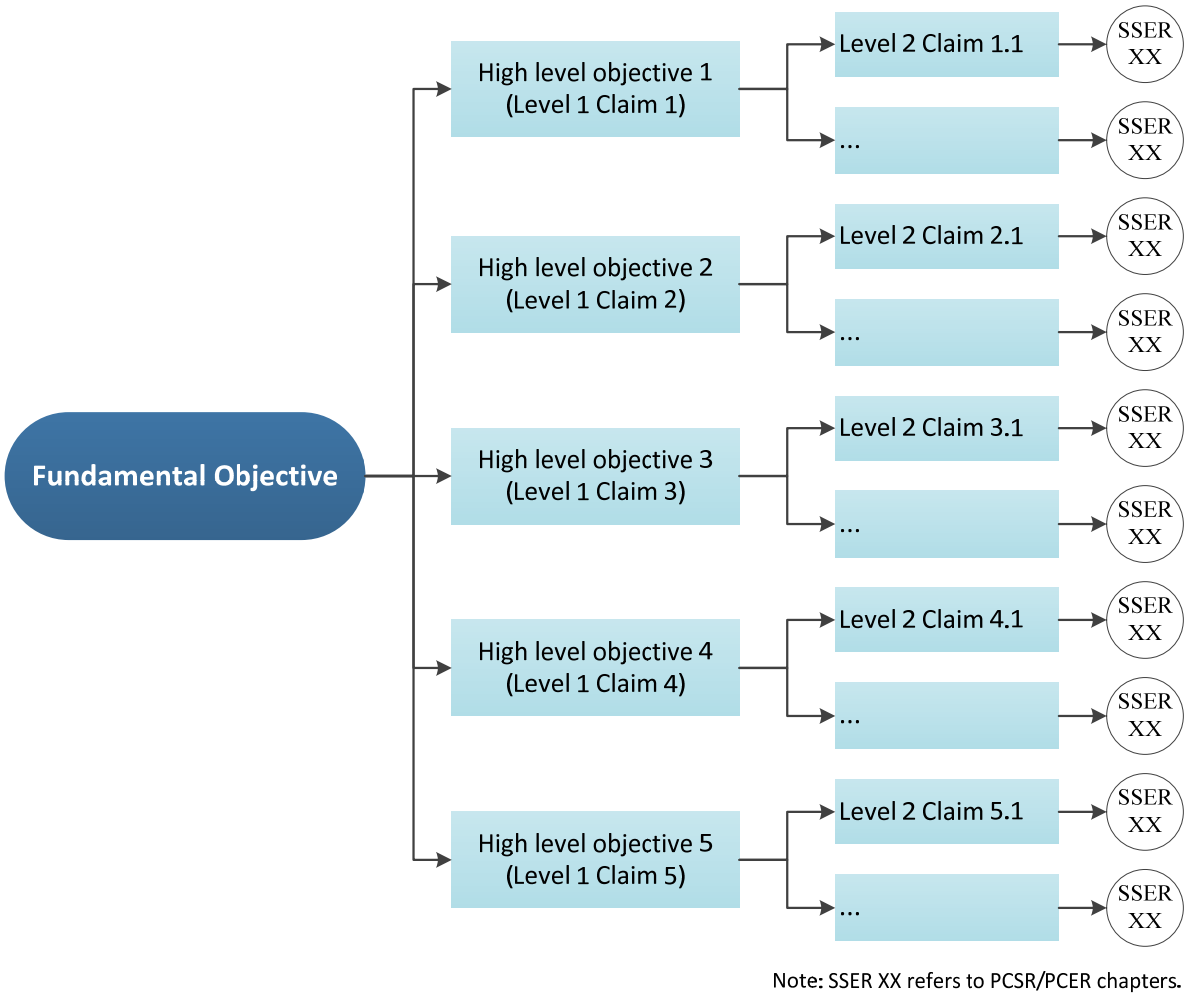
Meeting this Claim shows that the design and intended construction and operation of the UK HPR1000 enables the plant to be decommissioned by using current available technologies to reduce, so far as is reasonably practicable, the impact on the workers, the public, and the environment. This Level 1 Claim is underpinned by two Level 2 Claims:

a) ***Claim 5.1****: The design and intended operation will facilitate decommissioning using current available technologies;*

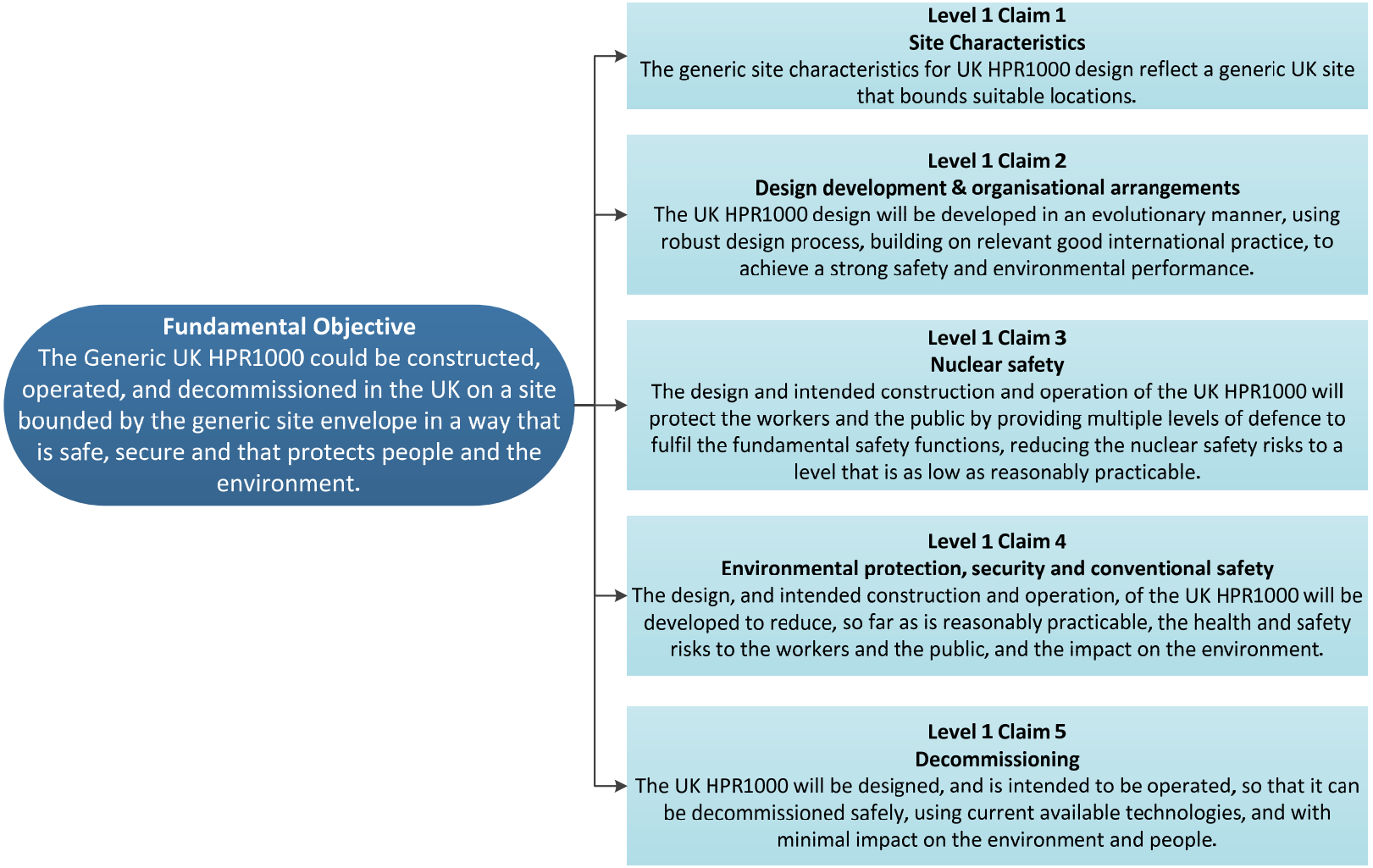
b) ***Claim 5.2****: The decommissioning strategy and plan are prepared and maintained for the generic design, which reflect UK policy.*

The decommissioning topic is addressed in PCSR Chapter 24 (Decommissioning), which draws from the material presented in multiple system chapters and fault analysis chapters, demonstrating that decommissioning is appropriately considered at the design phase of the project.

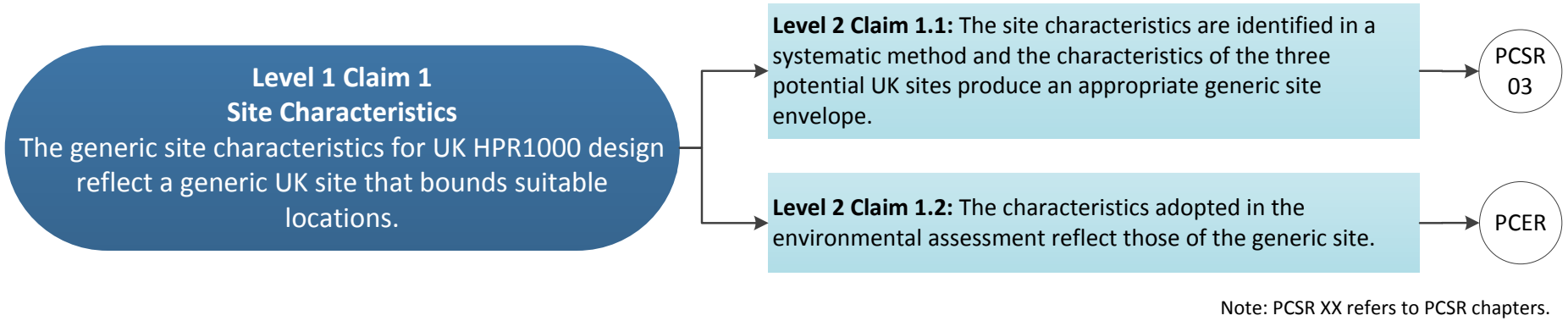
The hierarchy of Level 1 Claim 5 and supporting chapters are presented in F-1.6-7.



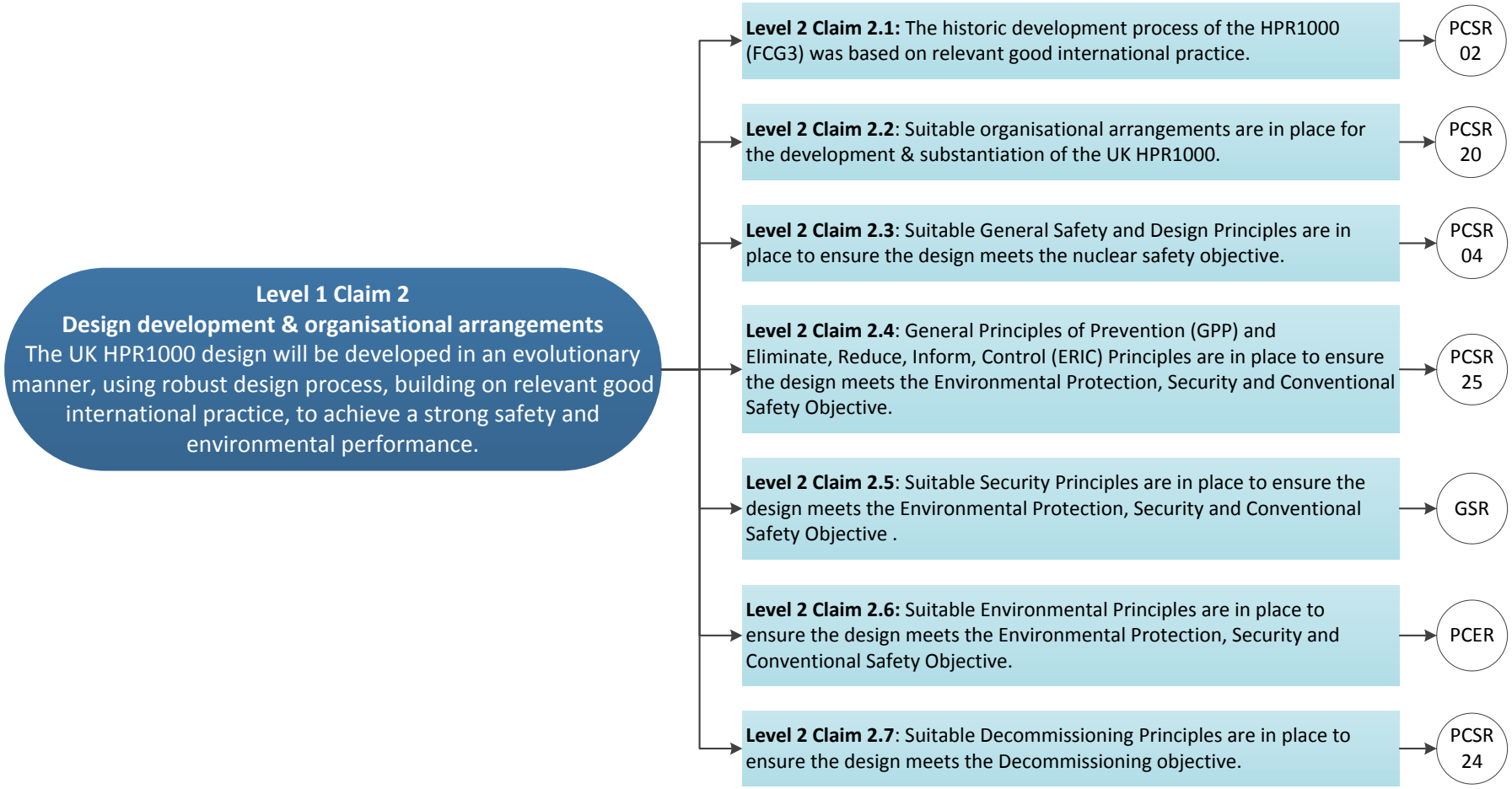
F-1.6-1 Overall Look of Route Map



F-1.6-2 Fundamental Objective

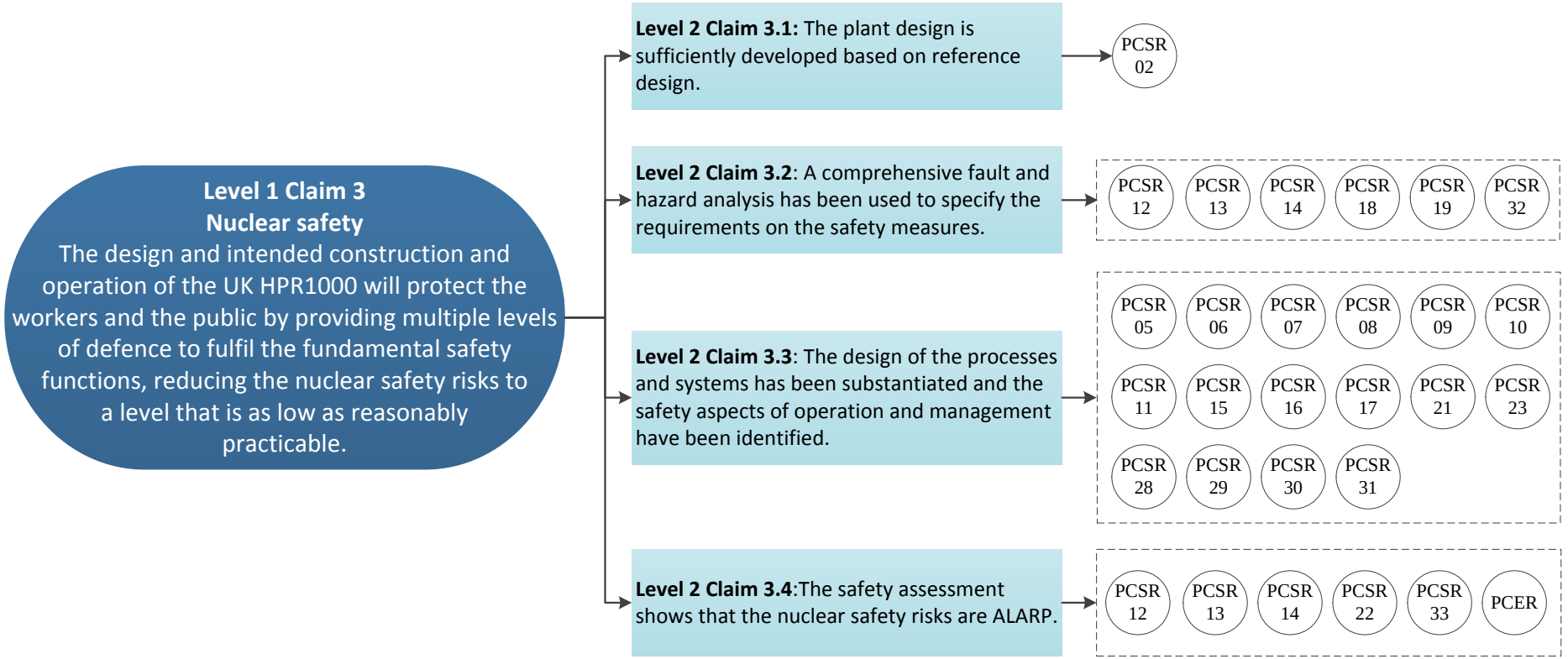


F-1.6-3 Site Characteristics

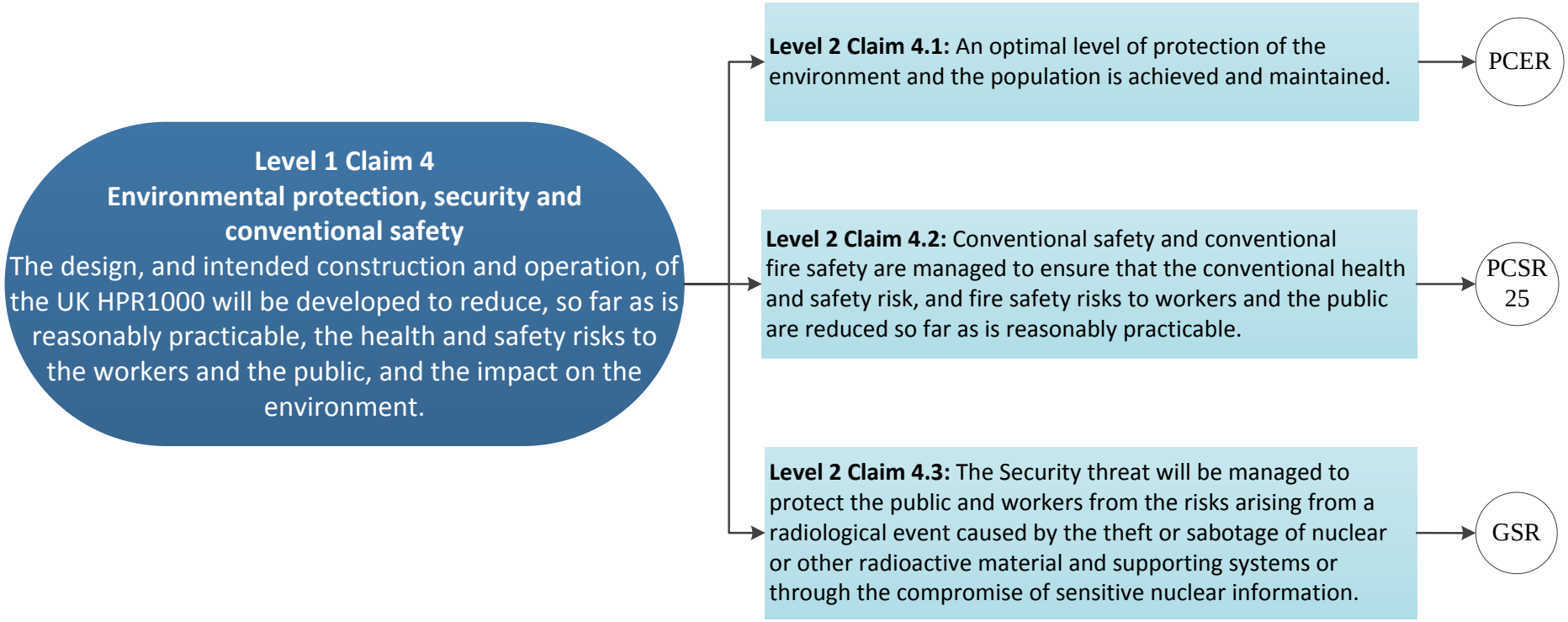


Note: PCSR XX refers to PCSR chapters.

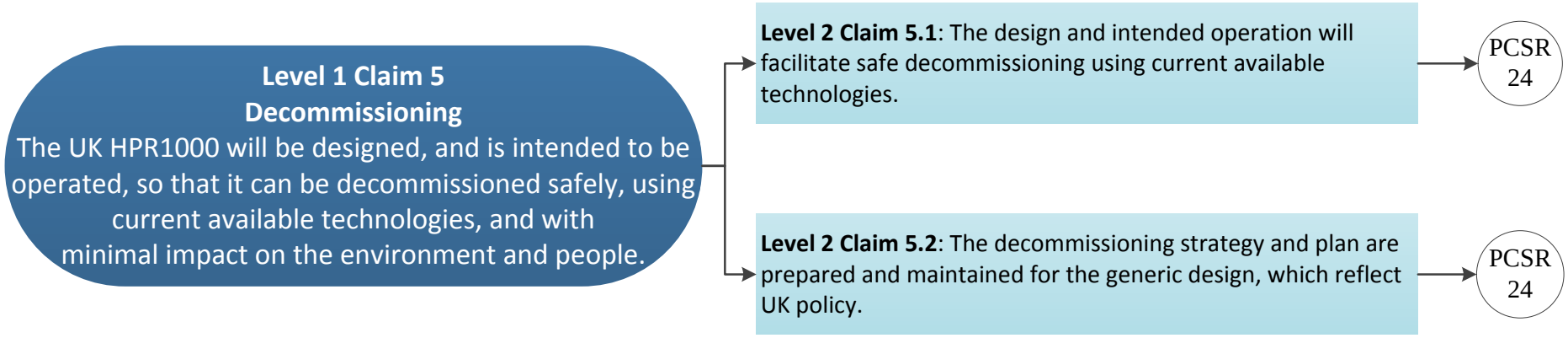
F-1.6-4 Design Development and Organisational Arrangements



F-1.6-5 Nuclear Safety



F-1.6-6 Environmental Protection, Security and Conventional Safety



Note: PCSR XX refers to PCSR chapters.

F-1.6-7 Decommissioning

1.7 Structure and Contents of the PCSR

This PCSR contains 33 chapters, and is divided into the following areas:

a) Inputs

   1) Principles and Management Arrangements;

   2) UK Generic Site Characteristics.

b) Plant Design, Commissioning, Operation and Decommissioning

   1) Structures, Systems and Components;

   2) Cross-cutting Topics;

   3) Commissioning;

   4) Operation;

   5) Decommissioning.

c) Analysis

   1) Nuclear Safety Analysis;

   2) Security Analysis;

   3) Conventional Safety Analysis;

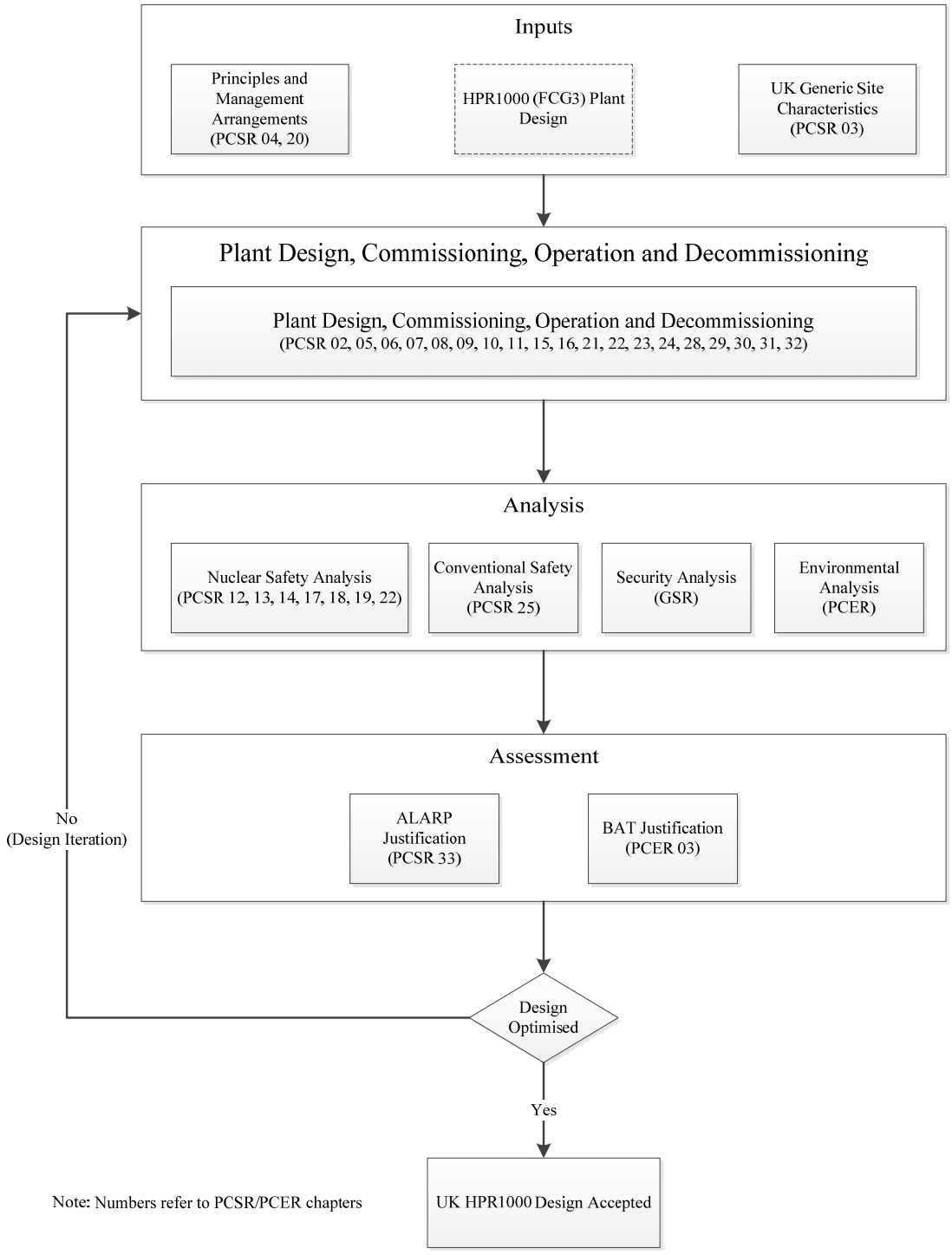
   4) Environmental Analysis.

d) Assessment

   1) Consideration of whether further optimisation is required;

   2) Demonstration that the design is optimised, reflecting best available techniques for environmental protection and reducing the security, conventional safety and nuclear safety risks ALARP.

The flow of information and the inter-dependencies between the chapters is briefly shown in F-1.7-1.



F-1.7-1 PCSR Process Flow Chart[2]

A summary of the structure and contents for each chapter is presented in T-1.7-1.

[2] This flow chart does not show the very precise logical relationship among 33 chapters. It just helps readers to understand the very high level relationship among 33 chapters.

T-1.7-1 Summary of the Structure and Contents of the PCSR Chapters

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
1	Introduction	This chapter provides an introduction to the GDA process, a summary of the content of the PCSR, and the high level objectives of UK HPR1000.This chapter outlines the following: − Purpose of the PCSR; − GDA scope; − Design reference; − Safety case route map; − Structure and contents of the PCSR.
2	General Plant Description	To briefly introduce the design of UK HPR1000 nuclear power plant, this chapter presents: − Evolution of the UK HPR1000 design; − Main technical characteristics of the UK HPR1000; − Brief introduction of the current system design configuration, the main civil structures and other plant information.
3	Generic Site Characteristics	This chapter produces the generic site envelope of UK HPR1000 in GDA via a systematic approach, and also presents the values for UK HPR1000 design, which could cover the generic site envelope
4	General Safety and Design Principles	This chapter presents the general safety and design principles applied in UK HPR1000, and support the claim that suitable general safety and design principles are in place to ensure the design meets the nuclear safety objective. The chapter includes: − Nuclear safety objective; − Defence in depth; − Safety analysis; − Identification of safety functions; − Categorisation of safety functions and classification of structures, systems and components; − Engineering substantiation; − Codes and standards.
5	Reactor Core	This chapter presents the substantiation of the reactor core and fuel system, ensuring that the fuel can be cooled and the reactivity controlled. The chapter includes: − Fuel system design; − Nuclear design; − Thermal hydraulic design.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
6	Reactor Coolant System	This chapter mainly presents the design information of the Reactor Coolant System. The chapter includes: − Description of Reactor Coolant System; − Description of main components of Reactor Coolant System; − Description of overpressure protection analysis.
7	Safety Systems	This chapter presents the substantiation of the safety systems. The systems covered in this chapter are: − Safety Injection System; − Emergency Boration System; − Atmospheric Steam Dump System; − Emergency Feedwater System; − Secondary Passive Heat Removal System; − Containment Heat Removal System; − Containment Filtration and Exhaust System; − Containment Leak Rate Testing and Monitoring System; − Containment Isolation; − Containment Combustible Gas Control System; − Extra Cooling System.
8	Instrumentation & Controls	This chapter presents the substantiation of the Instrumentation and Control (I&C) systems, showing that: − The plant condition is monitored during normal operations; − The plant is controlled to remain within stipulated limits of the operating conditions; − Where necessary, protection actions are initiated (such as safety measures and other mitigation measures), such that the plant reaches a safe shutdown state. The areas covered in this chapter are: − Design basis for I&C; − Route map for I&C safety case; − General architecture of the Instrumentation and Control Systems; − General description of F-SC1 Instrumentation and Control Systems; − General description of F-SC2 Instrumentation and Control Systems; − General description on the F-SC3 & NC Instrumentation and Control Systems; − General description on platform development and justification.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
9	Electric Power	This chapter presents the substantiation of electric power, ensuring that electric power is provided to support other systems in performing their required duties. The areas covered in this chapter are: − Architecture of electrical power system; − Off-site electrical power system; − On-site electrical power system; − Auxiliary electrical system; − Specific principles.
10	Auxiliary Systems	This chapter presents the substantiation of the auxiliary systems. The systems covered in this chapter are: − Heavy Load Lifting System; − Nuclear Auxiliary Systems; − Process Auxiliary Systems; − Heating, Ventilation and Air Conditioning Systems; − Fire Protection Systems; − Diesel Generators.
11	Steam and Power Conversion System	This chapter presents the substantiation of the Steam & Power Conversion System. The areas covered in this chapter are: − Steam and Power Conversion Systems (Safety Related); − Steam and Power Conversion System (Non-Safety Related).
12	Design Basis Condition Analysis	To demonstrate that a comprehensive fault analysis has been used to specify the requirements on the safety measures, this chapter: − Presents analysis showing that initiating design basis faults have been identified and fault sequences developed; − Identifies suitable safety measures and sets requirements on their design. To support the overall demonstration the nuclear safety risks are ALARP, this chapter demonstrates that the plant is designed with suitable safety measures to ensure that it is tolerant to design basis faults.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
13	Design Extension Conditions and Severe Accident Analysis	To demonstrate that a comprehensive fault analysis has been used to specify the requirements on the safety measures, this chapter: − Presents analysis that beyond design basis faults have been identified and fault sequences are developed; − Shows that analysis of design extension conditions, including severe accident, has been carried out to evaluate the effectiveness of protection and mitigation measures (and inform emergency arrangements). To support the overall demonstration the nuclear safety risks are ALARP, the analysis of design extension conditions, including severe accident, demonstrates further defence in depth, beyond the consideration of design basis conditions.
14	Probabilistic Safety Assessment	To show that a comprehensive fault analysis has been used to identify the requirements on the safety measures, this chapter demonstrates that a suitable probabilistic safety assessment has been carried out and has been used to inform the design and evaluate risk levels. In addition, Probabilistic Safety Assessment supports the overall demonstration that the nuclear safety risks are ALARP.
15	Human Factors	To support the demonstration that the UK HPR1000 design is being developed and substantiated by a competent organisation, using suitable processes, this chapter presents: − Integration of Human Factors into the design and the associated assessment and management processes; − Appropriate methods adopted for the assessment of Human Reliability. This chapter also supports the assessment of the nuclear safety risk by presenting the claims on operators.
16	Civil Works & Structures	This chapter presents the substantiation of the civil works & structures, and presents: − Safety function requirements and design requirements of civil structures; − Seismic analysis; − Design of nuclear safety-related structures; − Domain beyond the design basis; − Construction, test and in-service inspection requirements.
17	Structural Integrity	This chapter is to demonstrate that the UK HPR1000 achieves the requirements of structural integrity. This chapter includes: − Requirements and process for structural integrity classification process; − Methodology of constructing safety case reports of each class of components.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
18	External Hazards	As part of demonstrating that design basis faults have been identified and fault sequences developed, this chapter supports the safety analysis by justifying that a design basis external hazard event will not prevent the delivery of the fundamental safety functions. In addition, this chapter demonstrates the facility risks are ALARP. The chapter provides: – Identification and screening of external hazards; – Generic methodology for external hazards assessment; – External hazards protection design and assessment.
19	Internal Hazards	As part of demonstrating that design basis faults have been identified and fault sequences developed, this chapter supports the safety analysis by justifying that a design basis internal hazard event will not prevent the delivery of the fundamental safety functions. The chapter provides: – Identification of internal hazards; – Generic methodology for internal hazards assessment; – Internal hazards protection design and assessment.
20	MSQA and Safety Case Management	This chapter is to demonstrate that the UK HPR1000 design is being developed and substantiated by a competent organisation, using suitable processes. This chapter shows the following: – The responsible designers of the UK HPR1000 are a competent design organisation; – The RP has created an organisation that is competent to manage the development and substantiation of the design; – An appropriate management system supports the design development and substantiation of the UK HPR1000.
21	Reactor Chemistry	This chapter presents the primary and secondary water chemistry. It includes: – Primary water chemistry; – Secondary water chemistry; – Auxiliary water chemistry; – Accident chemistry; – Sampling and monitoring; – Construction and commissioning chemistry.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
22	Radiological Protection	The chapter presents the radiological protection of UK HPR1000. It includes: − Regulatory requirements and safety case; − Source term; − Strategy for ensuring exposures is ALARP; − Radiation protection measures; − Radiation and contamination monitoring; − Dose assessment for workers; − Dose assessment for public from direct radiation; − Post-accident accessibility.
23	Radioactive Waste Management	This chapter presents the substantiation of the radioactive waste management systems, ensuring that the nuclear safety risks are reduced to a level that is As Low As Reasonably Achievable. The systems covered in this chapter are: − Liquid radioactive waste management systems; − Gaseous radioactive waste management systems; − Solid radioactive waste management system.
24	Decommissioning	This chapter is to demonstrate the UK HPR1000 will be designed, and is intended to be operated, so that it can be decommissioned safely, using current available technologies, and with minimal impact on the environment and people. The chapter includes: − Considerations of facilitating decommissioning; − Decommissioning strategy; − Preliminary decommissioning plan.
25	Conventional Safety and Fire Safety	This chapter is to demonstrate that conventional health and safety as well as conventional fire safety are managed in accordance with UK legal requirements and relevant good practice, and the conventional health and safety risks and conventional fire risks are eliminated, reduced or controlled, so far as is reasonably practicable, to protect workers and the public. The chapter includes: − The management of conventional health and safety; − The management of conventional fire safety.
26	Environment	This chapter has been replaced by the PCER.
27	Security	This chapter has been replaced by the GSR.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
28	Fuel Route and Storage	This chapter is to demonstrate that Fuel Handling and Storage System has been substantiated, and the risks from fuel handling and storage operations are as low as reasonably practicable. The chapter includes: − General description of fuel route; − Fuel handling; − Fuel storage.
29	Interim Storage of Spent Fuel	This chapter is to demonstrate that suitable options for the interim storage of fuel on-site remain open. The chapter includes: − Spent fuel storage strategy; − Design requirements; − Technology options.
30	Commissioning	This chapter is to demonstrate that the overall commissioning strategy for safety measures could support the substantiation of those systems. This chapter includes: − Site licensee commissioning arrangements; − Commissioning programme scope.
31	Operational Management	This chapter provides arrangements for moving the safety case to operating regime. These arrangements ensure that the requirements of, and assumptions in, the safety case are identified in operational management. This chapter includes: − Operating procedures; − Operating limits and conditions; − Examination, Maintenance, Inspection and Testing; − Aging and degradation.
32	Emergency Preparedness	To support the demonstration that the nuclear safety risks are ALARP, this chapter presents the emergency arrangements and identifies the current accident management procedures to form the emergency arrangements. The chapter includes: − Emergency management; − On-site emergency response facilities; − Accident management onsite.

Chapter	Title	Summary of the PCSR Chapter Structure and Contents
33	ALARP Evaluation	To support the demonstration that the nuclear safety risks are ALARP, this chapter summarises the ALARP evaluation for UK HPR1000 design. The chapter includes: – ALARP methodology for UK HPR1000; – Historical design process of HPR1000 (FCG3); – Preliminary ALARP review of UK HPR1000; – Assessments of radiation protection targets.

1.8 Concluding Remarks

This chapter describes the structure and contents of the PCSR for UK HPR1000. It provides an introduction to the GDA process, a summary of the GDA scope, an introduction to the Design Reference and the high level objectives of the UK HPR1000.

The PCSR presents the high level claims, chapter level claims, arguments and summarises how these claims and arguments will be met and supported by a suit of supplementary substantiation documents. A later version of the PCSR will be produced that presents the full suite of supporting evidence, for the GDA Step 4 assessment.

1.9 References

[1] CGN, Glossary, GHX00100006DOZJ03GN, Revision A, June 2018.

[2] ONR, New Nuclear Reactors: Generic Design Assessment Guidance to Requesting Parties, ONR-GDA-GD-001, Revision 3, September 2016.

[3] GNS, GDA Scope for UK HPR1000 Project, HPR/GDA/REPO/0007, Revision 000, May 2018.

[4] CGN, UK HPR1000 Design Reference Report, NE15BW-X-GL-0000-000047, Revision C, July 2018.

[5] IAEA, Fundamental Safety Principles, No.SF-1, November 2006.

[6] IAEA, Safety of Nuclear Power Plants: Design, No.SSR-2/1, Revision 1, February 2016.