



# Office for Nuclear Regulation

## Civil Nuclear Reactor Build - Generic Design Assessment

### Step 2 Assessment of the Radioactive Waste Management, Spent Fuel Management and Decommissioning of Hitachi GE's UK Advanced Boiling Water Reactor (UK ABWR)

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## EXECUTIVE SUMMARY

This report presents the results of my assessment of the Radioactive Waste Management, Spent Fuel Management and Decommissioning aspects of Hitachi-GE Nuclear Energy Ltd's (Hitachi-GE) UK Advanced Boiling Water Reactor (UK ABWR) undertaken as part of Step 2 of the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA).

The GDA process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments getting increasingly detailed as the project progresses. Step 2 is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including review of key nuclear safety, nuclear security and environmental safety claims with the aim of identifying any fundamental safety or security shortfalls that could prevent the issue of a Design Acceptance Confirmation (DAC). Therefore during Step 2 my work has focused on the assessment of the key claims in the areas of Radioactive Waste Management, Spent Fuel Management and Decommissioning to judge whether they are complete and reasonable in the light of our current understanding of reactor technology.

For Radioactive Waste Management, Spent Fuel Management and Decommissioning safety claims are interpreted as being specific and supportable statements to show:

- That the strategies being developed for the management of radioactive waste and spent fuel and for decommissioning are consistent with Government policy, are integrated with other relevant strategies and integrated into the safety case.
- That the design ensures that the generation and accumulation of waste, from activation and contamination, are prevented or minimised and that all waste streams have a disposability route.
- That the design ensures that radioactive substances will be contained and the generation of radioactive waste through the spread of contamination by leakage will be prevented in normal operation, fault and accident conditions.
- That the anticipated timescales for the management of radioactive wastes and spent fuel, from generation to disposal, including potential intermediate steps can be achieved ensuring safety at all times.
- That continued safe storage of the radioactive material for the planned storage period can be achieved ensuring safety at all times and does not compromise future retrieval and treatment, transportation and eventual disposal.
- That the UK ABWR will incorporate design features to facilitate decommissioning and to reduce dose uptake by decommissioning workers.
- A plan for decommissioning that defines the decommissioning end-state for the facility and any interim states, and the ability to achieve these safely.

The standards I have used to judge the adequacy of the claims in these areas have been primarily:

- ONR's Safety Assessment Principles (SAP), in particular the SAPs related to Radioactive Waste Management, Containment and Ventilation, Control of Nuclear Matter, Radiological Protection and Decommissioning.
- ONR's Technical Assessment Guides dealing with management and storage of radioactive waste and spent fuel, decommissioning, civil engineering and content of nuclear safety cases.

My assessment work has involved continuous engagement with the RP in the form of technical exchange workshops and progress meetings. In addition, my understanding of the ABWR technology, and, therefore, my assessment, has significantly benefited from visits to Hitachi Work's Rinkai Factory, Shimane Unit 3 nuclear power plant and Japan Steel Works.

My assessment has been based on the RP's Preliminary Safety Report (PSR) and its references relevant to Radioactive Waste Management, Spent Fuel Management and Decommissioning. The RP's preliminary safety case aspects related to Radioactive Waste Management, Spent Fuel Management and Decommissioning, as presented in those documents, is summarised in PSR reports on:

- Radioactive Waste Management System – which describes at a high level the key safety claims for solid, liquid and gaseous waste management systems.
- Spent Fuel Interim Storage (SFIS) – which describes the high level safety requirements for the SFIS, and the outline process Hitachi-GE will use for the optioneering for the spent fuel storage concept design.
- Decommissioning – which describes at a high level how the decommissioning principles underpin the design, safety claims, and the outline for decommissioning plans and programme.

My assessment has identified the following areas of strength:

- The RP is developing strategies for radioactive waste management, spent fuel management and decommissioning for the UK ABWR which appear to be reasonable and adequate in principle. The radioactive waste strategies proposed have been developed for use across the world and are therefore advanced. The spent fuel and decommissioning strategies require more development, but the RP has made good progress and has shown awareness of the UK requirements, which is sufficient for Step 2.
- All major waste streams have been identified and disposability assessments, where applicable, are being discussed and will continue in Step 3<sup>\*</sup>.
- Designing the UK ABWR to facilitate decommissioning has already resulted in some design changes being proposed by the RP, which is sufficient for Step 2.

During Step 2 I have identified the following areas that require follow-up:

- All wastes such as potentially contaminated oils, and high level waste (e.g. reactor internals), need to be integrated into the relevant strategies i.e. decommissioning and waste strategies and proposed facilities i.e. waste processing and storage facilities.
- Further development of the safety case for the safe management of spent fuel over the currently anticipated timescales to final disposal is required.
- The construction sequence for the UK ABWR needs to be reviewed in terms of its safety impact, if any, on the safe decommissioning of the facility at the end of life.

Through my interactions with the RP's Subject Matter Experts (SME) in Radioactive Waste Management, Spent Fuel Management and Decommissioning, I have found the RP to be professional and to have committed considerable effort and resources to developing the UK ABWR safety case.

Overall, I see no reason, on Radioactive Waste Management, Spent Fuel Management and Decommissioning grounds, why the UK ABWR should not proceed to Step 3.

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<sup>\*</sup> For details of each Step of the GDA process visit [www.onr.org.uk](http://www.onr.org.uk)

## LIST OF ABBREVIATIONS

ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
BMS	Business Management System
DAC	Design Acceptance Confirmation
EA	Environment Agency
EDG	Emergency Diesel Generators
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
Hitachi-GE	Hitachi-GE Nuclear Energy Ltd
IAEA	International Atomic Energy Agency
JPO	(Regulators') Joint Programme Office
NPP	Nuclear Power Plant
ONR	Office for Nuclear Regulation
PCSR	Pre-construction Safety Report
PSR	Preliminary Safety Report
RO	Regulatory Observation
RP	Requesting Party
RPV	Reactor Pressure Vessel
RQ	Regulatory Query
SAP(s)	Safety Assessment Principle(s)
SFAIRP	So far as is reasonably practicable
SFIS	Spent Fuel Interim Storage
SME	Subject Matter Expert
TAG	Technical Assessment Guide(s)
TSC	Technical Support Contractor
WENRA	Western European Nuclear Regulators' Association

## TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION</b>	<b>7</b>
1.1	Background	7
1.2	Methodology	7
<b>2</b>	<b>ASSESSMENT STRATEGY</b>	<b>8</b>
2.1	Scope of the Step 2 Radioactive Waste Management, Spent Fuel Management and Decommissioning Assessment	8
2.2	Standards and Criteria	10
2.3	Use of Technical Support Contractors	12
2.4	Integration with Other Assessment Topics	12
<b>3</b>	<b>REQUESTING PARTY'S SAFETY CASE</b>	<b>14</b>
3.1	Summary of the RP's Preliminary Safety Case in the Areas of Radioactive Waste Management, Spent Fuel Management and Decommissioning	14
3.2	Basis of Assessment: RP's Documentation	15
<b>4</b>	<b>ONR ASSESSMENT</b>	<b>17</b>
4.1	Contamination and Activation	17
4.2	Decontamination	19
4.3	Radioactive Waste	20
4.4	Spent Fuel	23
4.5	Decommissioning	25
4.6	Out of Scope Items	27
4.7	Comparison with Standards, Guidance and Relevant Good Practice	27
4.8	Interactions with Other Regulators	27
<b>5</b>	<b>CONCLUSIONS AND RECOMMENDATIONS</b>	<b>28</b>
5.1	Conclusions	28
5.2	Recommendations	28
<b>6</b>	<b>REFERENCES</b>	<b>30</b>

### Table

Table 1: Relevant Safety Assessment Principles Considered During the Assessment

## 1 INTRODUCTION

### 1.1 Background

1. The Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA) process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments getting increasingly detailed as the project progresses. Hitachi-GE Nuclear Energy Ltd (Hitachi-GE) is the RP for the GDA of the UK Advanced Boiling Water Reactor (UK ABWR).
2. During Step 1 of GDA, which is the preparatory part of the design assessment process, the RP established its project management and technical teams and made arrangements for the GDA of its ABWR design. Also, during Step 1 the RP prepared submissions to be evaluated by ONR and the Environment Agency (EA) during Step 2.
3. Step 2 is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including review of key nuclear safety, nuclear security and environmental safety claims with the aim of identifying any fundamental safety or security shortfalls that could prevent the issue of a Design Acceptance Confirmation (DAC).
4. This report presents the results of my assessment of the Radioactive Waste Management, Spent Fuel Management and Decommissioning of the RP's UK ABWR as presented in the Preliminary Safety Report (PSR) (Ref. 1, 2 & 3) and its supporting documentation.

### 1.2 Methodology

5. My assessment has been undertaken in accordance with the requirements of ONR's How2 Business Management System (BMS) procedure PI/FWD (Ref. 4). The ONR Safety Assessment Principles (SAP) (Ref. 5), together with supporting Technical Assessment Guides (TAG) (Ref. 6), have been used as the basis for this assessment.
6. My assessment has followed my Step 2 Assessment Plan for Radioactive Waste Management, Spent Fuel Management and Decommissioning (Ref 7) prepared in December 2013 and shared with the RP to ensure effective engagement. The only aspects included in my plan that I have not been able to assess are:
  - That suitable and sufficient design features, locations, equipment and arrangements to support radioactive waste characterisation, segregation and other waste management operations are provided. This includes being able to obtain sufficient representative information from characterisation, for example non destructive assay measurements, to support future management activities.
  - That the anticipated timescales for the management of radioactive wastes, from production to disposal, including potential intermediate steps can be achieved with timescales to ensure safety at all times.
7. The only departures from the information expected from the RP as outlined in my Step 2 Assessment Plan are noted below, all other expectations have been met sufficiently for this stage:
  - The complete analysis of which areas of the UK ABWR can be contaminated under fault conditions and consequent waste routings, volumes, etc, identified for each material, including how minimisation has been achieved.
  - The un-redacted Chapter 11 of GE's ABWR 1997 Design Control Document Revision 4, submitted to the US NRC (or a later revision if more appropriate),

and / or the corresponding GE Nuclear Energy's ABWR Standard Safety Analysis Report.

8. Where appropriate the above departures from my Step 2 Assessment Plan are followed up in this report as part of sections highlighting items requiring follow-up in Step 3.

## **2 ASSESSMENT STRATEGY**

9. This section presents my strategy for the Step 2 assessment of the Radioactive Waste Management, Spent Fuel Management and Decommissioning of the UK ABWR (Ref 7). It also includes the scope of the assessment and the standards and criteria that I have applied.

### **2.1 Scope of the Step 2 Radioactive Waste Management, Spent Fuel Management and Decommissioning Assessment**

10. The objective of my Step 2 assessment was to review and judge whether the claims made by the RP related to Radioactive Waste Management, Spent Fuel Management and Decommissioning that underpin the safety, security and environmental aspects of the UK ABWR are complete and reasonable in the light of our current understanding of reactor technology.

11. For Radioactive Waste Management, Spent Fuel Management and Decommissioning "safety claim" is interpreted as being:

- Specific and measurable statements that show that radioactive waste in the UK ABWR meets the following expectations:
  - That the strategies being developed for radioactive waste are consistent with Government policy and are integrated with other relevant strategies.
  - That the design ensures that the generation of waste is prevented or minimised. The safety case should describe specific design provisions for waste minimisation and include a demonstration that the rate of production of radioactive waste has been minimised. Process and material selection, construction methods, envisaged operations and decommissioning should be such as to avoid the creation of radioactive waste or reduce to the minimum the amount of radioactive waste generated throughout the facility's lifetime.
  - That the accumulation of radioactive waste will be minimised.
  - That suitable and sufficient design features, locations, equipment and arrangements to support radioactive waste characterisation, segregation and other waste management operations are provided. This includes being able to obtain sufficient representative information from characterisation to support future management activities.
  - That all sources of radioactive waste are identified and disposal routes are available.
  - That the quantity of waste, the magnitude of radiological hazard, the potential for the hazard to be realised and the potential dose have been considered.
  - That the design ensures that radioactive substances will be contained and the generation of radioactive waste through the spread of contamination by leakage will be prevented.



- That nuclear containment and associated systems are designed to minimise radioactive releases to the environment in normal operation, fault and accident conditions.
  - That the anticipated timescales for the management of radioactive wastes, from production to disposal, including potential intermediate steps, can be achieved with timescales to ensure safety at all times.
  - That redundant storage is provided with sufficient capacity and associated services to ensure prolonged safe storage of the maximum anticipated volume of material requiring relocation, allowing for any volume increase due to the method of transfer.
  - That optioneering process will take account of all relevant factors. Where the design forecloses potential future options then this needs to be clearly stated and appropriately justified.
  - Identification and explanation of the interdependencies with off site disposal and / or treatment providers.
  - That radioactive waste is managed in a manner that minimises the need for future processing.
  - That the generation of radioactive waste of a type or form that is incompatible with currently available disposal technology is prevented.
  - That waste that cannot be managed using current techniques, or techniques under current development, is not created.
  - That the UK ABWR will be compatible with the requirements of permits granted by the environment agencies.
  - That operational limits and conditions required for safe storage are identified.
  - That the safety case is compatible with the waste strategy. That the radioactive waste is managed in accordance with good practice and good engineering principles.
  - Characteristics of the safety-related features of both the packages and containers and the storage facility, under normal and fault conditions, are identified for any radioactive waste stored in a facility.
  - That continued safe storage of the radioactive material for the planned storage period can be achieved to ensure safety at all times and does not compromise future retrieval and treatment and / or transportation.
  - That the design allows for the monitoring, examination, inspection and testing arrangements for the facility applicable to the stored radioactive waste for the anticipated storage duration.
  - That any intended deferral of the processing of radioactive waste into a passively safe state, together with the reason for the deferral will be substantiated.
  - The provisions for gathering information relevant to radioactive waste management and disposal such that appropriate records can be kept for future generations.
- Specific and measurable statements that show that decommissioning of the UK ABWR meets the following expectations:
- That design measures are provided to minimise activation and contamination
  - That design features are provided to facilitate decommissioning and to reduce dose uptake by decommissioning workers.
  - An initial decommissioning strategy, which is consistent with Government policy and strategies. The strategy should encompass the

anticipated timescales for the future operation, shutdown and decommissioning of facilities on the site, including any proposed new facilities.

- A plan for decommissioning that defines the decommissioning end-state for the facility and any interim states and confirmation that the plan will be supported by appropriate evidence to demonstrate that decommissioning can be undertaken safely and that the end state can be met.
  - The type and quantity of decommissioning wastes to be managed and the timescales over which the wastes arise.
  - If it is proposed to defer decommissioning and this is justified, a sufficiently developed plan should be provided to show that the relevant factors to facilitate safe decommissioning in the future have been taken into account.
  - The provisions for data gathering such that appropriate records relating to decommissioning can be kept for future generations.
12. During Step 2 I have also evaluated whether the safety claims related to Radioactive Waste Management, Spent Fuel Management and Decommissioning are supported by a body of technical documentation sufficient to allow me to proceed beyond Step 2.
13. Finally, during Step 2 I have undertaken the following preparatory work for my Step 3<sup>†</sup> assessment:
- decided on the scope and plan for the Step 3 assessment, including consideration of use of Technical Support Contractors (TSC) and setting-up the process to put required contracts in place for Step 3;
  - improved ONR's knowledge of the design including being shown the 3D model.
  - inspected an existing plant to inform ONR's view on how claims on radioactive waste have been implemented;
  - completed preparatory work and initial assessment, on a sampling basis, of RP's analyses pertinent to radioactive waste and decommissioning and supporting arguments;
  - liaised with other ONR and EA inspectors, as appropriate, to inform and focus my assessment work; and
  - identified whether any significant design or safety case changes may be needed, and informed the RP as appropriate.

## 2.2 Standards and Criteria

14. The goal of ONR's Step 2 assessment is to reach an independent and informed judgment on the adequacy of a nuclear safety case. For this purpose, assessment is undertaken in line with the requirements of the How2 Business Management System (BMS) document PI/FWD (Ref. 4). Appendix 1 of Ref. 4 sets down the process of assessment; Appendix 2 explains the process associated with sampling of safety case documentation.
15. In addition, the SAPs (Ref. 5) constitute the regulatory principles against which duty holders' safety cases are judged. Therefore, they are the basis for ONR's nuclear safety assessment and have been used for my Step 2 assessment of the UK ABWR. The SAPs 2006 Edition (Revision 1 January 2008) were benchmarked against the

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<sup>†</sup> For details of each Step of the GDA process visit [www.onr.org.uk](http://www.onr.org.uk)

International Atomic Energy Agency (IAEA) standards (as they existed in 2004). They are currently being reviewed.

16. Furthermore, ONR is a member of the Western European Nuclear Regulators Association (WENRA). WENRA has developed Reference Levels, which represent good practices for existing nuclear power plants, and Safety Objectives for new reactors.
17. The relevant SAPs, IAEA standards and WENRA reference levels are embodied and enlarged on in the TAGs on radioactive waste and materials, spent fuel and decommissioning (Ref. 6). These guides provide the principal means for assessing the Radioactive Waste Management, Spent Fuel Management and Decommissioning aspects in practice.

### **2.2.1 Safety Assessment Principles**

18. The key SAPs (Ref. 5) applied within the assessment are:

- Radioactive waste management SAPs RW.1 to RW.6;
- Containment and ventilation SAPs ECV.1, ECV.2 and ECV.4;
- Control of nuclear matter SAPs ENM.1, ENM.3, and ENM.5 to ENM.7; and
- Decommissioning SAPs DC.1 to DC.6.
- Radiological protection SAP RP.4

See also Table 1 for further details.

### **2.2.2 Technical Assessment Guides**

19. The following Technical Assessment Guides have been used as part of this assessment (Ref. 6):
  - NS-TAST-GD-026 Revision 3, Decommissioning.
  - NS-TAST-GD-024 Revision 4, Management of radioactive materials and radioactive waste on nuclear licensed sites.
  - NS-TAST-GD-081 Revision 1, Safety aspects specific to storage of spent nuclear fuel.
  - NS-TAST-GD-017 Revision 3, Civil engineering.
  - NS-TAST-GD-051 Revision 3, The purpose, scope, and content of safety cases.

### **2.2.3 National and International Standards and Guidance**

20. The following national and international standards and guidance have also been used as part of this assessment:
  - Relevant IAEA standards (Ref. 8):
    - Methods for the Minimization of Radioactive Waste from Decontamination and Decommissioning of Nuclear Facilities, Technical Report Series 401.
    - IAEA Safety Standards – Safety of Nuclear Fuel Facilities, NS-R-5.
    - IAEA Safety Standards – Decommissioning of Nuclear Fuel Cycle Facilities, WS-G-2.4.
    - IAEA Safety Standards – Decommissioning of Facilities Using Radioactive Material, WS-R-5.
    - Design Lessons Drawn from the Decommissioning of Nuclear Facilities, IAEA-TECDOC-1657.

- IAEA Safety Standards – Decommissioning of Nuclear Power Plants and Research Reactors, WS-G-2.1.
  - IAEA Safety Standards – Decommissioning of Medical, Industrial and Research Facilities, WS-G-2.2
  - IAEA Safety Standards – Storage of Spent Nuclear Fuel, SSG-15.
  - Data Requirements and Maintenance of records for spent Fuel Management, IAEA-TECDOC-1519.
  - IAEA Safety Standards - Predisposal Management of Radioactive Waste; General Safety Requirements Part 5, GSR Part 5.
  - IAEA Safety Standards – Fundamental Safety Principles, Safety Fundamentals SF-1.
- WENRA references (Ref. 9):
- Reactor Safety Reference Levels (January 2008).
  - Safety Objectives for New Power Reactors (December 2009) and Statement on Safety Objectives for New Nuclear Power Plants (November 2010).
  - Waste and Spent Fuel Storage Safety Reference Levels (February 2011).
  - Decommissioning Safety Reference Levels (March 2012).
  - Statement on Safety Objectives for New Nuclear Power Plants (March 2013) and Safety of New NPP Designs (March 2013).
- Other approved codes of practice, relevant policy & guidance:
- Joint guidance, The Management of Higher Activity Radioactive Waste on Nuclear Licensed sites, February 2011 (Ref. 10).
  - Industry Guidance - Interim Storage of Higher Activity Waste Package – Integrated Approach, November 2012 (Ref. 11).
  - Approved Code of Practice, Managing Health and Safety in Construction – Construction (Design and Management) Regulations 2007 (Ref. 12).
  - Approved Codes of Practice, Working with Ionising Radiation – Ionising Radiations Regulations 1999 (Ref. 13).

### **2.3 Use of Technical Support Contractors**

21. During Step 2 I have not engaged Technical Support Contractors (TSC).

### **2.4 Integration with Other Assessment Topics**

22. Early in GDA I recognised that during the project there would be a need to consult with other GDA assessors (including EA's assessors) as part of the Radioactive Waste Management, Spent Fuel Management and Decommissioning assessment process. Similarly, other assessors will seek input from my assessment. I consider these interactions very important to ensure the prevention of assessment gaps and duplications, and are, therefore, key to the success of the project. Thus, from the start of the project, I made every effort to identify potential interactions between my own and other technical areas, with the understanding that this position would evolve throughout the UK ABWR GDA.

23. Also, it should be noted that the interactions with some technical areas in GDA need to be formalised since aspects of the assessment in those areas constitute formal inputs

to the Radioactive Waste Management, Spent Fuel Management and Decommissioning assessment, and vice versa. These are:

- Civil engineering provides input to the decommissioning and containment aspects of the radioactive waste and decommissioning assessment. This formal interaction has commenced during GDA Step 2. This work is being led by the civil engineering team.
  - Reactor chemistry provides input to the source term aspects of the radioactive waste and decommissioning assessment. This formal interaction has commenced during GDA Step 2. This work is being led by the reactor chemistry team.
  - The fault studies assessment provides input to the aspects of the radioactive waste and decommissioning assessment related to the contamination of areas under fault conditions. This area also provides input for the Spent Fuel Interim Storage (SFIS) concept design. This formal interaction has not commenced during GDA Step 2. This work will be led by the fault studies team.
  - The fuel and core design assessment provides input to the aspects of the radioactive waste and decommissioning assessment related to spent fuel and radioactive waste. This formal interaction has commenced during GDA Step 2. This work is being led by the fuel and core team.
  - The internal hazards assessment provides input to the aspects of the radioactive waste and spent fuel management and decommissioning assessment related to contamination of areas. This formal interaction has commenced during GDA Step 2. This work is being led by the internal hazards team.
  - The mechanical engineering assessment provides input to the aspects of the radioactive waste and decommissioning assessment related to contamination of equipment. This formal interaction has commenced during GDA Step 2. This work is being led by the mechanical engineering team.
  - The radiological protection assessment provides input to the aspects of the radioactive waste and decommissioning assessment related to the contamination of areas. This formal interaction has commenced during GDA Step 2. This work is being led by the radiological protection team.
24. In addition to the above, during GDA Step 2 there have been interactions between Radioactive Waste Management, Spent Fuel Management and Decommissioning and the rest of the technical areas, e.g., human factors etc. Although these interactions, which are expected to continue thorough GDA, are mostly of an informal nature, they are essential to ensure consistency across the technical assessment areas.

### 3 REQUESTING PARTY'S SAFETY CASE

25. This section presents a summary of the RP's preliminary safety case in the area of Radioactive Waste Management, Spent Fuel Management and Decommissioning. It also identifies the documents submitted by the RP which have formed the basis of my Step 2 assessment.

#### 3.1 Summary of the RP's Preliminary Safety Case in the Areas of Radioactive Waste Management, Spent Fuel Management and Decommissioning

26. The aspects covered by the preliminary safety case in the areas of Radioactive Waste Management, Spent Fuel Management and Decommissioning can be broadly grouped under 5 headings which can be summarised as follows:

- Contamination and activation: the key safety claims in this area are:
  - The volume of radioactive structures is minimised.
  - The activity levels of irradiated components are minimised.
  - The toxicity of the waste is minimised.
  - The spread of contamination is minimised.
- Decontamination: the key safety claims in this area are:
  - Reduction of the degree of surface contamination.
  - Allowance for easier decontamination.
  - Design principles are used to reduce dose, including decontamination.
- Waste management: the key safety claims in this area are:
  - Total radioactive waste volumes from reactor operation are minimised.
  - The radioactive waste management system ensures safe segregation at source and collection of the various waste water streams resulting from reactor and turbine operations.
  - Treatment of waste water allows safe discharge to the environment.
  - Dose to both the operators and the public from normal operation of the radioactive waste management system are As Low As reasonably Practicable (ALARP).
  - Wastes are contained and controlled within appropriately engineered facilities.
  - Appropriate monitoring, measuring and sampling equipment are provided.
  - Doses to the public in faults are ALARP and within limits / targets.
  - Potential doses to operators in faults are ALARP, including potential doses associated with post-fault recovery actions.
  - The off-gas system minimises the release of gaseous radioactivity generated by plant operations, such that it is ALARP.
  - Adequate radiation shielding is provided to ensure that dose to plant operators is ALARP.
- Decommissioning: the UK ABWR preliminary safety report in this areas covers:
  - Development of decommissioning principles underpinning the UK ABWR.
  - Initial development of decommissioning plans.

- Ease of access to components to dismantle.
  - Limited radiation dose received by workforce.
  - Minimisation of the production of secondary waste.
- Spent Fuel Management: the UK ABWR preliminary safety report in this area addresses the following:
- The RP is in the process of considering options available for SFIS. For GDA a “preferred” option will be selected.
  - The “preferred” option will be consistent with the plant design and licensed operation.
  - As far as possible, the RP will avoid design and operational actions that would foreclose onward transport or processing of spent fuel.

### 3.2 Basis of Assessment: RP's Documentation

27. The RP's documentation that has formed the basis for my assessment of the safety claims related to Radioactive Waste Management, Spent Fuel Management and Decommissioning for the UK ABWR consists of:

- Preliminary Safety Report (PSR) on Radioactive Waste Management System (Ref. 1). This document describes at a high level the key safety claims for solid, liquid and gaseous waste management systems.
- PSR on Spent Fuel Interim Storage (Ref. 2). This document describes the high level safety requirements for SFIS for the UK ABWR, and the outline process the RP will use for the optioneering for the spent fuel storage concept design.
- PSR on Decommissioning (Ref. 3). This document describes at a high level the decommissioning principles underpinning the design, safety claims, and the outline for decommissioning plans and programme.
- UK ABWR Basis of Safety Case document “Off-Gas System Basis of Safety Case” (Ref. 14). This document presents a system summary description, design bases, system design description and an evaluation of the system design.
- UK ABWR GDA tracking sheet (Ref. 15).
- Responses to Regulatory Queries (RQ) RQ-ABWR-0026, 0028, 0030, 0031, 0032, 0035, 0036 and 0037.

28. A number of submissions made in other technical areas contained elements relevant to my assessment. These reports either included claims already made within the Radioactive Waste Management, Spent Fuel Management or Decommissioning PSR (Refs 1, 2 and 3), or identified related claims. While the full scope of the safety case presented by these reports did not form part of my assessment, any radioactive waste, spent fuel or decommissioning related claims did; my assessment of these is described in Section 4. The main documents considered were:

- PSR on Radiation Protection, Section 1 on Definition of Radioactive Sources (Ref. 16).
- PSR on Reactor Chemistry (Ref. 17).
- PSR on Reactor Core and Fuels (Ref. 18).
- Internal Hazards Report (Ref. 19).
- Fault Studies to Discuss Deterministic Analysis, PSA and Fault Schedule Development (Ref. 20).
- UK ABWR information in support of the generic environmental permit Radioactive Waste Management Arrangement (Ref. 21).
- Responses to RQs RQ-ABWR-0045, 0046, 0079, 0082 and 0126.

- Regulatory Observation (RO) RO-ABWR-0006 on Source Terms.
29. In addition, in May 2014 the RP submitted to ONR for information an advance copy of the UK ABWR Pre-Construction Safety Report (PCSR).
- Chapter 15 (Ref. 22) addresses Radioactive Waste Management.
  - Chapter 28 (Ref. 23) addresses Spent Fuel Management.
  - Chapter 27 (Ref. 24) addresses Decommissioning.

Although I have not covered this report in my Step 2 assessment, it has been useful for my planning and preparations for my Step 3 work.



## 4 ONR ASSESSMENT

30. My assessment has been carried out in accordance with ONR How2 BMS document PI/FWD, "Purpose and Scope of Permissioning" (Ref. 4).
31. My Step 2 Radioactive Waste Management, Spent Fuel Management and Decommissioning assessment has followed the strategy described in Section 2 of this report.
32. My assessment has involved regular engagement with the RP's Radioactive Waste Management, Spent Fuel Management and Decommissioning Subject Matter Experts (SME), i.e., three Technical Exchange Workshops (two in Japan and one in the UK) and 25 progress meetings have been held. I have also visited:
- Shimane Unit 3 ABWR where I could inspect the whole facility including the Control Building; Reactor Building (service floor from viewing gallery, upper drywell, main steam tunnel, suppression pool, lower drywell, pump room for reactor heat recovery, emergency diesel generators (EDG), EDG day tank; Turbine Building; Radioactive Waste Building – low conductivity waste systems and high conductivity waste systems; and the construction of the Backup Building and the 15m seawall.
  - Hitachi Rinkai Works where reactor internal components and fine motion control rod drive units are manufactured and tested where I gained an overview of the RP's manufacturing capability.
  - Japan Steel Works where large stainless steel components are manufactured and I could see the fabrication techniques and sections of reactor pressure vessels.
33. During Step 2, I have identified some shortfalls in documentation which have generally led to the issue of RQs; overall I have raised 20 RQs (at the time of writing the RP has provided answers to 12 Regulatory Queries (RQs)). Shortfalls in the safety case generally lead to the issue of Regulatory Observations (ROs); I have not raised any ROs during Step 2.
34. Details of my Step 2 assessment including the areas of strength that I have identified, as well as the items that require follow-up and the conclusions reached are presented in the following sub-sections.

### 4.1 Contamination and Activation

#### 4.1.1 Assessment

35. Systems and components which are connected to the primary circuit and contain or transport primary fluid (reactor water and main steam) are identified as the main radioactive sources in the plant. Other sources of contamination include the radioactive waste systems and the off-gas system, as well as transportation and storage of radioactive and / or contaminated items (Ref: 16).
36. Preventing contamination and activation to the extent that it is ALARP should be encompassed in the design of any new nuclear facility. This is because it reduces the waste arising and does not lead to additional risks and complications in decommissioning operations. The following principles in ONR SAPs have been specifically taken into consideration:

- ECV 1: Radioactive substances should be contained and the generation of radioactive waste through the spread of contamination by leakage should be prevented.
  - ECV 2: Nuclear containment and associated systems should be designed to minimise radioactive releases to the environment in normal operation, fault and accident conditions.
  - ECV 4: Where the radiological challenge dictates, waste storage vessels, process vessels, piping, ducting and drains (including those that may serve as routes for escape or leakage from containment) and other plant items that act as containment for nuclear matter, should be provided with further containment barrier(s) that have sufficient capacity to deal safely with the leakage resulting from any design basis fault.
  - RW 2: The generation of radioactive waste should be prevented or, where this is not reasonably practicable, minimised in terms in terms of quantity and activity.
  - ENM 3: Unnecessary or unintended generation, transfer or accumulation of nuclear matter should be avoided.
37. It is important to minimize the spread of radioactive contamination with a view to reducing dose and the need for decontamination, and hence also minimize the creation of secondary waste. As well as minimising the spread of radioactive contamination in the facility under normal conditions, the spread of contamination under fault conditions also needs to be considered.
38. In order to minimize the spread of contamination for radioactive material, there should be consideration of appropriate containment and the prevention of leak and escape.
39. On the basis of the above, I have assessed the safety claims put forward by the RP in relation to contamination and activation in the UK ABWR.

#### 4.1.2 Strengths

40. The UK ABWR safety case (Refs 1, 17 and 21) recognises that:
- Containment of the waste at all times is important.
  - The management of the reactor's chemistry can minimize radioactive waste and reduce dose rates, which are important throughout the plant life and when the facilities are being decommissioned.
  - Material selection can have an effect on activation or the amount of contamination.
  - The safety case notes that the ABWR minimizes the formation of radioactive hot spots during the shutdown due to the design and elimination of areas of stagnant flow or crevices. This will reduce both the amount of contamination during outages and during decommissioning as decontamination and post operative clean out (POCO) methods will be more effective.
  - The chemistry of the spent fuel pool contributes to maintaining the integrity of the spent fuel pool liner, which limits the potential for the spread of contamination due to leak and escape.
  - A number of claims have been made with respect to radiological protection for the public and workforce and these have been brought to the attention of the radiological protection specialist inspector.

### 4.1.3 Items that Require Follow-up

41. During my assessment of contamination and activation aspects of the UK ABWR preliminary safety case I have identified the following shortcomings that I will follow-up during Step 3:
- There is a safety requirement within the radioactive waste management PSR (Ref. 1) for containing radioactive liquid; the civil engineering PSR (Ref. 25) also recognises this need. How containment is achieved and minimises the potential for the spread of contamination will be progressed where appropriate, with the civil engineering specialist inspector.
  - The expected spread of contamination during normal operation (including outages) and under fault conditions is currently unclear. This information is needed for radioactive waste assessment and for establishing design features to aid decommissioning. This will be followed up jointly with the radiological protection specialist inspector.
  - Follow-up all outstanding RQs (Ref. 26) relating to:
    - Contaminated oils generated by an ABWR
    - Radiological fingerprint for activation of reactor core internals
    - ABWR lined pools and structures

### 4.1.4 Conclusions

42. Based on my assessment I have concluded that the RP understands the effect of a number of key contributors to the amount of contamination and activation in the UK ABWR. I have concluded that the documents provided by the RP form an adequate basis for further development of the contamination and activation aspects of the UK ABWR safety case during Step 3.

## 4.2 Decontamination

### 4.2.1 Assessment

43. Minimisation of the contamination of facilities and equipment can be achieved by designing for easy decontamination.
44. Areas in the UKABWR may need to be decontaminated during normal operations and after fault conditions. Material specification, design details, pre-treatment and application of appropriate coatings (for porous materials) can be useful in achieving reduced contamination build-up and in reducing the difficulty of subsequent decontamination. For example a concrete surface exposed to contamination under normal operation or during incidents will, as concrete is porous, become ingrained with contamination and this will migrate over time deeper into the concrete. Therefore it is appropriate to consider the application of a coating, which will hinder the migration of contamination, thus aiding decontamination.
45. The following principle in ONR's SAPs has been specifically taken into consideration:
- RP.4 Suitable and sufficient decontamination provisions for the people, the facility, its plant and equipment should be provided.
46. On the basis of the above, I have assessed the safety claims put forward by the RP in relation to decontamination in the UK ABWR.

### 4.2.2 Strengths

47. The UK ABWR preliminary safety case highlights the benefits of reducing the degree of surface contamination from:
- Adoption of concrete surface for ease of decontamination. The concrete surface, which could become contaminated, will be coated. In addition, lining will be employed to the surface of the fuel storage pool.
  - Pre-treatment of metal surface for prevention of contamination. Surface polishing of the metal in some system will be implemented.
  - Containment of leakages.
  - Design details, such as curvature of concrete floor, floor slope, etc, will be incorporated. Waterproofing treatment to the floor areas where contamination is possible will be applied as needed.
48. The UK ABWR preliminary safety report (Ref. 3) recognises that design for decontamination is necessary. The decommissioning PSR (Ref. 3) states “Section 5 of PCSR on Decommissioning, will present the strategic decommissioning options with respect to logistical challenges, envisaged sequence and methodology including considerations such as safety, decontamination, space, access, supporting systems and infrastructure requirements. It demonstrates how decommissioning can proceed throughout the plant allowing the contaminated equipment to be decontaminated and subsequently decommissioned safely”.
49. System decontamination of the radioactive materials deposited inside the pipes and vessels are recognized as being required.

#### **4.2.3 Items that Require Follow-up**

50. During my assessment of the decontamination aspects of the UK ABWR preliminary safety case I have identified the following shortcomings that I will follow-up during Step 3:
- A clear understanding of the expected spread of contamination under normal operations and under fault conditions will aid the design for decontamination (see section 4.1.3).
  - The requirement for sufficient space for personnel to be able to decontaminate the systems during normal operations and after fault conditions will need to be demonstrated in Steps 3 and 4. This will be progressed with the human factors specialist inspector.

#### **4.2.4 Conclusions**

51. Based on my assessment I have concluded that the RP understands the design requirements in a number of key areas which affect decontamination. I have concluded that the document provided by the RP forms an adequate basis for further development of the decontamination aspects of the UK ABWR safety case during Step 3.

### **4.3 Radioactive Waste**

#### **4.3.1 Assessment**

52. During operation and decommissioning quantities of radioactive solid, liquid and gaseous waste will be generated. Where it is unavoidable then the accumulation of radioactive waste should be minimised, as this reduces the potential hazard from the waste. When waste is accumulated on site the quantity of waste, the magnitude of radiological hazard, the potential for the hazard to be realised and the potential dose

must be considered. The waste generated must be compatible with currently available disposal technology.

53. Over the lifecycle of the facilities the UK ABWR will generate a variety of waste forms. Therefore, an appropriate radioactive waste strategy is required, which is consistent with Government Policy, integrated with other strategies (such as decommissioning) and which identifies and explains the interdependencies with off site disposal and / or treatment providers. The strategy also needs to anticipate timescales for the management of radioactive wastes, from production to disposal, including how potential intermediate steps can be achieved with timescales to ensure safety at all times. The waste strategy needs to be compatible with the safety case.
54. The design and optimisation of the facility and the process within it need to be developed to minimise the volumes of radioactive wastes. A key contributor to waste generation and optimisation is the chemistry regime used within the reactor and the associated processes; this is being assessed by the reactor chemistry specialist inspectors. The source term, which is a function of the reactor chemistry will be considered by both ONR and the EA. The source term has been defined in RO-ABWR-006 (Ref. 27) as:

*Source term - The types, quantities, and physical and chemical forms of the radionuclides present in a nuclear facility that have the potential to give rise to exposure to radiation, radioactive waste or discharges.*

The regulators would expect that the source terms for the UK ABWR design should be evaluated for the various operational states; this is the subject of RO-ABWR-006 (Ref. 27)<sup>‡</sup>, This evaluation is important for a number of reasons, including:

- to ensure that the design is optimised such that the source terms are reduced so far as is reasonably practicable (SFAIRP);
  - to demonstrate that consequential hazards such as radiation doses, generation of radioactive waste and discharges are also reduced SFAIRP and that Best Available Techniques (BAT) have been applied; and,
  - to demonstrate that the design ensures that numerical targets and legal limits, including restrictions on doses, are met.
55. Once waste is generated it needs to be disposed of and therefore it is important that all expected radioactive wastes generated in the UK ABWR have available/ or likely to be available<sup>§</sup>, waste disposal routes. In order to ensure that the waste can be disposed of via the most appropriate route the UK ABWR needs to ensure that suitable and sufficient design features, locations, equipment and arrangements to support radioactive waste characterisation, segregation and other waste management operations are provided. This includes being able to obtain and keep sufficient representative information from characterisation to support future management activities.
56. For those wastes which will be processed and stored on site prior to disposal, operational limits and conditions required for the safe processing and storage should be identified. This ought to include the claims for the safety-related features of processing, packages, containers and storage facilities, under normal and fault

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<sup>‡</sup> The entire scope of the regulators' interest in the topic of source terms extends beyond the boundary of this RO, to design basis and severe accidents.

<sup>§</sup> This is based on the appropriate Radioactive Waste Management Ltd advice

conditions. The design should include arrangements for the monitoring, examination, inspection and testing of the facilities used for waste processing and storage for the anticipated storage duration. The storage capacity is important as it needs to be sufficient to ensure prolonged safe storage of the maximum anticipated volume of material requiring relocation, allowing for any volume increase due to the method of transfer. The waste ought to be processed into a passive safe state as soon as is reasonably practical for storage in accordance with good engineering practice.

57. On the basis of the above, I have assessed the safety claims put forward by the RP in relation to radioactive waste in the UK ABWR.

#### 4.3.2 Strengths

58. The UK ABWR preliminary safety case on radioactive waste (Refs 1, 2, 17, 18, 20 and 21) has a number of strengths:

- The waste hierarchy is being used in the development of the safety case ( Ref. 10).
- It recognises the radioactive management options available in the UK for each of the major waste streams expected during operations of the UK ABWR.
- Demonstrates the need for appropriate disposability assessments for a number of waste streams.
- Estimated quantities of solid waste generation arising from operations are available.
- It recognises that fault analysis for the radioactive waste systems areas is needed and that this is underway.

#### 4.3.3 Items that Require Follow-up

59. During my assessment of radioactive waste aspects of the UK ABWR preliminary safety case I have identified the following shortcomings that I will follow-up during Step 3:

- Not all internal hazards in the radioactive waste management PSR have been identified, such as dropped loads. The RP's internal hazards report (Ref. 19) excludes the radioactive waste building and SFIS. This report, where applicable to my areas, also excludes possible effects on workers from internal hazards. This information is needed for radioactive waste management and spent fuel management assessment and will be followed up with the internal hazards specialist inspector.
- From all the documents sampled for this assessment it is unclear how the safety case for transportation of containers around the facilities and between facilities is being covered. Further clarification will be requested from the RP in Step 3.
- It is unclear how matters related to sumps and potential back flow of radioactive materials is being addressed, and further clarification will be requested from the RP.
- The RP is progressing fault analysis, including internal hazards, but needs to cover every aspect, for example, waste transportation and interim storage. This is being assessed by the fault studies and internal hazards specialist inspectors.
- Further demonstration of compliance with waste hierarchy (Ref. 10) for some waste streams and disposal routes needs to be developed over Steps 3 and 4, for example, the feasibility of incineration of LLW resins.

- Waste streams identified to date do not include materials that could be contaminated under fault conditions. This will be sampled further as wastes that could be generated under fault conditions are identified.
- Operational experience in the UK shows that existing nuclear reactors produce contaminated oils. The RP has been requested (Ref. 28) to review relevant operational experience in the UK and world wide. In this review, for each relevant piece of equipment, a clear explanation will be needed as to whether the operational experience is, or is not applicable, and where appropriate, explain how the UK ABWR is different and ensures that oil can not be contaminated. If contaminated oils can be generated under normal or fault conditions then an appropriate disposal route needs to be identified. ONR enquiries have already highlighted the potential for contaminated oils and as yet it is unclear if the contamination is such that the oils can be disposed of via incineration.
- Due to the anticipated power output and life expectancy of the UK ABWR, there is a potential for high level waste from activation of the reactor internals, which is in addition to the spent fuel. Currently the RP estimates that it will be 70 years (Ref. 29) before this material decays to be classified as ILW. Therefore, the processing and storage strategy and its interaction with other strategies, such as decommissioning, will be of interest to ONR in the next GDA steps.
- The specification for, and output from, the disposability assessments need to be provided by the RP and; I will review these in Step 3.
- Completion of the disposability assessment, with the source term as identified by completion of the RO (paragraph 54) and incorporation of assessment as appropriate, for example any storage limits and conditions placed by the disposability assessment on the ILW storage..
- Follow-up all outstanding RQs (Ref. 26) related to this topic area.
  - Implications of failed fuel for the disposal inventory
  - Availability of incineration for LLW resins
  - Large, solid radioactive waste items

#### 4.3.4 Conclusions

60. Based on the outcome of my assessment I have concluded that the RP understands the waste and the waste strategies required for going forward with the UK ABWR. I have concluded that the document provided forms an adequate basis for further development of the safety case for radioactive waste during Step 3.

### 4.4 Spent Fuel

#### 4.4.1 Assessment

61. Spent fuel will be generated from the UK ABWR; it will be first stored in the spent fuel pool inside the reactor building, for a number of years, and afterwards it will be transferred to a SFIS facility for the years required to cool-down before final disposal is possible. The same as for radioactive waste, the accumulation of spent fuel should be minimised, and the quantity, magnitude of radiological hazard, the potential for the hazard to be realised and the potential dose should be considered in the design.
62. The anticipated timescales for the management of spent fuel extend long after the reactor has ceased operations. The RP needs to ensure safety at all times from production to disposal. This needs to include potential intermediate steps e.g. interim storage, within the appropriate timescales e.g. ensuring safety at all times, until safe disposal. Identification and explanation of the interdependencies with off site disposal should also be recognised. The spent fuel management ought to be part of a strategy

63. The generation of spent fuel, its safe management and subsequent treatment should be such that a disposability assessment concludes that the spent fuel could be disposed of in the Geological Disposal Facility (GDF). The spent fuel should be managed in a manner that minimises the need for future processing.
64. For the spent fuel stored on site (in the spent fuel pool and, later, in an SFIS) prior to disposal, operational limits and conditions required for the safe processing and storage should be identified. This should include the claims for the safety-related features of processing, packages, containers and the storage facility, under normal and fault conditions. The spent fuel should be stored in accordance with good engineering practice and, if practical, in a condition of passive safety. The design should allow for the monitoring, examination, inspection and testing arrangements for the facilities used in processing as well as its storage for the anticipated storage duration. The storage capacity is important as it needs to be sufficient to ensure prolonged safe storage of the maximum anticipated volume of material requiring relocation, allowing for any volume increase due to the method of transfer\*\*.
65. Where the design for the spent fuel management forecloses potential future options then this needs to be clearly stated and appropriately justified.
66. In order to ensure continued safe interim storage, processing of the spent fuel into a form suitable for transportation, transportation to the GDF and safe storage in the GDF, appropriate records need to be identified and kept for radioactive waste for future generations.
67. On the basis of the above, I have assessed the safety claims put forward by the RP in relation to spent fuel in the UK ABWR.

#### 4.4.2 Strengths

68. In my assessment of the spent fuel aspects of the UK ABWR preliminary safety case (Refs 2, 17, 18 and 20) I have identified the following strengths:
  - The RP is aware that the SFIS should be designed to the same high safety level applied to the nuclear power plant.
  - The safe management up to and including being able to retrieve and eventually transfer the spent fuel to the final site is recognised by the RP.
  - An optioneering process is being carried out and this is outlined in the SFIS PSR.
  - The RP is progressing the disposability assessments for spent fuel.
  - The RP recognises that the selection of the chemistry regime for the UK ABWR is important to maintain the integrity of the fuel and any relevant structures.
  - The RP recognises that the water chemistry management and temperature control of the spent fuel pool is important to protect the fuel from corrosion.
  - The fuel is designed to contain radioactive materials during normal operations and frequent design basis faults.
  - The RP is conducting fault analysis for fuel handling and cask drop accident.

#### 4.4.3 Items that Require Follow-up

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\*\* Volume increase may occur as safe transportation of material may require the material to be over packed.



69. During my assessment of the spent fuel aspects of the UK ABWR preliminary safety case I have identified the following matters that I will follow-up during Step 3:
- The spent fuel needs to be cooled prior to disposal in the GDF. The RP currently assumes a period of 140 years (Ref. 29) and considers this to be a conservative value. This will require substantiation as this estimate is based on 65 GWd/t .
  - Any issues associated with the failed / defective spent fuel and its disposability assessment should be identified and taken into account appropriately in the safety case.
  - The safety case should define monitoring, inspection and maintenance regimes for the stored fuel and the spent fuel storage facilities over the currently estimated 140 years.
  - The RP is developing fault analysis, including internal hazards evaluations, for the UK ABWR, but these need to cover every aspect, for example spent fuel transportation and interim storage. This is being assessed by the fault studies and internal hazards specialist inspectors.
  - Completion of the disposability assessment, with the Spent Fuel source term and incorporation of assessment as appropriate, for example any storage limits and conditions placed by the disposability assessment on the interim storage..
  - The optioneering process for the SFIS will require further development and I will review the process during Step 3.
  - Further development of the safety case for the safe management of spent fuel over the currently anticipated timescales to final disposal is required.
  - Follow-up all outstanding RQs (Ref. 26) relating to fuel degradation mechanisms relevant to spent fuel interim storage.

#### **4.4.4 Conclusions**

70. Based on the outcome of my assessment of spent fuel I have concluded that the RP understands the safety issues associated with spent fuel and the information required for going forward. I have concluded that the document provided by the RP forms an adequate basis for further development of the spent fuel safety case during Step 3.

### **4.5 Decommissioning**

#### **4.5.1 Assessment**

71. At the end of the life of any nuclear power plant it is necessary to decommission the facility. Although decommissioning of the UK ABWR will not be until after 60 years of operational life, the design and optimisation of the facility and the processes within it, need to be developed to minimise the challenges associated with decommissioning.
72. The design needs to ensure sufficient access and space to carry out decommissioning activities and removal of waste packages, especially in areas where there are elevated levels of radiation. The design can also affect the time spent in the vicinity of elevated radiation by the workforce as well as the tools and techniques they use during decommissioning.
73. The construction methods used when building a new facility can also make decommissioning more (or less) challenging. Construction techniques which are irreversible (e.g. placement of a large piece of equipment in position and pour concrete around it to build a structure) will make the decommissioning more challenging.
74. Decommissioning strategy and plans need to be developed in line with Government policies and need to encompass the full extent of the decommissioning liabilities and

interdependencies between facilities. The strategy needs to be integrated with other relevant strategies such as radioactive waste and spent fuel management. This will enable the decommissioning strategy to describe decommissioning options and timescales, and to determine the relative decommissioning sequence. If a period of passively safe care and maintenance has been appropriately justified, this ought to be clear within the strategy. The strategy should describe the assumed end-state for the site.

75. Throughout the whole life cycle of the UK ABWR the documents and records that might be required for decommissioning purposes should be identified, prepared, updated and retained. This includes the appropriate information from the design.
76. On the basis of the above, I have assessed the safety claims put forward by the RP in relation to decommissioning of the UK ABWR.

#### 4.5.2 Strengths

77. The UK ABWR preliminary safety case (Ref. 3) recognises the following:
- That the minimisation of contamination and activation will aid decommissioning and will reduce hazards (see section 4.1).
  - The need to construct the facility with the ability to safely remove parts of walls to improve access.
  - A number of contributing factors, which will aid reducing doses to ALARP during decommissioning.
  - That the principles for the decommissioning plans, and their outline, are being developed.
  - That the management of radioactive wastes during decommissioning is important.
  - That the preferred decommissioning strategy is prompt decommissioning, which is in line with regulatory expectations.

#### 4.5.3 Items that Require Follow-up

78. During my Step 2 assessment of the decommissioning aspects of the UK ABWR preliminary safety case I have identified the following matters that I will follow-up during Step 3:
- For the design of a new facility it is important to ensure that there is sufficient space for a containment system to be erected and work space within the containment, where appropriate. I will conduct further analysis with the human factors specialist for key areas of plant, which will be progressed in Step 3.
  - The sample of documents I have reviewed to date has not identified any internal hazards assessment for decommissioning. I would expect the internal hazards assessment to at least consider drop loads for large equipment items, currently expected to be taken out intact (e.g. heat exchangers of the residual heat removal system). This information is needed to progress my assessment of the decommissioning safety case I will follow up this matter with the internal hazards specialist inspector.
  - The further development of interdependences between the decommissioning strategy and other strategies such as radioactive waste management will be of interest to ONR. For example as a result of the activation of some reactor internal components (see section 4.3.3) it may be ALARP to defer decommissioning of parts of the UK ABWR.
  - The construction sequence for the UK ABWR needs to be reviewed in terms of its safety impact, if any, on the safe decommissioning of the facility at the end

of life. To address this matter, in Step 3 I will undertake further assessment for key areas of plant with the civil engineering specialist.

- Follow-up all outstanding RQ relating to human factors for the whole plant lifecycle.

#### **4.5.4 Conclusions**

79. Based on the outcome of my assessment of decommissioning I have concluded that the RP understands the hazards from decommissioning and the need to develop decommissioning strategies and plans. I have concluded that the document provided by the RP forms an adequate basis for further development of the decommissioning safety case during Step 3.

#### **4.6 Out of Scope Items**

80. I have left outside the scope of my Step 2 assessment the concept design for the SFIS. The reason for leaving this matter out of the scope of my GDA Step 2 assessment is because the RP has yet to complete and present the outcome of the optioneering for SFIS options. The preferred option needs to be known for a concept design to be developed.

81. It should be noted that this omission does not invalidate the conclusions from my assessment. During Step 3 I will follow-up this item and will capture it within my Step 3 Assessment Plan as appropriate.

#### **4.7 Comparison with Standards, Guidance and Relevant Good Practice**

82. In Section 2.2 above I have listed the standards and criteria I have used during my Step 2 assessment to judge the adequacy of the preliminary safety case. My overall conclusions in this regard can be summarised as follows:

- SAPs: The approach proposed by the RP on Radioactive Waste Management, Spent Fuel Management and Decommissioning appears to be developing ensuring consistency with ONR's expectations in the relevant SAPs. Table 1 provides further details.
- TAGs: The approach proposed by the RP appears to be developing ensuring consistency with the TAGs dealing with management and storage of radioactive waste and spent fuel, decommissioning, civil engineering and content of nuclear safety cases.

#### **4.8 Interactions with Other Regulators**

83. As part of my Step 2 assessment I have worked with the EA as an integral part of the assessment process. In Step 3 I will continue to consider Radioactive Waste Management, Spent Fuel Management and Decommissioning specific topic areas that would benefit from detailed liaison with other regulators.

## 5 CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Conclusions

84. The RP has provided a PSR for the UK ABWR for assessment during Step 2 of GDA. The PSR together with its supporting references present a basis for development of their safety case for the UK ABWR.

85. During Step 2 I have conducted an assessment of the parts of the PSR and its references that are relevant to the areas of Radioactive Waste Management, Spent Fuel Management and Decommissioning against the expectations of the SAPs and TAGs. From the UK ABWR assessment done so far I conclude the following:

- From the information submitted, which has formed part of my assessment, I have concluded that generally the design fundamentals are in line with my expectations for Step 2, and where this has not been the case the RP is now proposing appropriate design changes.
- I have concluded that the claims made by the RP relating to Radioactive Waste Management, Spent Fuel Management and Decommissioning that underpin the safety, security and environmental aspects of the UK ABWR are sufficiently developed and reasonable in the light of our current understanding of reactor technology for Step 2.
- My technical engagement with the RP in Step 2 has provided an adequate level of assurance that the Step 3 submission will be aligned to my regulatory expectations.
- Several topic areas require follow-up (see sections 4.1.3, 4.2.3, 4.3.3, 4.4.3 and 4.5.3 for details). The key areas are:
  - All wastes such as potentially contaminated oils, and high level waste (e.g. reactor internals), need to be integrated into the relevant strategies i.e. decommissioning and waste strategies and proposed facilities i.e. waste processing and storage facilities.
  - Further development of the safety case for the safe management of spent fuel over the currently anticipated timescales to final disposal is required.
  - The construction sequence for the UK ABWR needs to be reviewed in terms of its safety impact, if any, on the safe decommissioning of the facility at the end of life.
- From my interactions with the RP SMEs in Radioactive Waste Management, Spent Fuel Management and Decommissioning, I have found the RP to be professional and have committed considerable effort and resources to developing the UK ABWR safety case.

86. Overall, I see no reason, on Radioactive Waste Management, Spent Fuel Management and Decommissioning grounds, why the UK ABWR should not proceed to Step 3.

### 5.2 Recommendations

87. My recommendations are as follows :

- Recommendation 1: The UK ABWR should proceed to Step 3 of the GDA process for Radioactive Waste Management, Spent Fuel Management and Decommissioning.

- Recommendation 2; All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 Assessment Plan for the UK ABWR in Radioactive Waste Management, Spent Fuel Management and Decommissioning.
- Recommendation 3: All the relevant out-of-scope items identified in sub-section 4.6 of this report and those items in the Step 2 plan, which have not yet been assessed (paragraph 6) should be included in ONR's GDA Step 3 Assessment Plan for the UK ABWR in Radioactive Waste Management, Spent Fuel Management and Decommissioning.

## 6 REFERENCES

- 1 *Preliminary Safety Report on Radioactive Waste Management System*  
[GA91-9901-0042-00001, Revision B](#)
- 2 *Preliminary Safety Report on Spent Fuel Interim Storage*  
[GA91-9901-0045-00001, Revision A](#)
- 3 *Preliminary Safety Report on Decommissioning*  
[GA91-9901-0043-00001, Revision B](#)
- 4 *ONR How2 Business Management System. BMS: Permissioning – Purpose and Scope of Permissioning.* NES-PR-GD-014 Revision 4. July 2014  
[www.hse.gov.uk/nuclear/operational/assessment/index.htm](http://www.hse.gov.uk/nuclear/operational/assessment/index.htm).
- 5 *Safety Assessment Principles for Nuclear Facilities.* 2006 Edition Revision 1. HSE. January 2008. [www.hse.gov.uk/nuclear/SAP/SAP2006.pdf](http://www.hse.gov.uk/nuclear/SAP/SAP2006.pdf).
- 6 *Technical Assessment Guides.*  
NS-TAST-GD-026, Revision 3, Decommissioning  
  
NS-TAST-GD-024, Revision 4, Management of Radioactive Materials and Radioactive waste on Nuclear Licensed sites  
  
NS-TAST-GD-081, Revision 1, Safety aspects specific to storage of spent nuclear fuel  
  
NS-TAST-GD-017, Revision 3, Civil engineering  
  
NS-TAST-GD-051, Revision 3, The purpose, scope, and content of safety cases.  
  
[www.hse.gov.uk/nuclear/operational/tech\\_asst\\_guides/index.htm](http://www.hse.gov.uk/nuclear/operational/tech_asst_guides/index.htm).
- 7 *Generic Design Assessment of HGNE's Advanced Boiling Water Reactor (ABWR) - Step 2 Assessment Plan for Radioactive Waste and Decommissioning*  
ONR-GDA-AP-13-011 Revision . ONR December 2013. TRIM Ref 2013/420955

8 *IAEA Standards and Guidance.*

*IAEA Methods for the Minimization of Radioactive Waste from Decontamination and Decommissioning of Nuclear Facilities, technical Report Series no: 401, Vienna 2001*

*IAEA Safety Standards – Safety of Nuclear Fuel facilities no: NS-R-5, Vienna 2008*

*IAEA Safety Standards – Decommissioning of Nuclear Fuel Cycle facilities No: WS-G-2.4, Vienna 2001.*

*IAEA Safety Standards – Decommissioning of Facilities Using Radioactive Material No: WS-R-5, Vienna 2006.*

*IAEA Design Lessons Drawn from the Decommissioning of Nuclear Facilities, TECDOC- 1657, Vienna 2011.*

*IAEA Safety Standards – Decommissioning of Nuclear Power Plants and Research Reactors No: WS-G-2.1, Vienna 1996.*

*IAEA Safety Standards – Decommissioning of Medical, Industrial and Research facilities No: WS-G-2.2, Vienna 1999*

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**Table 1**

Relevant Safety Assessment Principles Considered During the Assessment

SAP No and Title	Description	Interpretation	Comment
ECV.1	Engineering principles: containment and ventilation: containment design – prevention of leakage	Radioactive substances should be contained and the generation of radioactive waste through the spread of contamination by leakage should be prevented.	This is addressed in Section 4.1 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.
ECV.2	Engineering principles: containment and ventilation: containment design - Minimisation of releases	Nuclear containment and associated systems should be designed to minimise radioactive releases to the environment in normal operation, fault and accident conditions.	This is addressed in Section 4.1.1 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.
ECV.4	Engineering principles: containment and ventilation: containment design - Provision of containment barriers	Where the radiological challenge dictates, waste storage vessels, process vessels, piping, ducting and drains (including those that may serve as routes for escape or leakage from containment) and other plant items that act as containment for nuclear matter, should be provided with further containment barrier(s) that have sufficient capacity to deal safely with the leakage resulting from any design basis fault	This is addressed in Section 4.1 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.,
RW.1	Radioactive waste management – Strategies for radioactive waste	A strategy should be produced and implemented for the management of radioactive waste on a site.	This is addressed in Section 4.3 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.
RW.2	Radioactive waste management –Generation of radioactive waste	The generation of radioactive waste should be prevented or, where this is not reasonably practicable, minimised in terms of quantity and activity	This is addressed in Section 4.1 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
RW.3	Radioactive waste management – Accumulation of radioactive waste	The accumulation of radioactive waste on site should be minimised.	This is addressed in Section 4.3 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
RW.4	Radioactive waste management – Characterisation of radioactive	Radioactive waste should be characterised and segregated to facilitate subsequent safe and	This is addressed in Section 4.3 of this assessment report. My assessment has concluded that the aim

	waste	effective management.	of this SAP is not yet fully met.
RW.5	Radioactive waste management – Storage of radioactive waste and passive safety	Radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition.	This is addressed in Section 4.3 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
RW.6	Radioactive waste management – Passive safety timescales	Radioactive waste should be processed into a passively safe state as soon as is reasonably practicable.	This is addressed in Section 4.3 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.
ENM.1	Engineering principles: control of nuclear matter – Strategies for nuclear matter	A strategy (or strategies) should be made and implemented for the management of nuclear matter	This is addressed in Section 4.3 and Section 4.4 of this assessment report. My assessment has concluded that the aim of this SAP is partially me..
ENM. 3	Engineering principles: control of nuclear matter – Transfers and accumulation of nuclear matter	Unnecessary or unintended generation, transfer or accumulation of nuclear matter should be avoided.	This is addressed in Section 4.1 and Section 4.4 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.
ENM.5	Engineering principles: control of nuclear matter – Characterisation and segregation	Nuclear matter should be characterised and segregated to facilitate its safe management	This is addressed in Section 4.3 and Section 4.4 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.
ENM.6	Engineering principles: control of nuclear matter – Storage in a condition of passive safety	When nuclear matter is to be stored on site for a significant period of time it should be stored in a condition of passive safety and in accordance with good engineering practice.	This is addressed in Section 4.3 and Section 4.4 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
ENM.7	Engineering principles: control of nuclear matter – Retrieval and inspection of stored nuclear matter	Storage of nuclear matter should be in a form and manner that allows it to be retrieved and, where appropriate, inspected.	This is addressed in Section 4.3 and Section 4.4 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met, or is partially met.
DC.1	Decommissioning – Design and operation	Facilities should be designed and operated so that they can be safely decommissioned	This is addressed in Section 4.5 of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully me.,
DC.2	Decommissioning – Decommissioning Strategies	A decommissioning strategy should be prepared and maintained for each site and should be integrated with other relevant strategies.	This is addressed in Section 4.5 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.

DC.3	Decommissioning – Timing of decommissioning	Decommissioning should be carried out as soon as is reasonably practicable taking relevant factors into account.	This is addressed in Section 4.5 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
DC.4	Decommissioning - Planning for decommissioning	A decommissioning plan and programme should be prepared and maintained for each nuclear facility throughout its life-cycle to demonstrate that it can be safely decommissioned.	This is addressed in Section 4.5 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
DC.5	Decommissioning – Passive safety	The facility should be made passively safe before entering a care and maintenance phase.	The current RP safety case does not have a care and maintenance phase.
DC.6	Decommissioning – Records for decommissioning	Throughout the whole life-cycle of a facility the documents and records that might be required for decommissioning purposes should be identified, prepared, updated and retained.	This is addressed in Section 4.5 of this assessment report. My assessment has concluded that the aim of this SAP is partially met.
RP.4	Radiological Protection – contaminated areas	Suitable and sufficient decontamination provisions for the people, the facility, its plant and equipment should be provided	This is addressed in Section 4.2. of this assessment report. My assessment has concluded that the aim of this SAP is not yet fully met.