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UK ABWR Generic Design Assessment

GDA PCSR Development Strategy

Hitachi-GE Nuclear Energy, Ltd.

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Abbreviations and Acronyms

Abbreviations and Acronyms	Description
ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
AOO	Anticipated Operational Occurrence
CAE	Claims-Argument-Evidence
DAC	Design Acceptance Confirmation
GDA	Generic Design Assessment
GEP-RSR	Generic Environmental Permit - Radioactive Substance Regulation
ICRP	International Commission on Radiological Protection
ISI	In-Service Inspection
IRR	The Ionising Radiations Regulations
PCmSR	Pre-Commissioning Safety Report
PCSR	Pre-Construction Safety Report
POSR	Pre-Operational Safety Report
PSA	Probabilistic Safety Analysis
RCSs	Reactor Coolant Systems
REPPIR	The Radiation (Emergency Preparedness and Public Information) Regulations
RI	Regulatory Issue
RO	Regulatory Observation
RP	Requesting Party
RQ	Regulatory Query
SAP	Safety Assessment Principles
SLA	Site License Application
SoDA	Statement of Design Acceptability
SSCs	Systems, Structures and Components
SSR	Station Safety Report

Table of Contents

1. Introduction

This document describes the objectives of the UK Advanced Boiling Water Reactor (ABWR) Generic Design Assessment (GDA) Pre-Construction Safety Report (PCSR), the scope that it covers, and the general structure of relevant documents that Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE) intends to submit to the UK regulators during the UK ABWR GDA process. It also describes how the relevant GDA PCSR document submissions will be recorded, tracked and managed throughout the entire GDA process.

2. Objectives of GDA PCSR

The aim of the GDA PCSR is to demonstrate, to the UK regulators, the UK public and related UK stakeholders that a UK ABWR constructed on a generic UK site substantially meets UK safety standards, and legal requirements.

The underpinning objectives of the GDA PCSR will be to demonstrate that:

- For all operating and fault conditions, the UK ABWR design meets the As Low As Reasonably Practicable (ALARP) principle and safety targets.
- The UK ABWR design is based on good international practices.
- The radiological dose targets will be met.

To achieve these objectives, the GDA PCSR will provide descriptions of reactor Systems, Structures and Components (SSCs). In the descriptions, Hitachi-GE will provide claims on the roles each of the SSCs plays to achieve corresponding safety performance and functions, provide arguments based on the design philosophies and criteria of the SSCs along with corresponding evidence, to demonstrate that the claims on the UK ABWR design can be achieved.

3. Scope of GDA PCSR

The UK ABWR's GDA PCSR is aimed at presenting substantial information, necessary for the assessment of the design, to achieve Design Acceptance Confirmation (DAC) and Statements of Design Acceptability (SoDA) for the construction of a UK ABWR power plant in the UK.

The scope of demonstration will cover and justify the safety of the design at all phases of the plant life time; namely construction, commissioning, operation, maintenance to decommissioning. In particular, the GDA scope will include the following SSCs that are important to the safety of the plant.

- Reactivity control SSCs;
- Core cooling SSCs; and
- Containment SSCs.

The scope of SSCs to be included in the GDA PCSR will be defined after the safety claims of the UK ABWR are developed during Step 2 and agreed between the Regulators and Hitachi-GE before the end of Step 3.

The scope will also include on-site spent fuel management and radioactive waste management.

Some areas will not be addressed in detail during the GDA, but they will be developed in subsequent licensing phases. However, the UK ABWR GDA PCSR will include generic arrangements and/or processes by which they will be demonstrated, to ensure transition from GDA PCSR to the later licensing phases. These areas include, for example:

- Site specific issues such as site dependent hazards will be addressed in the Site Specific PCSR for Site License Application (SLA);
- Detailed commissioning and operational procedures will be addressed in Pre-Commissioning Safety Report (PCmSR) and Pre-Operational Safety Report (POSR) submissions. These submissions will be prepared during the construction phase and prior to plant operation.

4. Development of GDA PCSR contents and relevant Supporting Documentation

During GDA Hitachi-GE will prepare and submit a comprehensive, GDA PCSR and relevant Supporting Documentation to the regulators. In the development of the GDA PCSR and relevant Supporting documentation, Hitachi-GE will apply the following strategy to ensure that the documentation submitted reflects the UK Claims-Argument-Evidence (CAE) approach for nuclear safety cases.

Broadly the approach is as follows:

- Firstly, the corresponding safety targets or objectives to be included in the safety claims are defined, and developed accordingly;
- Secondly, the corresponding safety features that will deliver the above safety performances are defined;
- Thirdly, a set of specifications of the safety features enlisted above will be provided and the detailed technical justifications (including details of assessment and analysis).

The first set of safety targets corresponding to the claims are listed in the GDA PCSR, while the details of safety features and set of specifications to support the safety features will be provided in a lower tier supporting documentation. To provide a clear linkage between the claims in the PCSR and detailed Arguments in the lower documentation, a summary of related descriptions, including Arguments will also be provided in the PCSR.

The claims in the GDA PCSR will be developed in a hierarchical manner to facilitate assessment of their exhaustiveness, and completeness. The high level claims will be aligned with the UK Safety Assessment Principles (SAPs).

The GDA PCSR will be updated at the end of critical milestones such as completion of Step 3 and Step 4, to reflect additional details generated in response to regulatory assessment of the design. The dates for further PCSR revisions will be defined in the near future.

The lower tier supporting documentation will include Topic Reports, and design documentation submitted to and discussed with the regulators during the course of the GDA process, and reviewed accordingly to illustrate the basis of Hitachi-GE's arguments and evidence of the UK ABWR design.

Additional reports will be developed in response to technical issues raised and their resolution during GDA.

4.1 Development of GDA PCSR Contents

To cover all the relevant phases of the plant cycle, the GDA PCSR contents will be structured and developed with consideration of the following:

- Internationally recognized practices and guides for development of Safety Reports. Such guides include:
  - IAEA Safety Guide GS-G-4.1 (Ref-1);
  - HSE Technical Assessment Guide NS-TAST-GD-051 (Ref-2).

- Benchmarked against previous related documentation such as
  - GDA PCSRs from previous GDAs and Sizewell B Station Safety Report (SSR);
  - US Regulatory Guide 1.206 (Ref-3);
  - Establishment Permit Application for Nuclear Reactor Installation in Kashiwazaki-Kariwa Nuclear Power Station (Addition of Unit 6 and Unit 7) (Ref-4).

- Inclusion of additional chapters to facilitate incorporation of site specific and operational matters to enable transition from GDA into SLA.

Based on the above mentioned approach, the UK ABWR's GDA PCSR is comprised of 5 parts (as shown in Figure 1.3-1, which are further subdivided into 29 chapters (see Table 1.3-1) as described below. A summary of the content of individual chapters of the PCSR is provided in Section 5.

Although PCSR is divided into 29 Chapters, descriptions in corresponding Chapters will be provided to link related Chapters.

An explanation of the five parts in figure 1.3-1 is as follows:

Part-I: General Issues

This part provides an overview of the main specifications of the UK ABWR, including generic description of the design concept and functional requirements to be considered in the design to achieve safe management throughout the plant lifetime.

Part-II: Technical Systems

This section defines the main SSCs required to deliver principal safety features and functions. In addition, it provides specification of the corresponding SSCs.

Part-III: Systems and processes to support operation

This section defines auxiliary and support systems that are necessary for the SSCs above to deliver their defined safety functions, and the processes required to support safe operation of the plant. It will also provide the engineering substantiation to justify the claims made in the safety case on the design of the engineering systems.

Part-IV: Assessment

This section provides the necessary evidence toward justification and substantiation of the technical systems, and processes to support operation required for the safety of the plant. In the assessments, Design Basis Analysis, Probabilistic Safety Assessment, Beyond Design Basis and Severe Accident Analysis and Human-Factor Evaluation will be carried out to demonstrate the robustness of the design. Furthermore, ALARP Evaluation will be carried out to demonstrate that all relevant, reasonable and practicable design options have been put into consideration.

Part-V: Framework of dealing with issues specific to plant life phase

This section provides information on how safety will be achieved and maintained throughout the plant's lifetime. It includes details on safety aspects from commissioning, operation to decommissioning activities.

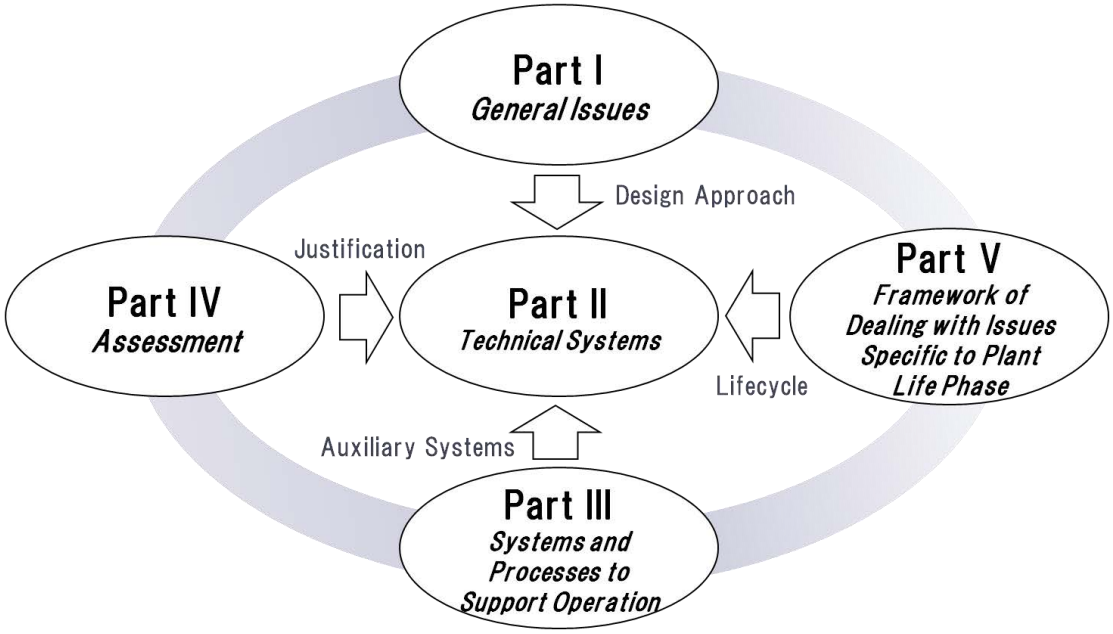

Figure 1.3-1: Development of PCSR contents

Table 1.3-1 : Summary of GDA PCSR parts and contents (chapters)

Part	Title	Corresponding Chapters
I	General Issues	1. Introduction
		2. Generic Site Envelope and Data
		*3. Site Characteristics [*SLA]*
		4. Safety Management throughout Plant Lifecycle
		5. General Design Aspects
II	Technical Systems	6. General Description
		7. Civil Works and Structures
		8. Reactor Core
		9. Reactor Coolant System and Associated Systems
		10. Containment and Associated Systems
		11. Reactor Instrumentation and Control
		12. Electrical Power Supplies
		13. Auxiliary Systems
		14. Steam and Power Conversion System

III	Systems and Processes to Support Operation, and Engineering Substantiation	15. Radioactive Waste Management
		16. Fuel Storage and Handling
		17. Radiological Protection
		18. Human-Machine Interface
		19. Emergency Preparedness
IV	Assessment	20. Design Basis Analysis
		21. Probabilistic Safety Assessment
		22. Beyond Design Basis and Severe Accident Analysis
		23. Human-Factor Evaluation
		24. ALARP Evaluation
V	Framework of Dealing with Issues Specific to Plant Life Phase	25. Commissioning
		26. Operation
		27. Decommissioning
		28. Spent Fuel Interim Storage
		29. Reactor Chemistry

4.2 Development of GDA PCSR Supporting Documentation

As the GDA progresses, Hitachi-GE will submit revised GDA PCSR and supporting documentation, such as topic reports and design documents as explained in a preceding section, to the regulators. In addition, documentation in response to Regulatory Queries (RQs), Regulatory Observations (ROs) and Regulatory Issues (RIs) raised by the regulators will be prepared and submitted to the regulators. Therefore, the GDA submissions will comprise a large number of documents at different stages of development. This requires an approach method for tracking and managing the status of the submissions, throughout the GDA process.

In order to manage this large number of documents, Hitachi-GE will provide regulators with a Submission Tracking Sheet according to the GDA Interface Arrangement. This document will be provided in the form of a spreadsheet and will keep track of the documents submitted, any subsequent status (updates) to these documents, and of any documents withdrawn etc.

In addition, Hitachi-GE will also provide the regulators with a GDA Master Document Submission List, which will list all the Safety, Security and Environmental reports and the supporting documentation. This list will be maintained as a 'living' document that allows the regulators to track what constitutes the latest versions of the scope of GDA for the UK ABWR design, and to specify the scope of the DAC/SoDA at the end of GDA. The list will identify all supporting documentation called upon by the documentation comprising the Safety, Security and Environmental submissions, including title, document number, revision status, date of issue and will identify the documents / sections of the Safety, Security and Environmental Submissions where they are referenced. The list will be updated periodically as required and resubmitted.

5. Summary of corresponding contents of the GDA PCSR chapters

This chapter provides a summary of the contents of each chapter of the GDA PCSR.

Chapter 1 Introduction

Chapter 1 will provide an overview of the purpose, structure, and the submission schedule of the GDA PCSR. It will also provide a comparison between the contents of the GDA PCSR (submitted by Hitachi-GE) and that of relevant international guidelines for preparation of safety assessment reports. In addition, this chapter will also provide a list of terminologies, abbreviations and acronyms that are likely to be regularly used in the GDA PCSR.

Chapter 2 Generic Site Envelope and Data

Chapter 2 will provide information regarding the generic site design conditions related to meteorological, hydrological, geological, and seismological characteristics of the site and vicinity that will be used in the generic plant design.

Chapter 3 Site Characteristics

Chapter 3 will be developed in the SLA. In the GDA PCSR, the approach expected to be undertaken during the SLA will be described.

Chapter 4 Safety Management throughout Plant Lifecycle

A significant portion of Chapter 4, which will be fully developed during the SLA, will demonstrate the management of safety aspects throughout the plant lifecycle.

Details of conduct of plant operations from start of construction to full power operations are addressed. The operator's organizational structure, training requirements, emergency planning requirements, and conduct of reviews and audits, are described. This chapter will also provide information regarding the plans for ensuring technical competence is established and maintained and that operating plans are adequate to protect public health and safety.

The GDA PCSR will only highlight the key approached expected to be developed during the SLA. Additionally, Chapter 4 will list up the laws and regulations, regarding conventional safety and fire that design and management will comply with in post GDA phase.

Chapter 5 General Design Aspect

Chapter 5 will address the following issues related to development of the UK ABWR design concept:

- Definition of general safety design basis
- Application of UK categorization and classification to UK ABWR design
- Definition of applicable codes and standards to UK ABWR design
- Identification of internal and external hazards. Additionally, the identified hazards will be screened to identify hazards to be considered in the UK ABWR design basis. Relevant protection and mitigation features that are incorporated into the UK ABWR design, against design basis hazards, will be addressed in Part II (see Table 1.3-1) of the PCSR. Furthermore, assessment and demonstration of UK ABWR's resilience against design basis hazards will be presented in Part IV (see Table 1.3-1) of the PCSR.

Chapter 6 General Description

Chapter 6 will provide a description of major plant technical characteristics and specifications including design life, rated output, plant availability, and safety characteristics. It will also provide details of the major buildings, and their layout within the generic site.

Chapter 7 Civil Works and Structures

Chapter 7 will identify, describe and discuss the principal architectural and engineering design features and aspects of civil structures related to plant safety. These aspects will include seismic design, engineering features to ensure plant safety against external hazards.

Chapter 8 Reactor Core

Chapter 8 will provide an evaluation and supporting information to establish the capability of the reactor to perform its safety functions throughout its design lifetime under all normal operational modes, including transient, steady-state, and accident conditions.

This chapter will cover the design areas related to reactor core such as fuel system design, nuclear design, thermal-hydraulic design, and functional design of reactivity control system. For these areas, it describes the design aspects such as design basis, structure of components, analytical methods, evaluation, etc. The performance and safety function will be also described.

Chapter 9 Reactor Coolant Systems and Associated Systems

Chapter 9 will provide a summary description of the Reactor Coolant Systems (RCSs) and associated components. This description will indicate the performance and safety functions of each component and will include a tabulation of important design and performance characteristics.

This chapter will include evaluations, together with the necessary supporting material, to show that the corresponding RCSs are capable of accomplishing intended objectives and maintain their integrity under conditions imposed during normal and accident conditions.

Chapter 10 Containment and Associated Systems

Chapter 10 will provide details of the containment system and associated engineered safety systems, including safety and functional requirements; system description; design criteria and assumptions, design details and safety evaluation analysis results.

Containment system includes Flammability Control System and Containment Spray system. The other engineering safety system includes Standby Gas Treatment system.

Chapter 11 Reactor Instrumentation and Control

The reactor instrumentation monitors the various reactor parameters and transmits appropriate signals to the control systems during normal operation and to the reactor trip systems and emergency systems during anticipated operational occurrences and in accident conditions. Chapter 11 will provide information on those instruments and their associated equipment that constitute the protection systems and those systems relied upon by operators to monitor plant conditions and to shut the plant down and maintain it in a safe shutdown for all of operation modes.

Chapter 12 Electrical Power Supplies

Chapter 12 will provide information on the function of the offsite power systems and onsite electric power systems as well as ensuring the power supply to auxiliary loads necessary.

In addition, this chapter will briefly describe the onsite electric system in general terms, and its associated interconnections to safety buses. This description will identify the safety functions performed, and the type of electric power required by each safety load.

In addition, this chapter will present and discuss the design bases, criteria, standards, and other documents to be used in the design of the safety-related electric systems.

Chapter 13 Auxiliary Systems

Chapter 13 will provide information about the facility's auxiliary systems. In particular, this chapter will identify systems that are essential for safe shutdown of the plant or for protection of the health and safety of the public. For each system, the description will provide the design bases for the system and its critical components, a safety evaluation demonstrating how the system satisfies the design bases, the testing and inspection to be performed to verify system capability and reliability, and the required instrumentation and controls.

In addition, the information provided will clearly show the system's capability to function without compromising the safe operation of the plant under both normal operating and transient situations.

Chapter 14 Steam and Power Conversion System

Chapter 14 will provide a summary description of principal design features of the plant steam and power conversion systems, emphasizing those aspects of the design and operation that affect or could potentially affect the reactor and its safety features or contribute toward the control of radioactivity. The information provided will show the capability of the system to function without compromising the safety of the plant, under both normal operating and transient situations.

In addition, this chapter will include an overall system flow diagram and a summary table of the important design and performance characteristics, including a heat balance at rated power.

Chapter 15 Radioactive Waste Management

Chapter 15 will describe the Safety Requirements, Functional Requirements, Design Criteria and System Specification of Radioactive Waste Treatment Systems. (Off-Gas Treatment, Liquid Waste Treatment and Solid Waste Treatment and Storage Systems)

Chapter15 will also cover the source term information for the discharge evaluation and solid waste inventory evaluation.

The system specifications will include Waste generation, system configuration, system capacity, and system capability to collect, treat liquid, gaseous, solid wastes and store solid waste that may contain radioactive materials.

The safety evaluation of Radioactive waste management will be covered in Chapter 20 (Fault Assessment). Radioactive material release and it's assessment including monitoring and sampling will be covered in GEP-RSR.

Chapter 16 Fuel Storage and Handling

Chapter 16 will include details of fuel storage handling, transportation within the site (where necessary), as well as cooling and clean up of corresponding fuel storage facilities. It will also provide details regarding refueling preparations.

Chapter 17 Radiological Protection

Chapter 17 will provide information on radiation protection methods and estimated occupational radiation exposures of operating personnel during normal operation and Anticipated Operational Occurrence (AOO) such as refueling; purging; fuel handling and storage; radioactive material handling, processing, use, storage, and disposal; maintenance; routine operational surveillance; in-service inspection (ISI); and calibration.

Specifically, this chapter will provide information on facility and equipment design techniques, and practices employed by the applicant to meet the corresponding legislative requirements in:

- International Commission on Radiological Protection (ICRP) ICRP 60
- The Ionising Radiations Regulations (IRR) (UK) 1999
- Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000
- The Radiation (Emergency Preparedness and Public Information) Regulations (UK) 2001 (REPPIR)

Chapter 17 will also include a discussion of how radiation practices are incorporated into plant policy and design decisions; a general description of the radiation source terms; radiation protection design features, including a description of plant shielding, ventilation systems, and area radiation and airborne radioactivity monitoring instrumentation; dose assessment for operating personnel.

Chapter 18 Human-Machine Interface

Chapter 18 will provide details on the design philosophy and design requirements of the main control room, and other systems such as Remote Shutdown System that involve human-machine interfaces. The design philosophy will be aimed at reducing operator burden and enhancing operability of functions significant to plant safety, during normal operation, and unexpected and/or abnormal conditions.

Chapter 19 Emergency Preparedness

Chapter 19 will discuss the emergency preparedness, management measures and facilities within the NPP site and necessary communication preparations between the site and related external organizations involved in emergency preparedness. It will also provide details on the capability to assess accidents, and the prospect consequential radiological releases to the environment.

Chapter 20 Design Basis Analysis

Chapter 20 will provide general approach on Design Basis Analysis and Fault Schedule. In the fault schedule the design basis faults will be identified. Additionally the chapter will demonstrate that the UK ABWR design can fully perform to satisfy their required safety functions. Furthermore, this chapter will also provide discussions on the UK ABWR compliance with Target 4.

Chapter 21 Probabilistic Safety Assessment

Chapter 21 will discuss the acceptability of the risks to public health and safety associated with operation of the UK ABWR as determined from the interpretation of the results and insights of the Probabilistic Safety Analysis (PSA) and severe accident evaluations. Additionally, this chapter will also provide discussions on the UK ABWR compliance with Target 7, 8, and 9.

Chapter 22 Beyond Design Basis and Severe Accident Analysis

Chapter 22 describes the methodologies used in assessment and analysis of severe accident progression for a number of accident sequences and the mitigation measures that are provided in the design against these highly unlikely events. The chapter demonstrates that the design is robust against such accidents.

Chapter 23 Human-Factor Evaluation

Chapter 23 provides details to demonstrate that relevant programs, engineering processes and practices have been applied to reduce any human actions or operation incidents that could adversely affect the safety of the nuclear power plant during all plant states, including normal operation, unexpected and/or abnormal conditions as well as during outages. The scope will also include human actions related to radwaste operations.

This will be demonstrated by showing that relevant SAPs have been taken into account, international human factors standards and guidelines have been applied to the design of the UK ABWR.

Chapter 24 ALARP Evaluation

Chapter 24 will provide description of application of the ALARP concept to UK ABWR design and its demonstration. This chapter will also review and benchmark UK ABWR design against relevant good practices in previous GDA.

Chapter 25 Commissioning

Chapter 25 provides details on the test programs that are required to ensure that the constructed / erected or installed SSCs and corresponding systems meet their design specifications and safety functional requirements. These tests, from pre-operation to cold commissioning test are performed prior to the first core loading to ensure that the post core loading tests, hot commissioning test, can be performed without impairing safety.

Chapter 26 Operation

Chapter 26 will describe how the designer, of the UK ABWR, will assist the licensee to understand and integrate the necessary know how in the training, operation manuals and procedures, to ensure safe operation of the plant. Also technical discussions for operational limits and conditions will be provided.

Details of Operation will be developed by the licensee during the site license, and the licensee will demonstrate that the plant operator will have the capability to safely operate the plant. Additionally, details such as arrangements for maintenance, surveillance, inspection and testing will also be provided.

Chapter 27 Decommissioning

Chapter 27 will provide preliminary details on the possibility of safe decommissioning the plant after its operational lifetime. In this chapter, the considerations put in place during the design phase, to demonstrate that SSCs can be demolished, transported and treated with minimal impact on the environment and exposure to workers will be demonstrated.

Chapter 28 Spent Fuel Interim Storage

Chapter 28 will provide details on the design requirements and assumptions for interim storage facility, a description of management strategy as well as a description of the storage facility options that shall be considered in the UK ABWR design. Further details such as safety requirements, risk identification and mitigation approaches will be developed at a later stage such as the SLA phase.

Chapter 29 Reactor Chemistry

Chapter 29 will provide details on water chemistry to demonstrate that the integrity of the structural materials and fuel is retained throughout the plant lifetime. Primary water chemistry control to minimize occupational radiation exposure and radioactive waste generation will be also described in this chapter. Accident chemistry will be described in Chapter 19.

6. Conclusion

This document provides an overview of the scope, structure and a summary of the approach, and details to be included in the UK ABWR GDA PCSR, and related documentation. It also provides an explanation of the key factors and inputs that Hitachi-GE considered in the development of table of contents of the UK ABWR GDA PCSR. The document also includes a summary of the details to be included in each of the chapters defined for the GDA PCSR.

7. References

Ref-1 IAEA Safety Guide, 'Format and Content of the Safety Analysis Report for Nuclear Power Plants', No. GS-G-4.1, 2004.

Ref-2 HSE report, 'The Purpose, Scope and Content of Safety Cases', NS-TAST-GD-051 Revision 3, July 2013.

Ref-3 US Regulatory Guide 1.206 'Combined License Applications for Nuclear Power Plant', June 2007.

Ref-4 Establishment Permit Application for Nuclear Reactor Installation
in Kashiwazaki-Kariwa Nuclear Power Station (Addition of Unit 6 and Unit 7), Tokyo Electric Power Company, May 1995 (available in Japanese).